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# SPACE SHUTTLE ENTRY AND LANDING NAVIGATION ANALYSIS

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## ABSTRACT

A navigation system for the entry phase of a Space Shuttle mission is evaluated in detail. The navigation system is an aided-inertial system which uses a Kalman filter to mix IMU data with data derived from external navigation aids. A drag pseudo-measurement used during radio blackout is treated as an additional external aid. The Kalman filter has a variable dimension of between 6 and 15 states. A comprehensive truth model with 101 states is formulated and used to generate detailed error budgets at several significant time points -- end-of-blackout, start of final approach, over runway threshold, and touchdown. Sensitivity curves illustrating the effect of variations in the size of individual error sources on navigation accuracy are presented. In addition, the sensitivity of the navigation system performance to filter modifications is analyzed. The projected overall performance is shown in the form of time histories of position and velocity error components. The detailed results are summarized and interpreted, and suggestions are made concerning possible software improvements.

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# 1. INTRODUCTION

This document describes the results of the second part of a study conducted by TASC, involving detailed error models and performance evaluations of candidate Space Shuttle navigation systems. The results of the preceding part were reported in Ref. 1. This study is one element of a general effort led by NASA to establish operational characteristics of the Space Shuttle Orbiter systems. Considerable progress has been made during the past two years in the portion of this effort related to navigation. The "baseline systems" treated herein are the result of a continuing process of design, evaluation, and refinement, in which individuals representing a number of organizations have participated.

## 1.1 OBJECTIVES AND SCOPE

The general purpose of this study is to aid in the evaluation and design of the multi-sensor schemes proposed for the Orbiter navigation system. The scope of the effort described herein covers the entry, energy management, and approach and landing phases of the mission -- from an altitude of 400,000 ft to touchdown. Figure 1.1-1 illustrates the current baseline approach and landing system operation. A single TACAN station provides external range and azimuth measurements beginning with the termination of radio blackout, and ending when the MLS (Microwave Landing System) signals are acquired in the vicinity of the runway. The MLS signals include range, azimuth, and elevation angle measurements. Some key elements not shown in the figure

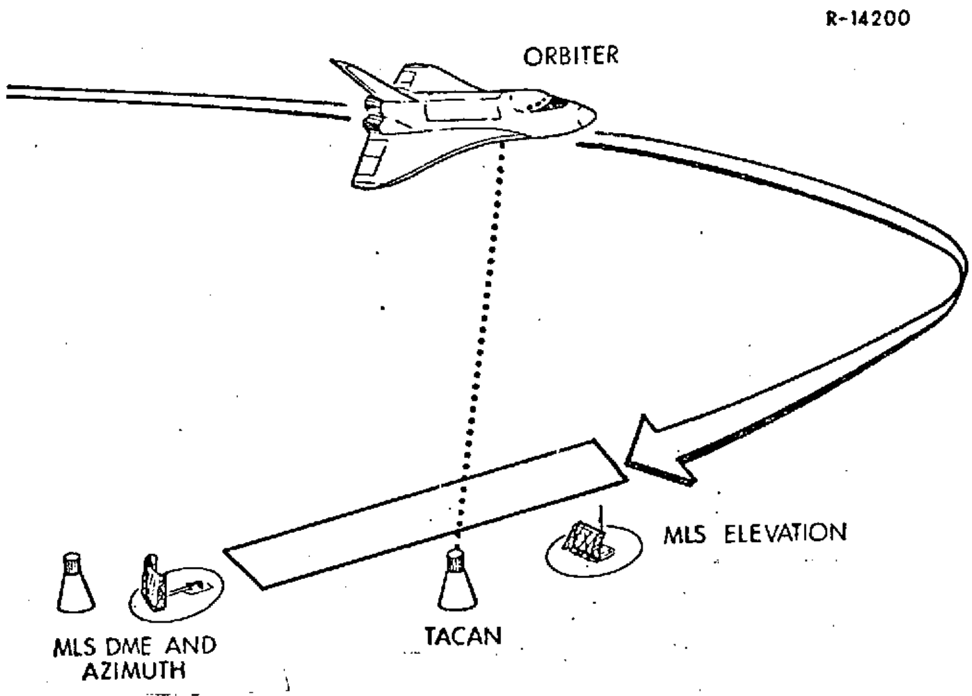


Figure 1.1-1 Baseline Orbiter Landing System

are the onboard IMUs (Inertial Measurement Units), altimeters, and computers. The latter are programmed to mix together (filter) the IMU data and the externally derived data. The algorithms used to accomplish this function are based on optimal filtering schemes developed by Kalman and others (Ref. 24).

Specific objectives of this effort are:

- Define and develop mathematical models describing all potentially significant sources of error for each navigation system considered.
- Develop a detailed, quantitative understanding of the contributions of individual error sources to overall system performance.
- Present results in a form which will help NASA choose or specify hardware elements or their characteristics.
- Evaluate software approaches to the navigation filter design problem.

Table 1.1-1 summarizes the main features of six candidate systems which have been evaluated in detail -- four in the previous part of this

TABLE 1.1-1

CANDIDATE SYSTEMS

| | IMU | EXTERNAL AIDS | FILTER | USE OF DRAG UPDATING |
|---|---|---|---|---|
| **PART I** | | | | |
| System A | KT-70 | 2 DMEs<br>Baro Altimeter<br>ILS (3 deg)<br>Radar Altimeter | 24-State Multi-Phase Filter | No |
| System B | KT-70 | 2 DMEs<br>Baro Altimeter<br>ILS (3 deg)<br>Radar Altimeter | 6-State Square-Root Filter | No |
| System C | KT-70 | One-Way Doppler<br>Baro Altimeter<br>Radar Altimeter | 22-State Multi-Phase Filter | No |
| System D | KT-70 | 1 DME } TACAN<br>1 VOR }<br>ILS (Localizer Only)<br>Baro Altimeter<br>Radar Altimeter | 23-State Multi-Phase Filter | Yes |
| **PART II** | | | | |
| Drag-Update Filter | KT-70 | None | 13-State Unified Filter | --- |
| System E | KT-70 | 1 DME } TACAN<br>1 VOR }<br>MLS<br>Baro Altimeter<br>Radar Altimeter | 15 → 6-State Unified Filter | Yes |

Acronyms:

- IMU – Inertial Measurement Unit
- DME – Distance Measuring Equipment (range)
- ILS – Instrument Landing System (elevation and azimuth)
- MLS – Microwave Landing System (range, elevation, and azimuth)
- VOR – VHF Omnidirectional Range (azimuth)

study and two in the current part. The latter correspond to two phases of the entry and landing trajectory using the current baseline system, as follows:

- The drag-update phase, covering the time from entry interface (400,000 ft) to the end of radio blackout (assumed here to be 130,000 ft).
- The approach and landing phase, covering the time from end-of-blackout to touchdown.

In the first phase, a 13-state drag-update filter is used to blend in drag "pseudo-measurements," as discussed in Chapters 4 and 5 and Appendix C. In the second phase, a variable-dimensioned System E filter is used to blend the inertial data with the externally derived data. Both of these filters are manifestations of a single "unified" filter structure whose maximum state dimension is 15. With the measurement sequence and groundrules established for this study, the maximum number of active states used at one time is 15; the minimum is 6 -- during final approach. The principal computational results of the study are the error budget tables given in Chapter 5. These tables list separate contributions to system error due to individual error sources, or small groups of error sources, at four critical trajectory points:

- The end of radio blackout (130,000 ft)
- The beginning of the terminal approach (12,000 ft)
- The runway threshold, and
- The touchdown.

## 1.2 RELATIONSHIP TO OTHER EFFORTS

Other efforts which relate to the present study fall into three categories as follows:

- Past multi-sensor navigation studies by TASC in which the methodology employed herein was developed.
- Past studies by others involving Shuttle filter design, IMU error propagation, and sensor error modeling.
- Ongoing and future efforts to establish operational characteristics of the Shuttle navigation system.

A discussion of the first two items above may be found in Section 1.2 of Ref. 1 and in Ref. 2. Highlights involve TASC's work for the Air Force on the CIRIS (Ref. 3) and CLASS (Ref. 4) programs; filter design studies by Lear of TRW (Ref. 5) and Kriegsman, Muller, and others of the Charles Stark Draper Laboratory (Refs. 6 through 9); a "one rev" Space Shuttle mission IMU error study by Clark and Mitchell (Ref. 10); and the periodically-revised NASA document (Ref. 11) describing various navigation subsystem characteristics and error models.

The relationship of this study to ongoing and future efforts involves its impact on software and hardware decisions to be made by NASA and its major contractors. The software decisions involve methods for mixing inertial data with externally-derived data -- such as the choice of filter states and parameters. The hardware decisions involve the selection of the onboard and ground-emplaced devices needed to obtain the external data, as well as the specification of particular hardware characteristics, required survey accuracy, etc. The detailed results generated in this study provide a sound quantitative basis for rational decisions.

## 1.3 APPROACH

The general approach and mathematical techniques described in Sections 1.3 and 2.4 of Ref. 1, were employed in essentially the same way in this part of the study. (Some important differences in the detailed truth model structure, required for the drag-update evaluation, are described in Appendix C.) The overall methodology used is briefly reviewed here with the aid of Fig. 1.3-1. The upper half of the diagram represents the recursive solution of the filter covariance propagate and update equations. These are solved once for a given trajectory and measurement schedule. Certain elements of the filter dynamics and measurement matrices are functions of the Shuttle position and velocity vectors and the relative geometry between the Shuttle and the ground-navaid antenna locations. The outputs are the time histories of the filter-indicated performance and the Kalman filter gain matrices. The latter are stored on tape and called a "gain file." The lower half of the diagram represents the recursive solution of the linear system covariance equations. These are solved repeatedly to produce an error budget, the same gain file being used each time. The trajectory-dependent matrices describing the real-world error model are of much higher dimension than the corresponding filter matrices. In individual error budget runs,

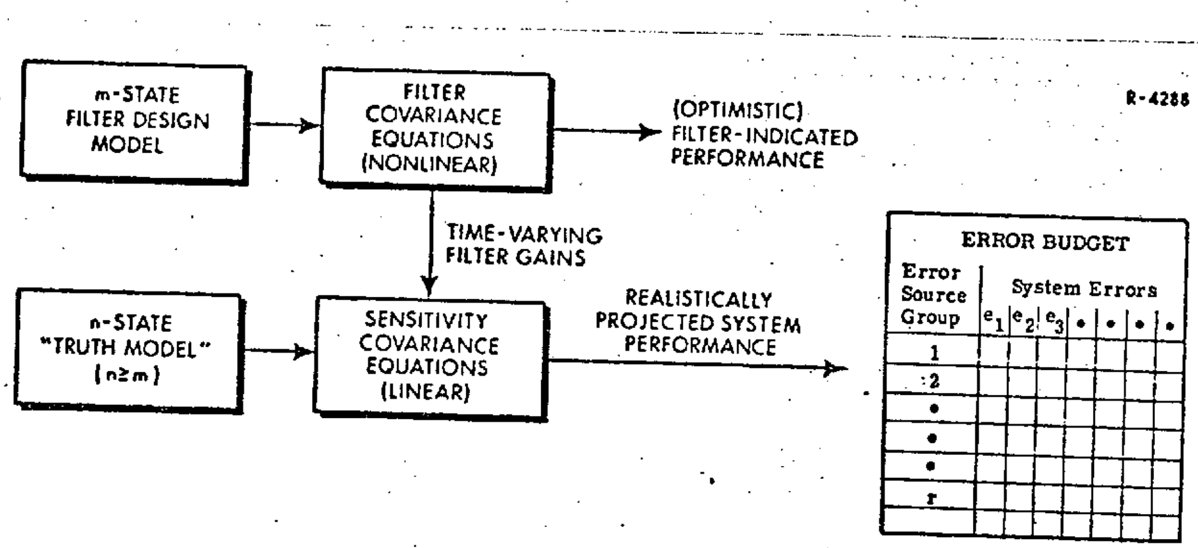


Figure 1.3-1 Realistic System Performance Projections

specific elements of input matrices, corresponding to specific error sources, are set to non-zero values, with all other elements set to zero. The output time history of the system error covariance matrix is then a statistical measure of the effect of that particular error source or small group of error sources, and generates one row of the error budget table. When the entire table is filled in, an overall system performance projection is calculated from the detailed error-source-by-error-source breakdown.

## 1.4 ORGANIZATION OF THE REPORT

Chapter 2 describes the approach and landing trajectory, and the measurement schedules used in evaluating the drag-update and the System E navigation performance. The trajectory is based on a one-orbit polar mission beginning and ending at Vandenberg Air Force Base.

Chapter 3 outlines the truth model states and error sources used in studying the two mission phases. The associated mathematical details are relegated to Appendices C, D and E. (Appendix D provides a useful discussion of non-standard atmospheric density and wind models.)

Chapter 4 defines the filter states, parameters, and algorithms used to compute filter-indicated performance and to generate the filter gain sequences, which were filed on magnetic tape.

Chapter 5 presents the major results of the study. For the two mission phases treated, the parameters defining error source statistics are listed and error budgets, detailing contributions to system error at important trajectory times, are given. Overall system performance projections, in the form of rms position and velocity error time histories, are plotted. (Detailed computer printouts, showing individual contribution time histories are given in Appendices F and G.) Sensitivity curves showing the effects of variations in the size of major error sources are presented. For the approach and landing phase, the effect of alternate filter configurations on overall system performance is also given. A general discussion of system performance, comparison with previous results, and filter design is included.

A brief summary of results, conclusions, and recommended future studies is provided in Chapter 6.

# 2. TRAJECTORY, MEASUREMENT SCHEDULES, AND METHODOLOGY

This Chapter describes the approach and landing trajectory and the measurement schedules used in evaluating the entry navigation system. Section 2.3 defines the basic terminology and states the linear covariance equations used in evaluating candidate systems.

## 2.1 NOMINAL TRAJECTORY

The reference trajectory was provided on magnetic tape by JSC (Ref. 12). The tape consists of the entry portion of the Shuttle reference mission 3B. This is a one-orbit abort mission initiated with a launch from Vandenberg Air Force Base into a 100 nautical mile circular orbit with an inclination of 104°. The trajectory from entry interface (400,000 ft altitude) to touchdown is illustrated in Fig. 2.1-1. The drag-update phase begins over Greenland and terminates over northern California. System E operation begins at this point and terminates at touchdown.

The ground track for the reference trajectory approach and landing is shown in greater detail in Fig. 2.1-2. The final approach begins at an altitude of approximately 12,000 ft. The final approach glide slope of 24° is maintained until a flare maneuver is initiated at an altitude of 1,360 ft -- approximately 27 sec before touchdown. Touchdown is 1,000 ft past the runway threshold.

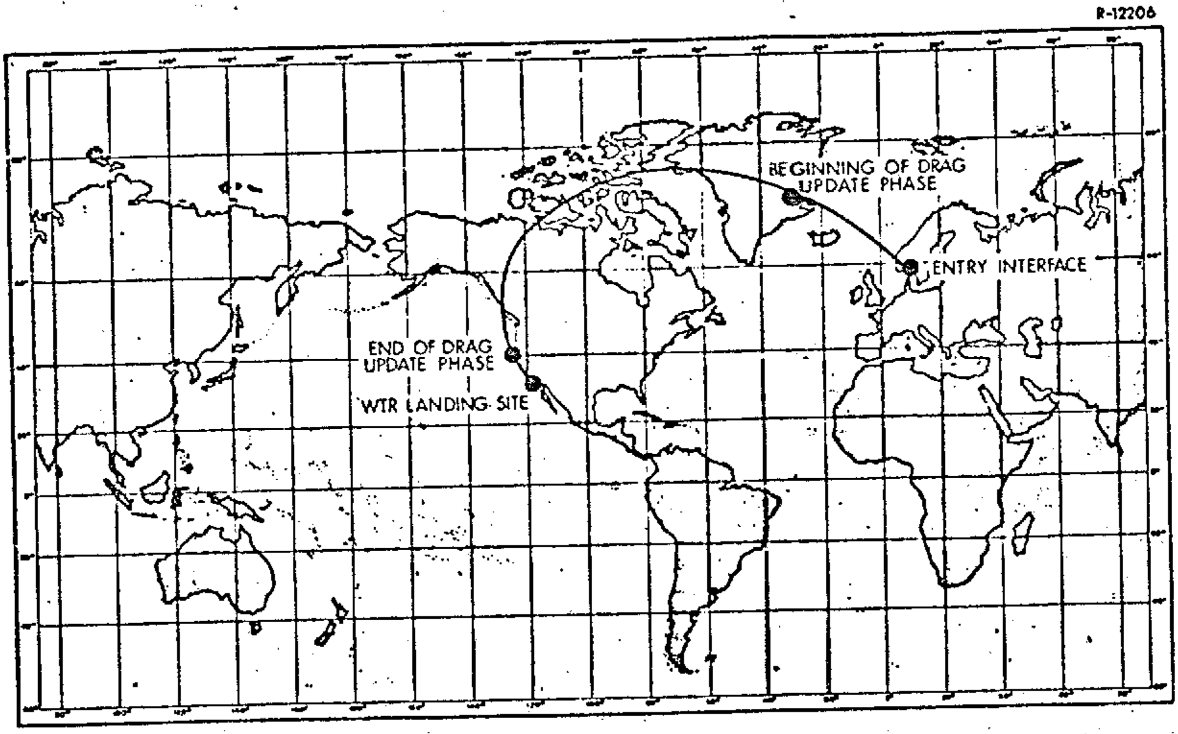


Figure 2.1-1 Shuttle Entry Ground Track for Reference Mission 3B

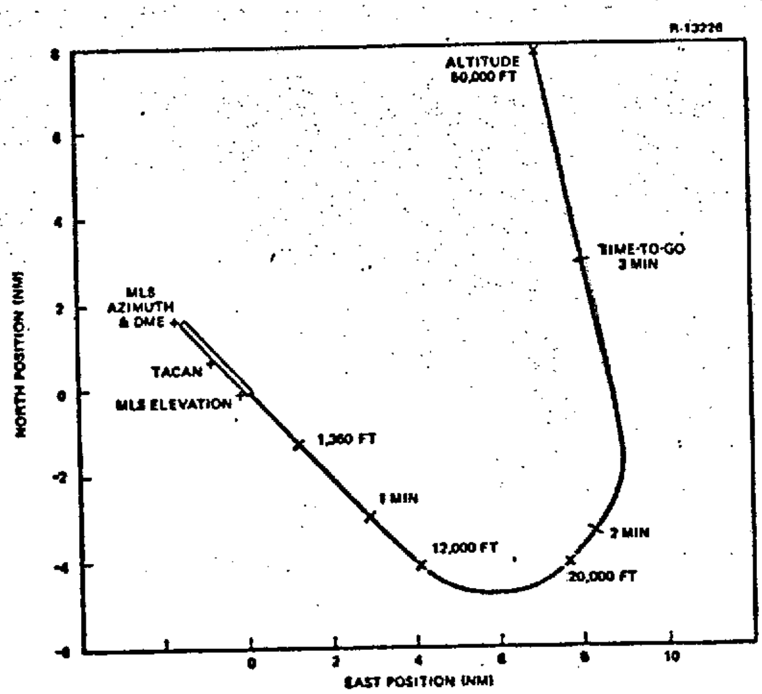


Figure 2.1-2 Approach and Landing Ground Track for Reference Mission 3B

## 2.2 MEASUREMENT SCHEDULE

The drag-update phase of the entry begins at the time of the first drag acceleration pseudo-measurement (see Section 3.1). This pseudo-measurement occurs at the time at which the deceleration magnitude reaches 0.1g. The drag-update phase ends at the time at which blackout terminates -- which is assumed to occur nominally at an altitude of 130,000 ft. Both times are indicated in Table 2.2-1 for the reference trajectory.

TABLE 2.2-1

KEY EVENTS FOR DRAG-UPDATE AND SYSTEM E EVALUATIONS

| Event | Elapsed Time (sec) | Time to Touchdown (sec) | Altitude (ft) | Relative Velocity (ft/sec) |
|---|---|---|---|---|
| Entry Interface, $T_0$ | 0. | 1946.5 | 399,989 | 26059. |
| First Drag Measurement, $T_{DRAG}$<br>Beginning of Drag-Update Phase | 312. | 1634.5 | 269,691 | 26072. |
| First TACAN Measurement, $T_{TACAN}$<br>End of Drag-Update Phase<br>Beginning of System E | 1432. | 514.5 | 129,904 | 6121. |
| First Baro Altimeter Measurement, $T_{BA}$<br>(No Drag Measurement) | 1550. | 396.5 | 99,676 | 3695. |
| First MLS Azimuth and Elevation Measurements, $T_{MLS}$<br>(No TACAN Measurement)<br>(No Baro Altimeter) | 1836. | 110.5 | 20,002 | 583. |
| First MLS DME Measurement, $T_{DME}$ | 1846. | 100.5 | 18,051 | 581. |
| Reduce Filter Dimension, $T_{SW}$<br>Switch from 2 sec Update Cycle to 0.5 sec Update Cycle | 1874. | 72.5 | 11,862 | 569. |
| First Radar Altimeter Measurement, $T_{RA}$<br>(No MLS Measurement)<br>Switch from 0.5 sec Update Cycle to 0.1 sec Update Cycle | 1943.5 | 3. | 12 | 317. |
| Touchdown | 1946.5 | 0. | 0 | 290. |

System E operation begins at the termination of the drag-update phase. The key events for System E are the times at which the first and last measurement from each sensor are processed, the times at which the dimension of the System E Kalman filter changes, and the times at which the measurement update rate changes. These events are indicated in Table 2.2-1. The MLS and TACAN antenna locations relative to the touchdown point are indicated in Table 2.2-2.

TABLE 2.2-2

SENSOR LOCATIONS WITH RESPECT TO TOUCHDOWN POINT

| | Downrange (ft) | Crossrange (ft) |
|---|---|---|
| MLS Elevation | 0 | 250 |
| MLS Azimuth and MLS DME | 15,000 | 250 |
| TACAN | 6,500 | 250 |

Above 100,000 ft the System E sensors are TACAN and the drag pseudo-measurement. Between 100,000 ft and MLS acquisition at 20,000 ft, the drag pseudo-measurement is replaced by the baro altimeter. Both TACAN and the baro altimeter are terminated at 20,000 ft.

The azimuth angle and the elevation angle segments of MLS are acquired at an altitude of 20,000 ft; the DME segment is acquired at 18,000 ft. MLS is the only external aid used between the altitudes of 20,000 ft and 12 ft -- at 12 ft the Shuttle is nominally over the runway threshold. MLS is terminated at the runway threshold and the radar altimeter is switched on for the final landing sequence.

The basic measurement update cycle for the drag-update phase and for System E is 2 sec -- one measurement from each operating sensor is processed every 2 sec. The interval between updates is reduced to 0.5 sec at the beginning of the final approach. It is further reduced to 0.1 sec at the runway threshold.

## 2.3 COVARIANCE EQUATIONS

Detailed system error budgets are generated in Chapter 5 by solving a set of linearized system covariance equations. Solution of these equations requires that a gain file of the measurement gains used in the navigation filter be generated. The relationship between the filter model from which the filter gains are computed, and the truth model from which the error budget is computed, is summarized in this section. Although covariance equations alone are sufficient to establish this relationship, the state equations for the two models are also presented.

The filter model ($F_F$, $H_F$) upon which the navigation filter is defined is a low-order approximation of the navigation system dynamics and of the real-world environment in which the filter is designed to operate. The filter, which may be nonlinear, generates an m-dimensional state estimate, $\hat{\underline{x}}_F$, which propagates between measurements according to

$$\hat{\underline{x}}_F(t_{k+1}^-) = \Phi_{F_k} \hat{\underline{x}}(t_k^+) + G \; \Delta\underline{V}(t_{k+1}) \qquad (2.3\text{-}1)$$

where $G$ is the control matrix, $\Phi_{F_k}$ is the filter state transition matrix, and $\Delta\underline{V}$ is the computed velocity change over the interval. If the filter dynamics matrix, $F_F(t)$, is constant between $t_k$ and $t_{k+1}$, $\Phi_{F_k}$ is given by

$$\Phi_{F_k} = \exp\left[F_F(t_k)(t_{k+1} - t_k)\right] \tag{2.3-2}$$

The system measurements, $\underline{z}$, are used to update the filter state estimates by first generating the measurement residual vector

$$\delta\underline{z}_S(t_k) = \underline{z}(t_k) - H_F(t_k)\,\hat{\underline{x}}(t_k^-) \tag{2.3-3}$$

and then using the filter update equation

$$\hat{\underline{x}}_F(t_k^+) = \hat{\underline{x}}(t_k^-) + K_F(t_k)\,\delta\underline{z}_S(t_k) \tag{2.3-4}$$

where $K_F(t_k)$ is the filter gain matrix and $H_F(t_k)$ is the filter measurement matrix.

Generation of a detailed error budget does not require that Eqs. (2.3-1) through (2.3-4) be solved; all that is necessary is to generate the filter gain matrices. If the navigation filter is suboptimal, an algorithm for computing the gains must be provided. If the navigation filter is a Kalman filter, the gains satisfy

$$K_F(t_k) = P_F(t_k^-)\,H_k(t_k)^T\left[H_F(t_k)\,P_F(t_k^-)\,H_F(t_k)^T + R_{F_k}\right]^{-1} \tag{2.3-5}$$

where $P_F(t_k^-)$ is the filter covariance matrix* before the measurement update and $R_{F_k}$ is the measurement noise covariance matrix used in the filter model. The filter covariance propagates from one measurement to the next by

$$P_F(t_{k+1}^-) = \Phi_{F_k}\,P_F(t_k^+)\,\Phi_{F_k}^T + Q_{F_k} \tag{2.3-6}$$

*The filter covariance is the filter-generated estimate of the variance of $\underline{x}_F$; it is not necessarily the true variance of $\underline{x}_F$.

where $Q_{F_k}$ is the process noise covariance matrix used in the filter model. The filter covariance after the measurement update is

$$P_F(t_k^+) = P_F(t_k^-) - K_F(t_k) H_F(t_k) P_k(t_k^-) \qquad (2.3\text{-}7)$$

In order to apply Eqs. (2.3-5) through (2.3-7); $P_F(0)$, $R_{F_k}$, and $Q_{F_k}$ must be provided for the filter model along with ($F_F$, $H_F$).

The truth model ($F_S$, $H_S$) upon which the error budget is based is a detailed model of both the navigation system dynamics and the real-world environment. The truth model includes all important error sources which affect the navigation system performance, including those which were omitted from the filter model. Because the error budget is concerned with navigation errors, the truth model can be linearized about the nominal system state. This yields a set of linearized covariance equations for the system errors.

Figure 2.3-1 is a conceptual representation of the mathematical structure of all truth models used in this study. An n-dimensional system

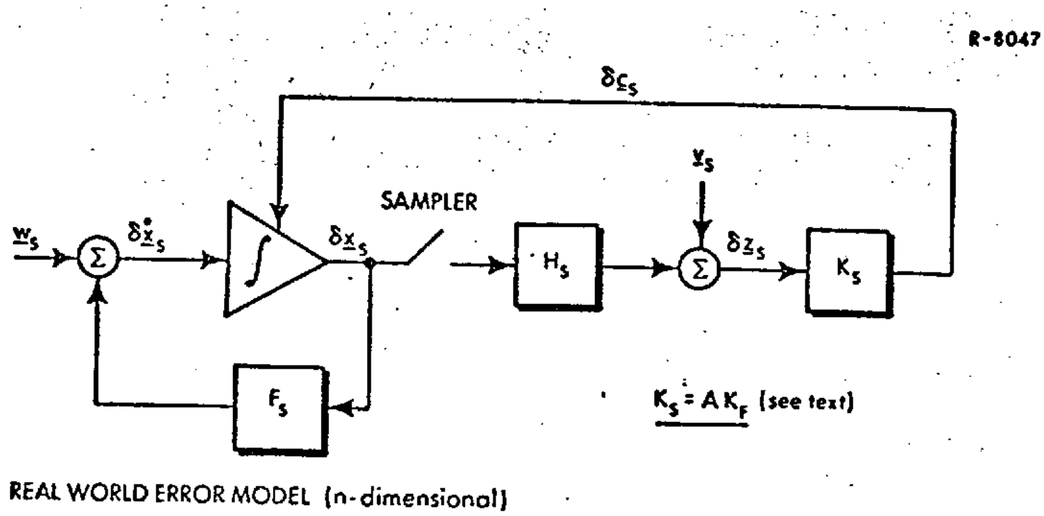


Figure 2.3-1 Truth Model Structure

error state vector, $\delta \underline{x}_S$, is defined which includes both the filter state estimation errors and the navigation error sources. The error state vector propagates between measurement times according to the linear, time-varying differential equation

$$\delta \dot{\underline{x}}_S(t) = F_S(t)\, \delta \underline{x}_S(t) + \underline{w}_S(t) \qquad (2.3\text{-}8)$$

where $F_S(t)$ is the system error dynamics matrix and $\underline{w}_S$ is a zero mean, gaussian process noise with

$$E\left[\underline{w}_S(t)\, \underline{w}_S(t-\tau)^T\right] = Q_S\, \delta(t-\tau) \qquad (2.3\text{-}9)$$

The measurement residual vector is the same as in Eq. (2.3-3), but it can be expressed in terms of the system error state vector and a random measurement noise

$$\delta \underline{z}_S(t_k) = H_S(t_k)\, \delta \underline{x}_S(t_k) + \underline{v}_S(t_k) \qquad (2.3\text{-}10)$$

where $H_S(t_k)$ is the system measurement matrix and $\underline{v}_S(t_k)$ is a zero mean, gaussian white measurement noise with

$$E\left[\underline{v}_S(t_k)\, \underline{v}_S(t_k)^T\right] = R_{S_k} \qquad (2.3\text{-}11)$$

After the filter update using Eq. (2.3-3), the system error state vector is

$$\delta \underline{x}_S(t_k^+) = \delta \underline{x}_S(t_k^-) + K_S(t_k)\, \delta \underline{z}_S(t_k) \qquad (2.3\text{-}12)$$

where $K_S(t_k)$ is a gain matrix with n rows.

$$K_S(t_k) = AK_F(t_k) = \begin{bmatrix} A' \\ \hline 0 \end{bmatrix} K_F(t_k) = \begin{bmatrix} A'K_F(t_k) \\ \hline 0 \end{bmatrix} \Big\} \begin{pmatrix} \text{n-m rows} \\ \text{of zeros} \end{pmatrix} \qquad (2.3\text{-}13)$$

A is an n x m matrix linearly relating the m filter states to the n truth model states.

The system error budgets presented in Chapter 5 are concerned with the variance of the error state vector $\delta \underline{x}_S$. Given the initial condition

$$P_S(0) = E\left[\delta \underline{x}_S(0)\ \delta \underline{x}_S(0)^T\right] \tag{2.3-14}$$

the truth model covariance propagates between measurements by

$$\boxed{P_S(t_{k+1}^-) = \Phi_k\, P_S(t_k^+)\, \Phi_k^T + Q_{S_k}} \tag{2.3-15}$$

where $\Phi_k$ is the error state transition matrix. If $F_S(t)$ is constant between $t_k$ and $t_{k+1}$, then

$$\Phi_k = \exp\left[F_S(t_k)\,(t_{k+1} - t_k)\right] \tag{2.3-16}$$

The discrete process noise matrix in Eq. (2.3-15) satisfies

$$Q_{S_k} = \int_{t_k}^{t_{k+1}} \exp\left[F_S(t_{k+1} - \tau)\right] Q_S \exp\left[F_S(t_{k+1} - \tau)\right]^T d\tau \tag{2.3-17}$$

Truncated matrix exponential series are used in evaluating the transition and discrete noise matrices defined above. For update of the system covariance matrix at $t_k$

$$P_S(t_k^+) = \left[I - K_S(t_k) H_S(t_k)\right] P_S(t_k^-) \left[I - K_S(t_k) H_S(t_k)\right]^T + K_S(t_k) R_{S_k} K_S(t_k)^T$$

(2.3-18)

Equations (2.3-15) and (2.3-18) are time-varying, linear equations in the system error covariance, $P_S(t)$. This fact allows easy computation of overall system performance by root-sum-squaring separate contributions and easy development of the sensitivity curves. The results in Chapter 5 are based upon repeated solution of Eqs. (2-3-13) through (2.3-18).

# 3. TRUTH MODELS

This section describes the "truth models" used in evaluating the entry navigation system.* Each truth model description includes a list of error sources, a detailed mathematical structure, and a data base. The overall mathematical structure is a set of linear differential and algebraic equations describing system error propagation, as in Eqs. (2.3-13), (2.3-15) and (2.3-18). Most of the detailed structure is given in terms of sub-matrices of $F_S$ and $H_S$, the system error dynamics matrix and measurement matrix, defined in Section 2.3. The data base is the set of numerical values used to represent real-world error source statistics.

The analysis of the current baseline Space Shuttle entry navigation system is undertaken in two phases:

- Drag-update phase
- System E approach and landing

The drag-update phase commences at 400,000 ft and terminates at the end of the blackout – nominally 130,000 ft. The approach and landing is initiated at 130,000 ft and terminates at touchdown. The only navigation hardware elements common to both phases are the KT-70 IMU and the AP-101 computer. Detailed error budgets for each phase are generated in Chapter 5. The truth models used to compute the error budgets are outlined in this chapter.

*By "truth model," we mean a mathematical model of all potentially significant sources of error and the way they affect system performance in the real world.

## 3.1 DRAG-UPDATE MODEL

The computer navigation program for the drag-update phase is based upon a 13-state Kalman filter (see Chapter 4). The only "external" aid operating during the drag-update phase of entry is a drag "pseudo-measurement." The pseudo-measurement is a drag acceleration measurement constructed from the IMU accelerometer outputs. The "measured" drag acceleration is compared with the expected drag acceleration computed from a nominal atmospheric density model, a nominal estimate of the Shuttle drag coefficient, $C_D$, and the current estimate of position and velocity. Although drag acceleration is not a state variable in the Kalman filter,* a measurement matrix, $H_F$, is constructed which relates the difference between the measured and expected drag accelerations to the error in the position and velocity estimates. The Kalman filter utilizes this $H_F$ to update the position and velocity estimates (Section 4.2). The corresponding measurement matrix, $H_S$, for the truth model is derived in Appendix C.

### 3.1.1 States and Error Sources

Incorporation of a drag pseudo-measurement into the drag-update filter requires both the pseudo-measurement and a drag acceleration prediction based upon the current filter state estimate. The pseudo-measurement of drag acceleration is defined in Appendix C as

$$q_{meas}(t) = |\underline{i}_{VR_c}(t) \cdot \Delta\underline{V}(t)|/\Delta t \qquad (3.1\text{-}1)$$

where $\underline{i}_{VR_c}(t)$ is a unit vector in the direction of the computed relative velocity, and $\Delta\underline{V}(t)$ is the velocity change over the last $\Delta t$ sec as

---

* The filter does include one "drag correlated error" state designed to account for non-standard atmosphere and aerodynamics, etc.

measured by the IMU. The computed drag acceleration based upon the filter estimates of position and velocity is

$$q_{pred}(t) = \frac{1}{2} C_{D_c}(t) \frac{A}{m} \rho_c(t) V_{R_c}^2(t) \tag{3.1-2}$$

where $C_{D_c}(t)$ is the computed drag coefficient for the Space Shuttle, A is its cross-sectional area, and m is its mass. $\rho_c(t)$ and $V_{R_c}(t)$ are the computed atmospheric density and relative velocity, respectively. The difference between $q_{meas}(t)$ and $q_{pred}(t)$ is the residual which the drag-update filter uses to improve the filter state estimates [see Eq. (2.3-4)]:

$$\delta z_S(t) = q_{meas}(t) - q_{pred}(t) \tag{3.1-3}$$

The accuracy of the drag-update filter is determined by the accuracy of the state estimate propagation between updates, and the accuracy of $q_{meas}(t)$ and $q_{pred}(t)$ used in the updates. The error in the propagation is due to the standard IMU error sources. The error in $q_{meas}(t)$ is due to the standard IMU acceleration error sources and to factors which contribute to errors in the computed unit relative velocity vector, $\underline{i}_{VR_c}(t)$, such as:

- position errors
- velocity errors
- atmospheric winds

The error in $q_{pred}(t)$ is attributable to these last three error sources, and in addition to:

- atmospheric density modeling errors
- drag coefficient modeling errors

The measurement sensitivities to the various error sources are developed in Appendix C. The truth model states and other error sources used in evaluating the drag-update filter are listed in Table 3.1-1, which divides them into three categories:

## TABLE 3.1-1

## DRAG-UPDATE TRUTH MODEL STATES AND ERROR SOURCES

| ERROR SOURCE NAMES | NUMBER OF STATES | NUMBER OF ERROR SOURCES |
|---|---|---|
| I. ESTIMATED STATES AND UNCORRELATED NOISES | | |
| Group 1. | | |
| Position Errors | 3 | 3 |
| Velocity Errors | 3 | 3 |
| Platform Misalignments | 3 | 3 |
| Accelerometer 'Biases' (First-Order Markovs) | 3 | 3 |
| Correlated Measurement Error (First-Order Markov) | | |
| Drag | 1 | 1 |
| Uncorrelated Measurement Noise | | |
| Drag | – | 1 |
| INS Quantization Noise | – | 3 |
| II. NON-ESTIMATED, IMU-RELATED STATES | | |
| Group 1a, True Platform Misalignments | 3 | 3 |
| Group 2. Accelerometer True Biases | 3 | 3 |
| Group 3. Accelerometer Scale Factor Errors | 3 | 3 |
| Group 4. Accelerometer Misalignments | 6 | 6 |
| Group 5. Accelerometer Nonlinearities | 3 | 3 |
| Group 6. Gravitational Deflections and Anomalies | 3 | 3 |
| Group 7. Gyro True Bias Drifts | 3 | 3 |
| Group 8. Gyro Mass Unbalances | 6 | 6 |
| Group 9. Gyro Anisoelasticities | 3 | 3 |
| III. NON-ESTIMATED, DRAG RELATED STATES | | |
| Group 21. Non-Standard Density | | |
| 1962 Standard Atmosphere Error | 1 | 1 |
| Time-Varying Bias | 1 | 1 |
| First-Order Markov | 1 | 1 |
| Group 22. Non-Standard Wind | | |
| Westerly (Time-Varying Bias) | 1 | 1 |
| Headwind (First-Order Markov) | 1 | 1 |
| Crosswind (Second-Order Markov) | 2 | 1 |
| Turbulence (First- and Second-Order Markovs) | 5 | 3 |
| Group 23. Non-Standard Aerodynamics | | |
| First-Order Markov | 1 | 1 |
| Totals | 59 | 60 |

- The 13 estimated states and uncorrelated measurement and process noises.
- Non-estimated states related to the inertial system.
- Non-estimated states related to the drag acceleration pseudo-measurement ($q_{meas}(t)$ and $q_{pred}(t)$).

Error budget results corresponding to the first category are generated using a truth model structure ($F_S$, $H_S$) which is similar to the filter error model structure -- the principal difference is in the definition of $H_F$ and $H_S$. Results corresponding to the other two categories are generated using a higher-dimensional truth model, which contains the basic 13-state structure plus other states representing time-correlated error sources not modeled explicitly in the filter design. For the baseline navigation system, these additional error sources are divided into a total of 23 groups. (The group numbers are consistent with those used in Ref. 1). Only those groups which affect the drag-update phase are summarized in Table 3.1-1.

The drag-update truth model requires a 13 x 13 filter dynamics matrix, $F_F$, and a 59 x 59 system matrix, $F_S$. These matrices, as well as the transformation matrix A, are defined in Appendix E. The measurement matrices $H_S$ and $H_F$, as defined in Appendix C and Section 4.2, respectively, complete the definition of the truth model.

### 3.1.2 Truth Model Data Base

In this section numerical values are assigned to the drag-update truth model matrix elements describing error source statistics. Most of these values are elements of the following matrices:

$P_S(0)$ – the initial system (real-world) error covariance matrix

$Q_S$ – the system process noise matrix

$R_S$ – the pseudo-measurement noise variance

In addition, however, there are elements of $F_S$ which must be defined. Typically, these are diagonal elements of $F_S$ which define the correlation times of markov processes. These elements of $F_S$ and corresponding elements of $P_S(0)$, $H_S$, and $Q_S$ are normally chosen together to define markov processes with desired properties. If the markov processes are nonstationary, the appropriate elements of $F_S$, $H_S$, and $Q_S$ may be time-varying. The details of these manipulations are found in Appendices C, D, and E.

Values are not given in this section for the Group 1 (estimated) first-order markov states. These are the estimated platform misalignments, acceleration errors, and drag correlated error. The truth model structure distinguishes between these estimated states and the "true" states modeled in Groups 1a through 23. The time constants associated with the Group 1 states are identical to those assigned by the drag-update filter (Section 4.2), but the truth model assigns them a zero initial covariance and no process noise.

The elements of $F_S$ associated with the standard IMU error sources (Groups 1a through 9) are assigned in Appendix E. The remaining task associated with these error sources is to determine $P_S(0)$ at entry interface.

The 9x9 portion of $P_S(0)$ associated with position, velocity, and true misalignment errors was based upon Table C-III-c in Ref. 10. The 9x9 matrix represents error statistics at entry interface following a "one-rev" mission in which pure inertial navigation is used from launch through to entry interface. The IMU model used in Ref. 10 is the KT-70; the assumed prelaunch alignment technique consists of gyrocompassing for azimuth alignment and accelerometer tilt leveling. The 9x9 error covariance matrix given in Ref. 10 was corrected to reflect the calibration and alignment errors at launch as given in Ref. 13 -- these errors are summarized in Groups 1 through 4 and 7 through 9 in Table 3.1-2. Reference 10 did not consider accelerometer nonlinearities (Group 5) or gravity deflections and anomalies (Group 6).

TABLE 3.1-2

DRAG-UPDATE TRUTH MODEL DATA BASE
FOR IMU-RELATED ERROR SOURCES

| Error Source | | Standard Deviation | Data Source |
|---|---|---|---|
| Group 1. | INS Quantization Error | 1.0 cm/sec | Ref. 13 |
| Group 2. | Accelerometer Biases | 50 $\mu g$ | Ref. 13 |
| Group 3. | Accelerometer Scale Factor | 40 ppm | Ref. 13 |
| Group 4. | Accelerometer Misalignments | 15 $\widehat{sec}$ | Ref. 13 |
| Group 5. | Accelerometer Nonlinearities | 3.5 $\mu g/g^2$ | Ref. 13 |
| Group 6. | Gravity Deflections and Anomalies* | 8 $\widehat{sec}$<br>67 mgal | Ref. 14 |
| Group 7. | Gyro Bias Drifts | 0.015 deg/hr | Ref. 13 |
| Group 8. | Gyro Mass Unbalances | 0.025 deg/hr/g | Ref. 13 |
| Group 9. | Gyro Anisoelasticities | 0.025 deg/hr/$g^2$ | Ref. 13 |

*Sea level values are specified here. The truth model data base uses the sea level values and the model in Ref. 14 to provide standard deviations and correlation times as a function of altitude.

The truth model states for gravity deflections and anomalies are considerably more detailed than they appear to be in Table 3.1-2. The standard deviations specified correspond to the errors at sea level for a crude on-board gravity model. The model in Ref. 14 provides for attenuation of the magnitude of the errors as a function of altitude, e.g., at 250,000 ft the standard deviations have been attenuated by a factor of three. The model also relates the correlation distance to altitude.

The error sources in Groups 21 through 23 can be divided into two categories:

- time-varying biases
- stationary or nonstationary markov processes

Models for non-standard atmospheric density errors (Group 21) and non-standard wind errors (Group 22) are developed in Appendix D. For both time-varying biases and the nonstationary markov processes, Appendix D assigns a variance for the individual error sources as a function of altitude, latitude, and season -- in the latter case correlation times are also expressed as a function of altitude, latitude, season, and flight-path angle. The parameter ranges for these error models are summarized in Table 3.1-3.

TABLE 3.1-3

DRAG-UPDATE TRUTH MODEL DATA BASE FOR DRAG-RELATED ERROR SOURCES

| Error Source | | Standard Deviation | Correlation Time (Distance) | Data Source |
|---|---|---|---|---|
| Group 21. | Non-Standard Density | | | |
| | 1962 Standard Atmosphere Error | 0 - 21% | -- | Fig. 3.1-1 |
| | Time-Varying Bias | 4 - 49% | -- | Fig. 3.1-2 |
| | First-Order Markov | 2 - 6% | (14 - 270 nm) | Table D-2 |
| Group 22. | Non-Standard Wind | | | |
| | Westerly (Time-Varying Bias) | 0 - 295 ft/sec | -- | Fig. 3.1-3 |
| | Headwind (First-Order Markov) | 40 - 110 ft/sec | (270 nm) | Fig. D-4 |
| | Crosswind (Second-Order Markov) | 40 - 110 ft/sec | (270 nm) | Fig. D-4 |
| | Turbulence (First- and Second-Order Markovs) | 13 ft/sec | (1750 ft) | Appendix D |
| Group 23. | $C_D$ Variations | 5% | 100 sec | – |

Only turbulence and $C_D$ (drag coefficient) variations are modeled in Table 3.1-1 as stationary markov processes; the range of values for the nonstationary processes is indicated in the table. The correlation time for the $C_D$ variation has not been documented in the literature. In composing the drag-update error budget, $C_D$ variations were assumed to be either a stationary markov process with a correlation time of 100 sec (Group 23) or a white random sequence (drag measurement noise in Group 1). Three of the error sources are modeled in Table 3.1-1 as time-varying biases rather than true random processes. These are:

- errors in the drag-update filter model of the 1962 Standard Atmosphere
- season- and latitude-dependent (time-varying) density bias
- westerly wind

The models developed in Appendix D for these error sources are summarized in the remainder of this section.

Altitude profiles for the drag-update filter density modeling error are shown in Fig. 3.1-1 for two different onboard density models --

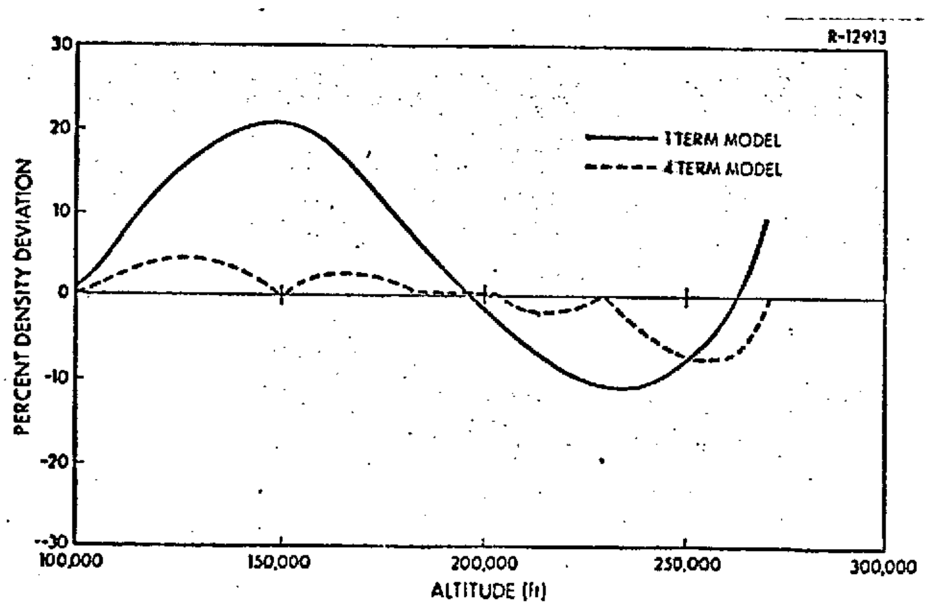


Figure 3.1-1 Deviation of Navigation Filter Density Models from 1962 Standard Atmosphere

the models are defined in Section 4.2. The density modeling errors are as great as 21% at 145,000 ft for the one-term model and 7% at 250,000 ft for the four-term model. Navigation errors due to both models are determined in Chapter 5.

The time-varying density bias exhibits both latitude- and season-dependence. Altitude profiles for both summer and winter are shown in Figs. 3.1-2a and 3.1-2b respectively as percent deviations from the 1962 Standard Atmosphere. Dashed lines on the profiles denote the mean density deviations corresponding to the reference mission 3B altitude-latitude profile. In both instances the deviations are greatest when the Shuttle is at high altitudes and high latitudes. Both models are analyzed in Chapter 5.

The mean westerly wind is also both season- and latitude-dependent. The season-dependence is shown in Fig. 3.1-3. Figure 3.1-3 was constructed explicitly for the reference mission 3B trajectory, it is not directly applicable to nonpolar entry trajectories. For reference, the standard deviation for the westerly wind is also indicated in Fig. 3.1-3. This is the same standard deviation indicated for the headwinds and crosswinds in Table 3.1-3. Again, navigation errors resulting from both profiles are analyzed in Chapter 5.

The non-standard atmospheric density and non-standard wind models summarized in this section provide a realistic statistical description of the individual drag-related error sources which affect the drag-update filter performance. Certain physical correlations, such as the correlations between wind and short term (first order markov) density deviations, were omitted from the error models; however, it is not expected that inclusion of these correlations would alter the performance analysis in Chapter 5 significantly. The correlations can be added for applications in which a more detailed model of atmospheric properties is necessary.

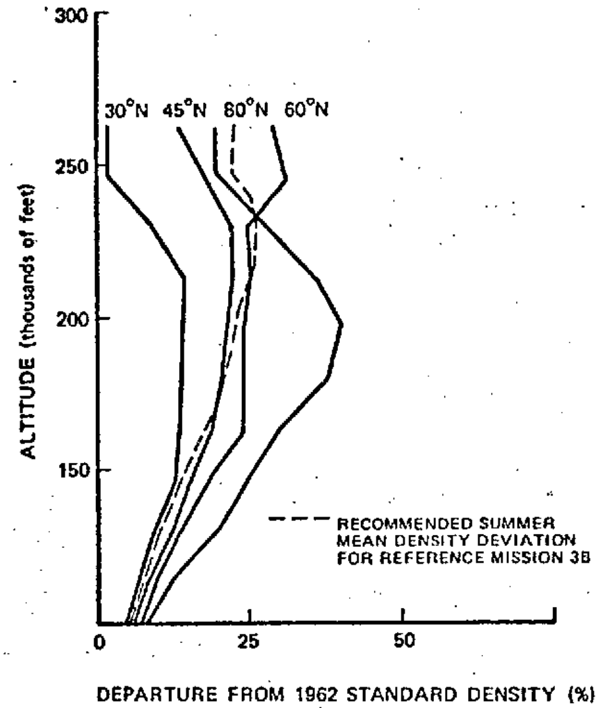


Figure 3.1-2a Time-Varying Density Bias for June-July Given as Percent Departure from 1962 Standard Atmosphere

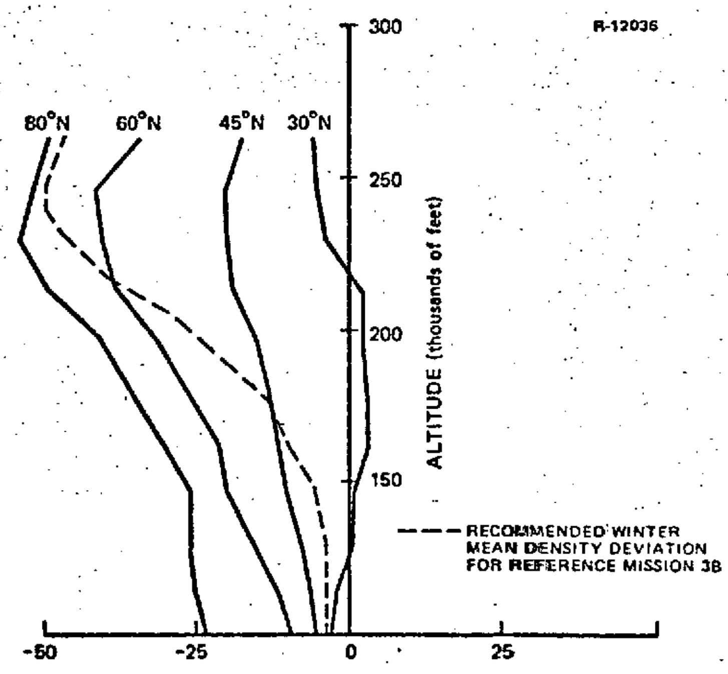




Figure 3.1-2b Time-Varying Density Bias for December-January Given as Percent Departure from 1962 Standard Atmosphere

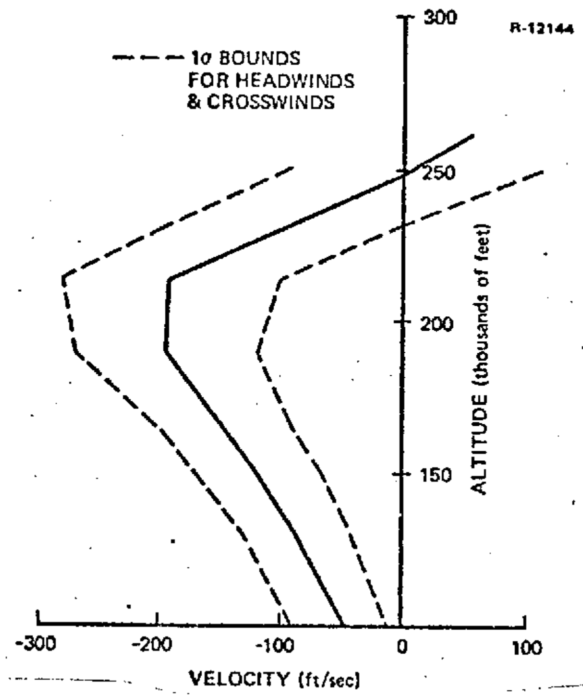


Figure 3.1-3a Mean Zonal (Westerly) Wind in July for Reference Mission 3B Entry

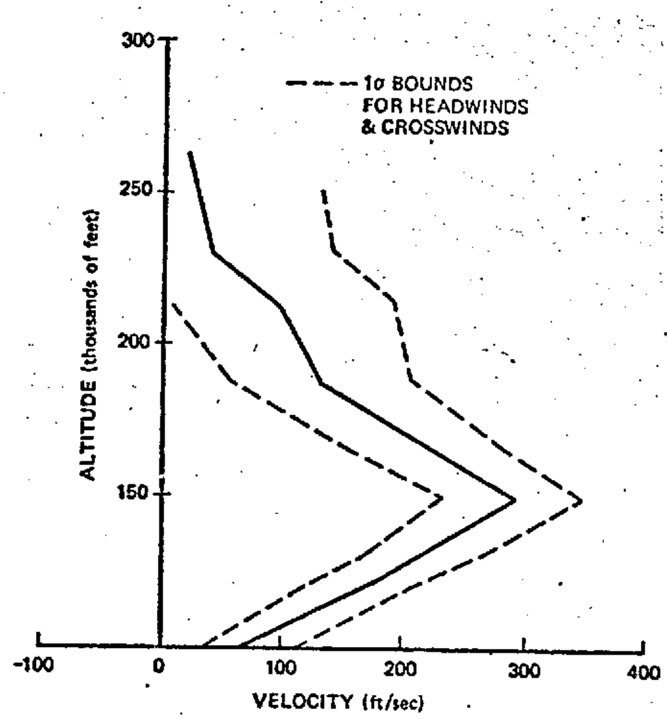


Figure 3.1-3b Mean Zonal (Westerly) Wind in January for Reference Mission 3B Entry

## 3.2 SYSTEM E MODEL

The external aids used in System E are the drag pseudo-measurement, TACAN, a baro altimeter, a radar altimeter, and MLS. With minor exceptions, the measurement sequence defined in Chapter 2 is structured such that one range measuring device, one bearing measuring device, and one altimeter are always operating -- during MLS, altitude is derived from elevation angle and range measurements. The computer navigation program includes a variable-dimension Kalman filter with between 6 and 15 states. A total of 19 different state variables are used in the filter.

### 3.2.1 States and Error Sources

The truth model for System E includes the truth model states and other error sources of the drag-update phase, and also includes states and error sources required to model the accuracy of the additional external navigation aids. The truth model states and other error sources used in evaluating the System E filter are listed in Table 3.2-1, which divides them into three categories:

- The 19 estimated states and uncorrelated measurement and process noises.
- Non-estimated states related to the inertial system.
- Non-estimated states related to the external navigation aids.

Error budget results for System E are generated similarly to those for the drag-update phase. The principal difference is that the truth model structure ($F_S$, $H_S$) for Group 1 is variable-dimensioned in a manner similar to that of the navigation system Kalman filter. Results

## TABLE 3.2-1

## SYSTEM E TRUTH MODEL STATES AND ERROR SOURCES

| ERROR SOURCE NAMES | NUMBER OF STATES | NUMBER OF ERROR SOURCES |
|---|---|---|
| I. ESTIMATED STATES AND UNCORRELATED NOISES | | |
| Group 1. | | |
| Position Errors | 3 | 3 |
| Velocity Errors | 3 | 3 |
| Platform Misalignments | 3 | 3 |
| Accelerometer 'Biases' (First-Order Markovs) | 3 | 3 |
| Correlated Measurement Errors (First-Order Markovs) | | |
| Drag | 1 | 1 |
| TACAN | 2 | 2 |
| Baro Altimeter | 1 | 1 |
| Radar Altimeter | 1 | 1 |
| MLS | 3 | 3 |
| Uncorrelated Measurement Noise | | |
| Drag | – | 1 |
| TACAN | – | 2 |
| Baro Altimeter | – | 1 |
| Radar Altimeter | – | 1 |
| MLS | – | 3 |
| INS Quantization Noise | – | 3 |
| II. NON-ESTIMATED, IMU-RELATED STATES | | |
| Group 1a. True Platform Misalignments | 3 | 3 |
| Group 2. Accelerometer True Biases | 3 | 3 |
| Group 3. Accelerometer Scale Factor Errors | 3 | 3 |
| Group 4. Accelerometer Misalignments | 6 | 6 |
| Group 5. Accelerometer Nonlinearities | 3 | 3 |
| Group 6. Gravitational Deflections and Anomalies | 3 | 3 |
| Group 7. Gyro True Bias Drifts | 3 | 3 |
| Group 8. Gyro Mass Unbalances | 6 | 6 |
| Group 9. Gyro Anisoelasticities | 3 | 3 |

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TABLE 3.2-1 (Continued)

SYSTEM E TRUTH MODEL STATES AND ERROR SOURCES

| ERROR SOURCE NAMES | | NUMBER OF STATES | NUMBER OF ERROR SOURCES |
|---|---|---|---|
| III. NON-ESTIMATED, EXTERNAL AID RELATED STATES | | | |
| Group 10. | TACAN Range Bias Error First-Order Markov | 1 | 1 |
| Group 11. | TACAN Range Scale Factor | 1 | 1 |
| Group 12. | Baro Altimeter Errors | | |
| | Bias | 1 | 1 |
| | Scale Factor | 1 | 1 |
| | First-Order Markov | 1 | 1 |
| | Static Defect | 1 | 1 |
| Group 13. | MLS Time-Varying Biases Range Bias | 1 | 1 |
| | Range Scale Factor | 1 | 1 |
| | Azimuth | 1 | 1 |
| | Elevation | 1 | 1 |
| Group 14. | MLS Second-Order Markov | | |
| | Range | 2 | 1 |
| | Azimuth | 2 | 1 |
| | Elevation | 2 | 1 |
| Group 15. | Radar Altimeter Errors | | |
| | Bias Error | 1 | 1 |
| | First-Order Markov | 1 | 1 |
| Group 16. | TACAN Survey Errors | 6 | 6 |
| Group 17. | MLS Survey Errors | 6 | 6 |
| Group 19. | TACAN Bearing Bias Error | 1 | 1 |
| | First-Order Markov | | |
| Group 20. | MLS Timing Errors | | |
| | Bias | 3 | 3 |
| Group 21. | Non-Standard Density | | |
| | 1962 Standard Atmosphere Error | 1 | 1 |
| | Time-Varying Bias | 1 | 1 |
| | First-Order Markov | 1 | 1 |
| Group 22. | Non-Standard Wind | | |
| | Westerly (Time-Varying Bias) | 1 | 1 |
| | Headwind (First-Order Markov) | 1 | 1 |
| | Crosswind (Second-Order Markov) | 2 | 1 |
| | Turbulence (First- and Second-Order Markovs) | 5 | 3 |
| Group 23. | Non-Standard Aerodynamics First-Order Markov | 1 | 1 |
| Totals | | 100 | 105 |

corresponding to Groups 1a through 23 are generated using a higher dimensional truth model, which contains the basic variable-dimensioned Kalman filter plus other states representing time-correlated error sources not modeled explicitly in the filter design. The group numbering system is consistent with that used in the drag-update phase evaluation.

The System E truth model requires a variable-dimension filter dynamics matrix, $F_F$, and a 100 x 100 system matrix, $F_S$. These matrices, as well as $H_F$, $H_S$, and A, are defined in Appendix E.

### 3.2.2 Truth Model Data Base

The general discussion in Section 3.1.2 pertaining to the drag-update phase data base applies to System E and is not repeated here. The principal difference is that System E includes truth model states and error sources related to TACAN, a baro altimeter, a radar altimeter, and MLS which did not appear in the drag-update phase data base. The necessary additions to the drag-update data base are made in this section.

The initial covariance matrix, $P_S(0)$, for System E is the final covariance matrix at 130,000 ft for the drag-update phase analysis. The error sources for System E which are not present in the drag-update phase include measurement noise (Group 1), and biases and correlated random errors (Groups 10 through 20) for the new sensors. The numerical values selected for these error sources are summarized in Table 3.2.2.

The uncorrelated measurement noises in Group 1 are used to model receiver noise from a variety of sources. For the radar altimeter, the principal source is a quantization error; for TACAN range, it is the ability to estimate the return pulse arrival time, etc. The measurement noise variances for each sensor are constant.

## TABLE 3.2-2

## SYSTEM E TRUTH MODEL DATA BASE (WHERE DIFFERENT FROM THE DRAG-UPDATE PHASE)

| ERROR SOURCE | | STANDARD DEVIATION | TIME CONSTANT | DATA SOURCE |
|---|---|---|---|---|
| Group 1. | TACAN Range Measurement Noise | 100 ft | -- | Ref. 11 |
| | TACAN Bearing Measurement Noise | 6 mrad | -- | Ref. 11 |
| | Baro Altimeter Measurement Noise | 5 ft | -- | Ref. 4 |
| | Radar Altimeter Measurement Noise | 1 ft | -- | Ref. 1 |
| | MLS Azimuth Measurement Noise | 0.1 mrad | -- | Ref. 15 |
| | MLS Elevation Measurement Noise | 0.1 mrad | -- | Ref. 15 |
| | MLS Range Measurement Noise | 17 ft | -- | Ref. 15 |
| Group 10. | TACAN Range Markov | 385 ft | 300 sec | Ref. 11 |
| Group 11. | TACAN Range Scale Factor | 100 ppm | - | Ref. 11 |
| Group 12. | Baro Altimeter Errors | | | |
| | Bias | 100 ft | - | Ref. 4 |
| | Scale Factor | 3% of alt | - | Ref. 1 |
| | Static Defect | $1.52 \times 10^{-4}$ ft/ft$^2$/sec$^2$ | - | Ref. 1 |
| | First-Order Markov | 20 ft | 100 sec | Ref. 4 |
| Group 13. | MLS Time-Varying Biases | | | |
| | Azimuth | 0.4 mrad | - | Ref. 15 |
| | Elevation | 0.4 mrad | - | Ref. 15 |
| | Range Bias | 8 ft | - | Ref. 15 |
| | Range Scale Factor | 400 ppm | - | Ref. 15 |
| Group 14. | MLS Second-Order Markov | | | |
| | Azimuth | 0.2 mrad | 4 sec | Ref. 15 |
| | Elevation | 0.2 mrad | 4 sec | Ref. 15 |
| | Range | 17 ft | 4 sec | Ref. 15 |
| Group 15. | Radar Altimeter Errors | | | |
| | Bias | 1 ft | - | Ref. 1 |
| | First-Order Markov | 1 ft | 1.5 sec | Ref. 1 |
| Group 16. | TACAN Survey Errors | 1 ft | - | Ref. 16 |
| Group 17. | MLS Survey Errors | 1 ft | - | Ref. 16 |
| Group 19. | TACAN Bearing Markov | 6 mrad | $2 \times 10^4$ ft/$V_R$ | Ref. 11 |
| Group 20. | MLS Timing Errors | 50 msec | - | Ref. 15 |

The TACAN range correlated errors are separated into a first-order markov, scale factor, and survey errors (Groups 10, 11, and 16, respectively). The markov process represents the combined errors in calibrating both the airborne and ground equipment. The scale factor components represent the inaccuracies in calibrating the index of refraction. Values ranging from 10 parts per million to 100 parts per million have been mentioned in the literature, varying with the extent to which knowledge of local atmospheric conditions and measurement geometry is used in the calibration procedure. Survey errors represent inaccuracies in knowledge of the ground transponder locations relative to the runway. Since, in this case, the devices are nearby, small survey errors are expected.

The TACAN bearing correlated errors are modeled as first-order markov and survey errors (Groups 19 and 16, respectively). The markov process is due primarily to a bending of the radiated constant bearing lines due to multipath effects. The time constant for the error is proportional to the Space Shuttle relative velocity and is somewhat longer than that suggested in Ref. 11. The survey errors are treated as distinct from the TACAN range errors because different antennae are involved.

Baro altimeter correlated errors (Group 12) are separated into bias, markov, scale factor, and static defect components. Values for the bias and markov components are taken from Ref. 4, which treats a baro-inertial-transponder system involving overflight of a transponder. In that case (the CLASS filter evaluation study) it was found to be important to include the markov state to account for moderately rapid changes in local weather conditions. Values for the scale factor and static defect components are taken from Ref. 1, which discusses them in the context of the Space Shuttle landing problem.

Models for the radar altimeter correlated errors (Group 15) have not been well established. The selection of bias and first-order markov errors was made in order to account for instrument errors and terrain variations. A scale factor error was not included in the model because of the low altitude at which the altimeter is to be used.

The basis for the MLS correlated error models (Groups 13, 14, and 17) is Ref. 15. The errors for each of the three sensors are separated into bias and second-order markov errors. In addition, a scale factor error is modeled for the MLS DME. The biases in the MLS azimuth and elevation measurements are attributable to errors in the antennae sweep angles and to angle pickoff errors; the bias in the MLS DME measurement is primarily due to hardware timing delays. The MLS DME scale factor error is a function of the measurement signal-to-noise ratio. For all three sensors, the second-order markov error models multipath effects. The four sec "correlation time" chosen for the second-order markov satisfies the model given in Ref. 15.

Measurements from each of the external sensors are subject to timing errors if the measurements are not accurately time tagged. In most instances the effect of the timing error can be included in the instrument bias model. A timing delay for MLS is included in the truth model (Group 20) to provide an indication of the magnitude of timing-induced errors relative to other error sources.

# 4. FILTER COVARIANCE AND GAIN CALCULATIONS

Two of the preliminary steps required prior to performing error budget calculations are the detailed definition of the filter which forms part of the system and the preparation of a filter covariance program. This program contains the covariance update and propagation algorithms specified by the filter designer and generates a sequence of gain vectors corresponding to a particular trajectory and measurement schedule. This sequence is saved on tape and repeatedly used by the truth model covariance program in generating the system error budget. Presented below are the specific algorithms used to represent the filter gain calculations corresponding to the navigation system evaluated in this study.

The detailed structure of the two phases of the navigation system -- the drag-update phase and System E -- are presented separately in Sections 4.2 and 4.3, respectively. The general structures of the navigation filter and of the filter covariance program are presented in Section 4.1.

## 4.1 FILTER STRUCTURE

Figure 4.1-1 is a macro flowchart indicating the overall organization of the filter covariance program. The principal inputs are the starting time, $t_0$, the initial filter covariance matrix, $P_F(0)$, and the nominal Space Shuttle trajectory. The principal output is the file of gain

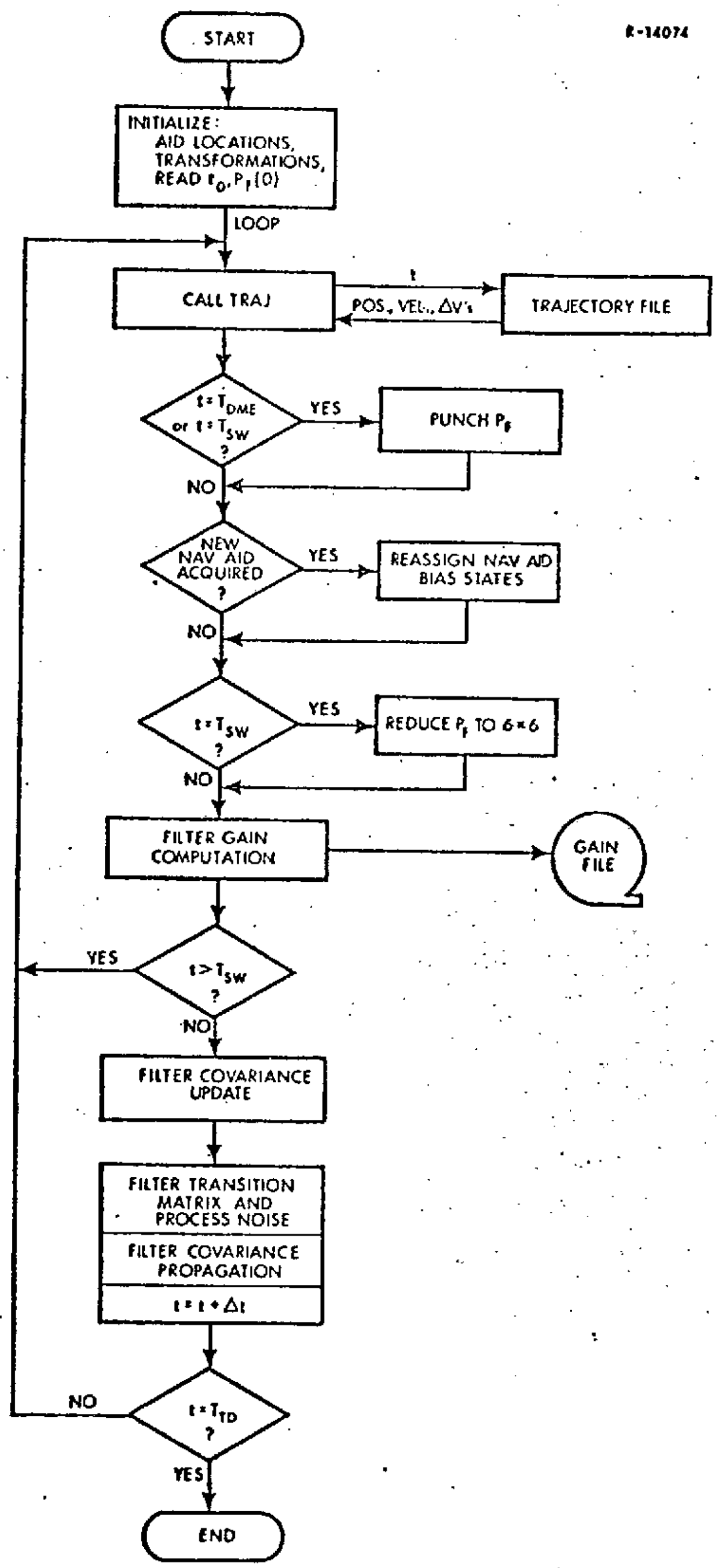



Figure 4.1-1 Filter Covariance Program Flow Chart (Drag-Update Phase and System E)

vectors to be used by the truth model covariance program. At the altitudes of 130,000 ft ($t = T_{DME}$) and 12,000 ft ($t = T_{SW}$), the current $P_F$ matrices are punched on cards. This gives the capability of restarting the program at the end of blackout, and the beginning of the final approach and landing, respectively.

The navigation filter is a variable-dimension Kalman filter with between 6 and 15 states. A maximum of three of the states are bias states associated with the operating external navigation aids (TACAN, etc.). As each new navigation aid is acquired, the filter is restructured and bias states are associated with that navigation aid. The exception is that no bias states are associated with the radar altimeter.

The navigation filter is implemented using the discrete time covariance formulation with exact process noise. The covariance propagation between measurements is accomplished using the "average G" numerical integration filter (Ref. 17). The covariance matrix is propagated only to the beginning of the final approach -- which occurs at a nominal altitude of 12,000 ft ($t = T_{SW}$). Below 12,000 ft, three different filter configurations are analyzed. The configuration indicated in Fig. 4.1-1 computes MLS gains below 12,000 ft based upon a 6 x 6 submatrix of $P_F$ saved from 12,000 ft -- a pre-stored gain schedule is used for the radar altimeter. There are no covariance reinitializations during entry.

At each measurement time, a sequence of filter gains are computed corresponding to a sequence of scalar measurements. For every measurement except radar altimeter measurements, the gain vector is calculated using

$$K_F(t_k) = P_F(t_k^-)\, H_F^T(t_k) \Big/ \left( H_F(t_k)\, P_F(t_k^-)\, H_F^T(t_k)\, u_{70} + \sigma_m^2 \right) \qquad (4.1\text{-}1)$$

where $H_F$ is the appropriate scalar measurement matrix, $P_F(t_k^-)$ is the covariance just prior to the measurement, $u_{70}$ is a scalar measurement underweighting factor,* and $\sigma_m^2$ is the assumed measurement noise variance.

At altitudes above 12,000 ft, the filter gains are used to sequentially update the filter covariance in accordance with

$$P_F(t_k^+) = P_F(t_k^-) - K_F(t_k) H_F(t_k) P_F(t_k^-) \qquad (4.1\text{-}2)$$

The covariance is then propagated forward to the next measurement timing using the standard formula presented in Section 2.3:

$$P_F(t_{k+1}^-) = \Phi_{F_k} P_F(t_k^+) \Phi_{F_k}^T + Q_{F_k} \qquad (4.1\text{-}3)$$

Equations (4.1-2) and (4.1-3) are not executed below 12,000 ft.

## 4.2 DRAG-UPDATE FILTER

The navigation filter for the drag-update phase is a 13-state Kalman filter. The general structure of the filter is:

| State Numbers | Variables |
|---|---|
| 1 - 3 | Position |
| 4 - 6 | Velocity |
| 7 - 9 | Misalignment angles |
| 10 - 12 | Acceleration errors |
| 13 | Drag correlated error |

*The scalar $u_{70}$ is normally unity, but has the value 1.2 during the early portion of the trajectory (see Ref. 5).

The time constants and measurement noise for states 7 - 13 are summarized in Table 4.2-1.

TABLE 4.2-1

FILTER STATE AND MEASUREMENT ERROR STATISTICS FOR DRAG-UPDATE PHASE*

| | Correlated Error (Filter State) | | Measurement Noise |
|---|---|---|---|
| | Standard Deviation | Correlation Time (sec) | Standard Deviation |
| Misalignment | 1 mrad | 600 | — |
| Acceleration | 0.0017 ft/sec | 60 | — |
| Drag | 30% of drag | 60 | 5% of drag |

States 7 - 13 are generalized error states and do not correspond precisely to physical error sources. The misalignment states differ from true IMU misalignment angles in that they do not have an infinite time constant; the acceleration states differ from true accelerometer biases because of the time constant and because they are defined in an inertial coordinate frame (Appendix E). The drag correlated error state is intended to account in a general manner for all error sources which directly affect either the drag pseudo-measurement or the predicted drag computation. The rationale behind selecting the values in Table 4.2-1 was to yield a filter covariance matrix which is reasonably consistent with the true navigation errors.

An initial covariance matrix for the entry interface at 400,000 ft has been provided by CSDL (Ref. 18). The matrix is the filter covariance

*Data from Ref. 7 and personal communication with B. Kriegsman of CSDL.

matrix at entry interface for the Shuttle reference mission 3A abort. This is a single orbit mission launched from Vandenberg Air Force Base into a 50 by 100 nautical mile orbit with an inclination of 104°. The filter covariance matrix was propagated from launch with no reinitializations.

The filter state noise matrix used to propagate the filter covariance during the drag-update phase is defined by

$$Q_{F_k} = \left[\begin{array}{cc|c} s_V \frac{\Delta t^2}{4} & s_V \frac{\Delta t}{2} & \\ s_V \frac{\Delta t}{2} & s_V & 0 \\ \hline & & \begin{matrix} s_7 & & 0 \\ & \ddots & \\ 0 & & s_{13} \end{matrix} \\ 0 & & \end{array}\right] \tag{4.2-1}$$

where $\Delta t$ is the update interval (2 sec), $s_V$ is a 3 x 3 matrix

$$s_V = \begin{bmatrix} \sigma_q^2 & 0 & 0 \\ 0 & \sigma_q^2 & 0 \\ 0 & 0 & \sigma_q^2 \end{bmatrix} \tag{4.2-2}$$

and $s_j$, j = 7 ··· 13, are scalars

$$s_j = \sigma_j^2 \left(1 - e^{-2\Delta t/\tau_j}\right) \tag{4.2-3}$$

The value of $\sigma_q$ suggested by CSDL personnel is

$$\sigma_q^2 = 0.001 \text{ (ft/sec)}^2$$

The values of $\sigma_j$ and $\tau_j$ are the entries in Table 4.2-1 for the appropriate filter states.

The only external aid used during the drag-update phase is the drag acceleration pseudo-measurement defined in Appendix C -- one pseudo-measurement is processed every 2 sec. The measurement matrix used in the gain computation and to update the filter covariance was taken from Ref. 19:

$$H_F(t) = q_{pred}(t) \left[ \frac{-\underline{i}_{R_c}^T}{h_{sc}} \;\middle|\; \frac{2\underline{i}_{VR_c}^T}{V_R(t)} \;\middle|\; 0 \;\middle|\; 0 \;\middle|\; \overbrace{1}^{\text{drag correlated random variable}} \right] \tag{4.2-4}$$

where $\underline{i}_{Rc}(t)$ and $\underline{i}_{VRc}(t)$ are computed unit vectors along the vertical and the relative velocity, respectively, $\underline{V}_R(t)$ is the computed relative velocity, and $h_{sc}$ is a scale height (see below). The predicted drag

$$q_{pred}(t) = \frac{1}{2} C_{D_c}(t) \frac{A}{m} \rho_c(t) V_{R_c}^2(t) \tag{4.2-5}$$

is based upon onboard models of the aerodynamic drag coefficient and the atmospheric density.

The onboard drag coefficient model from which $C_{D_c}(t)$ is computed was provided in tabular form by JSC (Ref. 20). The model is a function of Mach number and angle of attack. The values of the cross-sectional area, A, and the mass, m, used by JSC to generate the reference trajectory were also provided.

The onboard atmospheric density model for the navigation filter was assumed to be a simple exponential

$$\rho_c(t) = \rho_0 e^{-\frac{h_c(t)}{h_{sc}}} \tag{4.2-6}$$

where $h_c(t)$ is computed altitude. Two different variations of the model were considered:

- Single values of $h_{sc}$ and $\rho_0$ were chosen (1-term model).
- Values of $h_{sc}$ and $\rho_0$ were chosen for different altitude layers (4-term model).

The models were obtained from Refs. 5 and 21, respectively. The coefficient values used are summarized in Table 4.2-2. The resulting errors in modeling the 1962 Standard Atmosphere were illustrated in Fig. 3.1-1.

TABLE 4.2-2

COEFFICIENT VALUES FOR ATMOSPHERIC DENSITY MODELS

| Model | 1-Term Model | 4-Term Model | | | |
|---|---|---|---|---|---|
| Altitude | 100,000-270,000 ft | 100,000-150,000 ft | 150,000-200,000 ft | 200,000-230,000 ft | 230,000-270,000 ft |
| Scale Height $h_{sc}$ (ft) | 24018. | 22104. | 26590. | 26170. | 21206. |
| Sea Level Density $\rho_0$ (slugs/ft$^3$) | 0.00215 | 0.00306 | 0.00097 | 0.00110 | 0.00860 |

The filter covariance program based upon the 13-state filter outlined above has been exercised over the trajectory and measurement schedule outlined in Chapter 2. The time history of the filter-indicated performance is summarized in Table 4.2-3. RMS values of position and velocity components in the V frame (vertical, downrange, crossrange; see Appendix A) are given at key times -- at entry interface, just before and

TABLE 4.2-3

DRAG-UPDATE PHASE FILTER-INDICATED PERFORMANCE

| Event (see Table 2.2-1) | Time (sec) | RMS Position Errors (ft) | | | RMS Velocity Errors (ft/sec) | | |
|---|---|---|---|---|---|---|---|
| | | V | DR | CR | V | DR | CR |
| $T_0$ | 0 | 5571. | 26073. | 7774. | 27.52 | 5.40 | 4.31 |
| $T_{DRAG}$ | $312.^-$ | 4975. | 27447. | 8523. | 29.48 | 5.05 | 1.06 |
| | $312.^+$ | 4123. | 26497. | 8524. | 28.53 | 4.29 | 1.05 |
| $T_{TACAN}$ | $1432.^-$ | 4885. | 16780. | 9034. | 18.34 | 15.70 | 16.51 |

after the first drag pseudo-measurement, and at the end of the drag-update phase. The results given in Table 4.2-3 represent what the navigation system performance would be if the 13-state filter model were a completely accurate representation of real-world dynamics. The results given in Section 5.1 are a projection of the performance of the 13-state filter in a 59-state model of the real world.

## 4.3 SYSTEM E

The navigation filter for System E is a variable-dimension Kalman filter with between 6 and 15 states. The general structure of the filter is:

| State Numbers | Variables |
|---|---|
| 1 - 3 | Position |
| 4 - 6 | Velocity |
| 7 - 9 | Misalignment angles |
| 10 - 12 | Acceleration errors |
| 13 | Baro altimeter, drag, or elevation correlated error |
| 14 | Range correlated error |
| 15 | Azimuth correlated error |

. States 1 through 12 are defined precisely as they were for the drag-update filter. States 13 through 15 are correlated measurement errors. As a new sensor is acquired, one of the measurement error states is reinitialized and associated with that sensor -- the exception is that no bias states are associated with the radar altimeter. The precise filter state schedule is indicated in Fig. 4.3-1. The correlation times for states 7 through 15 and the measurement variances are summarized in Table 4.3-1.

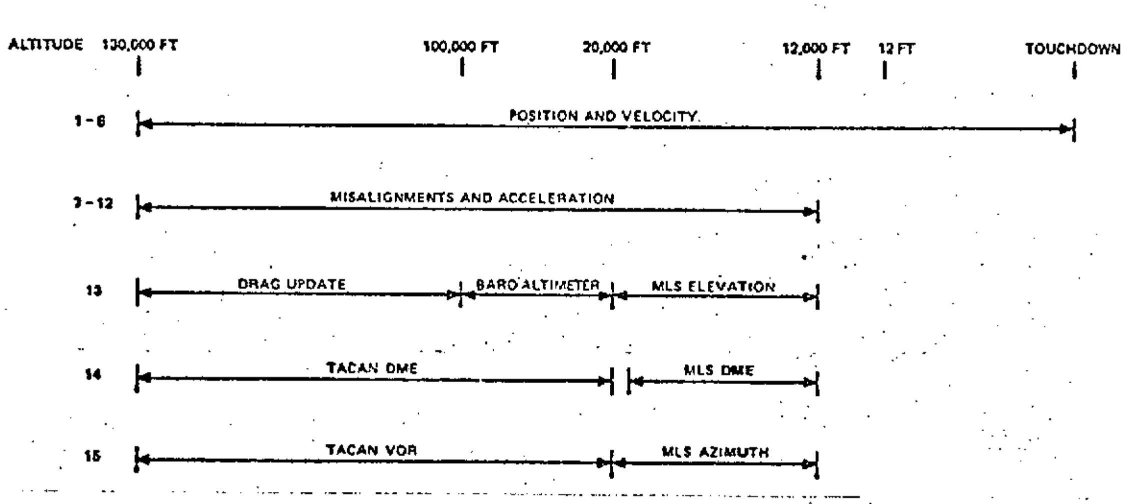



Figure 4.3-1 Schedule for System E Filter States

The initial covariance matrix for the System E filter is the filter covariance matrix at the end of the drag-update phase. The process noise matrix, $Q_{F_k}$, satisfies Eq. (4.2-1) through (4.2-3) with a maximum of 15 states. The measurement update interval is 2 sec until the beginning of the final approach and landing ($t = T_{SW}$) at 12,000 ft. The update interval is then reduced to 0.5 sec. At the radar altimeter turn-on ($t = T_{RA}$), the update interval is further reduced to 0.1 sec.

Computer duty cycle constraints require that during the final approach and landing:

TABLE 4.3-1

FILTER STATE AND MEASUREMENT
ERROR STATISTICS FOR SYSTEM E

| Measurement | Correlated Error (Filter State) | | Measurement Noise |
|---|---|---|---|
| | Standard Deviation | Correlation Time (sec) | Standard Deviation |
| Misalignments | 1 mrad | 600 | — |
| Acceleration | 0.0017 ft/sec$^2$ | 60 | — |
| Drag | 30% of drag | 60 | 5% of drag |
| Baro Altimeter | 3% altitude | 200 | 0.03% altitude |
| Radar Altimeter | 1 ft | ∞ | 0.1 ft |
| TACAN DME | 275 ft | 400 | 90 ft |
| TACAN VOR | 6 mrad | 400 | 6 mrad |
| MLS DME | 35 ft | ∞ | 24 ft |
| MLS Azimuth | 0.4 mrad | ∞ | 0.2 mrad |
| MLS Elevation | 0.4 mrad | ∞ | 0.2 mrad |

- The System E filter estimate only position and velocity (6 states)
- The filter covariance propagation be eliminated

Elimination of the covariance propagation implies that, below 12,000 ft, the filter gains must be computed from a suboptimal algorithm. A number of different algorithms have been proposed. The salient features of the algorithm selected for System E are summarized in Table 4.3-2. Descriptions are also provided of two alternative algorithms analyzed in Chapter 5.

Above 12,000 ft, the System E measurement matrices for all external navigation aids are of the form:

$$H_F = [h_p \mid h_v \mid 0 \mid 0 \mid h_b] \qquad (4.3\text{-}1)$$

TABLE 4.3-2

DESCRIPTION OF GAIN COMPUTATION ALGORITHMS FOR FINAL APPROACH AND LANDING*

| SYSTEM E FILTER | ALTERNATIVE 1 | ALTERNATIVE 2 |
|---|---|---|
| • 6 states<br>• no $P_F$ propagation<br>• $H_F$ computed for MLS and radar altimeter<br>• MLS gains computed from Kalman algorithm [Eq. (4.1-1)] with 6 x 6 $P_F$ saved from 12,000 ft<br>• gain schedule for radar altimeter provided by CSDL<br>• MLS and IMU bias estimates at 12,000 ft used to compensate data | • same as SYSTEM E filter except:<br>• MLS gains computed from Kalman algorithm [Eq. (4.1-1)] with 15 x 15 $P_F$ saved from 12,000 ft (only 6 elements of $K_F$ used) | • same as SYSTEM E filter except:<br>• MLS gains are those computed at 12,000 ft (azimuth and elevation gains scaled by range-to-go) |

where $h_p$ is the 1 x 3 partial derivative of the measurement with respect to the nominal position, $h_v$ is the partial derivative with respect to the nominal velocity, and $h_b$ is the partial derivative with respect to the bias states. Below 12,000 ft, $H_F$ is of the form:

$$H_F = [h_p \,\vdots\, h_v] \qquad (4.3\text{-}2)$$

For all external navigation aids except the drag pseudo-measurement, the first six elements of $H_F$ are identical to those of $H_S$ in the truth model. The equations for $H_F$ are developed in Appendix E.

*All three gain computation algorithms were provided by CSDL (Ref. 9).

The pre-stored gain schedule for the radar altimeter (Ref. 21) is used to update vertical position and velocity only. The gains for vertical position are

$$k_p = \begin{cases} 1. -3.75\ (t - T_{RA}) & t - T_{RA} \le 0.2 \text{ sec} \\ 0.25 & t - T_{RA} > 0.2 \text{ sec} \end{cases} \qquad (4.3\text{-}3)$$

and the gains for vertical velocity are

$$k_v = \begin{cases} -0.1 + 1.5\ (t - T_{RA}) & t - T_{RA} \le 0.2 \text{ sec} \\ 0.20 & t - T_{RA} > 0.2 \text{ sec} \end{cases} \qquad (4.3\text{-}4)$$

The filter gain matrix $K_F(t)$ is then

$$K_F(t) = \begin{bmatrix} k_p \underline{i}_{R_c}(t) \\ k_v \underline{i}_{R_c}(t) \end{bmatrix} \qquad (4.3\text{-}5)$$

where $\underline{i}_{R_c}(t)$ is the unit vector along vertical.

The filter covariance program based upon the System E filter outlined above has been exercised over the trajectory and measurement schedule outlined in Chapter 2. The time history of the filter-indicated performance is summarized in Table 4.3-3. RMS values of the position and velocity components in the V frame (vertical, downrange, cross-range; see Appendix A) are given at key times -- before and after the first measurement from each external navigation aid -- down to 12,000 ft. Below 12,000 ft, $P_F$ is not computed, and hence, no filter-indicated performance is available. The results given in Table 4.3-3 represent what the navigation system performance would be if the System E filter model

TABLE 4.3-3

SYSTEM E FILTER-INDICATED PERFORMANCE

| Event (see Table 2.2-1) | Time (sec) | RMS Position Errors (ft) | | | RMS Velocity Errors (ft/sec) | | |
|---|---|---|---|---|---|---|---|
| | | V | DR | CR | V | DR | CR |
| $T_{TACAN}$ | $1432.^-$ | 4885. | 16780. | 9034. | 18.34 | 15.70 | 16.51 |
| | $1432.^+$ | 4684. | 6742. | 6063. | 15.81 | 14.32 | 14.23 |
| $T_{BA}$ | $1550.^-$ | 4080. | 1013. | 1742. | 13.49 | 8.39 | 10.66 |
| | $1550.^+$ | 2744. | 790. | 1481. | 9.75 | 6.98 | 10.27 |
| $T_{MLS}$ | $1836.^-$ | 589. | 311. | 264. | 2.60 | 4.18 | 2.80 |
| | $1836.^+$ | 90. | 136. | 185. | 2.12 | 2.37 | 2.78 |
| $T_{DME}$ | $1846.^-$ | 91. | 167. | 168. | 1.73 | 1.98 | 2.76 |
| | $1846.^+$ | 25. | 35. | 32. | 1.29 | 1.78 | 1.55 |
| $T_{SW}$ | 1874. | 18. | 36. | 19. | 0.40 | 0.81 | 0.46 |
| $T_{RA}$ | $1943.5^-$ | — | — | — | — | — | — |
| | $1943.5^+$ | — | — | — | — | — | — |
| $T_D$ | $1946.5^+$ | — | — | — | — | — | — |

(Table 4.3-1) were a completely accurate description of real-world dynamics. The results given in Section 5.2 are a projection of the performance of the System E filter in a 100-state model of the real world.

# 5. RESULTS

This chapter presents detailed results for the entry navigation system. Overall performance curves are given for the drag-update filter and for System E, showing time histories of position and velocity errors due to all sources combined. In each case "Baseline Error Budget" tables are given, showing the contributions of individual error sources, or small groups of error sources, at certain times. Smaller tables of "Alternative Contributions" are provided, allowing the reader to see the effects of different truth model assumptions. Sensitivity curves illustrating the effect of variations in the rms value of a given major error source (or group of error sources) on overall system performance are also given. For System E, the effect of alternative filter configurations on overall system performance is also evaluated. Section 5.3 provides a general summary, including discussions of how particular groups of error sources contribute to the errors in each of the mission phases and of filter states which might be safely deleted or altered.

## 5.1 DRAG-UPDATE FILTER EVALUATION

The navigation error results presented below are for the drag-update phase of the reference mission 3B entry as defined in Section 2.1. The drag-update phase ends 1432 sec after entry interface at a nominal altitude of 130,000 ft. The only external navigation aid during this phase is the drag acceleration pseudo-measurement; the measurement schedule was defined in Section 2.2. A file of gain values, generated using the filter covariance program outlined in Sections 4.1 and 4.2, has been used repeatedly to compute detailed error contributions corresponding to the drag-update phase of this particular trajectory and measurement schedule.

### 5.1.1 Overall System Performance

Figures 5.1-1 and 5.1-2 present overall performance curves for the drag-update filter, showing position error components and velocity error components, respectively. The curves plotted represent rms errors due to the combined effects of all error source groups in the baseline error budget. They were generated by root-sum-squaring individual contributions at two-minute intervals (tabulated in Appendix F). At $T_{DRAG}$, when the first drag pseudo-measurement is made, the root-sum-square calculation was performed both before and after the update. Thus, the jumps which occur in certain component errors at this time are accurately shown. Otherwise, the curves are faired-in over the two-minute intervals between the calculated points.

At the time of the first drag pseudo-measurements, the vertical and downrange components of both position and velocity errors increase. The downrange errors remain essentially constant at the new levels; the vertical errors continue to increase for several hundred seconds before beginning to decline. Examination of the individual error contributions (Appendix F) verifies that the jump is primarily due to the effect of non-standard density errors (Group 21) on the pseudo-measurement. This suggests that the drag-update filter <u>overweights</u> the drag acceleration pseudo-measurement during the initial portion of the trajectory.

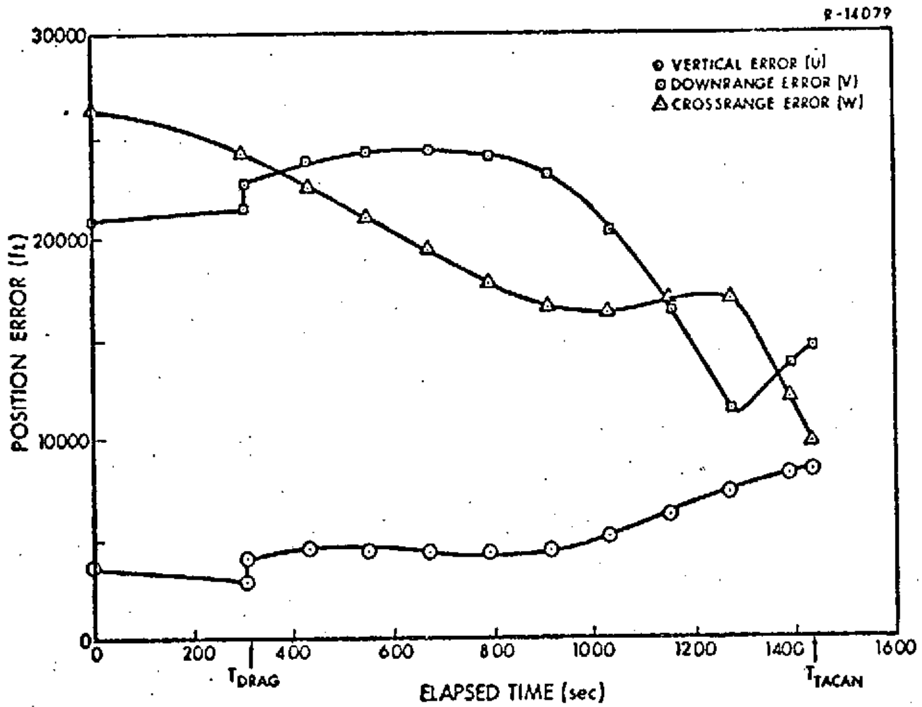



Figure 5.1-1 Drag-Update Phase Overall Performance: Position

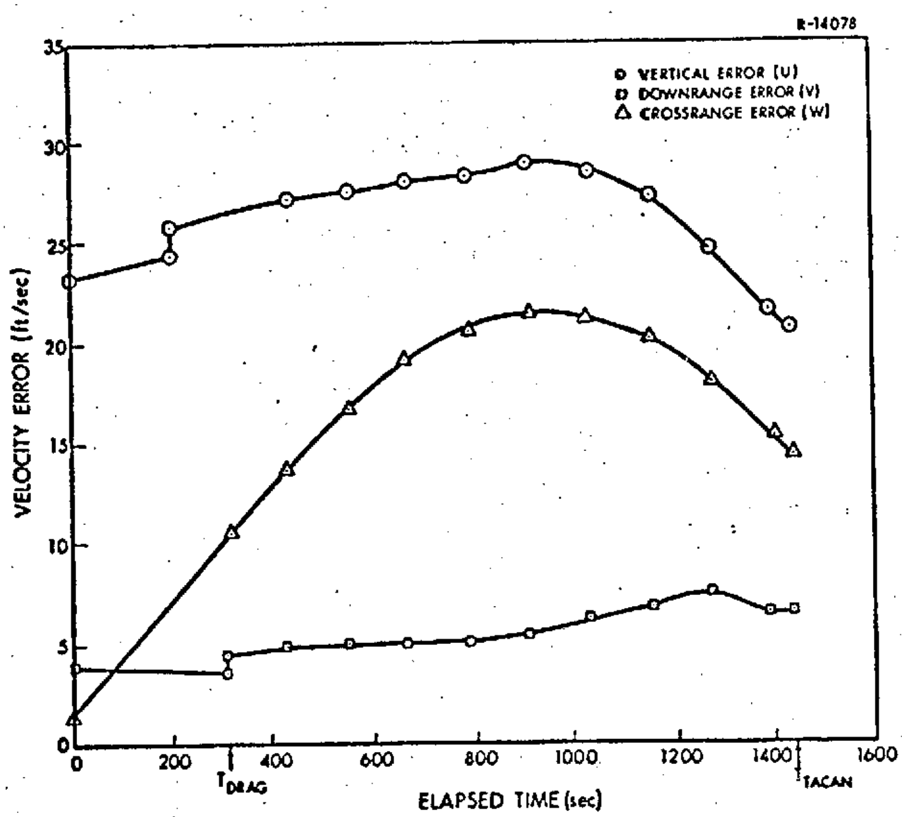



Figure 5.1-2 Drag-Update Phase Overall Performance: Velocity

Figures 5.1-1 and 5.1-2 indicate the performance of the drag-update filter, but they do not indicate the overall effectiveness of the filter in limiting the growth of navigation errors during entry. This information is provided in Table 5.1-1 by comparing the total projected drag-update filter performance at 130,000 ft with the performance of a pure inertial navigator* at the same altitude. The truth model for the inertial navigator consists of the important IMU-related states in the drag-update phase truth model (Groups 1a through 5 and 7 through 9), plus the INS quantization noise. The performance was obtained by correcting the data in Table D-III-c of Ref. 10 for the truth model data base given in Table 3.1-2.

TABLE 5.1-1

SUMMARY OF DRAG-UPDATE FILTER PERFORMANCE

| | ONE σ ERRORS AT 130,000 ft | | | | | |
|---|---|---|---|---|---|---|
| | Position (ft) | | | Velocity (ft/sec) | | |
| | V | DR | CR | V | DR | CR |
| Total Projected Drag-Update Filter Performance | 8389. | 14700. | 9723. | 20.97 | 6.70 | 14.51 |
| Pure Inertial Navigator Performance | 14756. | 21196. | 12184. | 42.01 | 9.75 | 14.44 |
| Filter Indicated Drag-Update Performance | 4885. | 16781. | 9035. | 18.34 | 15.70 | 16.51 |

The only significant difference between the mechanizations of the drag-update filter and the pure inertial navigator is that the drag-update filter uses drag acceleration pseudo-measurements to improve its state estimates. Table 5.1-1 indicates that the navigation errors for

*A pure inertial navigator uses only an initial state estimate and accumulated IMU outputs to obtain a current state estimate.

the drag-update filter are approximately two-thirds as great as the corresponding pure inertial navigator errors. The drag acceleration pseudo-measurement provides an estimate of instantaneous vertical position only; the filter uses correlations and trajectory geometry to achieve the indicated improvements in the downrange and crossrange channels. Table 5.1-1 verifies that the drag acceleration pseudo-measurement is a potentially valuable navigation aid and that the candidate drag-update filter effectively limits the growth of navigation errors during entry.

Table 5.1-1 also contains the filter-indicated drag-update filter performance at 130,000 ft (see Section 4.2). Comparison with the total projected drag-update filter performance indicates that the filter is quite optimistic in its estimate of the vertical position errors -- the true errors are nearly twice as large as the filter expects. It is reasonable to suspect that this optimistic outlook results in an underweighting of the pseudo-measurements during the final portion of the drag-update phase, but more information than Table 5.1-1 provides is necessary to confirm this suspicion. Regardless, it would seem desirable to modify the filter to bring the filter-indicated performance more in line with the total projected performance.

The observations made in this section suggest that the drag-update filter can be "tuned" to improve its performance. All the filter parameters are subjects for optimization and sensitivity studies. Several prospective modifications are discussed in Section 5.3.

### 5.1.2 Baseline Error Budget

System error covariances have been computed for each group of error sources over the entire drag-update phase of the reference trajectory. The total amount of data generated is quite large. In order to summarize important results in one table of manageable size, a "snapshot" view of conditions at the end of blackout (130,000 ft) is presented in Table 5.1-2. Table 5.1-2 is the Drag-Update Baseline Error Budget showing rms estimation errors in the position and velocity components at 130,000 ft. Each value is the rms contribution of the error source or sources indicated in the left-hand column; it comes from a computer run in which the parameters for that error source are set at truth model values -- and all others are zero. The entries in each column are root-sum-squared at the bottom of the table to generate the total projected performance of the 13-state drag-update filter. The total projected performance is compared at the bottom of the table with the filter-indicated performance and with the pure inertial navigator performance. Table 5.1-3 lists the Drag-Update Phase Alternative Contributions showing how different error source models would produce other contributions to position and velocity errors at 130,000 ft.

Particular numbers have been circled in Table 5.1-1 to focus attention on major contributors. The rule followed in deciding which numbers to circle was to include, in any column, every number whose magnitude is greater than 20% of the RMS total for that column. Thus, every circled number contributes at least 2% to the RMS error for the appropriate column.

Examination of Table 5.1-2 reveals that the major contributors to navigation errors at the end of the drag-update phase are:

- accelerometer scale factor error (Group 3)
- gyro bias drift (Group 7)
- non-standard atmospheric density modeling errors (Group 21)

## TABLE 5.1-2

## BASELINE ERROR BUDGET FOR DRAG-UPDATE FILTER

| ERROR SOURCE | VALUE | RMS NAVIGATION ERROR AT 130,000 ft: POSITION (ft) V | POSITION (ft) DR | POSITION (ft) CR | VELOCITY (ft/sec) V | VELOCITY (ft/sec) DR | VELOCITY (ft/sec) CR |
|---|---|---|---|---|---|---|---|
| I. Estimated States | | | | | | | |
| Uncorrelated Noise | 5% of drag | 1038. | 995. | 442. | 2.97 | 0.46 | 0.82 |
| Quantization Error | 0.0328 ft/sec | 165. | 176. | 167. | 0.20 | 0.23 | 0.20 |
| II. IMU-Related States | | | | | | | |
| 2. Accelerometer Biases | 50 μg | 648. | 3951. | 3000. | 3.72 | 1.93 | 3.39 |
| 3. Accelerometer Scale Factor Errors | 40 ppm | 4515. | 8119. | 3848. | 14.19 | 2.85 | 5.65 |
| 4. Accelerometer Misalignments | 15 sec | 1092. | 1536. | 1259. | 3.34 | 1.61 | 2.57 |
| 5. Accelerometer Nonlinearities | 3.5 μg/g$^2$ | 0. | 0. | 0. | 0.00 | 0.00 | 0.00 |
| 6. Gravity Anomalies and Deflections | 67 mgal - 8 sec | 110. | 176. | 112. | 0.28 | 0.23 | 0.25 |
| 7. Gyro Bias Drifts | 0.015 deg/hr | 4191. | 5268. | 6373. | 7.17 | 5.05 | 12.09 |
| 8. Gyro Mass Unbalances | 0.025 deg/hr/g | 949. | 480. | 559. | 1.95 | 1.14 | 1.34 |
| 9. Gyro Anisoelasticities | 0.025 deg/hr/g$^2$ | 49. | 130. | 80. | 0.23 | 0.20 | 0.41 |
| III. Drag-Related Sources | | | | | | | |
| 21. Non-Standard Density | | | | | | | |
| 1962 Standard Atmosphere Modeling Error | 1-term | 3285. | 5681. | 2898. | 7.46 | 0.87. | 2.02 |
| Time-Varying Bias | Winter | 4122. | 8357. | 4390. | 9.22 | 1.56 | 2.61 |
| First-Order Markov | Table D-1 | 405. | 421. | 300. | 1.10 | 0.14 | 0.32 |
| 22. Non-Standard Wind | | | | | | | |
| Westerly | Winter | 558. | 407. | 229. | 1.73 | 0.14 | 0.52 |
| Crosswind / Headwind | Table D-3 | 229. | 210. | 86. | 0.68 | 0.13 | 0.18 |
| 23. Non-Standard Aerodynamics First-Order Markov | 5% of $C_D$ | 705. | 889. | 415. | 1.74 | 0.40 | 0.55 |
| Total Projected Performance | | 8389. | 14700. | 9723. | 20.97 | 6.70 | 14.51 |
| Pure Inertial Navigator Performance | | 14756. | 21196. | 12184. | 42.01 | 9.75 | 14.44 |
| Filter-Indicated Performance | | 4885. | 16781. | 9035. | 18.34 | 15.70 | 16.51 |

TABLE 5.1-3

DRAG-UPDATE PHASE ALTERNATIVE CONTRIBUTIONS

| ERROR SOURCE | | VALUE | RMS NAVIGATION ERROR AT 130,000 ft | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | POSITION (ft) | | | VELOCITY (ft/sec) | | |
| | | | V | DR | CR | V | DR | CR |
| Group 21. | Non-Standard Density | | | | | | | |
| | 1962 Standard Atmosphere Error | 4 term | 2530. | 4868. | 2540. | 5.35 | 0.54 | 1.54 |
| | Time-Varying Bias | Summer | 3026. | 5320. | 2733. | 6.71 | 0.71 | 1.81 |
| Group 22. | Non-Standard Wind | | | | | | | |
| | Westerly | Summer | 443. | 321. | 197. | 1.48 | 0.10 | 0.26 |

The IMU-related contributions are primarily due to large initial errors at 400,000 ft -- velocity errors for Group 3 and misalignments for Group 7. The atmospheric density contributions are primarily due to the error in modeling the 1962 Standard Atmosphere and the season- and latitude-dependent (time-varying) bias. The importance of both these density sources could conceivably be diminished by improving the onboard atmospheric density model; but the emphasis should be on including the time-varying bias.

It is important to note that the IMU-related contributions to <u>all three position component errors</u> and to <u>vertical velocity errors</u> are comparable in magnitude to the drag-related contributions. This suggests that, considering performance at the end of blackout only, the <u>drag-update filter is doing a reasonable job of mixing inertially-derived information with the drag acceleration pseudo-measurement</u>. However, the observations made in Section 5.1.1 indicate that improved performance should be attainable by modifying the filter gains. More detailed discussion of the important error mechanisms and possible ways to reduce some of the contributions is given in Section 5.3.

Detailed tabulations of the error contribution time histories are given in Appendix F. For every row in Tables 5.1-2 and 5.1-3, there is a page in Appendix F, which is a reproduction of a computer printout page summarizing important results from one error budget run.

### 5.1.3 Sensitivity Curves: Drag-Update Phase

This section contains several curves illustrating the sensitivity of drag-update phase performance to variations in error source statistics. These "fixed-filter" sensitivity calculations answer the question: "What is the effect of an unknown variation in the rms value or values of an error source or group of error sources?" These calculations can be made easily, given the type of error budget information summarized in Table 5.1-2, because the appropriate error covariance equations are linear.

All of the example curves given in this section correspond to major contributors to the system performance. Similar sensitivity curves may be constructed for any error source group for which error budget data exists in Table 5.1-2. Sensitivity curves corresponding to error sources which produce minor contributions when their nominal values are assumed are quite flat and of little interest.

To illustrate the means by which the data points for the sensitivity curves were calculated, an example will be given. The sensitivity of crossrange position at 130,000 ft to gyro bias drift is shown in Fig. 5.1-3. The baseline data point for the example is the total

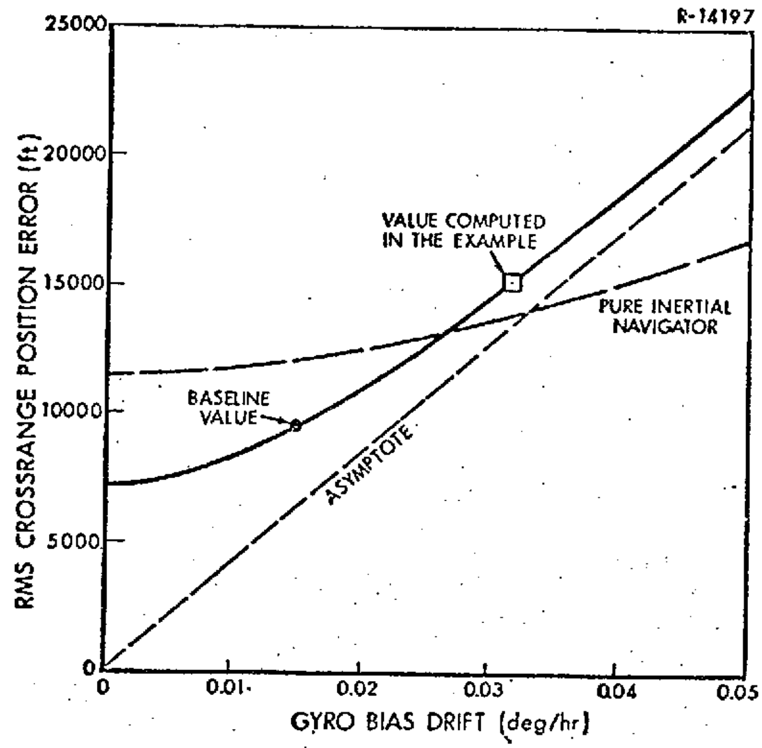



Figure 5.1-3 Sensitivity of Crossrange Position Errors at 130,000 ft to Gyro Bias Drift

crossrange position error for the drag-update filter (9,723 ft). The total includes the effect of a 0.015 deg/hr bias drift about each platform axis. The contribution of these bias drifts is shown in Table 5.1-2 to be 6,373 ft. To compute the effect of a 0.03 deg/hr gyro drift, the 0.015 deg/hr bias drift contribution is removed from the total system error and replaced with an error which is twice as large. Thus, the crossrange position error is

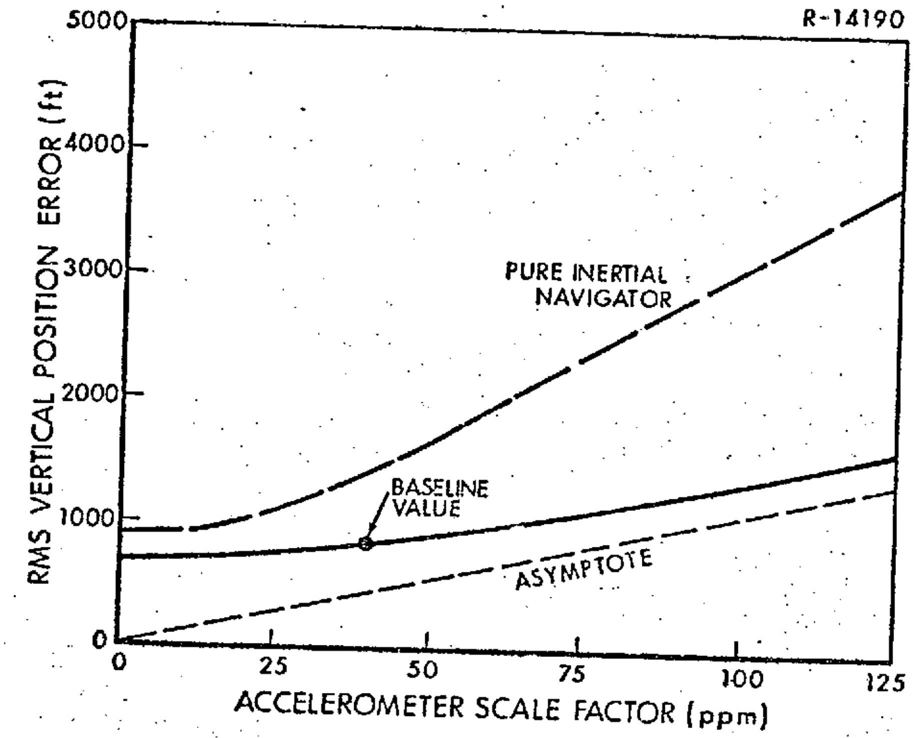
$$\sigma_c = [(9{,}723)^2 - (6{,}373)^2 + (12{,}746)^2]^{\frac{1}{2}}$$
$$= 14{,}710 \text{ ft}$$

This result is indicated in Fig. 5.1-3 as a boxed-in point. The dashed line through the origin is the asymptote approached by the total system error curve as the gyro bias drift contribution becomes large and dominates all others. The remaining points on the curve are obtained as illustrated above.

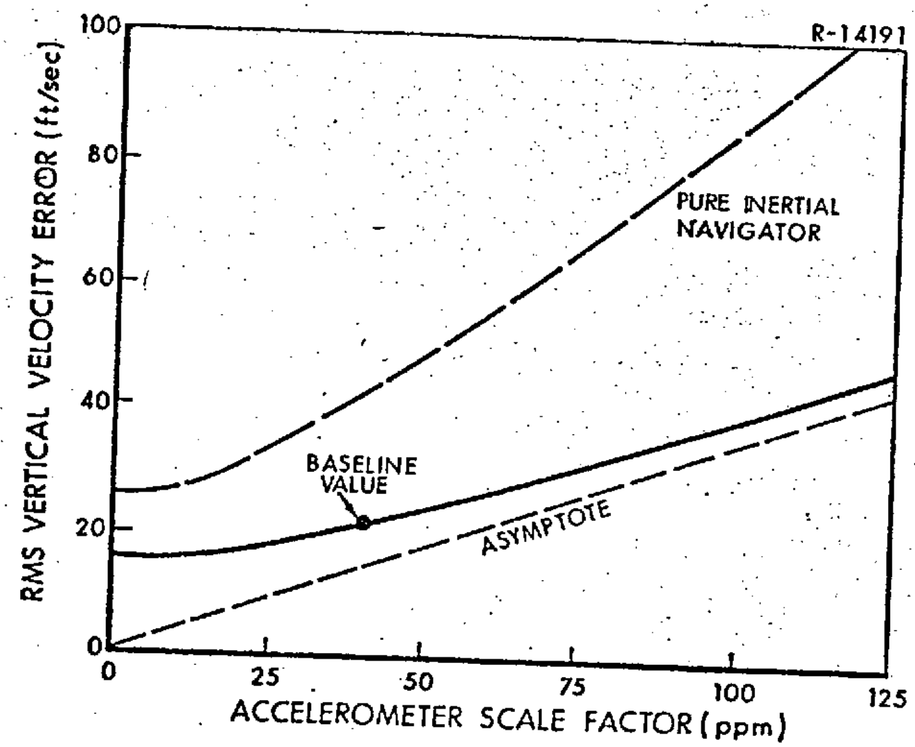
For reference purposes, Fig. 5.1-3 also includes the sensitivity of the pure inertial navigator (see Section 5.1-1) to gyro bias drift. The two curves intersect at a gyro bias drift error of 0.027 deg/hr, i.e., if the gyro bias drift error is greater than 0.027 deg/hr and <u>all other IMU-related error sources assume their baseline values</u>, a pure inertial navigator provides better crossrange position estimates than the candidate drag-update filter. The drag-update filter has <u>increased</u> the crossrange position performance sensitivity to gyro bias drift errors. The following example provides an instance for which the drag-update filter <u>decreases</u> performance sensitivity to a dominant error source.

Figure 5.1-4 shows the sensitivity of vertical position and velocity errors to variations in the accelerometer scale factor error. The major contributors to vertical position error are of roughly comparable magnitude so that the total projected error is not particularly sensitive to any given component. Accelerometer scale factor error is the dominant contributor to vertical velocity error, however, and an increase of the scale factor error to 80 ppm increases the vertical velocity error by 54 %. The pure inertial navigator performance would be degraded by 70%, however, and Fig. 5.1-4 indicates that the drag-update filter has <u>decreased</u> vertical channel performance sensitivity to accelerometer scale factor errors.

The time-varying density bias is latitude- and season-dependent. The contribution of this error source to the total projected error could be decreased by making the filter onboard density model both latitude- and season-dependent. Figures 5.1-5 and 5.1-6 illustrate the sensitivity of vertical position error and downrange position error,




a) Position




b) Velocity

Figure 5.1-4 Sensitivity of Vertical Position and Velocity Errors at 130,000 ft to Accelerometer Scale Factor Errors

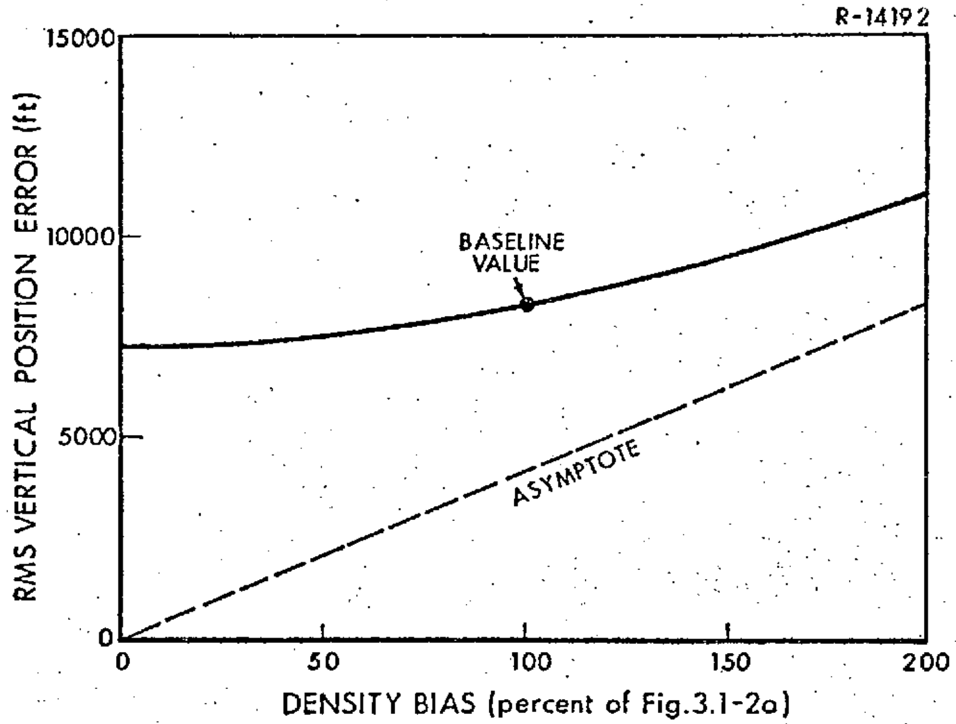



Figure 5.1-5 Sensitivity of Vertical Position Errors at 130,000 ft to Density Time-Varying Bias

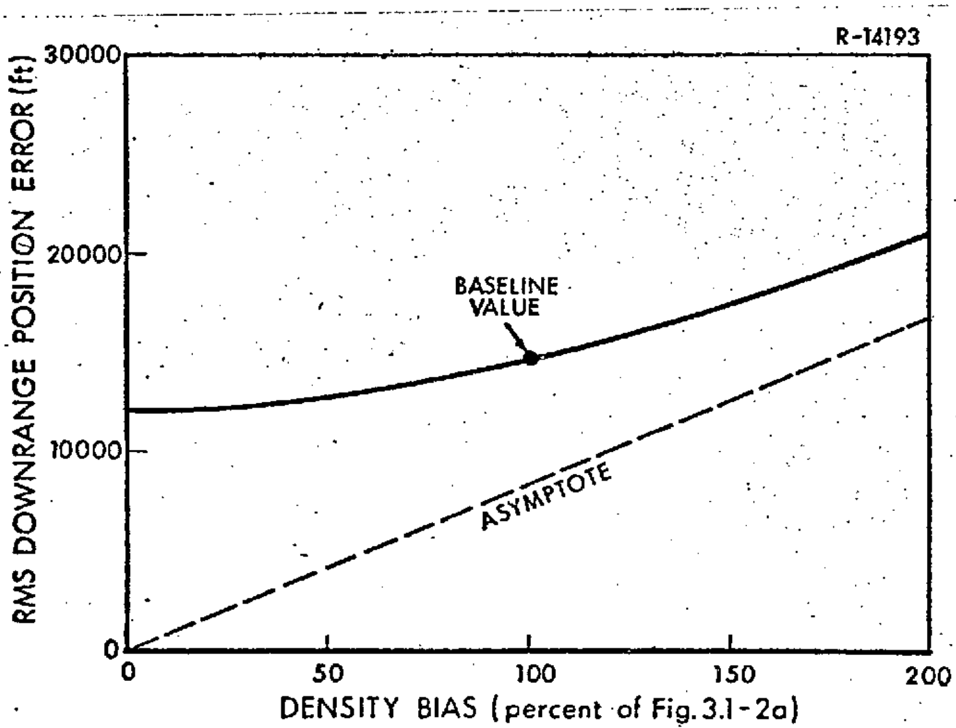



Figure 5.1-6 Sensitivity of Downrange Position Errors at 130,000 ft to Density Time-Varying Bias

respectively, to this error source. The curves were arrived at by scaling the time-varying bias defined in Fig. 3.1-2a by the indicated amount. The figures indicate that a large improvement in the density model accuracy would not result in a significant improvement in navigation accuracy if the filter gains for the pseudo-measurement were not modified.

It should be emphasized that the sensitivity analyses made in this section are for a "fixed-filter" configuration. The sensitivity curves would be altered if the filter were modified. As an example, if the filter were modified to increase the gains for the pseudo-measurement, the total projected performance would become much more sensitive to the time-varying density bias. For such a filter, an improvement in the onboard density model could result in a significant improvement in performance.

## 5.2 SYSTEM E

The navigation error results presented in this section are for the approach and landing phase of the reference mission 3B entry as defined in Section 2.1. System E starts at the termination of blackout, nominally 130,000 ft, and ends at touchdown. The measurement schedule for the external navigation aids is specified in Table 2.2-1. The filter covariance program defined in Sections 4.1 and 4.2 has been used to generate gain files for each of the three filter configurations summarized in Table 4.2-3. The gain file for the System E filter was used repeatedly to compute detailed error budgets at three significant time points:

- initiation of the final approach and landing sequence (12,000 altitude; $t = T_{SW}$)

- the runway threshold (12 ft altitude; $t = T_{RA}$)
- touchdown ($t = T_D$)

The gain files for the alternative System E filters were used to estimate the sensitivity of the projected navigation errors at the runway threshold to filter modifications.

### 5.2.1 Overall System Performance

Figures 5.2-1 and 5.2-2 present overall performance curves for System E, showing position error components and velocity error components, respectively. The curves plotted represent rms errors due to the combined effects of all error source groups in the baseline error budget. They were generated by root-sum-squaring individual contributions at one-minute intervals (tabulated in Appendix G). At $T_{TACAN}$, when the first TACAN measurements are made, and at other key times, such as $T_{BA}$, $T_{MLS}$, $T_{RA}$, and $T_{DME}$, the root-sum-square calculation was performed both before and after update. Thus, the large jumps which occur in certain component errors at these times are accurately shown. Otherwise, the curves are faired-in over the one-minute intervals between the calculated points.

At the time of the first TACAN measurements, $T_{TACAN}$, all three position errors decrease significantly -- the greatest improvement is in downrange position. The only significant velocity change is a decrease in vertical velocity error. Both position and velocity errors then decrease rapidly over the approximately two minutes between TACAN acquisition and baro altimeter acquisition. This improvement in all error components is in contrast to the performance of three of the

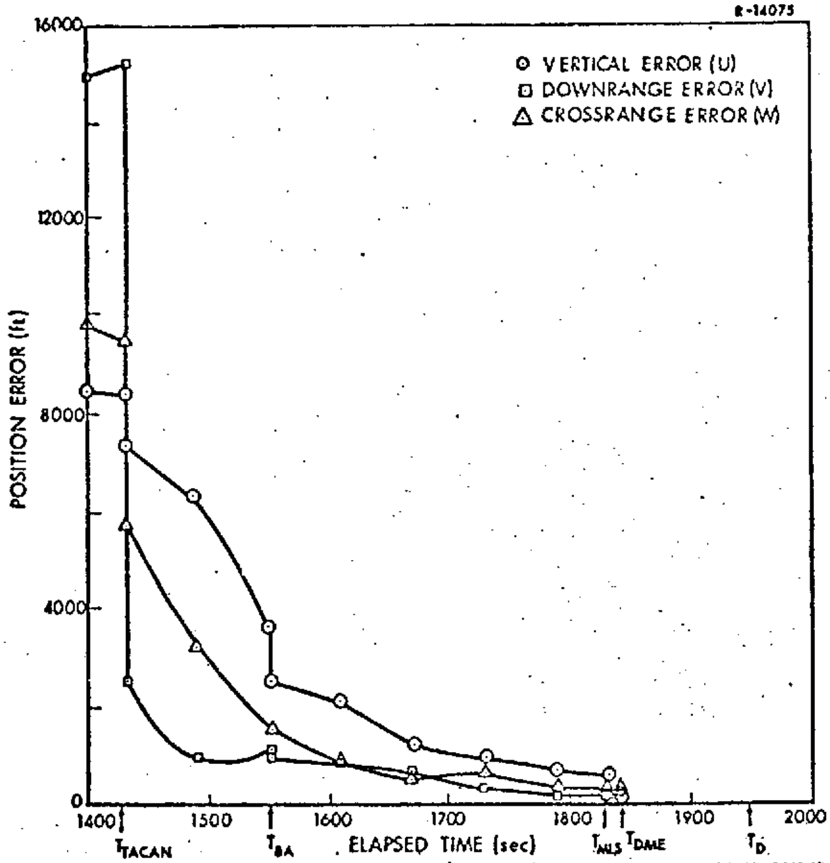



Figure 5.2-1 System E Overall Performance: Position

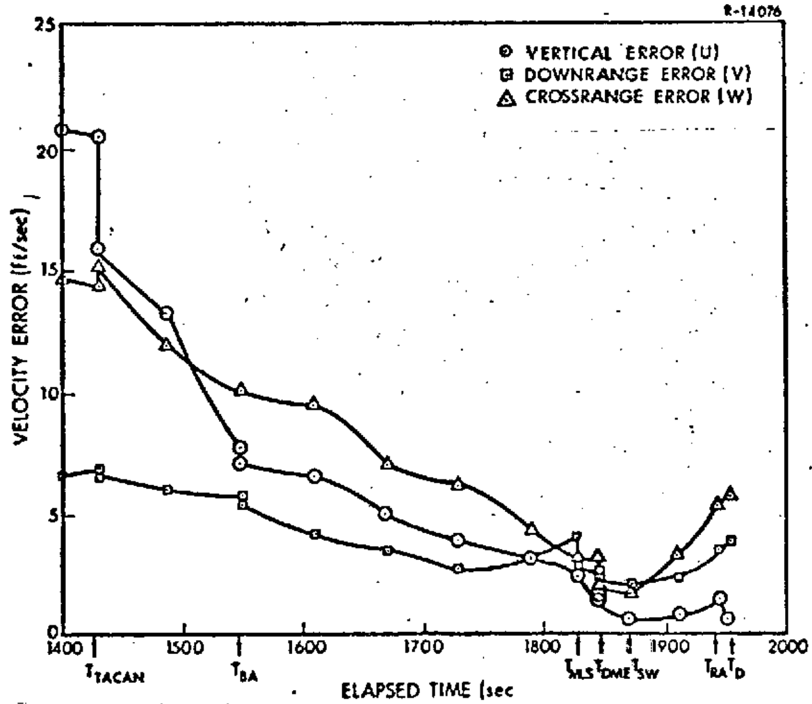



Figure 5.2-2 System E Overall Performance: Velocity

systems studied in Ref. 1. It suggests that a filter covariance matrix propagated through the orbital and drag-update phases of the mission generates correlations between error sources which are valuable in processing measurements during the early post-blackout portion of entry.

The System E navigation errors decrease steadily down to the acquisition of the azimuth and elevation segments of MLS at $T_{MLS}$ -- position errors for the final portion of entry are plotted on an enlarged scale in Fig. 5.2-3. At $T_{MLS}$, there is a large decrease in all three

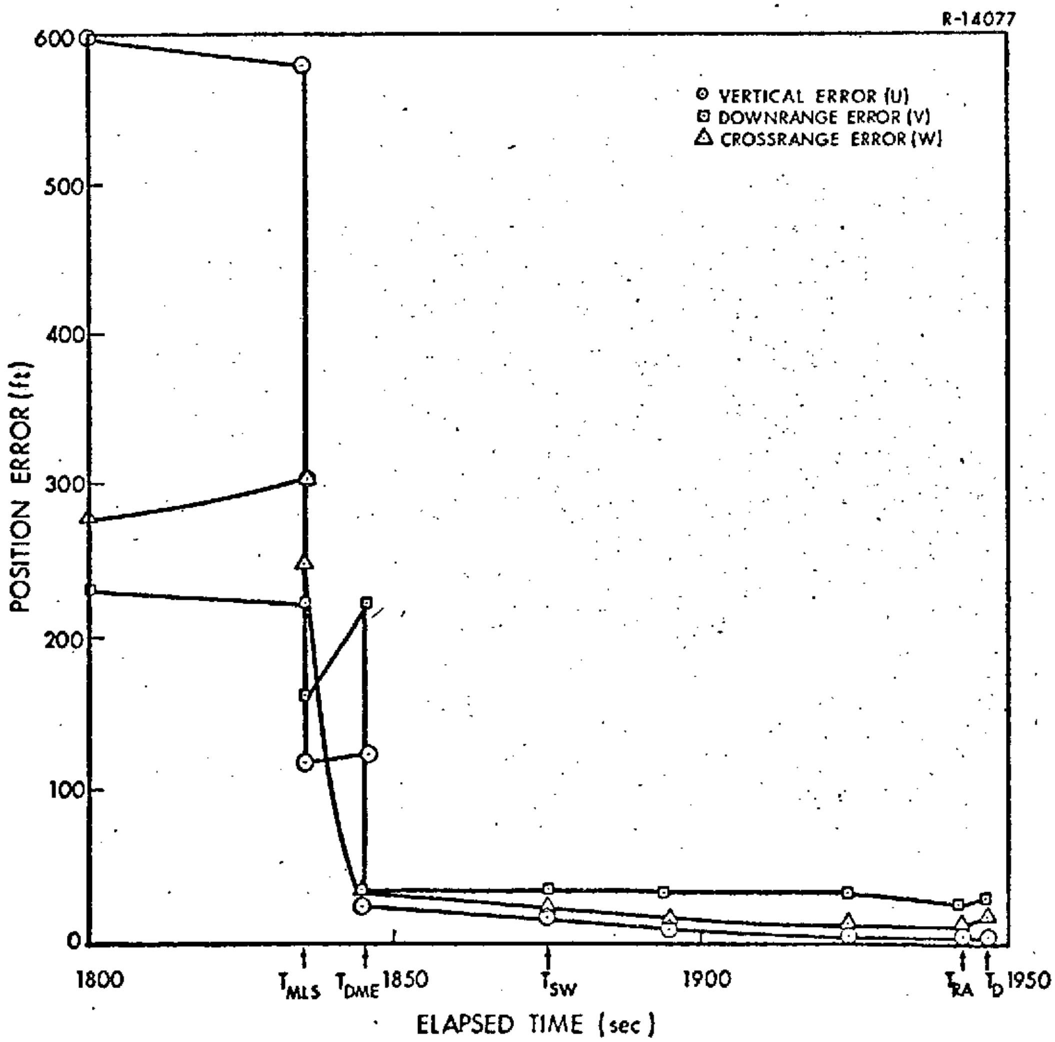



Figure 5.2-3 System E Overall Performance During Final Approach: Position

position error components, most notably in vertical position. The decrease in both downrange and crossrange errors is misleading. The azimuth and elevation segments of MLS do not decrease the range-to-go error, but at $T_{MLS}$, the Space Shuttle heading angle (Fig. 2.1-2) is such that both the crossrange and the downrange position errors contain a transverse component (with respect to the runway) which the azimuth measurement reduces. As the Space Shuttle completes its turning maneuver, the range-to-go error is transferred from the crossrange to the downrange channel -- thus accounting for the growth of downrange position error prior to $T_{DME}$. Following the MLS DME acquisition, the range-to-go error is reduced and the position navigation errors become essentially the navigation accuracy of MLS.

The growth of the crossrange and downrange velocity errors following the initiation of the final approach and landing sequence at $T_{SW}$ indicates a major difficulty with the System E filter. At $T_{SW}$, the navigation filter must switch to a suboptimal operation mode. The System E filter computes gains after $T_{SW}$ based upon a 6 x 6 submatrix of $P_F$ which preserves the correlations between position and velocity errors. Figure 5.2-2 indicates that this is not sufficient; it is also necessary to preserve the correlations between the MLS errors and the navigation errors. The alternative System E filters summarized in Table 4.2-3 attempt to account for these correlations; their performance is summarized in Section 5.2.3.

Figure 5.2-2 indicates that the crossrange and downrange position errors increase after the radar altimeter is switched on at $T_{RA}$. The increase is not due to the radar altimeter gains, but rather to the fact that MLS is simultaneously switched off. Thus after $T_{RA}$, the navigation system has no heading reference and no range reference. The crossrange and downrange position errors would not increase if MLS remained on until touchdown.

### 5.2.2 Detailed Error Budgets

System error covariances have been calculated for each group of error sources over the reference mission 3B trajectory from 130,000 ft (t = 1432 sec) to touchdown (t = 1946.5 sec). Detailed error budgets showing rms position and velocity errors were generated at three significant time points. Each entry in the error budgets is the rms contribution of the error source or sources indicated in the left-hand column; it comes from a computer run in which those errors alone are set at truth-model values -- and all others are zero. The overall System E performance at the indicated time is given at the bottom of each table and compared with the Space Shuttle landing navigation specification given in Ref. 22.* The filter-indicated performance is also presented for the error budget at 12,000 ft; the System E filter does not compute a performance measure below 12,000 ft.

Particular numbers have been circled in the error budgets to focus attention on major contributors. The rule followed in deciding which numbers to circle is the same rule employed in the drag-update phase analysis. In each column, every number whose magnitude is greater than 20% of the RMS total for that column is circled. Thus, every circled number contributes at least 2% to the RMS error for the appropriate column.

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*These landing specifications are guidelines, not inviolable requirements. The vertical velocity specification, in particular, may ultimately be relaxed.

The initialization of the final approach and landing sequence occurs nominally at 12,000 ft, $t = T_{SW}$. At this time, the navigation filter is required to switch to a "suboptimal" operating model. Table 5.2-1 presents a detailed error budget in order to evaluate the System E performance prior to the configuration change.

The measurement schedule outlined in Table 2.2-1 indicates that at $T_{SW}$ the navigation filter will have processed 38 sec of MLS azimuth and elevation measurements and 28 sec of MLS DME measurements. A general observation from Table 5.2-1 (and from Fig. 5.2-3) is that this is a sufficient length of time to permit the filter to improve its navigation accuracy to a desirable level. The position errors at $T_{SW}$ are almost entirely a function of MLS accuracy -- the major contributors are the biases and second-order markovs. If the filter continued to operate in an "optimal" mode, the vertical and crossrange position errors would decrease nearly linearly as the range to the elevation and azimuth antennae, respectively, decreased; and it is reasonable to suspect that, if necessary, MLS could satisfy the touchdown specifications in position without requiring a radar altimeter. The velocity errors at $T_{SW}$ indicate a continuing effect of error sources other than MLS -- IMU-related sources and TACAN -- but the downrange and crossrange velocity errors already satisfy the touchdown specifications.

The detailed error budget at the runway threshold -- 3 seconds from touchdown -- is presented in Table 5.2-2. The error budget was taken prior to processing the first radar altimeter measurement. The filter configuration used between 12,000 ft and the runway threshold is the suboptimal System E filter (see Table 4.2-3). In addition to using a 6 x 6 covariance matrix to compute MLS gains, the suboptimal filter uses the MLS bias estimates and IMU misalignment estimates

## TABLE 5.2-1
## SYSTEM E BASELINE ERROR BUDGET -- 12,000 ft

| ERROR SOURCE | VALUE | RMS NAVIGATION ERROR AT 12,000 ft: POSITION (ft) V | POSITION (ft) DR | POSITION (ft) CR | VELOCITY (ft/sec) V | VELOCITY (ft/sec) DR | VELOCITY (ft/sec) CR |
|---|---|---|---|---|---|---|---|
| I. Uncorrelated Noise | | | | | | | |
| TACAN Range | 100 ft | 0.3 | 0.8 | 0.4 | 0.03 | 0.06 | 0.05 |
| TACAN Bearing | 6 mrad | 0.4 | 1.0 | 0.5 | 0.05 | 0.05 | 0.08 |
| MLS Azimuth | 0.1 mrad | 0.4 | 1.4 | 3.9 | 0.01 | 0.04 | 0.13 |
| MLS Elevation | 0.1 mrad | 2.9 | 1.1 | 0.2 | 0.11 | 0.03 | 0.14 |
| MLS DME | 17 ft | 4.1 | 11.8 | 1.5 | 0.16 | 0.40 | 0.05 |
| Baro Altimeter | 5 ft | 0.0 | 0.0 | 0.0 | 0.00 | 0.00 | 0.00 |
| Quantization Error | 0.0328 ft/sec | 0.1 | 0.1 | 0.1 | 0.03 | 0.03 | 0.03 |
| II. IMU-Related States | | | | | | | |
| 2. Accelerometer Biases | 50 μg | 0.4 | 0.4 | 0.4 | 0.09 | 0.14 | 0.23 |
| 3. Accelerometer Scale Factor | 40 ppm | 0.2 | 0.2 | 0.1 | 0.02 | 0.04 | 0.09 |
| 4. Accelerometer Misalignments | 15 sec | 0.5 | 0.5 | 0.4 | 0.08 | 0.20 | 0.22 |
| 5. Accelerometer Nonlinearities | $3.5 \mu g/g^2$ | 0.0 | 0.0 | 0.0 | 0.00 | 0.00 | 0.00 |
| 6. Gravity Anomalies and Vertical Deflections | 67 mgal-8 sec | 0.2 | 0.2 | 0.1 | 0.04 | 0.03 | 0.05 |
| 7. Gyro Bias Drifts | 0.015°/hr | 0.4 | 1.2 | 1.5 | 0.20 | 0.67 | 0.52 |
| 8. Gyro Mass Unbalances | 0.025°/hr/g | 0.4 | 0.6 | 0.5 | 0.13 | 0.33 | 0.27 |
| 9. Gyro Anisoelasticities | $0.025°/hr/g^2$ | 0.0 | 0.1 | 0.1 | 0.02 | 0.09 | 0.04 |
| III. External Aid-Related Sources | | | | | | | |
| 10. TACAN Range Bias Error | 385 ft | 2.4 | 6.9 | 2.3 | 0.19 | 0.37 | 0.19 |
| 11. TACAN Range Scale Factor | 100 ppm | 0.0 | 0.1 | 0.0 | 0.00 | 0.02 | 0.00 |
| 12. Baro Altimeter Errors | | | | | | | |
| Bias | 100 ft | | | | | | |
| Scale Factor | 3% | | | | | | |
| Static Defect | $1.52 \times 10^{-4}$ $ft/ft^2/sec^2$ | 0.3 | 0.1 | 0.1 | 0.05 | 0.05 | 0.08 |
| First Order Markov | 20 ft | | | | | | |
| 13. MLS Time-Varying Biases | | | | | | | |
| Azimuth | 0.4 mrad | 0.0 | 2.8 | 18.9 | 0.02 | 0.07 | 0.15 |
| Elevation | 0.4 mrad | 13.7 | 3.3 | 0.3 | 0.18 | 0.07 | 0.03 |
| Range Bias | 8 ft | 2.6 | 7.3 | 1.0 | 0.00 | 0.01 | 0.03 |
| Range Scale Factor | 400 ppm | 6.4 | 17.8 | 2.5 | 0.07 | 0.14 | 0.08 |
| 14. MLS Second-Order Markov | | | | | | | |
| Azimuth | 0.2 mrad | 0.8 | 2.5 | 6.7 | 0.02 | 0.08 | 0.25 |
| Elevation | 0.2 mrad | 5.3 | 1.9 | 0.4 | 0.19 | 0.05 | 0.03 |
| Range | 17 ft | 3.5 | 10.0 | 1.2 | 0.16 | 0.40 | 0.04 |
| 16. TACAN Survey Errors | 1 ft | 0.0 | 0.0 | 0.0 | 0.00 | 0.00 | 0.00 |
| 17. MLS Survey Errors | 1 ft | 0.8 | 0.4 | 1.0 | 0.00 | 0.01 | 0.00 |
| 19. TACAN Bearing Bias | 6 mrad | 1.0 | 3.2 | 2.1 | 0.13 | 0.11 | 0.17 |
| 20. MLS Timing Bias Errors | | | | | | | |
| Azimuth | 50 msec | 0.1 | 0.7 | 2.5 | 0.00 | 0.01 | 0.48 |
| Elevation | 50 msec | 3.9 | 0.2 | 0.2 | 0.01 | 0.02 | 0.00 |
| Range | 50 msec | 9.4 | 26.4 | 3.5 | 0.06 | 0.18 | 0.14 |
| 1., 21.-23. Drag-Related Errors | | 1.8 | 1.6 | 0.6 | 0.15 | 0.04 | 0.20 |
| Total Projected Performance | | 20.4 | 37.3 | 21.4 | 0.53 | 1.09 | 0.96 |
| Filter-Indicated Performance | | 18.5 | 35.6 | 19.2 | 0.40 | 0.80 | 0.46 |
| Touchdown Specifications | | 3.0 | 80.0 | 4.7 | 0.20 | 3.00 | 2.00 |

# TABLE 5.2-2

## SYSTEM E BASELINE ERROR BUDGET -- RUNWAY THRESHOLD

| ERROR SOURCE | VALUE | RMS NAVIGATION ERROR AT RUNWAY THRESHOLD: POSITION (ft) V | POSITION (ft) DR | POSITION (ft) CR | VELOCITY (ft/sec) V | VELOCITY (ft/sec) DR | VELOCITY (ft/sec) CR |
|---|---|---|---|---|---|---|---|
| **I. Uncorrelated Noise** | | | | | | | |
| TACAN Range | 100 ft | 0.0 | 0.9 | 0.2 | 0.09 | 0.27 | 0.33 |
| TACAN Bearing | 6 mrad | 0.0 | 1.2 | 0.3 | 0.14 | 0.19 | 0.61 |
| MLS Azimuth | 0.1 mrad | 0.0 | 1.4 | 1.6 | 0.03 | 0.05 | 0.16 |
| MLS Elevation | 0.1 mrad | 0.2 | 0.9 | 0.1 | 0.18 | 0.06 | 0.13 |
| MLS DME | 17 ft | 1.0 | 9.3 | 0.2 | 0.20 | 0.09 | 0.18 |
| Baro Altimeter | 5 ft | 0.0 | 0.0 | 0.0 | 0.00 | 0.00 | 0.00 |
| Quantization Error | 0.0328 ft/sec | 0.0 | 0.2 | 0.1 | 0.09 | 0.09 | 0.16 |
| **II. IMU-Related States** | | | | | | | |
| 2. Accelerometer Biases | 50μg | 0.1 | 1.1 | 0.7 | 0.42 | 0.50 | 1.68 |
| 3. Accelerometer Scale Factor | 40 ppm | 0.1 | 0.2 | 0.2 | 0.16 | 0.24 | 0.58 |
| 4. Accelerometer Misalignments | 15 sec | 0.1 | 1.2 | 0.6 | 0.36 | 0.86 | 1.60 |
| 5. Accelerometer Nonlinearities | $3.5\mu g/g^2$ | 0.0 | 0.0 | 0.0 | 0.00 | 0.00 | 0.00 |
| 6. Gravity Anomalies and Vertical Deflections | 67 mgal-8 sec | 0.1 | 0.4 | 0.1 | 0.21 | 0.14 | 0.33 |
| 7. Gyro Bias Drifts | 0.015°/hr | 0.3 | 3.4 | 1.8 | 1.06 | 2.44 | 4.15 |
| 8. Gyro Mass Unbalances | 0.025°/hr/g | 0.1 | 1.4 | 0.7 | 0.45 | 1.57 | 1.86 |
| 9. Gyro Anisoelasticities | $0.025°/hr/g^2$ | 0.0 | 0.4 | 0.1 | 0.12 | 0.42 | 0.30 |
| **III. External Aid-Related Sources** | | | | | | | |
| 10. TACAN Range Bias Error | 385 ft | 0.1 | 7.7 | 0.8 | 0.49 | 1.61 | 1.37 |
| 11. TACAN Range Scale Factor | 100 ppm | 0.0 | 0.3 | 0.0 | 0.02 | 0.11 | 0.04 |
| 12. Baro Altimeter Errors | | | | | | | |
| Bias | 100 ft | 0.0 | 0.2 | 0.2 | 0.06 | 0.35 | 0.51 |
| Scale Factor | 3% | | | | | | |
| Static Defect | $1.52 \times 10^{-4}$ $ft/ft^2/sec^2$ | | | | | | |
| First Order Markov | 20 ft | | | | | | |
| 13. MLS Time-Varying Biases | | | | | | | |
| Azimuth | 0.4 mrad | 0.0 | 0.2 | 6.3 | 0.02 | 0.02 | 0.10 |
| Elevation | 0.4 mrad | 0.3 | 0.2 | 0.0 | 0.18 | 0.03 | 0.12 |
| Range Bias | 8 ft | 0.1 | 7.6 | 0.1 | 0.02 | 0.01 | 0.04 |
| Range Scale Factor | 400 ppm | 0.1 | 5.1 | 0.0 | 0.07 | 0.02 | 0.15 |
| 14. MLS Second-Order Markov | | | | | | | |
| Azimuth | 0.2 mrad | 0.1 | 2.8 | 3.9 | 0.05 | 0.09 | 0.33 |
| Elevation | 0.2 mrad | 0.3 | 1.8 | 0.3 | 0.34 | 0.10 | 0.24 |
| Range | 17 ft | 0.7 | 17.2 | 0.2 | 0.20 | 0.13 | 0.18 |
| 16. TACAN Survey Errors | 1 ft | 0.0 | 0.0 | 0.0 | 0.00 | 0.00 | 0.00 |
| 17. MLS Survey Errors | 1 ft | 1.0 | 1.2 | 1.0 | 0.01 | 0.01 | 0.00 |
| 19. TACAN Bearing Bias | 6 mrad | 0.1 | 4.0 | 0.8 | 0.35 | 0.43 | 1.35 |
| 20. MLS Timing Bias Errors | | | | | | | |
| Azimuth | 50 msec | 0.0 | 0.4 | 0.6 | 0.02 | 0.16 | 0.18 |
| Elevation | 50 msec | 0.2 | 0.6 | 0.1 | 0.01 | 0.01 | 0.13 |
| Range | 50 msec | 0.3 | 15.5 | 0.2 | 0.11 | 0.05 | 0.05 |
| 1., 21.-23. Drag-Related Errors | | 0.1 | 2.5 | 0.5 | 0.35 | 0.30 | 1.37 |
| Total Projected Performance | | 1.7 | 28.7 | 8.1 | 1.59 | 3.58 | 5.76 |
| Touchdown Specifications | | 3.0 | 80.0 | 4.7 | 0.20 | 3.00 | 2.00 |

saved from $T_{SW}$ to compensate the MLS measurements and to resolve the accelerometer outputs into the proper coordinates.

The position errors at the runway threshold reflect the expected continuing improvement in vertical and crossrange errors as the Space Shuttle approaches the MLS elevation and azimuth antennae -- the major contributors to position errors continue to be the MLS biases and second-order markovs. The vertical and downrange position errors satisfy the touchdown specifications, but the crossrange position error is somewhat larger than desired. The magnitude of the crossrange error is primarily due to the placement of the MLS azimuth antenna 15,000 ft downrange from the nominal touchdown point. If the antenna were 10,000 ft from the touchdown point, however, the crossrange position error would be close to the touchdown specification.

The disconcerting aspect of Table 5.2-2 is the significant growth of the velocity errors relative to their magnitude at 12,000 ft ($t = T_{SW}$). The major contributors remain the same as in Table 5.2-1, but the contributions due to the IMU-related error sources and TACAN have increased considerably. In particular, the contribution of gyro bias drift alone exceeds the touchdown specification for crossrange errors. The relatively larger downrange and crossrange velocity error contributions are a consequence of the filter's inability to estimate azimuth misalignment prior to $T_{SW}$, but the growth of the velocity errors is due to an inappropriate selection of filter velocity gains after $T_{SW}$.

The error budget at touchdown is presented in Table 5.2-3. In order to emphasize vertical channel errors, the table considers only three general error categories:

TABLE 5.2-3

SYSTEM E BASELINE ERROR BUDGET -- TOUCHDOWN

| ERROR SOURCE | VALUE | RMS NAVIGATION ERROR AT TOUCHDOWN | | | | | |
|---|---|---|---|---|---|---|---|
| | | POSITION (ft) | | | VELOCITY (ft/sec) | | |
| | | V | DR | CR | V | DR | CR |
| I. Uncorrelated Noise | | | | | | | |
| Radar Altimeter | 1 ft | 0.4 | 0.0 | 0.0 | (0.31) | 0.00 | 0.00 |
| RSS for Other External Navigation Aids | | 0.0 | (9.7) | 2.5 | 0.06 | 0.37 | 0.77 |
| II. IMU-Related States | | 0.0 | (12.7) | (17.8) | 0.07 | (3.23) | (5.30) |
| III. External Aid-Related States | | | | | | | |
| 15. Radar Altimeter States | | | | | | | |
| Bias | 1 ft | (1.0) | 0.0 | 0.0 | 0.00 | 0.00 | 0.00 |
| First-Order Markov | 1 ft | (1.0) | 0.0 | 0.0 | (0.52) | 0.00 | 0.00 |
| 10.-14, 16.-23. RMS for Other External Navigation Aids | | 0.0 | (27.2) | (11.4) | 0.04 | (1.81) | (2.50) |
| Total Projected Performance | | 1.5 | 31.5 | 21.4 | 0.61 | 3.73 | 5.92 |
| Touchdown Specifications | | 3.0 | 80.0 | 4.7 | 0.20 | 3.00 | 2.00 |

- radar-related error sources
- IMU-related error sources
- other external aid-related error sources

The radar altimeter is switched on at the runway threshold and MLS is switched off. Thus for the three seconds remaining until touchdown, the principal activity in the downrange and crossrange channels is the propagation of the velocity errors into the position errors. The principal contributors to the downrange and crossrange channel errors are the same as at the runway threshold.

The only significant contributors to the vertical channel errors are the radar altimeter-related error sources. The measurement noise contributes to both the position and the velocity error; the bias contributes to the position error only. The contribution of the first order markov alone exceeds the vertical velocity touchdown specification. Any of the data values in the truth model data base (Table 3.2-2) may change as hardware selections are made, but the radar altimeter error models are particularly likely to be revised. It should be noted, however, that the error model for the radar altimeter reflects instrument errors and terrain-dependent errors so that an accurate instrument would not automatically yield small vertical channel errors. Sensitivity curves relating the vertical channel errors to the radar altimeter error models are provided in Section 5.2.3.

The System E total projected performance is out-of-spec in all velocity components and in crossrange position. The crossrange position error can be reduced significantly by using MLS down to touchdown; the vertical velocity specification conceivably could be relaxed sufficiently enough for the System E performance to be in-spec. The principal question mark is the acceptability of the large downrange and crossrange velocity errors. The difficulty appears to be software- rather than hardware-related. Section 5.2.4 considers filter modifications for improving the velocity performance.

### 5.2.3 Sensitivity Curves: System E

This section contains several curves illustrating the sensitivity of System E performance to variations in error source statistics. The curves for vertical channel errors were produced using the error budget data at touchdown taken from Table 5.2-3; the curves for downrange and crossrange channel errors were produced using the error budget data at the runway threshold taken from Table 5.2-2. The method of generating the data for these curves is discussed in Section 5.1.3.

Similar sensitivity curves may be constructed for any error source group for which error budget data is available in Tables 5.1-2 and 5.1-3. All of the error curves in this section correspond to major contributors to system performance. Sensitivity curves corresponding to error sources which produce minor contributions are quite flat.

The vertical position and velocity error sensitivity to radar altimeter markov error is shown in Fig. 5.2-4. The relevant touchdown specifications are included in each of the graphs. Figure 5.2-4a is identical to the vertical position sensitivity to radar altimeter bias. It is apparent from Fig. 5.2-4b that the 0.2 ft/sec vertical velocity specification cannot be met even if the markov error is zero.

The sensitivity of the crossrange position error at the runway threshold to MLS azimuth measurement bias is shown in Fig. 5.2-5. The figure indicates that the touchdown specification could be met at the runway threshold only if the bias were reduced to less than 0.2 mrad. An alternative not considered in Fig. 5.2-5 would be to move the azimuth antenna closer to the nominal touchdown point.

The principal contributors to downrange position errors at the runway threshold are the MLS DME second-order markov and the MLS DME timing bias error. Sensitivity curves for these two error sources are presented in Figs. 5.2-6 and 5.2-7, respectively. It does not appear likely that either error source could become large enough to violate the touchdown specification.

The downrange and crossrange velocity errors at the runway threshold are due primarily to the IMU-related states. Figures 5.2-8

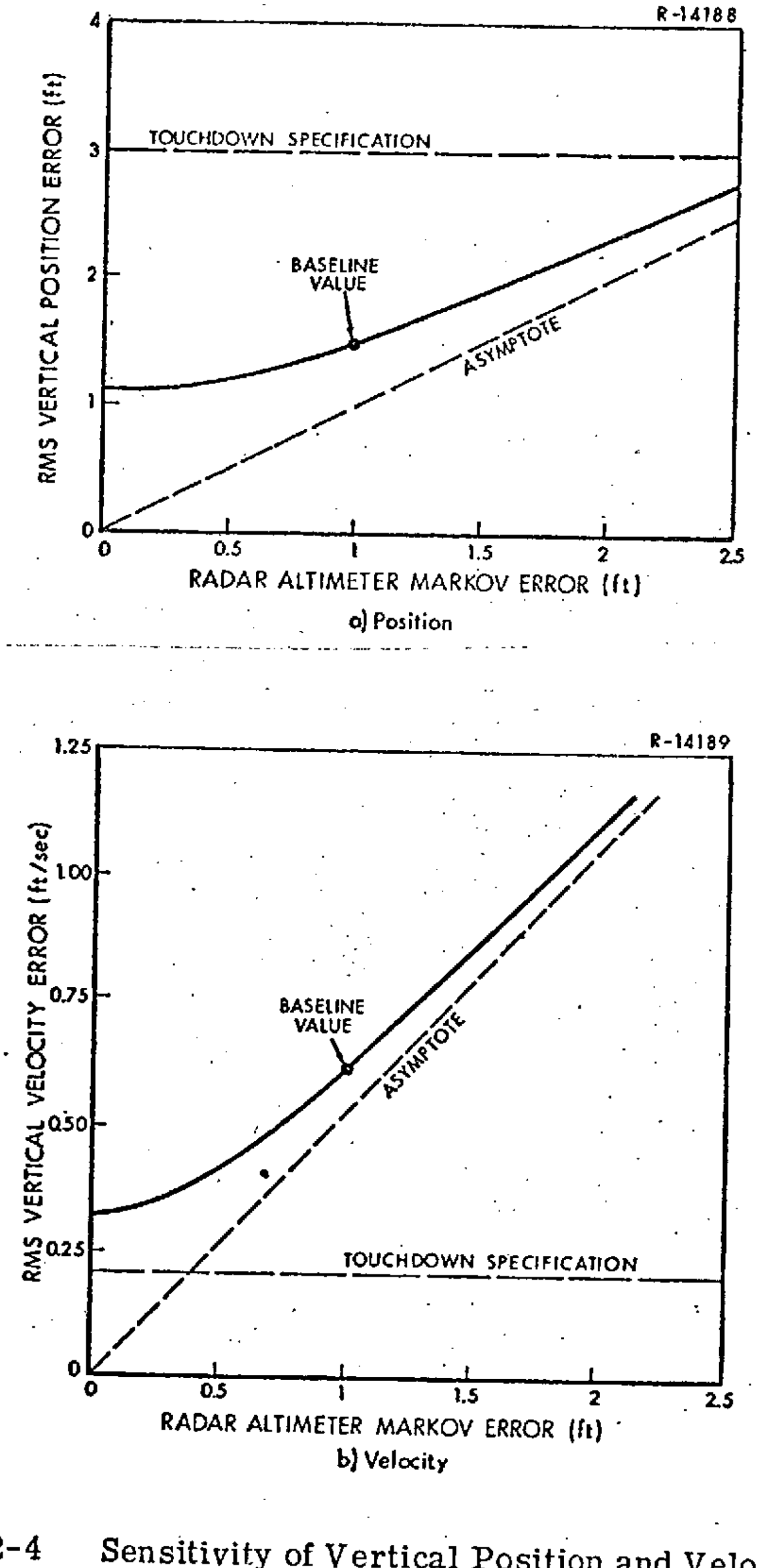




Figure 5.2-4 Sensitivity of Vertical Position and Velocity Errors at Touchdown to Radar Altimeter First-Order Markov Error

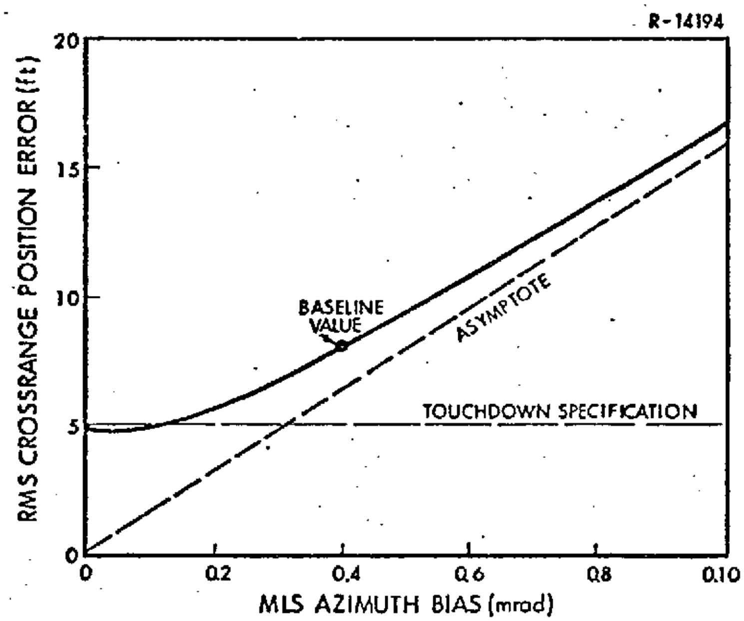


Figure 5.2-5 Sensitivity of Crossrange Position Error at Runway Threshold to MLS Azimuth Bias

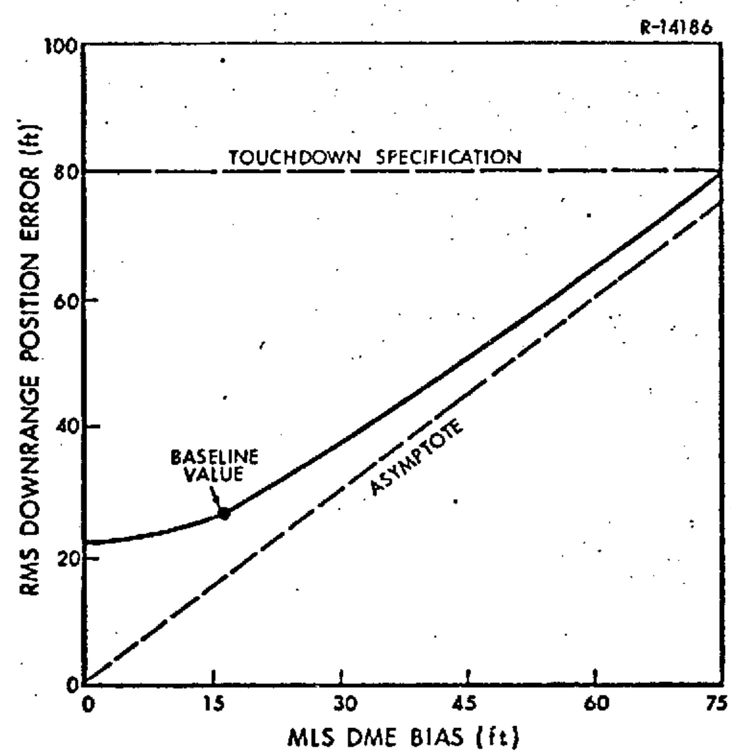


Figure 5.2-6 Sensitivity of Downrange Position Error at Runway Threshold to MLS DME Bias

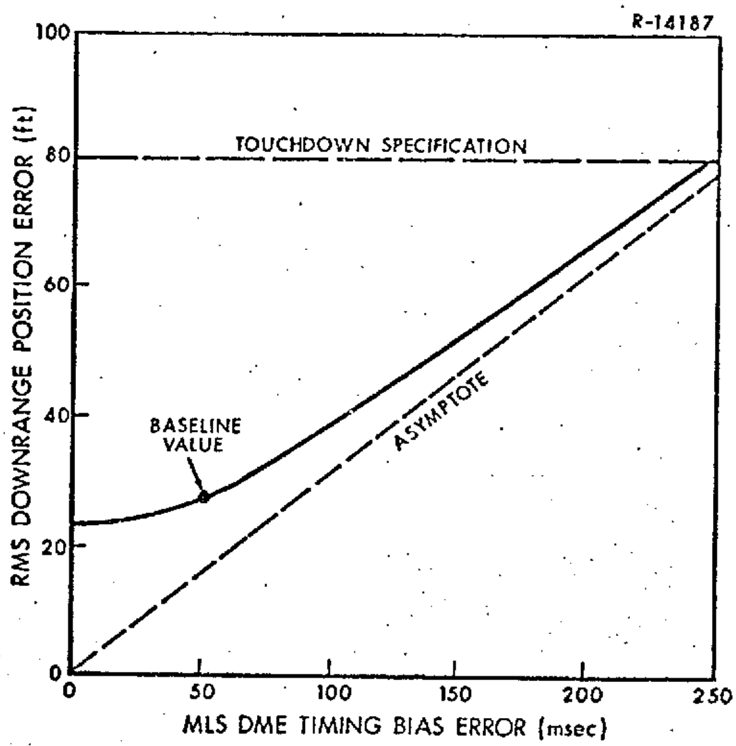


Figure 5.2-7 Sensitivity of Downrange Position Error at Runway Threshold to MLS DME Timing Bias Error



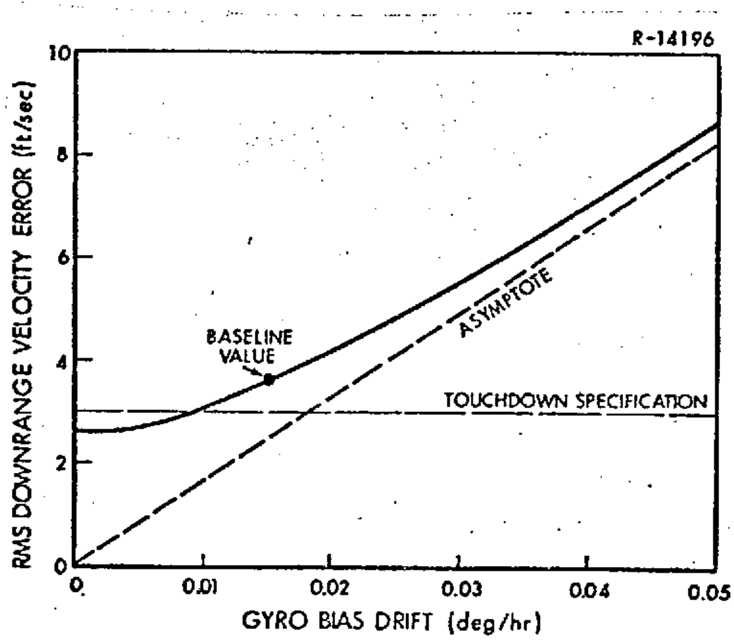


Figure 5.2-8 Sensitivity of Downrange Velocity Error at Runway Threshold to Gyro Bias Drift Error

and 5.2-9 present the velocity error sensitivity curves for gyro bias drift errors. The curves indicate that the velocity errors may become quite large if the gyro bias drift error exceeds the baseline value of 0.015 deg/hr by a significant amount. Similar curves can be drawn for accelerometer bias errors, accelerometer misalignments, and gyro mass unbalances; except that the curves will be somewhat flatter.

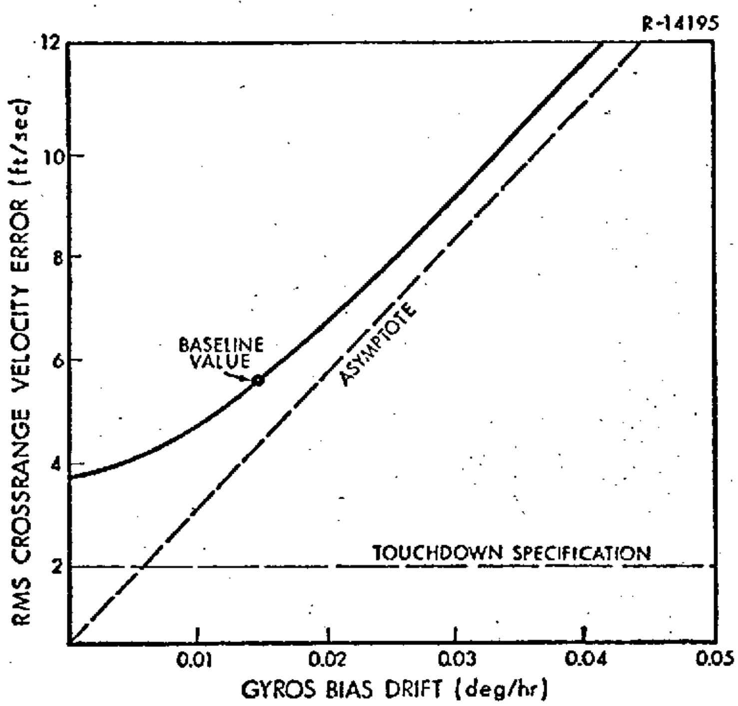




Figure 5.2-9 Sensitivity of Crossrange Velocity Error at Runway Threshold to Gyro Bias Drift Error

### 5.2.4 Performance Sensitivity to Filter Modifications: System E

The overall performance curves in Section 5.2.1 indicate that, after switching to a suboptimal operation mode at $T_{SW}$, the System E filter cannot further improve the velocity estimates. Instead, the downrange and crossrange errors increase significantly during the final approach and landing sequence. The study summarized in this section was undertaken to determine whether this velocity divergence is a general property of all suboptimal Space Shuttle navigation filters, or whether filter configurations which yield a significant improvement in performance can be devised.

The particular filter configurations analyzed are the System E filter and the alternative System E filters as defined in Table 4.2-3. The three filters are identical 15-state Kalman filters down to initiation of the final approach and landing sequence at $T_{SW}$. After $T_{SW}$, they are 6-state (position and velocity) suboptimal filters. The principal differences after $T_{SW}$ are the MLS gain computation algorithms:

- System E filter – gains are computed from Kalman algorithm with 6 x 6 covariance saved from $T_{SW}$.
- Alternative 1 – gains are computed from Kalman algorithm with 15 x 15 covariance saved from $T_{SW}$ (only six elements of gain vector are used).
- Alternative 2 – gains are the optimal gains computed at $T_{SW}$ (only six elements of gain vector are used; azimuth and elevation gains scaled by range-to-go)

The sensitivity analysis performed in this section is referenced to the System E filter and to the error budget at the runway threshold for that filter (Table 3.2-2). Gain files were generated for each of the alternative filters using a modified filter covariance program (see Section 4.1). The gain file for each alternative System E filter was used to determine the contribution of a single error source to the total projected performance for that filter. The error source selected was gyro bias drift (Group 7), which is the dominant contributor to the System E filter downrange and crossrange velocity errors. By comparing the effects of gyro bias drift on the performance of the three filters, it is then possible to make a general estimate of the performance of the alternative filters.

The navigation errors at the runway threshold due to gyro bias drift are presented in Table 5.2-4 for the System E filter and for the two alternative filters. The position errors for all three filters are comparable; the important differences are in the velocity errors. These are summarized below.

TABLE 5.2-4

NAVIGATION ERRORS AT RUNWAY THRESHOLD
DUE TO GYRO BIAS DRIFT ERRORS

| FILTER | POSITION ERRORS (ft) | | | VELOCITY ERRORS (ft/sec) | | |
|---|---|---|---|---|---|---|
| | V | DR | CR | V | DR | CR |
| System E Filter | 0.3 | 3.4 | 1.8 | 1.06 | 2.44 | 4.15 |
| Alternative 1 | 0.6 | 3.5 | 1.3 | 1.62 | 0.59 | 2.90 |
| Alternative 2 | 0.3 | 1.2 | 1.8 | 0.27 | 0.73 | 0.81 |

The downrange and crossrange velocity errors for Alternative 1 represent a significant improvement over the performance of the System E filter, but the vertical velocity performance is worse. It is reasonable to suspect that Alternative 1 would yield similar changes in the velocity errors due to the other major IMU-related error sources. If this occurred, the total projected performance at the runway threshold for Alternative 1 would satisfy the touchdown specifications in downrange velocity, but would still exceed the specifications in crossrange velocity and vertical velocity. Since vertical velocity information is provided by the radar altimeter once the runway threshold has been passed, the decrease in vertical velocity accuracy for Alternative 1 may not be important. Thus, it appears that Alternative 1 is an improvement over the System E filter.

The more interesting aspect of Table 5.2-4 is the performance of Alternative 2. Alternative 2 yields a factor of four improvement in the accuracy of all three velocity components. If similar improvements were realized in the velocity errors due to the other major IMU-related error sources, the total projected performance at the runway threshold for Alternative 2 would satisfy all touchdown specifications except in vertical velocity -- and the vertical velocity estimates would be better than those provided by either of the other filters. Thus, from a navigation accuracy vantage point, Alternative 2 appears to be superior to both Alternative 1 and to the System E filter.

It is not obvious why Alternative 2 appears to perform better than Alternative 1, but it is clear that both should perform better than the System E filter. At $T_{SW}$, the velocity and position errors are highly correlated with the MLS biases. The 15 x 15 covariance at $T_{SW}$ reflects this correlation and the filter gains for the state estimate update at $T_{SW}$ are selected accordingly. Thus, after $T_{SW}$, both Alternative 1 (saved 15 x 15 covariance) and Alternative 2 (saved gains) account for MLS biases. The System E filter, however, saves only a 6 x 6 covariance and therefore it cannot account for the correlation between the navigation errors and the MLS biases. The net result is that the System E filter makes a poor selection of velocity gains.

It should be emphasized that the sensitivity analysis presented in this section is based upon navigation errors from a single error source. The analysis indicates that the alternative filters do not experience the velocity estimation difficulties which plagued the System E filter, but this indication must be verified through a detailed error budget before a final performance determination can be made.

## 5.3 DISCUSSION

Sections 5.1 and 5.2 presented a description of the navigation filter performance during the drag-update phase and the approach and landing phase, respectively. The results are summarized in this section. A review is made of the dominant error sources for the two mission phases and of their effect upon the filter performance. The manner in which the various filter states contribute to the filter performance is then discussed and possible software modifications to improve the performance are presented.

### 5.3.1 Drag-Update Phase

The overall performance of the drag-update filter was evaluated in Section 5.1.1 via comparison with the performance of a pure inertial navigator. The analysis indicated that the drag-update filter, as presently designed, yields navigation errors approximately two-thirds as great as those for the pure inertial navigator. This result verifies that the drag acceleration pseudo-measurement is a potentially valuable navigation aid and that the drag-update filter effectively limits the growth of navigation errors during entry. However, a detailed study of the overall performance indicates that a significant improvement in performance may be obtainable through filter design changes. Formulation of the most promising design changes is a consequence of the analysis to follow.

An error budget provides a detailed breakdown of the contributions of individual error sources to the total navigation error at a particular time -- the error budget presented in Section 5.1.2 corresponds to the end of the drag-update phase. The major contributors to the navigation error at this time-point are:

- accelerometer scale factor error (Group 3)
- gyro bias drift (Group 7)
- non-standard atmospheric density modeling errors (Group 21)

Analysis of the individual error contribution time histories given in Appendix F reveals that the IMU-related contributions are primarily due to large initial errors at 400,000 ft -- velocity errors for Group 3 and misalignments for Group 7. The atmospheric density contributions are primarily due to errors in modeling the 1962 Standard Atmosphere and to a season- and latitude-dependent bias.

The time histories in Appendix F also provide a second important piece of information: The relative importance of the major error contributors is time-dependent. The IMU-related error sources (Groups 1a through 9) are the only contributors to navigation errors prior to the first drag acceleration pseudo-measurement ($t = T_{DRAG}$). In the several minutes following $T_{DRAG}$, the drag-related error sources --

primarily Group 21 -- are the principal contributors to vertical position errors. During the latter portion of the drag-update phase, the IMU-related error sources again become dominant in all error components. This exchange of dominance between IMU-related and drag-related error sources is not necessarily undesirable -- it could be a function of changes in the trajectory geometry, acceleration profiles, etc. -- however, to the extent that it is due to a poor selection of filter gains, it should be eliminated.

The analysis presented in Section 5.1.1 indicates that the drag-update filter overweights the drag pseudo-measurements for the first several minutes after $T_{DRAG}$. The evidence to support this observation is that:

- the vertical position error increases significantly after the first drag-update at $T_{DRAG}$
- drag-related error sources become the principal contributors to vertical position error for the first several minutes after $T_{DRAG}$.

On the other hand, there are three related indications that the drag-update filter underweights the drag pseudo-measurements during the last portion of the drag-update phase:

- the accuracy of a single drag pseudo-measurement increases as altitude decreases, i.e., the rms magnitude of the drag-related error sources decreases as altitude decreases (see Figs. 3.1-1 through 3.1-3)
- the filter-indicated performance at $T_{DME}$ is overly optimistic
- the relative error contribution of IMU-related error sources increases over the final minutes prior to $T_{DME}$.

On the basis of these observations, it seems desirable to modify the filter gain sequence such that the gains in the first portion of the drag-update phase are decreased, and the gains in the latter portion are increased.

The drag-update filter is a 13-state Kalman filter. The first six states are navigation states (position and velocity); the last seven states are error states (platform misaligments (3), acceleration errors (3), drag-correlated error (1)). The error states are generalized states which are used to describe the type of error sources to be encountered and to prevent the filter covariance from becoming unrealistically small, i.e., to prevent the filter from generating overly optimistic performance predictions. As an example, drag-related error sources are dominant contributors to navigation errors during the drag-update phase. The drag-update filter uses the drag-correlated error state to estimate the net effect of these error sources on the drag acceleration pseudo-measurement. If the estimate is accurate enough, the filter uses it to diminish the effect of the drag-related error sources on the position and velocity estimates. Even if the estimate is not accurate, however, the presence of the error state prevents the filter from assuming the pseudo-measurement is more accurate than it actually is.

The most straightforward mechanism for modifying the drag pseudo-measurement gains is to change the parameters associated with the drag-correlated error state. Increasing the variance of the drag-correlated state has the effect of decreasing the drag pseudo-measurement gains. The gain modifications suggested in the preceding paragraphs can therefore be effected by assigning an altitude dependence to the variance of the white noise associated with the drag-correlated state, e.g., the variance could be 40% of drag at high altitudes and 20% of drag at low altitudes. Equivalently, the variance could be maintained at 30% for all altitudes, but the filter measurement matrix [Eq. (4.2-4)] could be modified to

$$H_F(t) = q_{pred}(t) \left[ \frac{-\underline{i}_{R_c}^T}{h_{sc}} \;\vdots\; \frac{2\underline{i}_{VR_c}^T}{V_R(t)} \;\vdots\; 0 \;\vdots\; 0 \;\vdots\; a(h) \right] \qquad (5.3\text{-}1)$$

where a(h) is a decreasing function of altitude. It is possible that neither of these modifications will bring the filter-indicated performance at $T_{DME}$ into accord with the total projected performance. In this case, it may also be necessary to increase the process noise for the filter.

A second possibility for improving the performance of the drag-update filter is to improve the accuracy of the onboard atmospheric density model. The improvement could involve either a more accurate model of the 1962 Standard Atmosphere, i.e., the four-term model, or the selection of a season- and latitude-dependent model to minimize the importance of the time-varying bias. The Alternative Contributions Table (Table 5.1-3) indicates that the four-term model for the 1962 Standard Atmosphere is not significantly better than the one-term model; therefore, inclusion of a season- and latitude-dependence in the onboard density model is recommended. The sensitivity analysis in Section 5.1.3 indicates that a significant improvement in navigation accuracy cannot be achieved by improving the filter onboard density model unless accompanying modifications in the filter gains are made. If the error in the drag pseudo-measurement is reduced, the gains must be increased to take advantage of the improvement, etc. The previous paragraph outlines several mechanisms for increasing the gains.

The performance of the drag-update filter is a function not only of the filter gains, but also of the selection of a measurement matrix $H_F(t)$ for the drag acceleration pseudo-measurement. Comparison of $H_F(t)$ as defined in Eq. (4.2-4) or Eq. (5.3-1) with the first 13 components of $H_S(t)$ as defined in Eq. (C-42)

$$H_S(t) = q(t)\Bigg[\underbrace{\frac{-\underline{i}_R^T}{h_{sc}} + \left(\frac{\underline{F}_L}{q(t)} - \frac{2\underline{i}_{VR}^T}{V_R(t)}\right)(\Omega_E \times)}_{\text{position errors}} \;\Bigg|\; \underbrace{\frac{2\underline{i}_{VR}^T}{V_R(t)} - \frac{\underline{F}_L}{q(t)}}_{\text{velocity errors}} \;\Bigg|\; 0 \;\Bigg|\; 0 \;\Bigg|\; 1 \;\Bigg|\; \cdots\Bigg] \quad (5.3\text{-}2)$$

reveals that there are several terms which appear in $H_S(t)$ but do not appear in $H_F(t)$. These terms represent dynamic relationships which affect the pseudo-measurement, but which were not included in the filter model. The additional terms in the position components are due to minor dynamic effects and can be ignored; however, the two terms in the velocity components are of the same order of magnitude. The $2\underline{i}_R^T / \underline{V}_R(t)$ term relates the velocity estimation error to the error in computing the predicted drag; the $\underline{F}_L/q(t)$ term relates the velocity estimation error to the error in computing the drag component of the accelerometer outputs. If one of these terms is included in $H_F(t)$, the other should be also.

The most important terms in $H_F$ are the position component terms; the $-\underline{i}_R^T/h_{sc}$ term reflects the basic sensitivity of the pseudo-measurement to vertical position errors. A tradeoff study was undertaken to establish the importance of the velocity component terms. This study considered three different definitions of $H_F(t)$:

- $H_F(t)$ as defined in Eq. (4.2-4).
- $H_F(t)$ as defined in Eq. (4.2-4), but with the $-\underline{F}_L/q(t)$ velocity term added.
- $H_F(t)$ as defined in Eq. (4.2-4), but with no velocity terms.

The filter covariance program was used to generate a gain file corresponding to each definition of $H_F(t)$, and navigation errors due to atmospheric density modeling errors (Group 21) were computed for each gain file. There was no discernible difference between the performance of the three different filters. This suggests that the velocity component terms of $H_F(t)$ are unimportant and could be omitted.

A last comment should be made concerning the definitions of the error states used in the drag-update filter. If the drag-update filter uses an error state to estimate a correlated error source, or if it requires an error state to develop the proper correlations between navigation error components, the presence of that state is important for improving the filter performance. If the filter uses the state only to prevent itself from becoming overly optimistic in its performance predictions, however, the function of that state might be performed adequately by an appropriately defined process noise.* The drag acceleration pseudomeasurement is of sufficiently poor quality that the only error state used by the drag-update filter to estimate correlated error sources is the drag correlated error state. Thus, if only performance during the drag-update phase is considered, it is possible that a 7-state drag-update filter could be used. The possibility exists, however, that the misalignment and acceleration error states establish correlations in the filter covariance matrix during the drag-update phase which are important in the early portion of the approach and landing (System E) phase. This possibility is discussed further in the following section.

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*The advantage of using process noise in lieu of an error state is a reduction in the computational requirements for the filter.

### 5.3.2 System E

The overall performance of System E was evaluated in Section 5.2.1. The analysis indicated that, during the initial portion of the approach and landing, the System E filter effectively uses the drag acceleration pseudo-measurement, TACAN, the baro altimeter, and MLS to improve navigation accuracy. During the final approach and landing sequence, however, the velocity estimates become degraded to the extent that the System E filter violates the touchdown accuracy specification in all three velocity components. The degradation appears to be a function of the particular filter configuration studied, rather than an intrinsic limitation of the TACAN-MLS-radar altimeter landing system. Suggested modifications for improving the filter performance are a consequence of the analysis to follow.

Section 5.2.2 provides detailed error budgets for the System E filter at three significant time points:

- initiation of the final approach and landing sequence ($t = T_{SW}$; Table 5.2-1)
- the runway threshold ($t = T_{RA}$; Table 5.2-2)
- touchdown ( $t = T_D$; Table 5.2-3)

From the end of blackout ($t = T_{TACAN}$) until $T_{SW}$, the System E filter is a 15-state Kalman filter. Thus, the error budget at $T_{SW}$ is representative of the maximum potential navigation accuracy of a TACAN-MLS landing system at that point. After $T_{SW}$, the System E filter is a 6-state suboptimal filter and this suboptimality contributes significantly to the navigation errors. The important difference between the last two error budgets is in the vertical channel errors. The error budget at the runway threshold was made immediately prior to the first radar altimeter measurement. Comparison of the two error budgets permits an evaluation of the radar altimeter performance to be made.

The total projected navigation error at $T_{SW}$ reveals that the System E filter has already reduced the downrange and crossrange velocity errors to within the touchdown specifications. The filter also provides good vertical channel estimates, but this is not particularly important since the vertical channel errors at touchdown are expected to be dominated by the radar altimeter error sources. There are indications that, if the filter continued to operate in an "optimal" mode, the TACAN-MLS landing system could satisfy the touchdown specifications in all components except vertical velocity.

The "suboptimal" System E filter improves the position estimates during the final approach and landing sequence. At the runway threshold, both the vertical and downrange position errors satisfy the touchdown specifications, but the crossrange position error is somewhat larger than desired. The magnitude of the crossrange error is primarily due to the placement of the MLS azimuth antenna 15,000 ft downrange from the nominal touchdown point. If the antenna were 10,000 ft from the touchdown point, the crossrange position at the runway threshold would be close to the touchdown specification.

The effect of the switch to a suboptimal filter is evident in the significant growth of the velocity errors during the final approach and landing. At the runway threshold, all three velocity components violate the touchdown specifications. If the IMU-related errors are greater than the values assumed for the baseline error budget, the sensitivity analysis in Section 5.2.3 implies that the velocity errors at the runway threshold may be considerably greater than indicated in the error budget.

The touchdown error budget reveals that the downrange and crossrange position errors begin to increase once the runway threshold is crossed. This increase occurs because the measurement schedule given in Table 2.2-1 requires MLS to be switched off at the runway threshold. If MLS were used through touchdown and roll-out, this increase in downrange and crossrange position errors would not occur.

Comparison of the touchdown error budget with that at the runway threshold indicates that the radar altimeter reduces the vertical velocity error significantly, but that the error still violates the touchdown specification. It should be noted that the radar altimeter error model used to generate the error budget includes both instrument- and terrain variation-related errors. If the hardware specifications require a more accurate altimeter, and if the effect of terrain variations on the radiated signal are shown to be small, the sensitivity analysis in Section 5.2.3 can be used to estimate the vertical channel errors corresponding to the improved error model; however, it is not apparent that the radar altimeter will be accurate enough to meet the vertical velocity touchdown specification.

The major contributors to the total projected navigation errors are the same for all three error budgets -- the only exception is that the radar altimeter error sources dominate the vertical channel errors at touchdown. Otherwise, position errors are dominated by the MLS correlated error sources. Some smoothing of the MLS second-order markov errors is accomplished up to $T_{SW}$, but essentially the System E filter is "riding the MLS correlated errors," e.g., the downrange position error in all three error budgets is approximately the rms value of the MLS DME bias, scale factor, and second-order markov error magnitudes. The significant improvement in crossrange and vertical position errors as the Shuttle nears the runway is a geometric effect -- the crossrange position error due to an MLS azimuth bias is a linear function of the range to the antenna, etc.

The velocity errors in the three error budgets indicate a continuing effect of error sources other than MLS. In addition to the MLS correlated error sources and the MLS DME measurement noise, the major error contributors include gyro bias drift, gyro mass unbalance, and TACAN bias errors. An important aspect of the error budgets is that the relative importance of these error sources changes as the Shuttle nears the runway. At $T_{SW}$, the MLS-related and non-MLS-related error sources are of approximately equal importance. At the runway threshold, however, the non-MLS-related error sources are clearly dominant. As mentioned earlier, the dominant contributors to vertical velocity errors at touchdown are the radar altimeter error sources.

The sensitivity analysis undertaken in Section 5.2.4 confirmed that the velocity estimate degradation during the final approach and landing sequence is a software problem rather than a limitation of the hardware accuracy. The System E filter does not properly account for strong correlations between the navigation errors and the MLS biases. As a consequence, it makes a poor selection of the velocity components of the MLS gains. The sensitivity analysis indicates that either of the alternative filters analyzed in Section 5.2.4 would yield significantly better navigation accuracy than the System E filter. Preliminary indications are that the scaled-gain filter (Alternative 2) is the best of the three filters studied, but this observation should be verified through a detailed performance analysis.

The System E filter utilizes a total of 13 different error states -- platform misalignments (3), acceleration errors (3), and one bias state associated with each of the external navigation aids except the radar altimeter (7). The filter is not able to generate accurate estimates of any of the navaid biases; however, the filter does attempt to generate bias estimates. In addition, the filter develops correlations between the navigation errors and the bias states which appear to be extremely important in computing gains for the measurement updates. It is recommended that all of these navigation aid bias states be retained in the System E filter.

The system E filter uses the three platform misalignment states to compensate for the effects of IMU-related error sources. The vertical error state, which corresponds to azimuth misalignment, is used less than the other two components, but all three misalignment error states appear to perform an important function for the System E filter. In contrast, the three acceleration error states are not used by the filter. Correlated acceleration error sources have less effect than platform misalignments on the overall navigation system performance during entry, and consequently the System E filter is less able to observe and estimate such error sources. It appears that the three acceleration error states could be eliminated without degrading the System E performance, but this possibility should be verified through simulation.

# 6. CONCLUSIONS

## 6.1 SUMMARY OF FINDINGS

A navigation filter for the entry navigation system of the Space Shuttle Orbiter has been evaluated in detail. The baseline navigation system assumed for the study is an aided-inertial system with external data provided by a drag acceleration "pseudo-measurement," TACAN, a baro altimeter, MLS, and a radar altimeter. Prior to the final approach, the navigation filter is a variable-dimension Kalman filter with between 12 and 15 states; during the final approach it is a 6-state suboptimal filter. Comprehensive truth models representing all potentially significant error sources have been formulated and used to generate detailed error budgets and sensitivity curves. In addition, the effect of several major filter modifications upon the overall navigation system performance has been analyzed. A detailed summary of the results is contained in Section 5.3.

The major findings of the study are as follows:

- The drag acceleration pseudo-measurement is a potentially valuable navigation aid during radio blackout. It is capable of limiting the growth of navigation errors which would appear in a pure inertial system. In addition, it establishes correlations in the state estimates which are valuable for post-blackout navigation.
- The navigation filter utilizes the drag acceleration pseudo-measurement effectively, but a further improvement in performance seems possible. Filter modifications should be undertaken to decrease the pseudo-measurement gains during

the first portion of radio blackout and increase them during the last portion.

- Improvement of the onboard atmospheric density model used for the drag acceleration pseudo-measurement could result in a significant improvement in navigation accuracy at the end of radio blackout. Specifically, the model should reflect seasonal and latitudinal density variations. The filter gain structure should also be modified to reflect the model improvement.
- The TACAN-MLS-radar altimeter landing system appears capable of providing the desired navigation accuracy at touchdown in all components except vertical velocity. The ability to meet the vertical velocity specification is dependent upon the accuracy of the radar altimeter, the amount of radar altimeter data available for processing, and the effect of terrain variations on the radar altimeter signal.
- The navigation filter is not capable of meeting the touchdown specifications for velocity. Prior to the initiation of the final approach, the filter uses the external navigation aids effectively to improve navigation accuracy. During the final approach, however, the velocity estimates diverge.
- A study of alternate filter configurations during the final approach suggests that simple modifications of the navigation system can be made which would permit the touchdown accuracy specifications to be met in all position components and in both downrange and crossrange velocity.
- MLS azimuth should be used through touchdown and rollout to minimize the importance of crossrange velocity estimation errors.

A number of comments and suggestions regarding the choice of filter states and filter design parameters are given in Section 5.3. The error states associated with the various external navigation aids appear to be instrumental in permitting the filter to accommodate correlated errors in the measurements; however, some of the parameter values associated with these states should be modified. The misalignment states are used by the filter in compensating for IMU-related error sources, but the acceleration error states appear to be unnecessary. These and other suggested filter modifications must be verified through simulation.

## 6.2 RECOMMENDED FUTURE STUDIES

It is recommended that, as the design of the Space Shuttle navigation system is refined, similar detailed error budgets be generated to verify that the navigation system satisfies the mission requirements. The present study encompasses the entry phase of a Space Shuttle mission from entry interface at 400,000 ft to touchdown. Similar studies related to other Space Shuttle mission phases such as boost and rendezvous are also desirable.

The study of alternative filter configurations presented in Chapter 5 illustrates an important application of the error budget concept in filter design efforts. Given a detailed error budget for a baseline filter, the performance of alternative filters can be analyzed for a limited set of the most important error sources. Once a "good" design is approached, its performance can be verified using the full set of error states included in the truth model. This design technique can be used to increase the scope of future error budget analyses.

The System E analysis in Chapter 5 emphasized the sensitivity of vertical channel navigation errors at touchdown to radar altimetry errors -- either instrument errors or the effect of terrain variations upon the radiated signal. Accurate models for radar altimetry errors are not presently available. An effort should be made to improve these models in order to obtain more accurate navigation system performance estimates at touchdown.

# APPENDIX A

## COORDINATE FRAMES AND TRANSFORMATIONS

There are several coordinate frames whose relationship to each other had to be defined as part of the development of the Space Shuttle evaluation tools. These coordinate systems may be divided into three distinct groups:

- Systems which remain fixed in inertial space
- Systems which are fixed to and rotate with the earth
- Systems which are defined by the vehicle's position and velocity vectors.

It is the purpose of this appendix to define all of the necessary coordinate systems and their orientation with respect to each other.

The inertially fixed coordinate system group is composed of two reference frames: the I and the P frames. The I coordinate frame,* with unit vectors $\underline{1}_{x_I}$, $\underline{1}_{y_I}$, and $\underline{1}_{z_I}$ , is the system in which the navigation error analysis is performed and is also the system in which the Space Shuttle trajectory data was furnished. The $x_I$ axis is along the intersection of the ecliptic and the mean earth equatorial plane (the equinox) at the beginning of Besselian Year 1950. The $z_I$ axis is along the mean earth rotation axis of the same date.

*The I coordinate frame is referred to in Ref. 12 as the Basic Reference coordinate frame.

The second inertially fixed coordinate system is that of the nominal platform axes, the P coordinate frame. This frame has unit vectors $\underline{1}_{P_1}$, $\underline{1}_{P_2}$, and $\underline{1}_{P_3}$ (see Fig. E-2). The transformation from I to P is taken from Ref. 12.

$$T_{P/I} = \begin{bmatrix} -0.70098874 & 0.39396469 & 0.59448010 \\ 0.71294726 & 0.40805269 & 0.57026239 \\ -0.01791596 & 0.82358049 & -0.56691639 \end{bmatrix} \qquad \text{(A-1)}$$

The two earth-fixed coordinate frames are given the initials G and R. The G frame ($\underline{1}_{x_G}$, $\underline{1}_{y_G}$, $\underline{1}_z$) is an earth-centered reference system with its z axis along the true rotational axis of the earth. The $x_G$ and $y_G$ axes lie in the equatorial plane with $x_G$ passing through the Greenwich Meridian. The transformation from the I frame to the G frame is

$$T_{G/I} = \begin{bmatrix} \cos \Omega_E t & \sin \Omega_E t & 0 \\ -\sin \Omega_E t & \cos \Omega_E t & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0.9209857522 & 0.3895881588 & -0.0025121443 \\ -0.3895865546 & 0.9209891768 & 0.0011192091 \\ 0.0027496883 & -0.0000520780 & 0.9999962182 \end{bmatrix}$$

(A-2)

where $\Omega_E$ is the earth's spin rate and $t$ is elapsed time ($t = 0$ at 400,000 ft).

The R system (Up, Downrange, Crossrange) is located with respect to the landing sight and runway and is the system in which navigation aid locations and survey errors are defined. The system has axes R, D, and C. with R assumed parallel to the local vertical at the landing sight. The D axis is pointed down the runway (approximately southeast; see Fig. 2.1-2) and C is normal to R and D. The transformation from the I to the R system is

$$T_{R/I} = \begin{bmatrix} 0 & 0 & 1 \\ \sin\theta & \cos\theta & 0 \\ -\cos\theta & \sin\theta & 0 \end{bmatrix} \begin{bmatrix} -\sin\lambda_T & \cos\lambda_T & 0 \\ -\sin\varphi_T\cos\lambda_T & -\sin\varphi_T\sin\lambda_T & \cos\varphi_T \\ \cos\varphi_T\cos\lambda_T & \cos\varphi_T\sin\lambda_T & \sin\varphi_T \end{bmatrix} T_{G/I} \quad \text{(A-3)}$$

where

$\theta$ = 136.0° rotation of runway east of north

$\lambda_T$ = 239.4347° longitude of the touchdown point

$\varphi_T$ = 34.7219° latitude of the touchdown point

There are three vehicle position and velocity related coordinate systems used in the Space Shuttle evaluation programs. The first to be discussed is a locally level, L frame, with one axis pointed towards north. This system is used to relate westerly winds to the inertial system. The unit vectors which define this system may be written in terms of the vehicle's position vector ($\underline{R}$) and the North Pole vector ($\underline{1}_z$) as follows:

$$\underline{1}_u = \underline{R}/|\underline{R}| \quad \text{(A-4)}$$

$$\underline{1}_e = \underline{1}_z \times \underline{1}_u / |\underline{1}_z \times \underline{1}_u| \quad \text{(A-5)}$$

$$\underline{1}_n = \underline{1}_u \times \underline{1}_e \quad \text{(A-6)}$$

with these unit vectors defined it is easily shown that the transformation from the L system to the I system may be written as

$$T_{I/L} = \begin{bmatrix} \uparrow & \uparrow & \uparrow \\ \underline{1}_{u(I)} & \underline{1}_{e(I)} & \underline{1}_{n(I)} \\ \downarrow & \downarrow & \downarrow \end{bmatrix}^* \quad \text{(A-7)}$$

*The quantity $\underline{a}_{(I)}$ means the vector $\underline{a}$ coordinatized in the I frame.

The remaining two coordinate systems (U and V) are related to the vehicle's inertial and earth relative velocity vectors ($\underline{V}$ and $\underline{V}_R$) respectively, as well as position. The U frame is the one in which the data of Ref. 10 is defined and that data must be rotated to the I system. The V frame is used to output position and velocity errors and platform misalignments in a physically meaningful coordinate system, and to relate gravity errors and headwinds and crosswinds to the inertial system. The U system has unit vectors $\underline{1}_U$, $\underline{1}_V$, and $\underline{1}_W$ which may be evaluated using the expressions below.

$$\underline{1}_U = \underline{R}/|\underline{R}| \tag{A-8}$$

$$\underline{1}_W = \underline{R} \times \underline{V}/|\underline{R} \times \underline{V}| \tag{A-9}$$

$$\underline{1}_V = \underline{1}_W \times \underline{1}_U \tag{A-10}$$

The transformation from U to I is given by the following equation.

$$T_{I/U} = \begin{bmatrix} \uparrow & \uparrow & \uparrow \\ \underline{1}_{U(I)} & \underline{1}_{V(I)} & \underline{1}_{W(I)} \\ \downarrow & \downarrow & \downarrow \end{bmatrix} \tag{A-11}$$

The V system's unit vectors ($\underline{1}_u$, $\underline{1}_v$, $\underline{1}_w$) are defined in the same manner as the U systems except that earth relative rather than inertial velocity is used. That is:

$$\underline{1}_u = \underline{R}/|\underline{R}| \tag{A-12}$$

$$\underline{1}_w = \underline{R} \times \underline{V}_R/|\underline{R} \times \underline{V}_R| \tag{A-13}$$

$$\underline{1}_v = \underline{1}_w \times \underline{1}_u \tag{A-14}$$

in like manner $T_{I/V}$ is given by Eq. (A-15) below.

$$T_{I/V} = \begin{bmatrix} \uparrow & \uparrow & \uparrow \\ \underline{1}_{u(I)} & \underline{1}_{v(I)} & \underline{1}_{w(I)} \\ \downarrow & \downarrow & \downarrow \end{bmatrix} \tag{A-15}$$

This completes the definition of the coordinate frames used in the Space Shuttle programs. Figure A-1 shows pictorially the way in which all these systems interrelate in order to produce the desired entry and landing error budgets for the Space Shuttle mission.

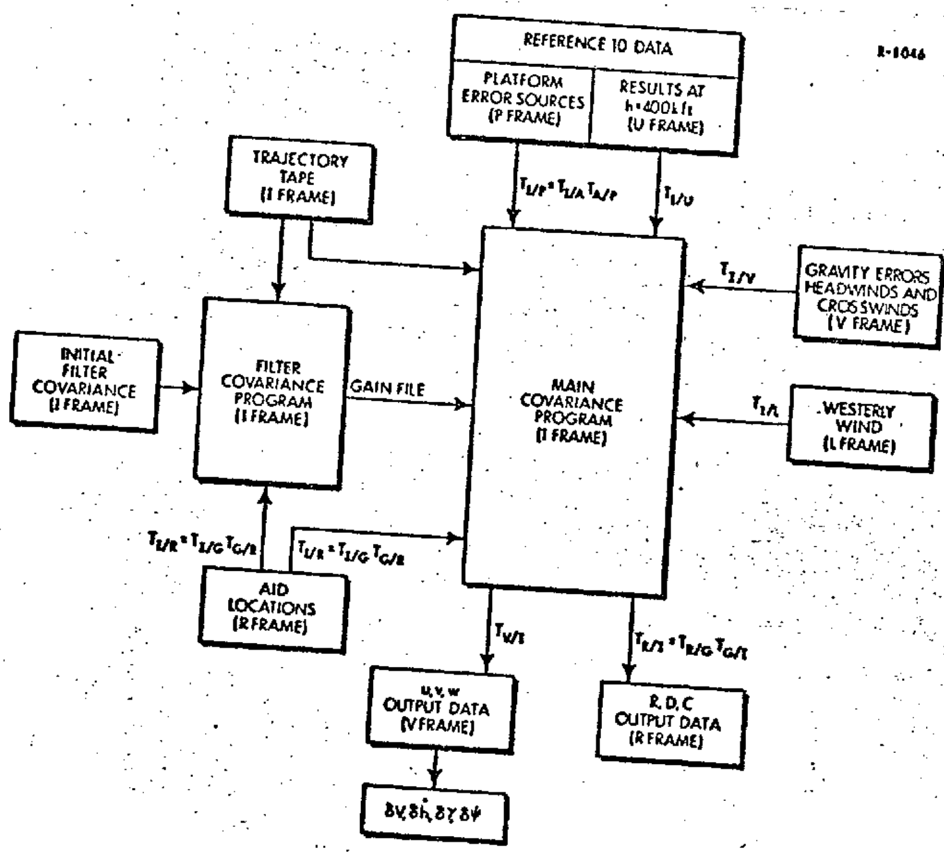


Figure A-1 Use of Transformation Matrices

# APPENDIX B

## COMPUTATION OF SPECIAL OUTPUT QUANTITIES

In addition to the output that is obtained from a typical navigation error analysis program, such as position, velocity, and platform alignment errors in the navigation coordinate system, several special quantities were requested for the Space Shuttle study. These included position, velocity, and platform alignment errors in the runway coordinate system (R) and the coordinate system (V) which is referenced to the position and earth relative velocity vector. The rms values of the error in computing altitude rate $(\delta\dot{h})$, velocity magnitude $(\delta v_R)$, flight path angle $(\delta\gamma)$, and track angle $(\delta\psi)$ were also desired. These quantities are tabulated at the end of each error analysis run for specific output times, and the tables are included in Appendix C. The equations required to calculate these errors and their statistics are derived in this appendix.

The rotation of the position, velocity, and platform alignment errors from the inertial (I) to either the R or V coordinate systems is complicated only by the fact that the major interest here is in earth relative rather than inertial velocity errors. The error analysis program determines the error in computing inertial velocity. This difference is easily adjusted for by the application of Eq. (B-1) which relates inertial to earth relative velocity errors.

$$\underline{\delta v}_R = \underline{\delta v} - \underline{\Omega}_E \times \underline{\delta r} \qquad \text{(B-1)}$$

Thus, the errors in position, earth relative velocity, and platform alignment may be related to the inertial errors using Eq. (B-2).

$$\begin{bmatrix} \delta\underline{r}_{(I)} \\ \hline \delta\underline{v}_{R_{(I)}} \\ \hline \delta\underline{\varphi}_{(P)} \end{bmatrix} = \left[\begin{array}{c|c|c} I & 0 & 0 \\ \hline \begin{matrix} 0 & \Omega_E & 0 \\ -\Omega_E & 0 & 0 \\ 0 & 0 & 0 \end{matrix} & I & 0 \\ \hline 0 & 0 & I \end{array}\right] \begin{bmatrix} \delta\underline{r}_{(I)} \\ \hline \delta\underline{v}_{R_{(I)}} \\ \hline \delta\underline{\varphi}_{(P)} \end{bmatrix} = M_E \begin{bmatrix} \delta\underline{r}_{(I)} \\ \hline \delta\underline{v}_{R_{(I)}} \\ \hline \delta\underline{\varphi}_{(P)} \end{bmatrix} \tag{B-2}$$

If the covariance matrix associated with $\delta\underline{r}_{(I)}$, $\delta\underline{v}_{R_{(I)}}$, and $\delta\underline{\varphi}_{(P)}$ is defined to be $P_I$ (the output of the navigation error analysis program), then a similar matrix $P_E$ may be evaluated using Eq. (B-3).

$$P_E = M_E P_I M_E^T \tag{B-3}$$

The coordinate rotations $T_{I/R}$, $T_{I/V}$, and $T_{I/P}$, defined in Appendix A, may now be used to obtain the desired errors and/or error statistics in the R and V coordinate frames. This is done using Eqs. (B-4) through B-7).

$$\begin{bmatrix} \delta\underline{r}_{(R)} \\ \hline \delta\underline{v}_{R_{(R)}} \\ \hline \delta\underline{\varphi}_{(R)} \end{bmatrix} = \left[\begin{array}{c|c|c} T_{R/I} & 0 & 0 \\ \hline 0 & T_{R/I} & 0 \\ \hline 0 & 0 & T_{R/I}\,T_{I/P} \end{array}\right] \begin{bmatrix} \delta\underline{r}_{(I)} \\ \hline \delta\underline{v}_{R_{(I)}} \\ \hline \delta\underline{\varphi}_{(P)} \end{bmatrix} = M_R \begin{bmatrix} \delta\underline{r}_{(I)} \\ \hline \delta\underline{v}_{R_{(I)}} \\ \hline \delta\underline{\varphi}_{(P)} \end{bmatrix} \tag{B-4}$$

$$P_R = M_R P_E M_R^T \tag{B-5}$$

$$\begin{bmatrix} \delta\underline{r}_{(V)} \\ \hline \delta\underline{v}_{R_{(V)}} \\ \hline \delta\underline{\varphi}_{(V)} \end{bmatrix} = \left[\begin{array}{c:c:c} T_{V/I} & 0 & 0 \\ \hdashline 0 & T_{V/I} & 0 \\ \hdashline 0 & 0 & T_{V/I}\,T_{I/P} \end{array}\right] \begin{bmatrix} \delta\underline{r}_{(I)} \\ \hline \delta\underline{v}_{R_{(I)}} \\ \hline \delta\underline{\varphi}_{(P)} \end{bmatrix} = M_V \begin{bmatrix} \delta\underline{r}_{(I)} \\ \hline \delta\underline{v}_{R_{(I)}} \\ \hline \delta\underline{\varphi}_{(P)} \end{bmatrix} \tag{B-6}$$

$$P_V = M_V P_E M_V^T \tag{B-7}$$

The derivation of the equations used to evaluate altitude rate, velocity magnitude, flight path angle, and track angle errors are somewhat more difficult and are derived, one at a time, below. The error in each of the four quantities is the difference between the actual value and the value which would be computed using the navigator's estimate of position and earth relative velocity.

Altitude rate $(\dot{h})$ is defined as

$$\dot{h} = \frac{\underline{R} \cdot \underline{V}_R}{|\underline{R}|} \tag{B-8}$$

and the calculated value $(\dot{h}_c)$ is evaluated using Eq. (B-9) below.

$$\dot{h}_c = \frac{\underline{R}_c \cdot \underline{V}_{R_c}}{|\underline{R}_c|} \tag{B-9}$$

However:

$$\delta\underline{r} = \underline{R} - \underline{R}_c \tag{B-10}$$

$$\delta \underline{V}_R = \underline{V}_R - \underline{V}_{R_c} \tag{B-11}$$

$$\delta h = h - h_c \tag{B-12}$$

If Eqs. (B-10) through (B-12) are inserted into Eq. (B-9), the following equation results:

$$\dot{h} - \delta\dot{h} = \frac{(\underline{R} - \delta\underline{r}) \cdot (\underline{V}_R - \delta\underline{v}_R)}{[(\underline{R} - \delta\underline{r}) \cdot (\underline{R} - \delta\underline{r})]^{\frac{1}{2}}} \tag{B-13}$$

Equation (B-12) may now be expanded and only first-order terms maintained. The result is an equation relating $\delta\dot{h}$ to $\delta\underline{r}$ and $\delta\underline{v}_R$.

$$\delta\dot{h} = \left[ \frac{\left[(\underline{R}_{(I)} \times)^{*} (\underline{V}_{R_{(I)}} \times) \underline{R}_{(I)}\right]^T}{|\underline{R}|^3} \;\vdots\; \frac{\underline{R}_{(I)}^T}{|\underline{R}|} \;\vdots\; 0 \right] \begin{bmatrix} \delta\underline{r}_{(I)} \\ \hline \delta\underline{v}_{R_{(I)}} \\ \hline \delta\underline{\varphi}_{(P)} \end{bmatrix} = M_{\dot{h}} \begin{bmatrix} \delta\underline{r}_{(I)} \\ \hline \delta\underline{v}_{R_{(I)}} \\ \hline \delta\underline{\varphi}_{(P)} \end{bmatrix} \tag{B-14}$$

The variance of $\delta h$ $(\sigma^2_{\delta h})$ may be calculated using Eq. (B-14) below, all the terms of which have been defined in other places in this appendix.

$$\sigma^2_{\delta\dot{h}} = M_{\dot{h}} P_E M_{\dot{h}}^T \tag{B-15}$$

---

* If $\underline{a}_{(I)} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix}$ then $(\underline{a}_{(I)} \times) \triangleq \begin{bmatrix} 0 & -a_3 & a_2 \\ a_3 & 0 & -a_1 \\ -a_2 & a_1 & 0 \end{bmatrix}$

The velocity magnitude error equations are derived using the same logic as that which was employed to obtain the altitude rate error equation. Equstions (B-15) and (B-16) show the definition of velocity magnitude and the means of computing it.

$$V_R = (\underline{V}_R \cdot \underline{V}_R)^{\frac{1}{2}} \tag{B-16}$$

$$V_{R_c} = \left(\underline{V}_{R_c} \cdot \underline{V}_{R_c}\right)^{\frac{1}{2}} = V_R - \delta v_R \tag{B-17}$$

With the aid of Eqs. (B-11) and (B-17) as well as the definition of Eq. (B-16) the following equation for $\delta v_R$ may be written:

$$\delta v_R = \left[\begin{array}{c|c|c} 0 & \dfrac{\underline{V}_{R(I)}}{V_R}^T & 0 \end{array}\right] \begin{bmatrix} \delta \underline{r}_{(I)} \\ \hline \delta \underline{v}_{R_{(I)}} \\ \hline \delta \underline{\varphi}_{(P)} \end{bmatrix} = M_V \begin{bmatrix} \delta \underline{r}_{(I)} \\ \hline \delta \underline{v}_{R_{(I)}} \\ \hline \delta \underline{\varphi}_{(P)} \end{bmatrix} \tag{B-18}$$

In addition, the variance of $\delta \underline{v}_R$ may be calculated using Eq. (B-19) below.

$$\sigma^2_{\delta v_R} = M_V P_E M_V^T \tag{B-19}$$

The equations which define flight path angle ($\gamma$) and track angle ($\psi$) are given below.

$$\sin \gamma = \frac{\underline{V}_R \cdot \underline{u}}{V_R} \tag{B-20}$$

$$\tan \psi = \frac{\underline{V}_R \cdot \underline{e}}{\underline{V}_R \cdot \underline{n}} \tag{B-21}$$

where the unit vector along the earth's axis, $\underline{1}_z$, is needed to define

$$\underline{u} = \frac{\underline{R}}{|\underline{R}|} \tag{B-22}$$

$$\underline{e} = \frac{\underline{1}_z \times \underline{u}}{|\underline{1}_z \times \underline{u}|} \tag{B-23}$$

$$\underline{n} = \underline{u} \times \underline{e} \tag{B-24}$$

The equations used, in an onboard computer, to compute $\gamma$ and $\psi$ are the same except that the computed values of $\underline{u}$, $\underline{e}$, and $\underline{n}$ as well as $\underline{V}_R$ are required. This leads to the interesting problem of trying to compute quantities in a coordinate frame which itself must be computed. Thus, there are two causes of error in the real time computation of $\gamma$ and $\psi$: errors in computing $\underline{V}_R$ and errors in computing $\underline{R}$, which result in errors in the computation of $\underline{u}$, $\underline{e}$, $\underline{n}$. Before expressions for $\delta\gamma$ and $\delta\psi$ are evaluated, it is required that $\delta\underline{u}$, $\delta\underline{e}$, and $\delta\underline{n}$ be evaluated. The derivation follows exactly the logic used thus far and the algebra will not be presented here. The results, however, are Eqs. (B-25) through (B-27) below.

$$\delta\underline{u}_{(I)} = \frac{1}{|\underline{R}|}\left[I - \underline{u}_{(I)}\,\underline{u}_{(I)}^T\right]\delta\underline{r}_{(I)} = M_u\,\delta\underline{r}_{(I)} \tag{B-25}$$

$$\delta\underline{e}_{(I)} = \frac{1}{|\underline{1}_z \times \underline{u}|}\left[I - \underline{e}_{(I)}\,\underline{e}_{(I)}^T\right](\underline{1}_z \times)\,\delta\underline{u}_{(I)} = M_e\,\delta\underline{r}_{(I)} \tag{B-26}$$

$$\delta\underline{v}_{(I)} = (\underline{u}_{(I)} \times)\,\delta\underline{e}_{(I)} - (\underline{e}_{(I)} \times)\,\delta\underline{u}_{(I)} = M_v\,\delta\underline{r}_{(I)} \tag{B-27}$$

With Eqs. (B-25) through (B-27) defined, it is quite straightforward to derive expressions for $\delta\gamma$ and $\delta\psi$. The equation used to compute $\gamma_c$ is:

$$\sin \gamma_c = \frac{\underline{V}_{R_c} \cdot \underline{u}_c}{V_{R_c}} \tag{B-28}$$

However, the definitions

$$\delta\gamma = \gamma - \gamma_c \tag{B-29}$$

$$\delta\underline{u} = \underline{u} - \underline{u}_c \tag{B-30}$$

along with (B-11) and (B-25) may be substituted into (B-28) to obtain the following expression for $\delta\gamma$.

$$\delta\gamma = \frac{\sec\gamma}{V_R}\left[\frac{1}{|\underline{R}|}\left[(\underline{u}_{(I)}\times)(\underline{V}_{R_{(I)}}\times)\underline{u}_{(I)}\right]^T \;\vdots\; \frac{1}{V_R^2}\left[(\underline{V}_{R_{(I)}}\times)(\underline{u}_{(I)}\times)\underline{V}_{R_{(I)}}\right]^T \;\vdots\; 0\right]\begin{bmatrix}\delta\underline{r}_{(I)}\\ \hdashline \delta\underline{v}_{R_{(I)}}\\ \hdashline \delta\underline{\varphi}_{(P)}\end{bmatrix}$$

$$= M_\gamma \begin{bmatrix}\delta\underline{r}_{(I)}\\ \hdashline \delta\underline{v}_{R_{(I)}}\\ \hdashline \delta\underline{\varphi}_{(P)}\end{bmatrix} \tag{B-31}$$

The variance for $\delta\gamma$ is also easily shown to be:

$$\sigma_{\delta\gamma}^2 = M_\gamma P_E M_\gamma^T \tag{B-32}$$

Finally, the expression for $\delta\psi$ and $\sigma_{\delta\psi}^2$ may be shown, with some effort, to be given by Eqs. (B-33) and (B-34).

$$\delta\underline{\phi}_{(I)} = \frac{1}{\left[(\underline{V}\cdot\underline{n})^2 + (\underline{V}\cdot\underline{e})^2\right]} \left[ (\underline{V}_R \cdot \underline{n})(\underline{V}_{R_{(I)}}{}^T M_e) - (\underline{V}_R \cdot \underline{e})(\underline{V}_{R_{(I)}}{}^T M_n) \;\vdots\; \left[(\underline{V}_{R_{(I)}} \times)\underline{u}_{(I)}\right]^T \;\vdots\; 0 \right] \begin{bmatrix} \delta\underline{r}_{(I)} \\ \hdashline \delta\underline{v}_{R_{(I)}} \\ \hdashline \delta\underline{\phi}_{(P)} \end{bmatrix}$$

$$= M_\psi \begin{bmatrix} \delta\underline{r}_{(I)} \\ \hdashline \delta\underline{v}_{R_{(I)}} \\ \hdashline \delta\underline{\phi}_{(P)} \end{bmatrix} \tag{B-33}$$

$$\sigma_{\delta\psi}^2 = M_\psi \, P_E \, M_\psi{}^T \tag{B-34}$$

This completes the development of the equations used to evaluate the special output quantities for the Space Shuttle landing system evaluation.

# APPENDIX C

## TRUTH MODEL MEASUREMENT MATRIX FOR DRAG ACCELERATION PSEUDO-MEASUREMENT

The drag update filter used in the Space Shuttle entry navigation system during blackout employs an atmospheric drag pseudo-measurement in order to improve the on-board estimate of position and velocity. The Kalman filter used in the computer navigation program requires the definition of a measurement matrix $H_F$ for the pseudo-measurement. If the performance of the drag update filter is to be evaluated using a "truth model", the measurement matrix $H_S$ for the truth model must also be defined. The measurement matrix associated with a truth model similar to that defined in Appendix E is derived in this appendix.

The atmospheric drag pseudo-measurement is defined to be a drag acceleration measurement constructed from the IMU accelerometer outputs. The measured drag acceleration $q_{meas}(t)$ is related to the state vector of the truth model by the matrix of first partial derivatives $H_{meas}$. The expected drag acceleration $q_{pred}(t)$ is computed from a nominal atmospheric density model, estimates of the shuttle's aerodynamic coefficients, and the current estimate of position and velocity. $q_{pred}(t)$ is related to the state estimate vector generated by the truth model by the matrix of first partial derivatives $H_{pred}$. It is shown in this appendix that $H_S$ can be defined in terms of $H_{meas}$ and $H_{pred}$.

The drag acceleration pseudo-measurement extracted from the accelerometer outputs is

$$q_{meas}(t) = |\underline{i}_{VR_c}(t) \cdot \Delta\underline{\dot{V}}(t)|/\Delta t = |\underline{i}_{VR_c}(t) \cdot \underline{f}_c(t)| \qquad \text{(C-1)}$$

where $\underline{i}_{VR_c}(t)$ is a unit vector in the direction of the computed relative velocity and $\underline{f}_c(t)$ is the measured specific force. The expected drag acceleration is

$$q_{pred}(t) = \frac{1}{2} C_{D_c}(t) \frac{A}{m} \rho_c(t) V_{R_c}^2(t) \qquad \text{(C-2)}$$

where $C_{D_c}(t)$ is the computed drag coefficient for the Space Shuttle, A is its cross-sectional area, and m is its mass. $\rho_c(t)$ and $\dot{V}_{R_c}(t)$ are the computed atmospheric density and relative velocity, respectively. The difference between $q_{meas}(t)$ and $q_{pred}(t)$ is the residual

$$\delta z_S(t) = q_{meas}(t) - q_{pred}(t) \qquad \text{(C-3)}$$

which appears in the update equation for the truth model error state vector

$$\delta\hat{\underline{x}}_S(t^+) = \delta\hat{\underline{x}}_S(t^-) - K_S(t)\,\delta z_S(t) \qquad \text{(C-4)}$$

where $\delta\hat{\underline{x}}_S(t^-)$ is the estimation error prior to the update and $\delta\hat{\underline{x}}_S(t^+)$ is the estimation error after the update.

A linear covariance analysis requires that $q_S(t)$ be expressed as a linear function of $\delta\hat{\underline{x}}_S(t^-)$. The drag accelerations $q_{meas}(t)$ and $q_{pred}(t)$ in Eq. (C-3) can first be referenced to the true drag acceleration $q(t)$

$$q_{meas}(t) = q(t) - \delta q_{meas}(t)$$

$$q_{pred}(t) = q(t) - \delta q_{pred}(t) \qquad \text{(C-5)}$$

where q(t) is the solution to either Eq. (C-1) or Eq. (C-2) in the special case of perfect measurements, perfect state estimates, and precise atmospheric and drag coefficient models. The perturbations $\delta q_{meas}(t)$ and $\delta q_{pred}(t)$ are then related to $\delta \hat{\underline{x}}_S(t^-)$ by the first partial derivative matrices $H_{meas}(t)$ and $H_{pred}(t)$, respectively

$$\delta q_{meas}(t) = H_{meas}(t)\, \delta \hat{\underline{x}}_S(t^-) + \eta_{meas}(t)$$

$$\delta q_{pred}(t) = H_{pred}(t)\, \delta \hat{\underline{x}}_S(t^-) + \eta_{pred}(t) \qquad \text{(C-6)}$$

where $\eta_{meas}(t)$ and $\eta_{pred}(t)$ are zero mean white Gaussian sequences with variances

$$E[\eta_{meas}(t)\, \eta_{meas}(t)^T] = R_{S_{meas}}$$

$$E[\eta_{pred}(t)\, \eta_{pred}(t)^T] = R_{S_{pred}} \qquad \text{(C-7)}$$

These Gaussian sequences are used to model accelerometer quantization errors, uncorrelated errors in the estimates of atmospheric density and the drag coefficient, etc.

The measurement matrix $H_S(t)$ for the truth model can be defined by

$$H_S(t) = H_{pred}(t) - H_{meas}(t) \qquad \text{(C-8)}$$

With the composite zero mean white Gaussian sequence $\eta_S(t)$ defined

$$\eta_S(t) \triangleq \eta_{meas}(t) - \eta_{pred}(t)$$

$$E[\eta_S(t)\eta_S(t)^T] \triangleq R_S \qquad \text{(C-9)}$$

the residual $\delta z_S$ in (C-3) then becomes

$$\delta z_S(t) = \delta q_{pred}(t) - \delta q_{meas}(t)$$

$$\approx H_S(t)\,\delta\hat{\underline{x}}_S(t^-) + \eta_S(t) \qquad \text{(C-10)}$$

The update in Eq. (C-4) can then be expressed in the desired form

$$\delta\hat{\underline{x}}_S(t^+) = \delta\hat{\underline{x}}_S(t^-) - K_S(t)\,H_S(t)\,\delta\hat{\underline{x}}_S(t^-) - K_S(t)\,\eta_S(t) \qquad \text{(C-11)}$$

This formulation of the update equation requires an explicit computation of $H_S(t)$ from Eq. (C-8).

The perturbation $\delta q_{meas}(t)$ in the measured drag acceleration can be determined by considering small perturbations about the nominal values in Eq. (C-1). These perturbations are depicted graphically in Fig. C-1. $\underline{f}(t)$ is the resultant of the lift and drag accelerations on the Space Shuttle

$$\underline{L}(t) = \underline{i}_{VR}(t) \times \left(\underline{f}(t) \times \underline{i}_{VR}(t)\right)$$

$$\underline{q}(t) = -\left(\underline{i}_{VR}(t) \cdot \underline{f}(t)\right)\underline{i}_{VR}(t) \qquad \text{(C-12)}$$

Clearly $\underline{i}_{VR}(t) \cdot \underline{f}(t)$ must always be negative. Hence, the absolute value in Eq. (C-1) can be ignored in defining the perturbation

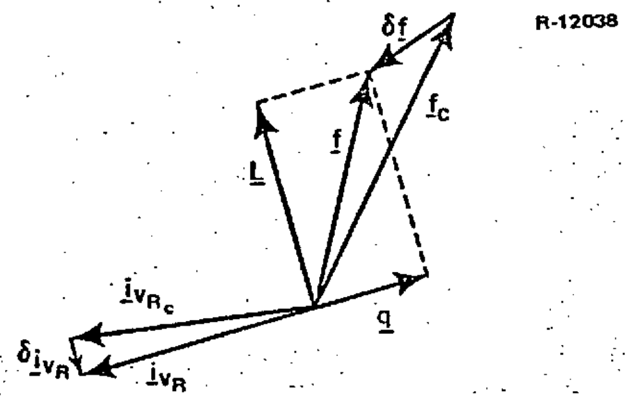


Figure C-1 Definition of Perturbations in Unit Relative Velocity Vector and Specific Force Vector

$$\delta q_{meas}(t) = \delta \underline{i}_{VR}(t) \cdot \underline{f}(t) + \underline{i}_{VR}(t) \cdot \delta \underline{f}(t) \tag{C-13}$$

where

$$\delta \underline{i}_{VR}(t) = \underline{i}_{VR}(t) - \underline{i}_{VR_c}(t)$$

$$\delta \underline{f}(t) = \underline{f}(t) - \underline{f}_c(t) \tag{C-14}$$

The error $\delta \underline{f}(t)$ in measured acceleration can be attributed to the standard IMU acceleration error sources defined in the drag-update phase truth model (Table 3.1-1)

- platform misalignments (Group 1a)
- accelerometer errors (Groups 2 through 5)
- quantization errors (Group 1)

Since the drag acceleration pseudo-measurement is formed directly from the accelerometer output, $\delta \underline{f}(t)$ in Fig. C-1 is the same acceleration error which drives the velocity components of $\delta \hat{\underline{x}}_S(t)$ in the truth model (see Appendix E). The perturbation $\delta \underline{i}_{VR}(t)$ is defined in Fig. C-1 to be perpendicular to $\underline{i}_{VR}(t)$. Thus the principal effect of using the computed normalized relative velocity vector $\underline{i}_{VR_c}(t)$ in the drag acceleration pseudo-measurement is that a fraction of the Space Shuttle lift acceleration is resolved into the pseudo-measurement.

The relative velocity of the Space Shuttle with respect to the atmosphere is

$$\underline{V}_R(t) = \underline{V}(t) - \underline{\Omega}_E \times \underline{R}(t) - \underline{V}_W(t) \tag{C-15}$$

where $\underline{\Omega}_E$ is earth rate and $\underline{V}_W(t)$ is the atmospheric wind. The unit vector $\underline{i}_{VR}(t)$ is then

$$\underline{i}_{VR}(t) = \frac{\underline{V}(t) - \underline{\Omega}_E \times \underline{R}(t) - \underline{V}_W(t)}{|\underline{V}(t) - \underline{\Omega}_E \times \underline{R}(t) - \underline{V}_W(t)|} \tag{C-16}$$

The computed relative velocity is a function of computed inertial position and velocity only

$$\underline{V}_{R_c}(t) = \underline{V}_c(t) - \underline{\Omega}_E \times \underline{R}_c(t) \tag{C-17}$$

and the unit vector is

$$\underline{i}_{VR_c}(t) = \frac{\underline{V}_c(t) - \underline{\Omega}_E \times \underline{R}_c(t)}{|\underline{V}_c(t) - \underline{\Omega}_E \times \underline{R}_c(t)|} \tag{C-18}$$

$\underline{R}_c(t)$ and $\underline{V}_c(t)$ are related to the position and velocity components of $\delta\hat{\underline{x}}_S(t)$ by

$$\delta\underline{v}(t) = \underline{V}(t) - \underline{V}_c(t)$$

$$\delta\underline{r}(t) = \underline{R}(t) - \underline{R}_c(t) \tag{C-19}$$

The relationship of $\underline{i}_{VR_c}(t)$ to $\underline{i}_{VR}(t)$ can be determined by substituting Eq. (C-19) into Eq. (C-16):

$$\underline{i}_{VR}(t) = \frac{\underline{V}_c(t) + \delta\underline{v}(t) - \underline{\Omega}_E \times (\underline{R}(t) + \delta\underline{r}(t)) - \underline{V}_W(t)}{|\underline{V}_c(t) + \delta\underline{v}(t) - \underline{\Omega}_E \times (\underline{R}(t) + \delta\underline{r}(t)) - \underline{V}_W(t)|} \tag{C-20}$$

With the definition

$$\delta\underline{v}_R(t) = \delta\underline{v}(t) - \underline{\Omega}_E \times \delta\underline{r}(t) - \underline{V}_W(t) \tag{C-21}$$

it can be shown that a first-order expansion of Eq. (C-20) yields

$$\underline{i}_{VR}(t) \approx \underline{i}_{VR_c}(t) + \frac{\delta\underline{v}_R(t)}{|\underline{V}_c(t) - \underline{\Omega}_E \times \underline{R}_c(t)|} - \underline{i}_{VR_c}(t)\left(\frac{\underline{i}_{VR_c}(t)\cdot\delta\underline{v}_R(t)}{|\underline{V}_c(t) - \underline{\Omega}_E \times \underline{R}_c(t)|}\right) \tag{C-22}$$

With Eq. (C-14), the above can be solved for $\delta\underline{i}_{VR}$

$$\delta\underline{i}_{VR} \approx \frac{\delta\underline{v}_R(t)}{|\underline{V}_c(t) - \underline{\Omega}_E \times \underline{R}_c(t)|} - \underline{i}_{VR_c}(t)\left(\frac{\underline{i}_{VR_c}(t)\cdot\delta\underline{v}_R(t)}{|\underline{V}_c(t) - \underline{\Omega}_E \times \underline{R}_c(t)|}\right) \tag{C-23}$$

The second term in Eq. (C-23) is minus the component of the first term along $\underline{i}_{VR_c}(t)$. It follows that $\delta\underline{i}_{VR}(t)$ has no component along $\underline{i}_{VR_c}(t)$ and therefore is perpendicular to $\underline{i}_{VR_c}(t)$. By the small angle approximation implied by the first-order expansion, $\delta\underline{i}_{VR}(t)$ is also approximately perpendicular to $\underline{i}_{VR}(t)$ as was noted in Fig. C-1.

Equation (C-23) and the standard IMU acceleration error sources defined in Table 3.1-1 permit $H_{meas}(t)$ in Eq. (C-6) to be written. The partitions indicated below correspond to similar partitions of the error state vector $\delta\hat{\underline{x}}_S(t)$ in Appendix E. To simplify the notation, it is assumed in Eq. (C-24) that the non-standard wind components have been transformed to inertial coordinates.

$$H_{meas}(t) = \Big[ \underbrace{-\underline{F}_L(\underline{\Omega}_E \times)}_{\text{position errors}} \;\Big|_{3}\; \underbrace{\underline{F}_L}_{\text{velocity errors}} \;\Big|_{6}\; 0 \;\Big|_{13}\; \underbrace{\underline{i}_{VR}^T T_{I/P} F_P}_{\text{true platform misalignments}} \;\Big|_{16}\; \underbrace{\underline{i}_{VR}^T T_{I/P}}_{\text{accelerometer biases}} \;\Big|_{19}$$

$$\Big|\; \underbrace{\underline{i}_{VR}^T T_{I/P} F_3}_{\text{accelerometer scale factor errors}} \;\Big|_{22}\; \underbrace{\underline{i}_{VR}^T T_{I/P} F_4}_{\text{accelerometer misalignments}} \;\Big|_{28}\; \underbrace{\underline{i}_{VR}^T T_{I/P} F_5}_{\text{accelerometer nonlinearities}} \;\Big|_{31}\; 0 \;\Big|_{49}\; \underbrace{-\underline{F}_L \;\; 0}_{\text{winds}} \;\Big|_{58}\; 0 \Big]_{59} \quad \text{(C-24)}$$

where

$$\underline{F}_L(t) = \frac{\underline{f}^T(t)}{|\underline{V}_c(t) - \underline{\Omega}_E \times \underline{R}_c(t)|} - \frac{\underline{f}^T \underline{i}_{VR_c}(t)\, \underline{i}_{VR_c}(t)^T}{|\underline{V}_c(t) - \underline{\Omega}_E \times \underline{R}_C(t)|} \quad \text{(C-25)}$$

$$\underline{\Omega}_E = \begin{bmatrix} 0 \\ 0 \\ \Omega_E \end{bmatrix} \quad \text{(C-26)}$$

$T_{I/P}$ = transformation matrix from platform to inertial reference coordinates

$$F_p = \begin{bmatrix} 0 & -f_3 & f_2 \\ f_3 & 0 & -f_1 \\ -f_2 & f_1 & 0 \end{bmatrix} \quad \text{(C-27)}$$

$$F_3 = \begin{bmatrix} f_1 & 0 & 0 \\ 0 & f_2 & 0 \\ 0 & 0 & f_3 \end{bmatrix} \quad \text{(C-28)}$$

$$F_4 = \begin{bmatrix} f_2 & f_3 & 0 & 0 & 0 & 0 \\ 0 & 0 & f_1 & f_3 & 0 & 0 \\ 0 & 0 & 0 & 0 & f_1 & f_2 \end{bmatrix} \quad \text{(C-29)}$$

$$F_5 = \begin{bmatrix} f_1^2 & 0 & 0 \\ 0 & f_2^2 & 0 \\ 0 & 0 & f_3^3 \end{bmatrix} \quad \text{(C-30)}$$

---

The elements of $F_p$, $F_3$, $F_4$, and $F_5$ are the components of the specific force $\underline{f}(t)$ coordinatized in platform coordinates.

The computation of $H_S(t)$ requires that both $H_{meas}(t)$ and $H_{pred}(t)$ be determined; therefore it is necessary to determine

$\delta q_{pred}(t)$ by considering small perturbations about the nominal values in Eq. (C-2)*

$$\delta q_{pred}(t) = \frac{1}{2}\,\delta C_D(t)\,\frac{A}{m}\,\rho(t)\,V_R^2(t) + \frac{1}{2}\,C_D(t)\,\frac{A}{m}\,\delta\rho(t)V_R^2(t) + C_D(t)\frac{A}{m}\,\rho(t)\,\underline{V}_R(t)\cdot\delta\underline{v}_R(t) \qquad \text{(C-31)}$$

where

$$\begin{aligned}
\delta\rho(t) &= \rho(t) - \rho_c(t) \\
\delta C_D(t) &= C_D(t) - C_{D_c}(t) \\
\delta\underline{v}_R(t) &= \underline{V}_R(t) - \underline{V}_{R_c}(t) \\
&= \delta\underline{v}(t) - \underline{\Omega}_E \times \delta\underline{r}(t) - \underline{V}_W(t)
\end{aligned} \qquad \text{(C-32)}$$

The expression for $\delta q_{pred}(t)$ can be simplified by writing it in terms of the true drag q(t)

$$\delta q_{pred}(t) = q(t)\left\{\frac{\delta C_D(t)}{C_D(t)} + \frac{\delta\rho(t)}{\rho(t)} + \frac{2\,\underline{1}_{VR}(t)\cdot\delta\underline{v}_R(t)}{V_R(t)}\right\} \qquad \text{(C-33)}$$

Relating $\delta\rho(t)$ and $\delta C_D(t)$ to $\delta\hat{\underline{x}}_S(t^-)$ requires that both the computational models for the atmospheric density and drag coefficient be known and also that their true values be known.

Assume that the atmospheric density model from which $\rho_c(t)$ is computed is a simple exponential function of computed altitude $h_c(t)$

---

* The perturbation $\delta C_D(t)$ is assumed to include perturbations in A and M. A more precise notation would be $\delta\left(C_D(t)\,\frac{A}{M}\right)$.

$$\rho_c(h_c) = \rho_o e^{-\frac{h_c(t)}{h_{sc}}} \tag{C-35}$$

and that the true atmospheric density satisfies

$$\rho(R) = \rho_o e^{-\frac{h(t)}{h_{sc}}} + \rho_f(R) \tag{C-36}$$

where h(t) is true altitude. In the above $\rho_o$ and $h_{sc}$ are constants and $\rho_f(R)$ is the difference between the true atmospheric density and the atmospheric density predicted by the model. A first-order expansion for $\delta\rho(t)$ similar to that used for $\delta \underline{i}_{VR}(t)$ yields

$$\delta\rho(R) \approx -\rho_c(t) \frac{\underline{i}_R(t) \cdot \delta\underline{r}(t)}{h_{sc}} + \rho_f(R) \tag{C-37}$$

where $\underline{i}_R(t)$ is the unit vector along $\underline{R}(t)$.

One possible choice of the computational model of the drag coefficient is a quadratic function of the computed angle of attack $\alpha_c(t)$

$$C_{D_c}(\alpha_c) = C_0 + C_1 \alpha_c + C_2 \alpha_c^2 \tag{C-38}$$

where $C_0$, $C_1$, and $C_2$ are constants. The true drag coefficient can then be referenced to the model

$$C_D(\alpha, M) = C_{D_c}(\alpha_c) + C_{D_f}(\alpha, M, t) \tag{C-39}$$

where $\alpha(t)$ is the true angle of attack and M(t) is the Mach number. If the error in $\alpha_c(t)$ is a negligible contributor to the error in $C_{D_c}(\alpha_c)$, then a first-order expansion of $\delta C_D(t)$ is

$$\delta C_D(t) = C_{D_f}(\alpha, M, t) \tag{C-40}$$

If this assumption is not true, $\delta C_D(t)$ must be derived based upon the computational algorithm for $\alpha_c(t)$ and Eqs. (C-38) and (C-39).

Equations (C-32) through (C-40) permit $H_{pred}(t)$ to be written. The partitions indicated below correspond to similiar partitions of the error state vector $\delta\hat{\underline{x}}_S(t^-)$ coordinatized in an inertial reference coordinate system. Two of the non-zero partitions below (for density and drag coefficient errors) correspond to partitions of $H_{meas}$ in Eq. (C-34) which were zero. $H_{pred}(t)$ as given in (C-41) assumes that the drag correlated error (Group 1), non-standard density errors (Group 21), and non-standard aerodynamics errors (Group 23) are defined as percent deviations from their nominal values. It is also assumed that the non-standard wind components have been transformed into inertial coordinates.

$$H_{pred}(t) = q(t)\Big[\underbrace{-\frac{\underline{1}_R^T}{h_{sc}} - \frac{2\underline{1}_{VR}^T(\Omega_E\times)}{V_R(t)}}_{\text{position errors}} \;\Big|\; \underbrace{\frac{2\underline{1}_{VR}^T}{V_R(t)}}_{\text{velocity errors}} \;\Big|\; 0 \;\Big|\; \underbrace{1}_{\text{drag correlated error}} \;\Big|\; 0 \;\Big|\; \underbrace{1 \quad 1 \quad 1}_{\text{non-standard density error model}} \;\Big|\; \underbrace{-\frac{2\underline{1}_{VR}^T}{V_R(t)} \quad 0}_{\text{non-standard wind}} \;\Big|\; \underbrace{1}_{\text{non-standard aerodynamics errors}}\Big]$$

(partition end columns: 3, 6, 12, 13, 46, 49, 58, 59)

(C-41)

This completes the derivation of the truth model measurement matrix $H_S(t)$, which is obtained by substituting Eqs. (C-24) and (C-41) into

$$H_S(t) = H_{pred}(t) - H_{meas}(t) \tag{C-42}$$

This definition of $H_S(t)$ properly relates the error in the drag acceleration pseudo-measurement to the error sources included in the truth model. If additional error sources not considered in this appendix are included in the truth model, and if these error sources affect the pseudo-measurement, the corresponding additional non-zero partitions of $H_S(t)$ can be computed using the approach presented above.

# APPENDIX D

## NON-STANDARD ATMOSPHERE MODEL FOR SHUTTLE ENTRY NAVIGATION

The drag update filter used in the Space Shuttle entry navigation system during blackout requires an atmospheric density model in order to compare accelerometer outputs with predicted drag acceleration. This comparison is used to improve the onboard estimate of position and velocity. The accuracy of the drag-update filter is degraded by both atmospheric winds and the difference between the true atmospheric density at a given altitude and the density predicted by the atmospheric density model. These error sources are referred to as non-standard atmosphere errors – by definition, the standard atmosphere is the nominal atmosphere model used in the drag-update filter. In order to statistically evaluate the performance of the drag-update filter, a reasonable statistical description of the atmosphere in the 100,000 ft to 270,000 ft altitude range is required. The non-standard atmosphere model developed in this appendix is consistent with the limited amount of data available in the open literature.

### D.1 NON-STANDARD DENSITY MODEL

The atmospheric density model used in the drag update filter mechanization is some function of altitude $\rho_c(h_c)$. As an example, it may be a simple exponential model

$$\rho_c(h_c) = \rho_o e^{\frac{h_c(t)}{h_{sc}}} \qquad \text{(D-1)}$$

where $h_c(t)$ is computed altitude. If the true atmospheric density $\rho(R)$ is a function of latitude and longitude as well as altitude, then the difference

$$\delta\rho(R) = \rho(R) - \rho_c(h_c) \qquad \text{(D-2)}$$

is the non-standard atmospheric density error. The non-standard atmospheric density model developed in this appendix is comprised of three components

$$\rho(R) = \rho_{62}(R) + \rho_B(R) + \rho_M(R) \qquad \text{(D-3)}$$

where $\rho_{62}(R)$ is a standard reference model, $\rho_B(R)$ is a position-dependent bias, and $\rho_M(R)$ is a first-order markov process. The three components of $\rho(R)$ in Eq. (D-3) are defined such that the statistical properties of $\delta\rho(R)$ are similar to those that can be expected from an actual flight test.

The most commonly used reference for atmospheric density models is the 1962 Standard Atmosphere (Ref. 36). The model consists of a single density versus altitude table with data points at 500 ft intervals. The component $\rho_{62}(R)$ in Eq. (D-3) is defined to be a linear interpolation of the 1962 Standard Atmosphere.

The true atmosphere density may differ from $\rho_{62}(R)$ for a variety of reasons. The most significant density variations in the altitude range of interest are:

- Long-term deviations due to season changes

- Diurnal deviations due to thermal heating and tidal interactions, and
- Short term deviations due to weather patterns.

Each of these effects has a correlation time considerably longer than the entry flight time of the Space Shuttle; therefore, the principal time-dependent deviations from $\rho_{62}(R)$ during reentry are a function of the spatial distributions of the density deviations. The long-term deviations at different altitudes and latitudes have a strong spatial correlation and can be modeled by the position-dependent bias $\rho_B(R)$. Diurnal and short term density deviations do not exhibit strong spatial correlations and are best modeled in Eq. (D-3) by the markov process $\rho_M(R)$.

Models of the long-term density deviations are contained in U.S. Standard Atmosphere Supplements, 1966 (Ref. 37). This reference defines separate density versus altitude profiles for each season at several different latitudes. As a rule, the most significant differences from the 1962 Standard Atmosphere are in the winter and summer profiles. From experimental data, Cole (Ref. 29) has determined probability distributions for percent departure from the 1962 Standard Atmosphere as a function of latitude for both the December-January and the June-July time periods. The median departures determined by Cole are presented in Fig. D-1. The data in Fig. D-1 corresponds well with the supplementary atmospheres of Ref. 37.

During entry, the Space Shuttle will not pass through blackout at a constant latitude except for near-equatorial orbits. In modeling the effect of long-term density deviations on the drag-update filter performance, therefore, it is necessary to consider the particular altitude-latitude profile being flown. This can be done by scribing that profile onto Fig. D-1. This procedure is illustrated by the dashed lines in

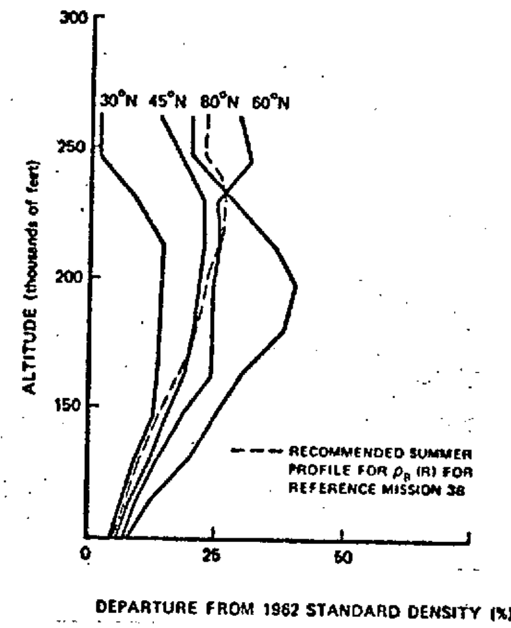


Figure D-1a Median Densities Given as Percent Departure from U.S. Standard Atmosphere, 1962 During June-July at 80°N, 60°N, 45°N, and 30°N

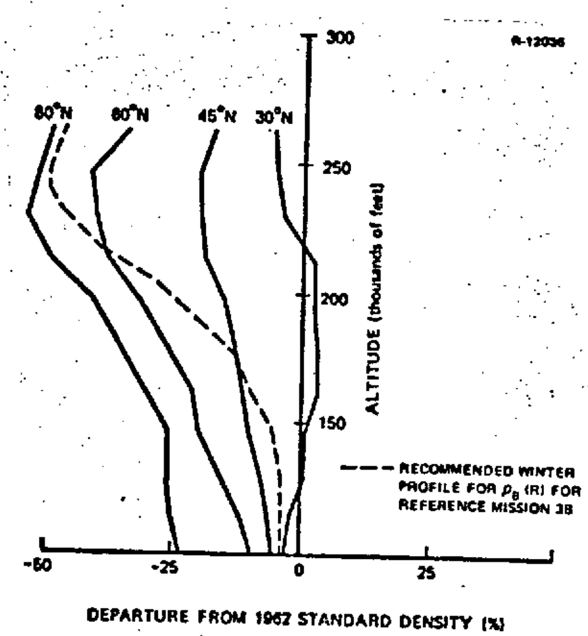


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Figure D-1b Median Densities Given as Percent Departure from U.S. Standard Atmosphere, 1962 During December-January at 80°N, 60°N, 45°N, and 30°N

Fig. D-1 for the reference mission 3B entry from a 104° inclination orbit with a landing at Vandenberg AFB. This trajectory crosses 269,000 ft at 74°N and ends blackout at 130,000 ft and 37.3°N. For the indicated seasons, the two dashed lines in Fig. D-1 provide a reasonable model of the long-term density deviations to be encountered on the reference trajectory.

The position-dependent bias $\rho_B(R)$ is defined to be one of two altitude-density profiles – a summer profile corresponding to the dashed line in Fig. D-1a and a winter profile corresponding to the dashed line in Fig. D-1b.* This choice of $\rho_B(R)$ is conservative in that the long-term density deviation expected along this trajectory for a spring or fall mission would be smaller than $\rho_B(R)$. The model is preferable to treatment of the long-term density deviation as a Gaussian random bias, however, because for four to six months of every year, the long-term density deviations can be expected to have the amplitudes shown. Guassian statistics are not satisfactory for describing phenomena in which large positive or negative values are more likely (or nearly as likely) as small values.

Data on the cumulative magnitude of the diurnal and short-term density deviations from $\rho_{62}(R)$ is available from two sources – the distribution functions computed by Cole (Ref. 29) and spatial correlation functions computed by Justus and Woodrum (Ref. 33 and 34). In addition, Cole (Ref. 30) and Daniels (Ref. 32) provide estimates of spatial correlation distances. Although there is a latitude dependence cited in the literature, it is not of major importance and can be ignored. Table D-1 summarizes the relevant information.

*For a different reference trajectory, $\rho_B(R)$ should be defined for the appropriate altitude-latitude profile.

TABLE D-1

CORRELATION FUNCTION COEFFICIENTS FOR SUM OF DIURNAL AND SHORT-TERM DENSITY DEVIATIONS FROM LONG-TERM (SEASONAL) AVERAGE

| Source | Justus and Woodrum | | Cole | | | Daniels |
|---|---|---|---|---|---|---|
| Altitude | 115,000-210,000 ft | 210,000-280,000 ft | 113,000 ft | 210,000 ft | 230,000 ft | all altitudes |
| Standard deviation (% of average density) | 2% | 8% | 2.75% | 6% | 6% | — |
| Vertical displacement correlation distance | 11 nm | 11 nm | 14 nm | 14 nm | 14 nm | — |
| Horizontal displacement correlation distance | 54 nm | 54 nm | 270nm* | 270nm* | 270nm* | 270nm* |

*Data was inferred from statements that density deviations for horizontal displacements greater than 600 nm are uncorrelated.

The entries in Table D-1 are reasonably consistent except for the horizontal displacement correlation distances. Little information on this parameter is available and the different authors admit to uncertainty in their estimates. The estimates attributed to Daniels and to Cole are made from macro-scale observations and are consistent with wind horizontal correlation distances computed by Buell (Ref. 28). The recommended design parameters for $\rho_M(R)$ are summarized in Table D-2.

With the standard deviation $\sigma_M$, and the correlation distances $\tau_Z$ and $\tau_X$ determined from Table D-2, definition of $\rho_M(R)$ requires that the form of its correlation function be established. If the change in $\rho_M(R)$ resulting from an altitude displacement $\Delta Z'$ is independent of the change from a horizontal displacement $\Delta X$, the correct choice for the correlation function is

TABLE D-2

RECOMMENDED CORRELATION FUNCTION COEFFICIENTS FOR THE FIRST-ORDER MARKOV PROCESS $\rho_M(R)$ IN THE NON-STANDARD ATMOSPHERE MODEL

| Altitude | 130,000 ft | 210,000 ft | 230,000 ft | 280,000 ft |
|---|---|---|---|---|
| Standard deviation, $\sigma_M$ (% of standard reference plus bias) | 2% | 6% | 6% | 8% |
| Vertical displacement correlation distance, $\tau_h$ | 14 nm | 14 nm | 14 nm | 14 nm |
| Horizontal displacement correlation distance, $\tau_X$ | 270 nm | 270 nm | 270 nm | 270 nm |

$$C_M(\Delta h, \Delta X) = E\left[\frac{\rho_M(R)}{\rho_{62}(R) + \rho_B(R)} \cdot \frac{\rho_M(R + \Delta h + \Delta X)}{\rho_{62}(R + \Delta h + \Delta X) + \rho_B(R + \Delta h + \Delta X)}\right]$$

$$= \sigma_M^2(R)\, e^{-\left(\frac{\Delta h^2}{\tau_Z^2} + \frac{\Delta X^2}{\tau_X^2}\right)^{\frac{1}{2}}} \qquad \text{(D-4)}$$

Since only density variations along the shuttle flight path are of concern, $\Delta X$ and $\Delta h$ are related by

$$\Delta h = \Delta R \sin \gamma$$

$$\Delta X = \Delta R \cos \gamma \qquad \text{(D-5)}$$

where $\gamma$ is the flight path angle and $\Delta R$ is the net position displacement. The exponent in (D-4) can therefore be simplified

$$\left(\frac{\Delta h^2}{\tau_h^2} + \frac{\Delta X^2}{\tau_X^2}\right)^{\frac{1}{2}} = \Delta R\left(\frac{\sin^2\gamma}{\tau_h^2} + \frac{\cos^2\gamma}{\tau_X^2}\right)^{\frac{1}{2}} \triangleq \frac{\Delta R}{\tau_R} \qquad \text{(D-6)}$$

With $\tau_R$ as defined in Eq. (D-6), the two-dimensional correlation function $C_M(\Delta h, \Delta X)$ can then be replaced by the one-dimensional correlation function

$$C_M(\Delta R) = \sigma_M^2(R)\, e^{-\frac{\Delta R}{\tau_R}} \qquad \text{(D-7)}$$

Eq. (D-7) implies that $\rho_M(R)$ satisfies the first-order differential equation

$$\dot{\rho}_M(R) = -\frac{1}{\tau_R}\rho_M(R) + \eta_M(R) \qquad \text{(D-8)}$$

where $\eta_M(R)$ is a zero mean white Gaussian noise with a variance of

$$E[\eta_M(R)^2] = \frac{2\sigma_M^2(R)}{\tau_R} \qquad \text{(D-9)}$$

This equation can be expressed in discrete form, but it is important to remember that the independent variable by which $\dot{\rho}_M(R)$ is defined in Eq. (D-8) is position rather than time. The state transition matrix for $\rho_M(R)$ is therefore

$$\Phi(\Delta R) = e^{-\frac{\Delta R}{\tau_R}} \qquad \text{(D-10)}$$

This completes the development of the non-standard atmospheric density model. The model is defined as a sum of three terms in Eq. (D-3). The first term $\rho_{62}(R)$ is the standard atmospheric density reference model and defines the density as a function of altitude only. The second term $\rho_B(R)$ adds the necessary latitude and season dependence to the model; recommended profiles are given in Fig. D-1. The last term $\rho_M(R)$ adds the diurnal and short-term dependence to the model; a recommended model for this term is defined by Eq. (D-8) and the values given in Table D-2.

## D.2 WIND MODEL

The second item required for the non-standard atmosphere model is a non-standard wind model. The drag-update filter mechanization may not include a wind model, although it may account for turbulence by increasing the estimate of the pseudo-measurement variance. With this possible exception, the non-standard wind error is equal to the non-standard wind model. Because wind is a vector quantity, the model must describe both the wind direction and its velocity. This results in a model which is more complicated than the non-standard atmospheric density model. A second complication is that the wind at a given location is analyzed in East-West and North-South coordinates in the literature, but the spatial correlation of the wind encountered by a reentry vehicle is analyzed in terms of headwinds and crosswinds. This implies that much of the data must be transformed into trajectory-oriented coordinates before it can be used to define the non-standard wind model.

The non-standard wind model defined in this appendix is composed of four components

$$\underline{V}_W(R, t) = \underline{V}_{ZW}(R) + \underline{V}_H(R) + \underline{V}_C(R) + \underline{V}_T(t) \qquad \text{(D-11)}$$

where

$\underline{V}_{ZW}(R,t)$ = a westerly (zonal) wind, modeled as an altitude-dependent bias

$\underline{V}_{H}(R)$ = a headwind along the relative velocity vector of the Space Shuttle, modeled as a first-order markov process

$\underline{V}_{C}(R)$ = a crosswind in the horizontal plane and perpendicular to the relative velocity vector of the Space Shuttle, modeled as a second-order markov process, and

$\underline{V}_{T}(t)$ = turbulence along the longitudinal, lateral and vertical axes of the Space Shuttle; modeled as first- and second-order markov processes.

The characteristics of the non-standard wind which most greatly affect the performance of the drag update filter can be accounted for by developing stochastic models for the magnitudes of these four components.

Average winds are generally modeled as East-West (zonal) and North-South (meridional) components. The zonal wind is the only component with sufficient spatial correlation to warrant treatment as a bias in the non-standard wind model. Groves (Ref. 31) has tabulated monthly means for the zonal wind in the northern hemisphere as a function of altitude and latitude. A sample histogram corresponding to 200,000 ft and 40°N is given in Fig. D-2. From the skewed distribution

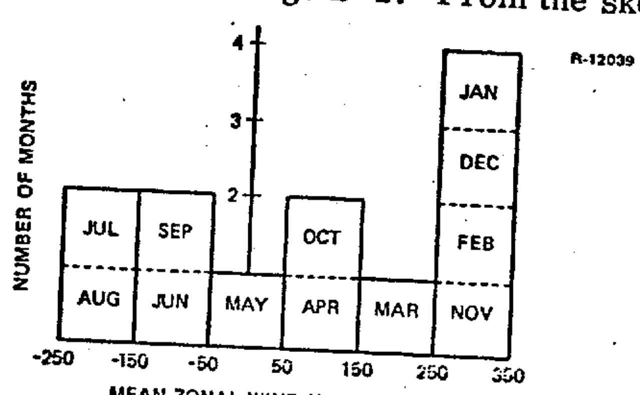


Figure D-2 Histogram of Monthly Mean Zonal (Westerly) Wind Components (fps) for 40°N and an Altitude of 200,000 ft in Fig. D-2 it is clear that the average zonal wind cannot adequately be modeled as a Gaussian random bias. A more reasonable approach is that previously adopted for the long-term density deviations, i.e., to define $V_{ZW}(R)$ deterministically using the January and July zonal wind profiles. This approach corresponds roughly with a worst-case average zonal wind model. Figure D-3 presents the July and January profiles for $V_{ZW}(R)$ based upon the 104° inclination orbit and a landing at Vandenberg AFB. For different trajectories, the necessary profiles for $V_{ZW}(R)$ can be taken from Tables 7a and 10 of Groves (Ref. 31).

The zonal wind component encountered during reentry can differ from the appropriate monthly mean by a significant amount. The available data on the standard deviation is summarized in Tables 15 and 17 of Ref. 31 as a function of altitude, latitude, and month. The latitude

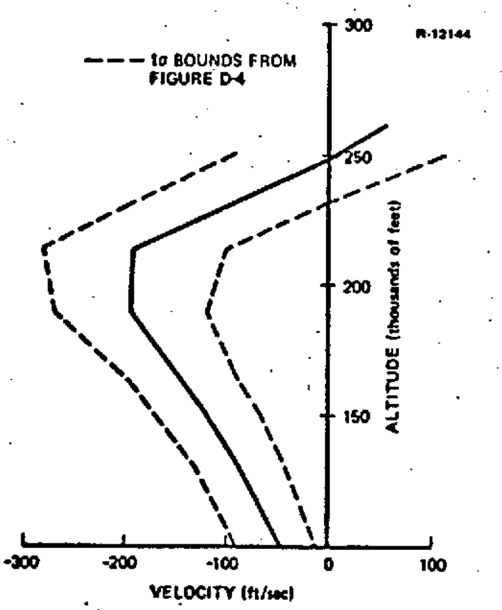


Figure D-3a Mean Zonal (Westerly) Wind in July for Reference mission 3B Entry

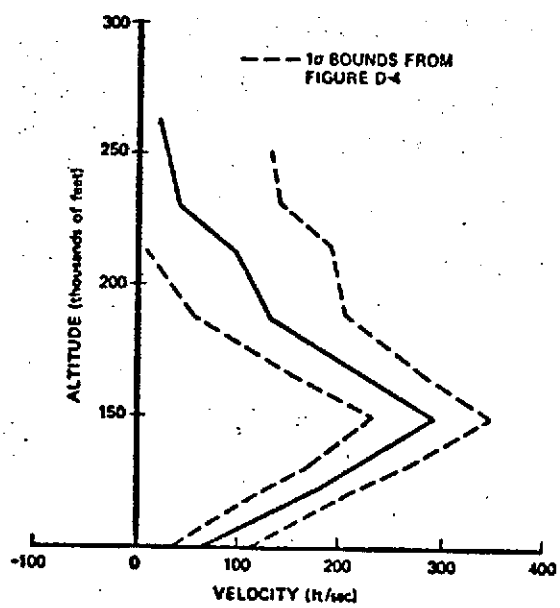


Figure D-3b Mean Zonal (Westerly) Wind in January for Reference Mission 3B Entry dependence is not significant and can be ignored. Figure D-4 presents the season-averaged standard deviations as a function of altitude only — this is in contrast to the season and trajectory dependence of $V_{ZW}(R)$. As an indication of the likely range in magnitude of the zonal wind component, 1$\sigma$ bounds derived from Fig. D-4 are shown in Fig. D-3.

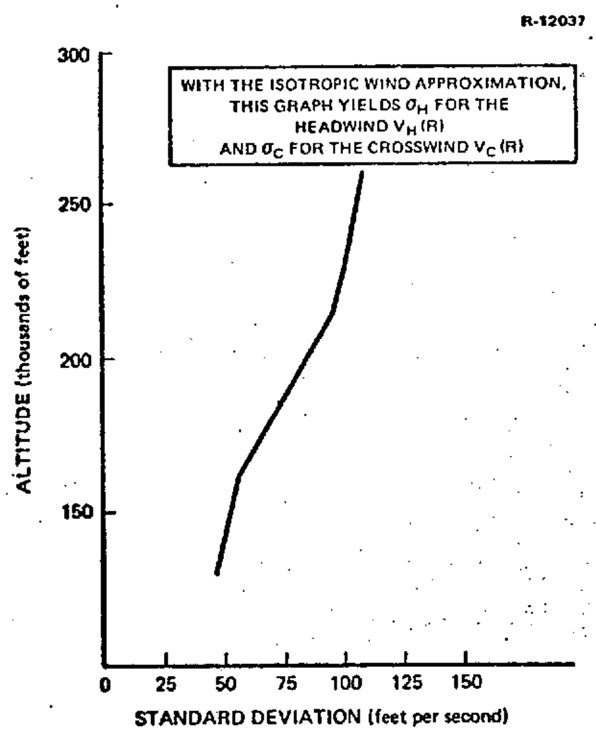




Figure D-4 Season-averaged Standard Deviation of Zonal Wind Component as a Function of Altitude

The data in Fig. D-4 must be used to define the standard deviation of the trajectory-oriented wind components $V_H(R)$ and $V_C(R)$. Before this definition can be made, however, it is necessary to determine the standard deviation of the meridional wind component. The meridional wind is characterized at a given latitude, longitude, and altitude by a small monthly mean and a larger standard deviation (Ref. 31). The monthly mean does not exhibit strong spatial correlation so that the meridional wind encountered along a reentry trajectory can be assumed to be unbiased. Data on the standard deviation of the meridional wind is scarce, but that supplied by Groves indicates that the data in Fig. D-4 can also be used for the meridional wind. The advantage of this result is that it permits wind variations to be modeled as isotropic, i.e., at a given altitude, the standard deviation of the wind component in an arbitrary (horizontal) direction is a constant which is independent of the direction. In particular, the standard deviations of $V_H(R)$ and $V_C(R)$ are given by Fig. D-4.

In order to complete the definition of the spatial correlation functions of $V_H(R)$ and $V_C(R)$, it is necessary to determine the spatial correlation coefficients. Justus and Woodrum (Ref. 34) have experimentally determined spatial correlation coefficients in the desired altitude range, but their analysis includes only the high frequency portion of the wind spectrum. Consequently, the standard deviations of the random processes which they analyzed are less than the corresponding values in Fig. D-4. Buell (Ref. 28) determined the horizontal correlation coefficient for the full wind spectrum, but at an altitude of 20,000 ft. Both sets of results are summarized in Table D-3. If Buell's results are extended to the appropriate altitudes, it is possible to show that the two sets of data are consistent – a random process defined by Buell's displacement correlation coefficient and the standard deviations in Fig. D-4 has nearly the same expected change for a small horizontal displacement as is predicted by Justus and Woodrum's model. This consistency implies that Buell's results can reasonably be used in the desired altitude range.

TABLE D-3

SPATIAL CORRELATION DISTANCES AND STANDARD DEVIATIONS FOR ISOTROPIC WINDS ($V_H(R)$ AND $V_C(R)$ IN NON-STANDARD WIND MODEL)

| Source | Justus and Woodrum | | Buell |
|---|---|---|---|
| Altitude | 150,000-210,000 ft | 210,000-280,000 ft | all altitudes |
| Horizontal displacement correlation distance $\tau_X$ | 27 nm | 55 nm | 270 nm |
| Standard deviation for horizontal correlation function $\sigma_H$, $\sigma_C$ | 20 ft/sec | 59 ft/sec | Fig. D-4 |
| Vertical displacement correlation distance | 3.4 nm | 5.5 nm | — |
| Standard deviation for vertical correlation function | 6.5 ft/sec | 16 ft/sec | — |

The horizontal displacement coefficient $\tau_X$ chosen for $V_H(R)$ and $V_C(R)$ is the 270 nm value from Buell. The small standard deviation which Justus and Woodrum associated with the vertical displacement coefficient indicates that the horizontal winds at different altitudes are strongly correlated. Compounded with the fact that Space Shuttle reentry trajectories have small flight path angles, this implies that the vertical displacement variation in $V_H(R)$ and $V_C(R)$ can be ignored.

Given that the spatial correlation functions for $V_H(R)$ and $V_C(R)$ are functions of horizontal displacement only, they can be expressed in terms of Fig. D-4 and the chosen value for $\tau_X$. Buell makes an important distinction between the two correlation functions. The headwind $V_H(R)$ is modeled as a first-order random process with the correlation function

$$C_H(\Delta X) = \sigma_H^2 e^{-\frac{\Delta X}{\tau_X}} \tag{D-12}$$

but the crosswind is modeled as a second-order random process with the correlation function

$$C_C(\Delta X) = \sigma_C^2 (1 - \tau_X \Delta X) e^{-\frac{\Delta X}{\tau_X}} \tag{D-13}$$

The standard deviations $\sigma_H$ and $\sigma_C$ are the appropriate entries from Fig. D-4. These two functions are illustrated in Fig. D-5. The negative value for $C_C(\Delta X)$ for a displacement greater than 600 nm is a consequence of the cyclonic nature of weather patterns – a reentry vehicle crossing a low pressure region in the northern hemisphere will experience crosswinds first from port and then from starboard.

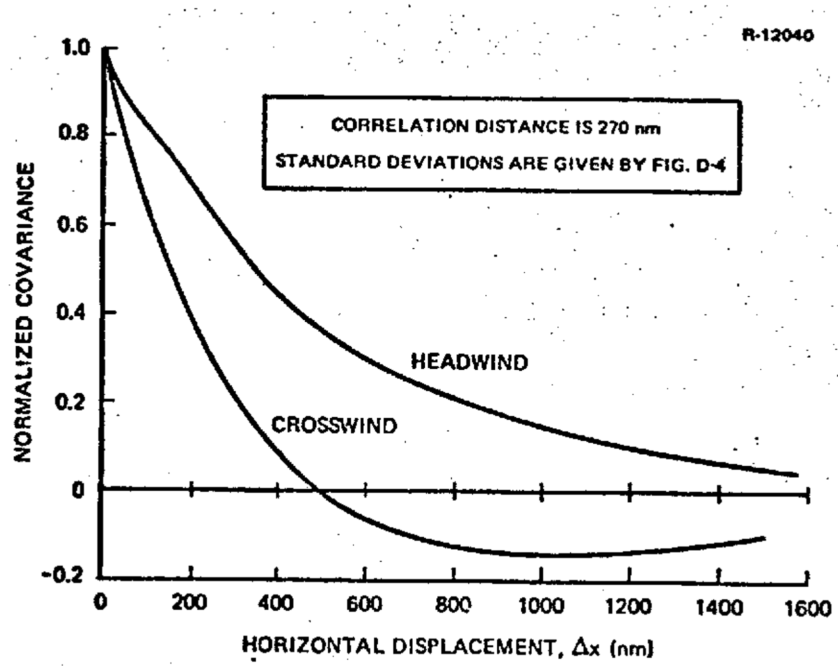


Figure D-5 Correlation Functions for Headwind $V_H(R)$ and Crosswind $V_C(R)$ as Defined by Eqs. (D-12) and (D-13)

Equation (D-12) implies that $V_H(R)$ satisfies the first-order differential equation

$$\dot{V}_H(R) = -\frac{1}{\tau_X} V_H(R) + \eta_H(R) \tag{D-14}$$

On the other hand, $V_C(R)$ is the output of a second-order differential equation

$$\dot{W}_C(R) = F_C W_C(R) + G_C \eta_C(R)$$

$$V_C(R) = H_C W(R) \tag{D-15}$$

where

$$F_C = \begin{bmatrix} -\frac{2}{\tau_X} & 1 \\ -\frac{1}{\tau_X^2} & 0 \end{bmatrix}$$

$$G_C = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$H_C = [\,1 \quad 0\,] \tag{D-16}$$

The inputs in Eqs. (D-14) and (D-15) are zero mean white Gaussian noises with variances of

$$E[\eta_H(R)^2] = \frac{2\,\sigma_H^2}{\tau_X}$$

$$E[\eta_C(R)^2] = \frac{4\,\sigma_C^2}{\tau_X} \qquad \text{(D-17)}$$

In all the above equations the independent variable is horizontal displacement. In the discrete case, the state transition matrices are

$$\Phi_H(\Delta X) = e^{-\frac{\Delta X}{\tau_X}}$$

$$\Phi_C(\Delta X) = e^{F_C\,\Delta X} \qquad \text{(D-18)}$$

The last component of the non-standard atmospheric wind model is the turbulence component $V_T(t)$. Turbulence in the free atmosphere can be modeled by the Dryden spectrum (Ref. 32). The Dryden spectrum for turbulence along the relative velocity vector is

$$\Psi_{TV}(s) = \frac{L\,\sigma_T^2}{V_R(t)} \; \frac{1}{1 + L^2 s^2 / V_R(t)^2} \qquad \text{(D-19)}$$

and the spectrum for turbulence perpendicular to the relative velocity vector is

$$\Psi_{T\perp} = \frac{L\,\sigma_T^2}{2V\,(t)} \; \frac{1 + 3\,s^2 L^2 / V_R(t)^2}{\left[1 + s^2 L^2 / V_R(t)^2\right]^2} \qquad \text{(D-20)}$$

where $V_R(t)$ is relative velocity and L and $\sigma_T$ are design parameters. The suggested values of L and $\sigma_T$ during blackout are

$$
\begin{aligned}
L &= 1750 \text{ feet} \\
\sigma_T &\geq 13 \text{ ft/sec}
\end{aligned}
\tag{D-21}
$$

These are the values used in the definition of $V_T(t)$.

Random processes with the spectra given by Eqs. (D-19) and (D-20) can be defined by passing white noise through the appropriate linear system. The turbulence along the relative velocity vector is defined by the first-order system

$$
\begin{aligned}
W_{TV}(t) &= -\frac{V_R(t)}{L} W_{TV}(t) + \eta_{TV}(t) \\
V_{TV}(t) &= \frac{\sqrt{2V_R(t)}}{L} W_{TV}(t)
\end{aligned}
\tag{D-22}
$$

and the turbulence perpendicular to the relative velocity vector is defined by the second-order system

$$
\begin{aligned}
W_{T\perp}(t) &= F_{T\perp} W_{T\perp}(t) + G_{T\perp} \eta_{T\perp}(t) \\
V_{T\perp}(t) &= H_{T\perp} W_{T\perp}(t)
\end{aligned}
\tag{D-23}
$$

where

$$
F_{T\perp} = \begin{bmatrix} 0 & 1 \\ -\frac{V_R^2(t)}{L^2} & -2\frac{V_R(t)}{L} \end{bmatrix}
$$

$$G_{T\perp} = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$H_{T\perp} = \sqrt{\frac{V_R(t)}{2L}} \begin{bmatrix} \frac{V_R(t)}{L} & \sqrt{3} \end{bmatrix} \tag{D-24}$$

The inputs to Eqs. (D-22) and (D-23) are zero mean white Gaussian noises with variances

$$E[\eta_{TV}(t)^2] = E[\eta_{T\perp}(t)^2] = \sigma_T^2 \tag{D-25}$$

It should be noted that the independent variable in the above equations is time. This is in contrast to the models developed for $V_H(R)$ and $V_C(R)$. The discrete versions of Eq. (D-22) and Eq. (D-24) respectively, are

$$\Phi_{TV}(\Delta t) = e^{-\frac{V_R(t)}{L}\Delta t}$$

and

(D-26)

$$\Phi_{T\perp}(\Delta t) = e^{F_{T\perp}\Delta t} \tag{D-27}$$

This completes the development of the non-standard wind model. The model is defined as a sum of four terms in Eq. (D-11). The first term $V_{ZW}(R)$ is the average zonal (westerly) wind as a function of altitude, latitude, and season; recommended profiles are given in Fig. D-3. The terms $V_H(R)$ and $V_C(R)$ (headwind and crosswind, respectively) add the long period wind variations due to diurnal effects and weather patterns; recommended models and values are given in Eqs. (D-14) and (D-15) and Table D-3, respectively. The last term $V_T(t)$, is a function of time only and adds the high frequency wind components. $V_T(t)$ is expressed in vehicle coordinates and is modeled by a longitudinal component $V_{TV}(t)$ and a transverse component $V_{T\perp}(t)$; recommended models and values are given by Eqs. (D-22), (D-23) and (D-24), respectively.

# APPENDIX E

## TRUTH MODEL STRUCTURE FOR SHUTTLE ENTRY AND LANDING NAVIGATION STUDIES

The basic truth model structure is shown in Fig. 2.3-1. The truth model ($F_S$, $H_S$) is related to the filter model ($F_F$, $H_F$) by a transformation matrix A. Equations for $H_S$ and $H_F$ during the drag-update phase were developed in Appendix D and Section 4.2, respectively; $F_S$, $F_F$, and A for the drag-update phase are developed in this appendix. In addition, all five matrices are developed for System E.

## E.1 DRAG-UPDATE PHASE

The drag-update phase truth model requires a 13 x 13 filter dynamics matrix, $F_F$, and a 59 x 59 system dynamics matrix $F_S$. The only external navigation aid is the drag acceleration pseudo-measurement.

Figure E.1-1 presents the overall structure of the $F_S$ matrix for the drag-update phase. The upper-left partition of $F_S$ is the 13 x 13 matrix $F_{1,1}$, whose elements define the dynamic interaction between the Group 1 error states. This sub-matrix of $F_S$ corresponds* to the filter matrix, $F_F$. The horizontal row of sub-matrices, $F_{1,1a}$ through

*$F_{1,1}$ and $F_F$ are identical except that states 7 through 12 are expressed in the I frame in $F_F$ and in the P frame for $F_{1,1}$. The definition of A in Eq. (E.1-21) provides the necessary transformation between the two representations.

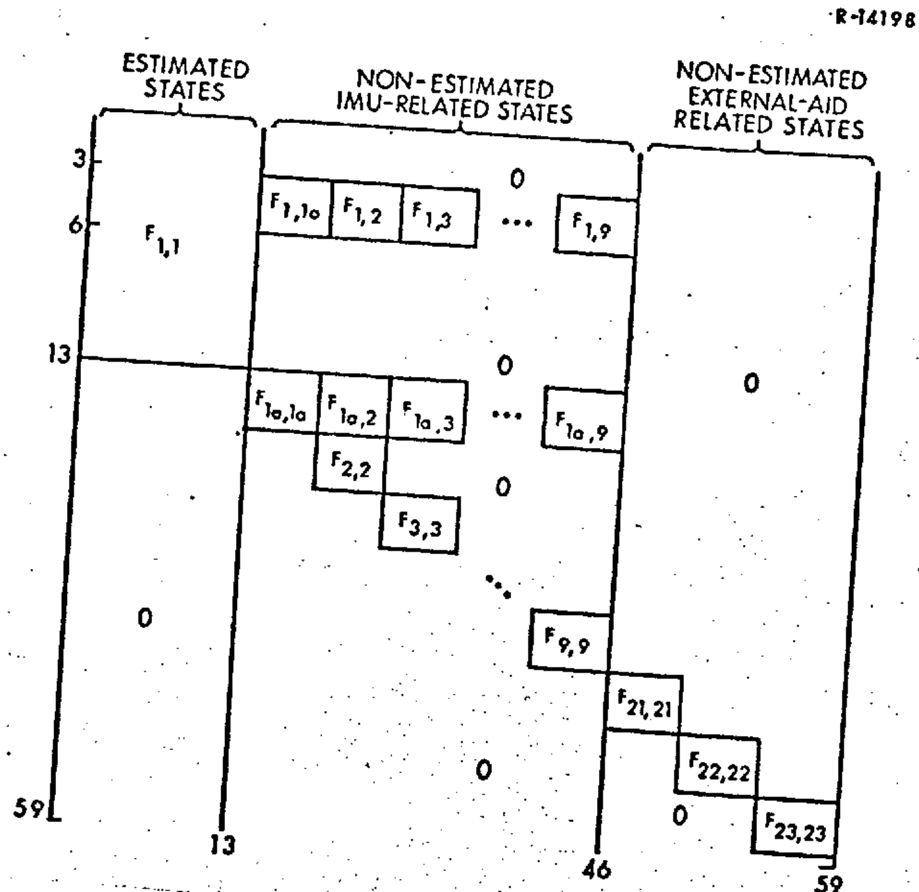




Figure E.1-1 Drag-Update Phase Truth Model System Matrix Structure

$F_{1,9}$, defines the effects of the non-estimated, IMU-related error sources (Groups 1a through 9) on the velocity errors (states 4 through 6). The submatrices along the main diagonal, $F_{1a,1a}$ through $F_{9,9}$ and $F_{21,21}$ through $F_{23,23}$, define the dynamics of all non-estimated, correlated error sources. For a group of random-constant error sources, this submatrix is zero.

The submatrices $F_{i,j}$ are defined in detail below, using the group-number designations given in Table 3.1-1.

Group 1 – Estimated States (See also, Section 4.2)

$$
\begin{array}{c}
\\
F_{1,1} =
\end{array}
\begin{array}{ccccc}
\text{Position Errors} & \text{Velocity Errors} & \text{Misalignments} & \text{Accelerations} & \text{Drag-Correlated Error} \\
\left[\begin{array}{c|c|c|c|c}
0 & I & 0 & 0 & 0 \\
\hline
G_r & 0 & T_{I/P}F_P & I & 0 \\
\hline
0 & 0 & \begin{matrix} s_7 & & 0 \\ & s_8 & \\ 0 & & s_9 \end{matrix} & 0 & 0 \\
\hline
0 & 0 & 0 & \begin{matrix} s_{10} & & 0 \\ & s_{11} & \\ 0 & & s_{12} \end{matrix} & 0 \\
\hline
0 & 0 & 0 & 0 & s_{13}
\end{array}\right] \\
3 \quad\quad 6 \quad\quad 9 \quad\quad 12 \quad 13
\end{array}
\qquad (E.1\text{-}1)
$$

where

$$s_i = -\frac{1}{\tau_i} \qquad i = 7 \cdots 13$$

and $\tau_7 \cdots \tau_{13}$ are the drag-update filter time constants assigned in Table 4.2-1. Also

$$G_r = -\frac{\mu}{|\underline{R}|^3}\left[I - \frac{3}{|\underline{R}|^2}\,\underline{R}\,\underline{R}^T\right] \qquad (E.1\text{-}3)$$

$\mu$ = gravitational constant

$I$ = 3 x 3 identity matrix

$\underline{R}$ = position vector (in I frame; see Appendix A)

$$F_P = \begin{bmatrix} 0 & -f_3 & f_2 \\ f_3 & 0 & -f_1 \\ -f_2 & f_1 & 0 \end{bmatrix} \qquad \text{(E.1-4)}$$

$\begin{bmatrix} f_1 \\ f_2 \\ f_3 \end{bmatrix}$ = specific force vector in the P frame



$T_{I/P}$ = 3 x 3 matrix which transforms vector in the P (platform) frame to the I (navigation error analysis) frame; see Appendix A. See also, the discussion of the A matrix, at the end of this section.

<u>Group 1a – True Platform Misalignments</u> (3 states)

$$F_{1,1a} = \left[T_{I/P} F_P\right]_{3\times 3} \; ; \; F_{1a,1a} = [0]_{3\times 3} \qquad \text{(E.1-5)}$$

<u>Group 2 – Accelerometer True Biases</u>, (3 sensors, 1 state each)

$$F_{1,2} = \left[T_{I/P}\right]_{3\times 3} \; ; \; F_{1a,2} = F_{2,2} = [0]_{3\times 3} \qquad \text{(E.1-6)}$$

<u>Group 3 – Accelerometer Scale Factor Errors</u> (3 sensors, 1 state each)

$$F_{1,3} = \left[T_{I/P} F_3\right]_{3\times 3} \; ; \; F_{1a,3} = F_{3,3} = [0]_{3\times 3} \qquad \text{(E.1-7)}$$

where

$$F_3 = \begin{bmatrix} f_1 & 0 & 0 \\ 0 & f_2 & 0 \\ 0 & 0 & f_3 \end{bmatrix} \quad \text{(E.1-8)}$$

Group 4 – Accelerometer Misalignments
(3 sensors, 2 states each)

$$F_{1,4} = \left[T_{I/P}\, F_4\right]_{3\times 6} \; ; \; F_{1a,4} = [0]_{3\times 6} \; ; \; F_{4,4} = [0]_{6\times 6}$$

(E.1-9)

where

$$F_4 = \begin{bmatrix} f_2 & f_3 & 0 & 0 & 0 & 0 \\ 0 & 0 & f_1 & f_3 & 0 & 0 \\ 0 & 0 & 0 & 0 & f_1 & f_2 \end{bmatrix} \quad \text{(E.1-10)}$$

Group 5 – Accelerometer Nonlinearities
(3 sensors, 1 state each)

$$F_{1,5} = \left[T_{I/P}\, F_5\right]_{3\times 3} \; ; \; F_{1a,5} = F_{5,5} = [0]_{3\times 3} \quad \text{(E.1-11)}$$

where

$$F_5 = \begin{bmatrix} f_1^2 & 0 & 0 \\ 0 & f_2^2 & 0 \\ 0 & 0 & f_3^2 \end{bmatrix} \quad \text{(E.1-12)}$$

Group 6 – Gravity Deflections and Anomaly
(in the vehicle relative velocity coordinate system (V frame))

$$F_{1,6} = [T_{I/V}]_{3\times 3};\ F_{1a,6} = [0]_{3\times 3};\ F_{6,6} = \begin{bmatrix} -1/\tau_u & 0 & 0 \\ 0 & -1/\tau_v & 0 \\ 0 & 0 & -1/\tau_w \end{bmatrix} \quad \text{(E.1-13)}$$

where

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$$\tau_u = d_u/V_R$$
$$\tau_v = d_v/V_R$$
$$\tau_w = d_w/V_R$$

and $d_u$, $d_v$, $d_w$ are correlation distances which are expressed in tabular form as a function of altitude (Ref. 14).

Group 7 – Gyro Bias Drifts (3 sensors, 1 state each)

$$F_{1a,7} = [I]_{3\times 3};\ F_{1,7} = F_{7,7} = [0]_{3\times 3} \quad \text{(E.1-14)}$$

Group 8 – Gyro Mass Unbalances (3 sensors, 2 states each)

$$F_{1a,8} = \begin{bmatrix} f_1 & f_2 & 0 & 0 & 0 & 0 \\ 0 & 0 & f_2 & f_3 & 0 & 0 \\ 0 & 0 & 0 & 0 & f_3 & f_2 \end{bmatrix};\ F_{1,8} = [0]_{3\times 6};\ F_{8,8} = [0]_{6\times 6} \quad \text{(E.1-15)}$$

The elements of $F_{1,8}$ and $F_{1,9}$ below, are determined by the gyro input and spin axis directions shown in Fig. E.1-2.

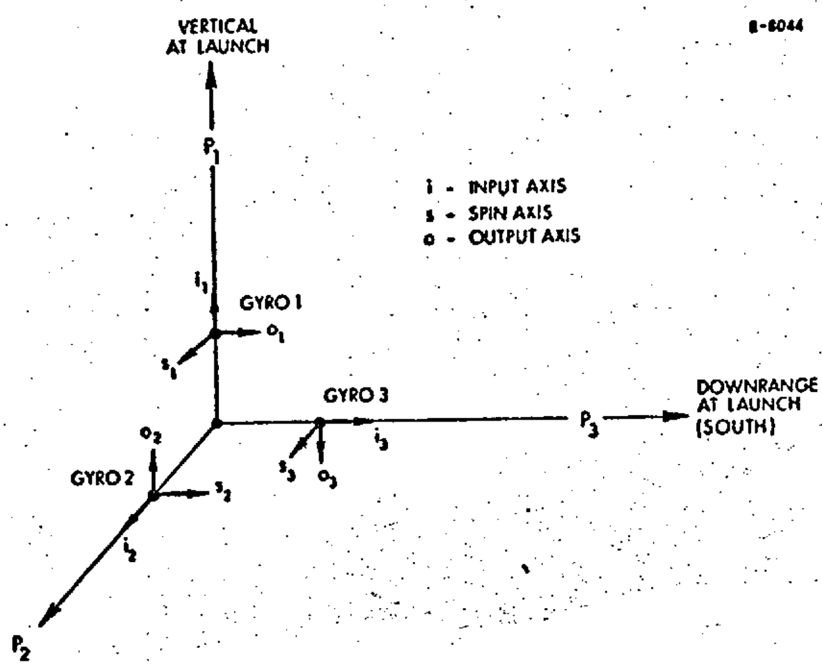



Figure E.1-2 Orientation of Gyro Axes

Group 9 – Gyro Anisoelasticity, (3 sensors, 1 state each)

$$F_{1a,9} = \begin{bmatrix} f_1 f_2 & 0 & 0 \\ 0 & f_2 f_3 & 0 \\ 0 & 0 & f_2 f_3 \end{bmatrix}_{3 \times 3} \quad ; \; F_{1,9} = F_{9,9} = [0]_{3\times 3} \qquad \text{(E.1-16)}$$

<u>Group 21 – Non-Standard Density</u> (3 error sources, 3 states)

$$F_{21,21} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -\frac{V_R}{\tau_R} \end{bmatrix} \begin{matrix} \text{1962 Standard Atmosphere modeling error} \\ \text{time-varying bias} \\ \text{markov} \end{matrix} \qquad \text{(E.1-17)}$$

where $\tau_R$ is determined as a function of altitude and flight path angle in Appendix D.

<u>Group 22 – Non-Standard Wind</u> (4 error sources, 9 states)

$$F_{22} = \left[\begin{array}{cccc|c} 0 & 0 & 0 & 0 & \\ 0 & -\frac{V_R}{\tau_x} & 0 & 0 & \\ 0 & 0 & \frac{-2V_R}{\tau_x} & \frac{-V_R}{\tau_x} & 0 \\ 0 & 0 & \frac{V_R}{\tau_x} & 0 & \\ \hline & & 0 & & F_T \end{array}\right] \begin{matrix} \text{westerly} \\ \text{headwind} \\ \left.\begin{matrix} \\ \\ \end{matrix}\right\} \text{crosswind} \\ \\ \text{turbulence} \end{matrix}$$

(E.1-18)

where $\tau_x$ is given in Table 3.1-3. Equations for turbulence dynamics are defined in Appendix D, but the time constants are so short and the magnitude of the disturbance is so small that they are not used in the truth model. Instead, the assignment

$$F_T = [0]_{5\times 5} \qquad \text{(E.1-19)}$$

is made and turbulence is included as a portion of the 5% drag acceleration measurement noise in Group 1.

Group 23 – Non-Standard Aerodynamics (1 error source, 1 state)

$$F_{23,23} = \left[-\frac{1}{\tau_{CD}}\right] \quad \text{markov} \qquad \text{(E.1-20)}$$

where $\tau_{CD}$ is given in Table 3.1-3.

A Matrix

The 59 × 13 matrix relating the drag-update filter states to the truth model states has the form

$$A = \left[\frac{A'}{0}\right] \qquad \text{(E.1-21)}$$

where $A'$ is a 13 × 13 submatrix



$$A' = \begin{array}{c} \begin{array}{cccc} \quad\quad 6 & \quad\quad 9 & \quad 12 & \quad 13 \end{array} \\ \left[\begin{array}{c|c|c|c} I_{6\times 6} & 0 & 0 & 0 \\ \hline 0 & T_{P/I} & 0 & 0 \\ \hline 0 & 0 & T_{P/I} & 0 \\ \hline 0 & 0 & 0 & I_{1\times 1} \end{array}\right] \end{array} \qquad \text{(E.1-22)}$$

The filter states 7 through 12 (misalignments and accelerations) are defined in the inertial (I) frame. The corresponding truth model states in

Group 1 are defined in the platform (P) frame in order to relate them more readily to Groups 1a and 2. Thus, the transformation I to P appears in the A matrix. The drag-update filter system matrix is related to $F_{1,1}$ in Eq. (E.1-1) by

$$F_F = A' F_{1,1} (A')^{-1} \tag{E.1-23}$$

The markov processes in Groups 1a through 23 in the drag-update phase truth model require that the elements of the system process noise matrix $Q_{S_k}$ associated with those states be non-zero. If all the non-zero markov processes are stationary, then the continuous process noise matrix $Q_S$ defined in Eq. (2.3-9) is related to $F_S$ and $P_S(0)$ by

$$Q_S = - F_S P_S(0) - P_S(0) F_S^T \tag{E.1-24}$$

The discrete process noise is then related to $Q_S$ by

$$Q_{S_k} = \int_{t_k}^{t_{k+1}} \exp\left[F_S(t_{k+1} - \tau)\right] Q_S \exp\left[F_S(t_{k+1} - \tau)\right]^T d\tau \tag{E.1-25}$$

To illustrate the application of Eqs. (E.1-24) and (E.1-25), if the $i^{th}$ truth model state is a stationary first-order markov process, a correlation time, $\tau_i$, for the state is assigned in one of Eqs. (E.1-1) through (E.1-20) and a variance, $\sigma_i^2$, is defined in either Table 3.1-2 or 3.1-3. The corresponding elements of $P_S(0)$, $F_S$, and $Q_{S_k}$ are

$$P_{S_{ii}}(0) = \sigma_i^2 \tag{E.1-26}$$

$$F_{S_{ii}} = -\frac{1}{\tau_i} \tag{E.1-27}$$

$$Q_{S_{k_{ii}}} = \frac{2\sigma_i^2}{\tau_i} \tag{E.1-28}$$

Similar results are obtained for stationary second-order markov processes, although the expression for $Q_{S_k}$ depends upon the precise structure of the 2 × 2 submatrices of $P_S(0)$ and $F_S$ associated with the markov processes.

Constant error sources can be considered a special case of Eqs. (E.1-26) through (E.1-28) with $\tau_i = \infty$ and $F_{S_{ii}} = Q_{S_{k_{ii}}} = 0$. Nonstationary markov processes with slowly-varying parameters can be modeled by recomputing $Q_{S_{k_{ii}}}$ as $\tau_i$ and $\sigma_i^2$ change. For time-varying biases which have no associated dynamics, such as the time-varying density bias (Group 21) or the mean westerly wind (Group 22), the corresponding components of $F_S$ and $Q_{S_k}$ are set equal to zero and the corresponding elements of $P_S(t)$ are obtained directly from the appropriate profiles in Appendix D.

## E.2 SYSTEM E

The System E truth model requires a variable-dimensioned navigation system Kalman filter dynamics matrix, $F_F$, and a truth model system dynamics matrix, $F_S$. The maximum possible dimensions are assumed in this appendix, i.e., $F_F$ and $F_S$ are 15 × 15 and 100 × 100, respectively. The discussion in Section 4.3 indicates which states of $F_F$ should be removed when the Kalman filter has fewer than 15 states. The relationship developed below between $F_F$ and $F_S$ then indicates which states should be removed from $F_S$.

Figure E.2-1 presents the overall structure of the $F_S$ and $H_S$ matrices for System E. The structure of $F_S$ is similar to that of $F_S$ for the drag-update phase. The eight system measurement matrices (row vectors) are outlined in the lower half of Fig. E.2-1. For all but the drag pseudo-measurement ($H_{S_8}$), the first 15 elements are the same as those of the corresponding filter measurement matrix. Other non-zero submatrices, $H_{i,j}$, define the effects of the correlated error sources (Group j) in question on the measurement residual, $\delta z_i$, in question.

The only submatrices of $F_S$ which have changed from the drag-update phase are $F_{1,1}$ and the new block diagonal matrices $F_{10,10} \cdots F_{20,20}$. These submatrices and $H_{i,j}$ are defined below using the group number designations given in Table 3.2-1. In addition, the filter measurement matrices $H_{F_1} \cdots H_{F_2}$ are also defined; $H_{F_8}$ is defined in Section 4.2.

Group 1 – Estimated States (see also Section 4.3)

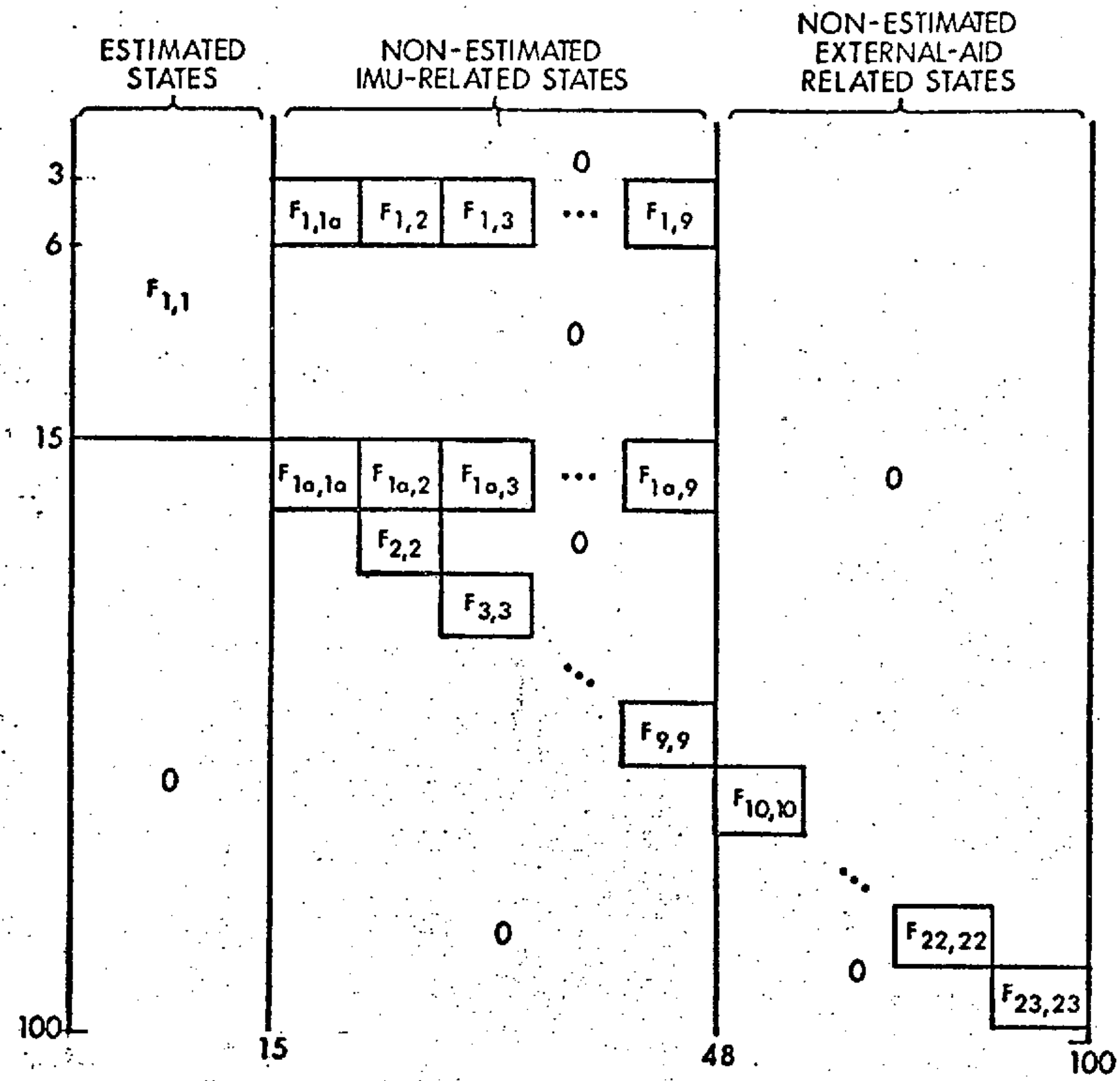
Two possibilities exist:

- $F_{1,1}$ is the upper left $6 \times 6$ submatrix of $F_{1,1}$ as defined in Eq. (E.1-1).
- $F_{1,1}$ is as defined in Eq. (E.1-1), except that states 14, and perhaps 15, may be added. The only non-zero elements of $F_{1,1}$ associated with these states are the diagonal elements $s_{14}$ and $s_{15}$, respectively.

Group 10 – TACAN Range Bias Error
(1 station, 1 state)

$$F_{10,10} = [0]_{1 \times 1} \qquad \text{(E.2-1)}$$

$$H_{1,10} = 1 \qquad \text{(E.2-2)}$$




15 48 100

$$H_{S_1} = [\, H_{F_1} \mid 0 \mid H_{1,10}\; H_{1,11} \mid 0 \mid H_{1,10} \mid 0 \,]$$

$$H_{S_2} = [\, H_{F_2} \mid 0 \mid \quad \mid H_{2,16} \mid 0 \mid H_{2,19} \mid 0 \,]$$

$$H_{S_3} = [\, H_{F_3} \mid 0 \mid 0 \mid H_{3,12} \mid 0 \,]$$

$$H_{S_4} = [\, H_{F_4} \mid 0 \mid 0 \mid H_{4,13}\; H_{4,14} \mid 0 \mid H_{4,17} \mid 0 \mid H_{4,20} \mid 0 \,]$$

$$H_{S_5} = [\, H_{F_5} \mid 0 \mid 0 \mid 0 \mid H_{5,15} \mid 0 \,]$$

$$H_{S_6} = [\, H_{F_6} \mid 0 \mid 0 \mid H_{6,13}\; H_{6,14} \mid 0 \mid H_{6,17} \mid 0 \mid H_{6,20} \mid 0 \,]$$

$$H_{S_7} = [\, H_{F_7} \mid 0 \mid 0 \mid H_{7,13}\; H_{7,14} \mid 0 \mid H_{7,17} \mid 0 \mid H_{7,20} \mid 0 \,]$$

$$H_{S_8} = \text{Eq. (C-42)}$$

Figure E.2-1 System E Truth Model Structure

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Group 11 – TACAN Range Scale Factor (1 station, 1 state)

$$F_{11,11} = [-1/\tau_{sf}]_{1 \times 1} \qquad \text{(E.2-3)}$$

$$H_{1,11} = |\underline{\rho}_1| \qquad \text{(E.2-4)}$$

where $\tau_{sf}$ is defined in Table 3.2-1 and $|\underline{\rho}_1|$ is the range to the TACAN station.

Group 12 – Baro Altimeter Errors (4 error sources, 4 states)

$$F_{12,12} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & -1/\tau_a & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{matrix} \text{bias} \\ \text{scale factor} \\ \text{markov} \\ \text{static defect} \end{matrix} \qquad \text{(E.2-5)}$$

$$H_{3,12} = \begin{bmatrix} 1 & h & 1 & V_R^2 \end{bmatrix} \qquad \text{(E.2-6)}$$

where $\tau_a$ is defined in Table 3.2-2, h is altitude, and $V_R$ is the Shuttle relative velocity with respect to earth.

Group 13 – MLS Time-Varying Biases
(azimuth bias, elevation bias, range bias,
range scale factor; 4 states)

$$F_{13,13} = [0]_{4 \times 4} \qquad \text{(E.2-7)}$$

$$H_{4,13} = [\,1 \quad 0 \quad 0 \quad 0\,] \qquad \text{(E.2-8)}$$

$$H_{6,13} = [\,0 \quad 1 \quad 0 \quad 0\,] \qquad \text{(E.2-9)}$$

$$H_{7,13} = [\,0 \quad 0 \quad 1 \quad |\underline{\rho}_A|\,] \qquad \text{(E.2-10)}$$

where $|\underline{\rho}_A|$ is the range to the MLS DME antenna.

Group 14 – MLS Second-Order Markovs (3 error sources; 6 states)

$$F_{14,14} = \left[\begin{array}{cc|cc|cc} -\frac{2}{\tau_a} & \frac{1}{\tau_a} & \multicolumn{2}{c|}{0} & \multicolumn{2}{c}{0} \\ -\frac{1}{\tau_a} & 0 & & & & \\ \hline \multicolumn{2}{c|}{0} & -\frac{2}{\tau_e} & \frac{1}{\tau_e} & \multicolumn{2}{c}{0} \\ & & -\frac{1}{\tau_e} & 0 & & \\ \hline \multicolumn{2}{c|}{0} & \multicolumn{2}{c|}{0} & -\frac{2}{\tau_{DME}} & \frac{1}{\tau_{DME}} \\ & & & & -\frac{1}{\tau_{DME}} & 0 \end{array}\right] \begin{array}{l} \text{azimuth} \\ \\ \text{elevation} \\ \\ \text{range} \\ \\ \end{array}$$

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$$H_{4,14} = [\ 1 \quad 0 \ | \ 0 \ | \ 0 \ ] \qquad (E.2\text{-}12)$$

$$H_{6,14} = [\ 0 \ | \ 1 \quad 0 \ | \ 0 \ ] \qquad (E.2\text{-}13)$$

$$H_{7,14} = [\ 0 \ | \ 0 \ | \ 1 \quad 0 \ ] \qquad (E.2\text{-}14)$$

where $\tau_a$, $\tau_e$, and $\tau_{DME}$ are assigned in Table 3.2-2.

Group 15 – Radar Altimeter (2 error sources, 2 states)

$$F_{15,15} = \begin{bmatrix} 0 & 0 \\ 0 & -\frac{1}{\tau_{ra}} \end{bmatrix}_{2\times 2} \qquad (E.2\text{-}15)$$

$$H_{5,15} = [\ 1 \quad 1\ ] \qquad (E.2\text{-}16)$$

where $\tau_{ra}$ is defined in Table 3.2-2.

Group 16 – TACAN Survey Errors
(2 antennae, 3 components each)

$$F_{16,16} = [0]_{6\times 6} \tag{E.2-17}$$

$$H_{1,16} = \begin{bmatrix} \frac{-\rho_{1_R}}{|\underline{\rho}_1|} & \frac{-\rho_{1_D}}{|\underline{\rho}_1|} & \frac{-\rho_{1_C}}{|\underline{\rho}_1|} & 0 & 0 & 0 \end{bmatrix} \tag{E.2-18}$$

$$H_{2,16} = \begin{bmatrix} 0 & 0 & 0 & \frac{-u_{2_R}}{|\underline{\rho}_{s_1}|} & \frac{-u_{2_D}}{|\underline{\rho}_{s_1}|} & \frac{-u_{2_C}}{|\underline{\rho}_{s_1}|} \end{bmatrix} \tag{E.2-19}$$

where $\rho_{1_R}$, $\rho_{1_D}$, $\rho_{1_C}$ are the components in the R frame of the vector $\underline{\rho}_1$ (see Fig. E.2-2); $\underline{\rho}_1$ is the relative position vector from TACAN to the Shuttle. $u_{2R}$, $u_{2C}$, $u_{2D}$ are the components of the unit vector $\underline{u}_2$, perpendicular to $\underline{\rho}_1$ and lying in the horizontal plane (see Fig. E.2-2). The vector $\underline{\rho}_{s_1}$ is the projection of $\underline{\rho}_1$ onto horizontal plane.

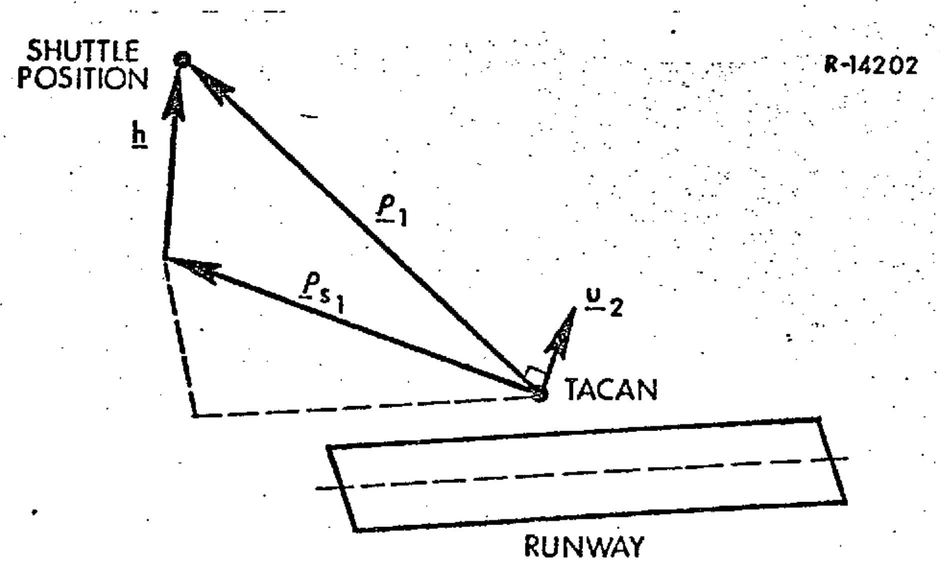


Figure E.2-2 TACAN-Shuttle Geometry

Group 17 – MLS Survey Errors
(3 antennae; 3 components each)

$$F_{17,17} = [0]_{9 \times 9} \quad \text{(E.2-20)}$$

$$H_{4,17} = \left[ -\delta\alpha_R \;\; -\delta\alpha_D \;\; -\delta\alpha_C \;\middle|\; 0 \;\middle|\; 0 \right] \quad \text{(E.2-21)}$$

$$H_{6,17} = \left[ 0 \;\middle|\; -\delta\beta_R \;\; -\delta\beta_D \;\; -\delta\beta_C \;\middle|\; 0 \right] \quad \text{(E.2-22)}$$

$$H_{7,17} = \left[ 0 \;\middle|\; 0 \;\middle|\; \frac{-\rho_{A_R}}{|\underline{\rho}_A|} \;\; \frac{-\rho_{A_D}}{|\underline{\rho}_A|} \;\; \frac{-\rho_{A_C}}{|\underline{\rho}_A|} \right] \quad \text{(E.2-23)}$$

where $\delta\alpha_R$, $\delta\alpha_D$, and $\delta\alpha_C$ are the components in the R frame of the vector $\underline{\delta\alpha}$ (see Fig. E.2-3) defined by

$$\underline{\delta\alpha} = \frac{(\underline{\rho}_A \times \underline{c})}{|\underline{\rho}_A \times \underline{c}|^2} \quad \text{(E.2-24)}$$

$\delta\beta_R$, $\delta\beta_D$, and $\delta\beta_C$ are the components in the R frame of the vector $\underline{\delta\beta}$ (see Fig. E.2-4) defined by

$$\underline{\delta\beta} = \frac{-\underline{\rho}_E \times \underline{a}}{|\underline{\rho}_E \times \underline{a}|^2} \quad \text{(E.2-25)}$$

and $\rho_{A_R}$, $\rho_{A_D}$, $\rho_{A_C}$ are the components in the R frame of $\underline{\rho}_A$.

Group 18 – Not Used for System E

Group 19 – TACAN Bearing Bias Error (1 error source; 1 state)

$$F_{19,19} = \left[ -\frac{V_R}{20,000} \right]_{1 \times 1} \quad \text{(E.2-26)}$$

$$H_{2,19} = [\;1\;] \quad \text{(E.2-27)}$$

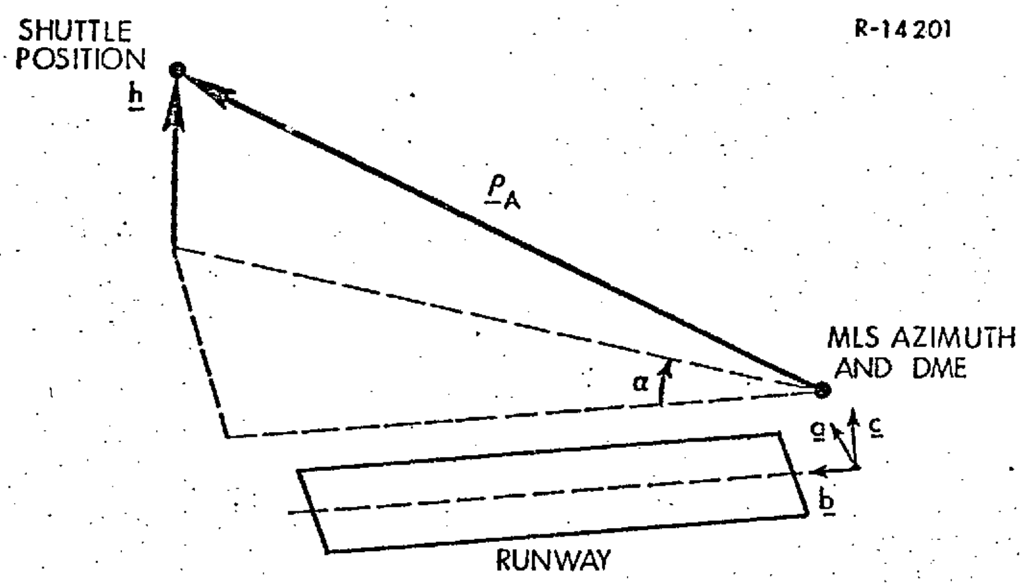


Figure E.2-3 MLS Azimuth-Shuttle and MLS DME-Shuttle Geometries



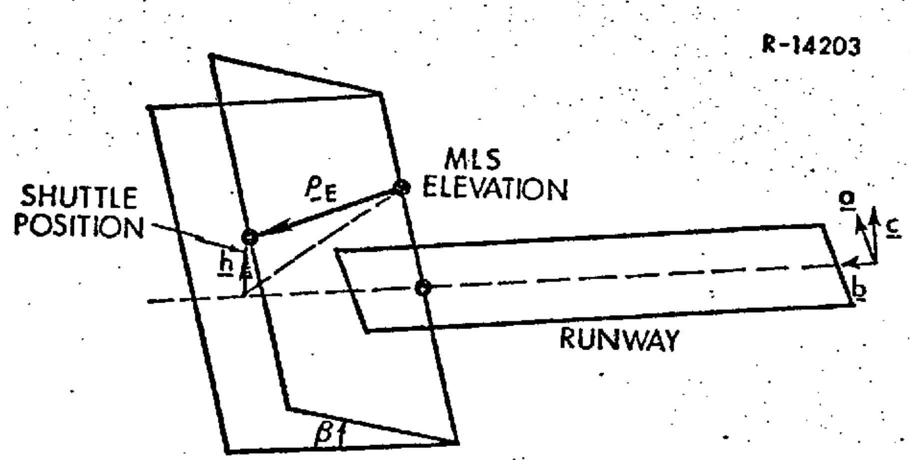


Figure E.2-4 MLS Elevation-Shuttle Geometry

Group 20 – MLS Timing Errors (3 error sources; 3 states)

$$F_{20,20} = [0]_{3 \times 3} \qquad \text{(E.2-28)}$$

$$H_{4,20} = [\dot{\alpha} \quad \dot{\beta} \quad 0] \qquad \text{(E.2-29)}$$

$$H_{7,20} = [0 \quad 0 \quad |\dot{\underline{\rho}}_A|] \qquad \text{(E.2-30)}$$

where $\dot{\alpha}$, $\dot{\beta}$, $|\dot{\underline{\rho}}_A|$ are the azimuth rate, elevation rate, and range rate, respectively, of the Shuttle relative to the appropriate MLS antenna.

The only elements of $F_S$ and $H_S$ which have not been defined are the filter measurement matrices $H_{F_1} \cdots H_{F_7}$

(column partitions after columns 3, 6, 12)

$$H_{F_1} = [\; -H_{1,16} \;|\; 0 \;|\; 0 \;|\; 0 \quad 1 \quad 0 \;] \qquad \text{(E.2-32)}$$

$$H_{F_2} = [\; -H_{2,16} \;|\; 0 \;|\; 0 \;|\; 0 \quad 0 \quad 1 \;] \qquad \text{(E.2-33)}$$

$$H_{F_3} = [\; i_{R_1} \quad i_{R_2} \quad i_{R_3} \;|\; 0 \;|\; 0 \;|\; 1 \quad 0 \quad 0 \;] \qquad \text{(E.2-34)}$$

$$H_{F_4} = [\; -H_{4,17} \;|\; 0 \;|\; 0 \;|\; 0 \quad 0 \quad 1 \;] \qquad \text{(E.2-35)}$$

$$H_{F_5} = [\; i_{R_1} \quad i_{R_2} \quad i_{R_3} \;|\; 0 \;] \qquad \text{(E.2-36)}$$

$$H_{F_6} = [\; -H_{6,17} \;|\; 0 \;|\; 0 \;|\; 1 \quad 0 \quad 0 \;] \qquad \text{(E.2-37)}$$

$$H_{F_7} = [\; -H_{7,17} \;|\; 0 \;|\; 0 \;|\; 0 \quad 1 \quad 0 \;] \qquad \text{(E.2-38)}$$

where $i_{R_1}$, $i_{R_2}$, and $i_{R_3}$ are the components in the I frame of the unit vector in the vertical direction.

## A Matrix

The A matrix for System E is a 100 x 15 matrix relating the Kalman filter states to the truth model states. A has the form

$$A = \left[\frac{A'}{0}\right] \qquad \text{(E.2-39)}$$

where $A'$ is a 15 x 15 matrix which differs from $A'$ as defined in Eq. (E.1-22) only in that the $I_{1\times 1}$ submatrix is replaced by a $I_{3\times 3}$ submatrix.

# APPENDIX F

## DRAG-UPDATE ERROR CONTRIBUTION TIME HISTORIES

This appendix presents the time histories associated with the error budget results summarized in Section 5.1. The data is presented in tabular form with each table indicating the rms errors in position and velocity, and the rms values of the platform alignment estimates, in both the R (runway)* and V (relative velocity) coordinate frames (see Appendix A), which result from a specific error source or group of errors. The rms errors in altitude, velocity magnitude, flight path angle ($\gamma$), and track angle ($\psi$) are also presented. In addition, the rms value of each of states 10 through 13 is given at 130,000 ft.

The time points in each table correspond to entry interface at 400,000 ft (t = 0 sec), just before and after the first drag acceleration pseudo-measurement (t = 312 sec), and every 60 seconds thereafter until just before the first TACAN measurement (t = 1432 sec). The magnitudes and mathematical description of the error sources are given in Chapter 3. Units are in feet, feet/sec, radians, and radians/sec.

*Note that the order of the runway coordinate printout is (Vertical, Crossrange, Downrange) in Appendix F and (Vertical, Downrange, Crossrange) in Appendix G.

GROUP 1 5 PERCENT MEASUREMENT NOISE

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 312.00 | 5.103E+02 | 7.557E+02 | 1.163E+02 | 2.590E-01 | 6.810E-01 | 2.780E-01 | 2.664E-06 | 8.606E-07 | 5.449E-06 | 1.526E-01 | 3.238E-01 |
| 372.00 | 2.136E+02 | 3.686E+02 | 6.077E+01 | 1.529E-01 | 3.965E-01 | 1.316E-01 | 1.123E-06 | 4.156E-07 | 2.632E-06 | 7.216E-02 | 1.494E-01 |
| 432.00 | 1.818E+02 | 3.510E+02 | 6.054E+01 | 1.776E-01 | 3.487E-01 | 1.251E-01 | 1.050E-06 | 2.891E-07 | 2.486E-06 | 6.310E-02 | 1.270E-01 |
| 492.00 | 1.607E+02 | 3.464E+02 | 6.218E+01 | 2.059E-01 | 3.150E-01 | 1.236E-01 | 1.152E-06 | 1.588E-07 | 2.610E-06 | 5.373E-02 | 1.096E-01 |
| 552.00 | 1.441E+02 | 3.510E+02 | 6.569E+01 | 2.379E-01 | 2.889E-01 | 1.255E-01 | 1.396E-06 | 4.063E-07 | 2.990E-06 | 4.327E-02 | 9.425E-02 |
| 612.00 | 1.288E+02 | 3.623E+02 | 7.072E+01 | 2.745E-01 | 2.660E-01 | 1.302E-01 | 1.720E-06 | 8.553E-07 | 3.608E-06 | 3.257E-02 | 7.939E-02 |
| 672.00 | 1.533E+02 | 7.792E+02 | 1.283E+02 | 6.011E-01 | 5.298E-01 | 3.011E-01 | 5.247E-06 | 2.767E-06 | 1.151E-05 | 3.467E-02 | 1.891E-01 |
| 732.00 | 1.196E+02 | 8.110E+02 | 1.456E+02 | 6.721E-01 | 4.461E-01 | 3.118E-01 | 4.933E-06 | 2.866E-06 | 1.083E-05 | 5.968E-02 | 1.775E-01 |
| 792.00 | 8.625E+01 | 8.433E+02 | 1.640E+02 | 7.508E-01 | 4.366E-01 | 3.230E-01 | 4.697E-06 | 3.152E-06 | 1.052E-05 | 1.075E-01 | 1.651E-01 |
| 852.00 | 5.919E+01 | 8.766E+02 | 1.836E+02 | 8.412E-01 | 3.808E-01 | 3.355E-01 | 4.505E-06 | 3.589E-06 | 1.059E-05 | 1.789E-01 | 1.533E-01 |
| 912.00 | 5.707E+01 | 9.099E+02 | 2.050E+02 | 9.456E-01 | 3.184E-01 | 3.489E-01 | 4.301E-06 | 4.088E-06 | 1.100E-05 | 2.776E-01 | 1.437E-01 |
| 972.00 | 8.954E+01 | 9.376E+02 | 2.275E+02 | 1.062E+00 | 2.508E-01 | 3.613E-01 | 4.046E-06 | 4.598E-06 | 1.170E-05 | 4.112E-01 | 1.390E-01 |
| 1032.00 | 1.409E+02 | 9.606E+02 | 2.518E+02 | 1.188E+00 | 1.896E-01 | 3.701E-01 | 3.679E-06 | 4.921E-06 | 1.245E-05 | 5.792E-01 | 1.355E-01 |
| 1092.00 | 2.024E+02 | 9.676E+02 | 2.742E+02 | 1.305E+00 | 1.616E-01 | 3.673E-01 | 3.161E-06 | 4.875E-06 | 1.304E-05 | 7.684E-01 | 1.315E-01 |
| 1152.00 | 2.646E+02 | 9.429E+02 | 2.878E+02 | 1.373E+00 | 1.908E-01 | 3.424E-01 | 2.503E-06 | 4.283E-06 | 1.314E-05 | 9.414E-01 | 1.216E-01 |
| 1212.00 | 3.244E+02 | 9.058E+02 | 2.952E+02 | 1.412E+00 | 2.486E-01 | 3.025E-01 | 1.893E-06 | 3.206E-06 | 1.296E-05 | 1.093E+00 | 1.045E-01 |
| 1272.00 | 3.681E+02 | 8.406E+02 | 2.881E+02 | 1.379E+00 | 3.017E-01 | 2.436E-01 | 1.451E-06 | 1.773E-06 | 1.231E-05 | 1.173E+00 | 9.710E-02 |
| 1332.00 | 8.536E+02 | 1.272E+03 | 5.209E+02 | 3.229E+00 | 9.027E-01 | 4.229E-01 | 1.730E-06 | 3.274E-06 | 2.863E-05 | 2.891E+00 | 1.109E-01 |
| 1392.00 | 9.413E+02 | 1.109E+03 | 4.895E+02 | 3.059E+00 | 8.503E-01 | 3.762E-01 | 1.854E-06 | 4.580E-06 | 2.263E-05 | 2.742E+00 | 2.837E-01 |
| 1432.00 | 9.979E+02 | 1.020E+03 | 4.748E+02 | 2.977E+00 | 8.175E-01 | 3.670E-01 | 1.945E-06 | 6.008E-06 | 1.946E-05 | 2.695E+00 | 3.606E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.835E-15 | 3.835E-15 |
| 312.00 | 3.313E+02 | 8.575E+02 | 1.833E+00 | 9.055E-01 | 3.100E-01 | 6.720E-02 | 3.222E-08 | 1.591E-06 | 5.915E-06 | 6.042E-06 | 1.219E-04 |
| 372.00 | 1.556E+02 | 4.011E+02 | 8.200E+00 | 4.191E-01 | 1.458E-01 | 3.182E-02 | 1.622E-07 | 6.476E-07 | 2.814E-06 | 2.842E-06 | 6.941E-05 |
| 432.00 | 1.369E+02 | 3.755E+02 | 1.343E+01 | 3.900E-01 | 1.257E-01 | 2.980E-02 | 2.114E-07 | 6.757E-07 | 2.620E-06 | 2.495E-06 | 6.871E-05 |
| 492.00 | 1.234E+02 | 3.661E+02 | 2.034E+01 | 3.798E-01 | 1.090E-01 | 2.860E-02 | 2.680E-07 | 9.576E-07 | 2.678E-06 | 2.158E-06 | 6.034E-05 |
| 552.00 | 1.135E+02 | 3.669E+02 | 2.836E+01 | 3.824E-01 | 9.383E-02 | 2.733E-02 | 3.297E-07 | 1.492E-06 | 2.953E-06 | 1.773E-06 | 4.885E-05 |
| 612.00 | 1.063E+02 | 3.743E+02 | 3.769E+01 | 3.951E-01 | 7.898E-02 | 2.573E-02 | 3.928E-07 | 2.236E-06 | 3.404E-06 | 1.366E-06 | 3.865E-05 |
| 672.00 | 2.691E+02 | 7.460E+02 | 1.349E+02 | 8.345E-01 | 1.881E-01 | 2.935E-02 | 8.120E-07 | 7.414E-06 | 1.058E-05 | 1.485E-06 | 6.489E-05 |
| 732.00 | 2.694E+02 | 7.726E+02 | 1.545E+02 | 8.680E-01 | 1.762E-01 | 2.584E-02 | 4.845E-07 | 7.437E-06 | 9.709E-06 | 2.832E-06 | 5.362E-05 |
| 792.00 | 2.718E+02 | 7.997E+02 | 1.794E+02 | 9.117E-01 | 1.634E-01 | 2.748E-02 | 5.147E-07 | 7.745E-06 | 9.073E-06 | 4.911E-06 | 4.545E-05 |
| 852.00 | 2.770E+02 | 8.269E+02 | 2.124E+02 | 9.700E-01 | 1.510E-01 | 3.938E-02 | 7.348E-07 | 8.379E-06 | 8.640E-06 | 8.505E-06 | 3.973E-05 |
| 912.00 | 2.861E+02 | 8.516E+02 | 2.572E+02 | 1.046E+00 | 1.411E-01 | 6.270E-02 | 9.563E-07 | 9.303E-06 | 8.297E-06 | 1.386E-05 | 3.592E-05 |
| 972.00 | 2.997E+02 | 8.648E+02 | 3.181E+02 | 1.137E+00 | 1.364E-01 | 9.915E-02 | 1.140E-06 | 1.053E-05 | 7.890E-06 | 2.181E-05 | 3.366E-05 |
| 1032.00 | 3.209E+02 | 8.609E+02 | 4.022E+02 | 1.243E+00 | 1.349E-01 | 1.480E-01 | 1.282E-06 | 1.183E-05 | 7.154E-06 | 3.322E-05 | 3.321E-05 |
| 1092.00 | 3.490E+02 | 8.238E+02 | 5.019E+02 | 1.343E+00 | 1.321E-01 | 2.080E-01 | 1.394E-06 | 1.289E-05 | 5.987E-06 | 4.850E-05 | 3.442E-05 |
| 1152.00 | 3.778E+02 | 7.366E+02 | 5.972E+02 | 1.397E+00 | 1.226E-01 | 2.699E-01 | 1.486E-06 | 1.324E-05 | 4.439E-06 | 6.667E-05 | 3.695E-05 |
| 1212.00 | 4.102E+02 | 6.144E+02 | 6.835E+02 | 1.424E+00 | 1.047E-01 | 3.290E-01 | 1.545E-06 | 1.307E-05 | 2.919E-06 | 8.858E-05 | 4.157E-05 |
| 1272.00 | 4.319E+02 | 4.506E+02 | 7.318E+02 | 1.381E+00 | 9.145E-02 | 3.699E-01 | 1.596E-06 | 1.231E-05 | 1.647E-06 | 1.110E-04 | 4.688E-05 |
| 1332.00 | 9.369E+02 | 7.875E+02 | 1.058E+03 | 3.209E+00 | 1.380E-01 | 1.052E+00 | 3.316E-06 | 2.811E-05 | 5.677E-06 | 3.270E-04 | 1.368E-04 |
| 1392.00 | 9.965E+02 | 9.406E+02 | 6.917E+02 | 3.042E+00 | 3.297E-01 | 9.275E-01 | 2.484E-06 | 2.054E-05 | 1.043E-05 | 3.841E-04 | 1.440E-04 |
| 1432.00 | 1.038E+03 | 9.947E+02 | 4.419E+02 | 2.965E+00 | 4.560E-01 | 8.176E-01 | 2.196E-06 | 1.634E-05 | 1.211E-05 | 4.369E-04 | 1.445E-04 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)
1.628E-08  1.371E-08  1.187E-07  5.048E-02

GROUP 1 QUANTIZATION ERROR

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 312.00 | 2.116E+01 | 2.164E+01 | 2.113E+01 | 1.174E-01 | 1.211E-01 | 1.167E-01 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.263E-01 | 1.156E-01 |
| 312.00 | 6.226E+01 | 8.200E+01 | 2.370E+01 | 1.195E-01 | 1.390E-01 | 1.183E-01 | 2.923E-07 | 9.444E-08 | 5.979E-07 | 1.306E-01 | 1.180E-01 |
| 372.00 | 4.175E+01 | 3.359E+01 | 2.649E+01 | 1.263E-01 | 1.174E-01 | 1.244E-01 | 1.145E-07 | 3.442E-08 | 2.264E-07 | 1.453E-01 | 1.233E-01 |
| 432.00 | 4.742E+01 | 3.626E+01 | 3.288E+01 | 1.357E-01 | 1.276E-01 | 1.331E-01 | 1.070E-07 | 3.025E-08 | 2.124E-07 | 1.603E-01 | 1.316E-01 |
| 492.00 | 5.387E+01 | 4.05[illegible]E+01 | 3.970E+01 | 1.450E-01 | 1.372E-01 | 1.409E-01 | 1.048E-07 | 2.693E-08 | 2.127E-07 | 1.752E-01 | 1.389E-01 |
| 552.00 | 6.090E+01 | 4.568E+01 | 4.688E+01 | 1.544E-01 | 1.463E-01 | 1.479E-01 | 1.079E-07 | 2.363E-08 | 2.237E-07 | 1.900E-01 | 1.453E-01 |
| 612.00 | 6.857E+01 | 5.154E+01 | 5.436E+01 | 1.641E-01 | 1.547E-01 | 1.543E-01 | 1.181E-07 | 2.478E-08 | 2.484E-07 | 2.048E-01 | 1.512E-01 |
| 672.00 | 7.689E+01 | 5.952E+01 | 6.216E+01 | 1.751E-01 | 1.629E-01 | 1.602E-01 | 1.632E-07 | 6.083E-08 | 3.507E-07 | 2.196E-01 | 1.565E-01 |
| 732.00 | 8.603E+01 | 6.642E+01 | 7.013E+01 | 1.862E-01 | 1.700E-01 | 1.654E-01 | 1.745E-07 | 7.373E-08 | 3.761E-07 | 2.341E-01 | 1.615E-01 |
| 792.00 | 9.607E+01 | 7.386E+01 | 7.823E+01 | 1.975E-01 | 1.763E-01 | 1.699E-01 | 1.953E-07 | 1.032E-07 | 4.279E-07 | 2.481E-01 | 1.663E-01 |
| 852.00 | 1.069E+02 | 8.183E+01 | 8.639E+01 | 2.089E-01 | 1.818E-01 | 1.738E-01 | 2.243E-07 | 1.486E-07 | 5.087E-07 | 2.613E-01 | 1.710E-01 |
| 912.00 | 1.184E+02 | 9.036E+01 | 9.455E+01 | 2.201E-01 | 1.866E-01 | 1.771E-01 | 2.582E-07 | 2.077E-07 | 6.180E-07 | 2.731E-01 | 1.758E-01 |
| 972.00 | 1.302E+02 | 1.003E+02 | 1.024E+02 | 2.257E-01 | 1.907E-01 | 1.789E-01 | 3.201E-07 | 3.146E-07 | 8.388E-07 | 2.803E-01 | 1.807E-01 |
| 1032.00 | 1.416E+02 | 1.103E+02 | 1.103E+02 | 2.329E-01 | 1.945E-01 | 1.805E-01 | 3.609E-07 | 4.061E-07 | 1.031E-06 | 2.856E-01 | 1.851E-01 |
| 1092.00 | 1.521E+02 | 1.212E+02 | 1.180E+02 | 2.376E-01 | 1.985E-01 | 1.814E-01 | 3.956E-07 | 5.036E-07 | 1.259E-06 | 2.862E-01 | 1.890E-01 |
| 1152.00 | 1.598E+02 | 1.344E+02 | 1.252E+02 | 2.307E-01 | 2.036E-01 | 1.808E-01 | 4.340E-07 | 6.328E-07 | 1.624E-06 | 2.750E-01 | 1.913E-01 |
| 1212.00 | 1.662E+02 | 1.459E+02 | 1.327E+02 | 2.299E-01 | 2.094E-01 | 1.806E-01 | 4.367E-07 | 6.943E-07 | 1.875E-06 | 2.651E-01 | 1.905E-01 |
| 1272.00 | 1.676E+02 | 1.594E+02 | 1.398E+02 | 2.143E-01 | 2.191E-01 | 1.795E-01 | 4.241E-07 | 7.332E-07 | 2.274E-06 | 2.407E-01 | 1.862E-01 |
| 1332.00 | 1.679E+02 | 1.700E+02 | 1.470E+02 | 2.022E-01 | 2.294E-01 | 1.787E-01 | 3.815E-07 | 6.966E-07 | 2.525E-06 | 2.252E-01 | 1.912E-01 |
| 1392.00 | 1.677E+02 | 1.774E+02 | 1.537E+02 | 1.939E-01 | 2.397E-01 | 1.784E-01 | 3.111E-07 | 5.686E-07 | 2.639E-06 | 2.176E-01 | 2.128E-01 |
| 1432.00 | 1.674E+02 | 1.812E+02 | 1.579E+02 | 1.918E-01 | 2.470E-01 | 1.785E-01 | 2.582E-07 | 4.391E-07 | 2.657E-06 | 2.144E-01 | 2.335E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.838E-15 | 3.838E-15 |
| 312.00 | 2.190E+01 | 2.103E+01 | 2.100E+01 | 1.240E-01 | 1.156E-01 | 1.155E-01 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 4.854E-06 | 6.580E-06 |
| 312.00 | 3.798E+01 | 9.633E+01 | 2.100E+01 | 1.426E-01 | 1.177E-01 | 1.157E-01 | 3.537E-09 | 1.746E-07 | 6.491E-07 | 5.024E-06 | 1.490E-05 |
| 372.00 | 2.187E+01 | 4.854E+01 | 2.717E+01 | 1.199E-01 | 1.234E-01 | 1.248E-01 | 1.243E-08 | 6.947E-08 | 2.461E-07 | 5.631E-06 | 1.025E-05 |
| 432.00 | 2.777E+01 | 5.228E+01 | 3.376E+01 | 1.319E-01 | 1.316E-01 | 1.330E-01 | 1.491E-08 | 6.657E-08 | 2.298E-07 | 6.300E-06 | 1.077E-05 |
| 492.00 | 3.509E+01 | 5.686E+01 | 4.071E+01 | 1.443E-01 | 1.389E-01 | 1.400E-01 | 1.727E-08 | 7.009E-08 | 2.275E-07 | 7.014E-06 | 1.006E-05 |
| 552.00 | 4.345E+01 | 6.169E+01 | 4.796E+01 | 1.571E-01 | 1.453E-01 | 1.460E-01 | 1.935E-08 | 8.268E-08 | 2.346E-07 | 7.772E-06 | 8.730E-06 |
| 612.00 | 5.274E+01 | 6.677E+01 | 5.544E+01 | 1.701E-01 | 1.512E-01 | 1.512E-01 | 2.115E-08 | 1.087E-07 | 2.530E-07 | 8.575E-06 | 7.467E-06 |
| 672.00 | 6.340E+01 | 7.286E+01 | 6.316E+01 | 1.848E-01 | 1.565E-01 | 1.556E-01 | 2.635E-08 | 1.975E-07 | 3.371E-07 | 9.433E-06 | 6.609E-06 |
| 732.00 | 7.458E+01 | 7.831E+01 | 7.097E+01 | 1.987E-01 | 1.615E-01 | 1.592E-01 | 2.357E-08 | 2.321E-07 | 3.507E-07 | 1.035E-05 | 6.000E-06 |
| 792.00 | 8.645E+01 | 8.431E+01 | 7.887E+01 | 2.122E-01 | 1.663E-01 | 1.622E-01 | 2.498E-08 | 2.935E-07 | 3.811E-07 | 1.135E-05 | 5.705E-06 |
| 852.00 | 9.892E+01 | 9.092E+01 | 8.685E+01 | 2.250E-01 | 1.709E-01 | 1.646E-01 | 3.008E-08 | 3.861E-07 | 4.256E-07 | 1.244E-05 | 5.667E-06 |
| 912.00 | 1.118E+02 | 9.813E+01 | 9.490E+01 | 2.368E-01 | 1.756E-01 | 1.665E-01 | 3.947E-08 | 5.130E-07 | 4.765E-07 | 1.364E-05 | 5.865E-06 |
| 972.00 | 1.239E+02 | 1.070E+02 | 1.033E+02 | 2.419E-01 | 1.804E-01 | 1.682E-01 | 5.291E-08 | 7.572E-07 | 5.735E-07 | 1.487E-05 | 6.375E-06 |
| 1032.00 | 1.361E+02 | 1.154E+02 | 1.120E+02 | 2.482E-01 | 1.848E-01 | 1.701E-01 | 7.645E-08 | 9.998E-07 | 5.944E-07 | 1.638E-05 | 7.234E-06 |
| 1092.00 | 1.472E+02 | 1.239E+02 | 1.214E+02 | 2.513E-01 | 1.886E-01 | 1.732E-01 | 1.058E-07 | 1.294E-06 | 5.560E-07 | 1.805E-05 | 8.631E-06 |
| 1152.00 | 1.549E+02 | 1.327E+02 | 1.330E+02 | 2.425E-01 | 1.909E-01 | 1.793E-01 | 1.339E-07 | 1.730E-06 | 4.643E-07 | 1.947E-05 | 1.092E-05 |
| 1212.00 | 1.619E+02 | 1.388E+02 | 1.451E+02 | 2.399E-01 | 1.900E-01 | 1.889E-01 | 1.681E-07 | 2.029E-06 | 2.065E-07 | 2.147E-05 | 1.415E-05 |
| 1272.00 | 1.631E+02 | 1.440E+02 | 1.603E+02 | 2.228E-01 | 1.854E-01 | 2.052E-01 | 1.838E-07 | 2.415E-06 | 1.436E-07 | 2.275E-05 | 1.909E-05 |
| 1332.00 | 1.636E+02 | 1.526E+02 | 1.693E+02 | 2.097E-01 | 1.896E-01 | 2.134E-01 | 1.945E-07 | 2.639E-06 | 5.644E-08 | 2.537E-05 | 2.395E-05 |
| 1392.00 | 1.642E+02 | 1.667E+02 | 1.689E+02 | 1.999E-01 | 2.112E-01 | 2.058E-01 | 1.825E-07 | 2.560E-06 | 8.908E-07 | 3.025E-05 | 2.814E-05 |
| 1432.00 | 1.646E+02 | 1.759E+02 | 1.666E+02 | 1.966E-01 | 2.299E-01 | 1.953E-01 | 1.622E-07 | 2.255E-06 | 1.486E-06 | 3.416E-05 | 3.066E-05 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)
7.818E-10 4.311E-10 5.107E-09 7.325E-03

GROUP 2 ACCELEROMETER BIAS

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 6.348E+03 | 1.079E+03 | 1.203E+03 | 2.790E+00 | 6.565E+00 | 2.482E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 4.171E-01 | 1.167E+00 |
| 312.00 | 5.170E+03 | 2.828E+03 | 4.425E+02 | 4.626E+00 | 4.666E+00 | 2.572E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 6.113E-01 | 1.031E+00 |
| 312.00 | 5.659E+03 | 3.531E+03 | 3.521E+02 | 4.879E+00 | 5.496E+00 | 2.846E+00 | 2.641E-06 | 8.532E-07 | 5.402E-06 | 6.330E-01 | 7.315E-01 |
| 372.00 | 5.416E+03 | 3.942E+03 | 2.384E+02 | 5.236E+00 | 5.149E+00 | 2.882E+00 | 2.697E-06 | 8.440E-07 | 5.472E-06 | 6.975E-01 | 7.442E-01 |
| 432.00 | 5.100E+03 | 4.249E+03 | 2.369E+02 | 5.517E+00 | 4.682E+00 | 2.874E+00 | 2.489E-06 | 7.580E-07 | 5.050E-06 | 7.490E-01 | 8.012E-01 |
| 492.00 | 4.767E+03 | 4.527E+03 | 3.397E+02 | 5.758E+00 | 4.195E+00 | 2.857E+00 | 2.312E-06 | 6.747E-07 | 4.690E-06 | 8.026E-01 | 8.597E-01 |
| 552.00 | 4.419E+03 | 4.772E+03 | 4.826E+02 | 5.954E+00 | 3.697E+00 | 2.831E+00 | 2.161E-06 | 5.848E-07 | 4.378E-06 | 8.605E-01 | 9.332E-01 |
| 612.00 | 4.061E+03 | 4.985E+03 | 6.372E+02 | 6.106E+00 | 3.198E+00 | 2.797E+00 | 2.036E-06 | 4.910E-07 | 4.114E-06 | 9.231E-01 | 1.021E+00 |
| 672.00 | 3.695E+03 | 5.162E+03 | 7.949E+02 | 6.213E+00 | 2.707E+00 | 2.758E+00 | 1.912E-06 | 4.187E-07 | 3.848E-06 | 9.922E-01 | 1.121E+00 |
| 732.00 | 3.324E+03 | 5.307E+03 | 9.525E+02 | 6.276E+00 | 2.242E+00 | 2.713E+00 | 1.799E-06 | 3.984E-07 | 3.618E-06 | 1.071E+00 | 1.230E+00 |
| 792.00 | 2.951E+03 | 5.419E+03 | 1.108E+03 | 6.297E+00 | 1.827E+00 | 2.662E+00 | 1.694E-06 | 4.700E-07 | 3.419E-06 | 1.166E+00 | 1.344E+00 |
| 852.00 | 2.579E+03 | 5.496E+03 | 1.261E+03 | 6.275E+00 | 1.503E+00 | 2.606E+00 | 1.593E-06 | 6.319E-07 | 3.253E-06 | 1.284E+00 | 1.458E+00 |
| 912.00 | 2.213E+03 | 5.538E+03 | 1.408E+03 | 6.206E+00 | 1.335E+00 | 2.544E+00 | 1.492E-06 | 8.593E-07 | 3.128E-06 | 1.436E+00 | 1.568E+00 |
| 972.00 | 1.856E+03 | 5.556E+03 | 1.551E+03 | 6.104E+00 | 1.366E+00 | 2.475E+00 | 1.524E-06 | 1.230E-06 | 3.496E-06 | 1.639E+00 | 1.661E+00 |
| 1032.00 | 1.515E+03 | 5.523E+03 | 1.683E+03 | 5.925E+00 | 1.576E+00 | 2.392E+00 | 1.452E-06 | 1.588E-06 | 3.680E-06 | 1.909E+00 | 1.728E+00 |
| 1092.00 | 1.200E+03 | 5.449E+03 | 1.804E+03 | 5.683E+00 | 1.881E+00 | 2.300E+00 | 1.402E-06 | 1.999E-06 | 4.176E-06 | 2.235E+00 | 1.740E+00 |
| 1152.00 | 9.238E+02 | 5.337E+03 | 1.908E+03 | 5.380E+00 | 2.218E+00 | 2.195E+00 | 1.425E-06 | 2.539E-06 | 5.444E-06 | 2.586E+00 | 1.698E+00 |
| 1212.00 | 7.095E+02 | 5.180E+03 | 1.997E+03 | 5.012E+00 | 2.545E+00 | 2.090E+00 | 1.386E-06 | 2.912E-06 | 6.746E-06 | 2.914E+00 | 1.628E+00 |
| 1272.00 | 5.680E+02 | 4.992E+03 | 2.066E+03 | 4.590E+00 | 2.841E+00 | 1.981E+00 | 1.337E-06 | 3.169E-06 | 8.908E-06 | 3.156E+00 | 1.624E+00 |
| 1332.00 | 5.140E+02 | 4.769E+03 | 2.120E+03 | 4.177E+00 | 3.078E+00 | 1.890E+00 | 1.203E-06 | 3.066E-06 | 1.112E-05 | 2.929E+00 | 1.647E+00 |
| 1392.00 | 5.218E+02 | 4.571E+03 | 2.186E+03 | 3.914E+00 | 3.293E+00 | 1.828E+00 | 1.011E-06 | 2.381E-06 | 1.233E-05 | 2.645E+00 | 1.695E+00 |
| 1432.00 | 5.558E+02 | 4.443E+03 | 2.231E+03 | 3.754E+00 | 3.431E+00 | 1.792E+00 | 9.161E-07 | 1.680E-06 | 1.275E-05 | 2.569E+00 | 1.905E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 8.202E+02 | 6.494E+03 | 2.416E+02 | 7.431E+00 | 1.298E+00 | 3.616E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.555E-05 | 2.073E-04 |
| 312.00 | 8.998E+02 | 5.834E+03 | 2.639E+02 | 6.952E+00 | 1.125E+00 | 4.458E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 2.378E-05 | 8.418E-04 |
| 312.00 | 5.714E+02 | 6.650E+03 | 2.651E+02 | 7.824E+00 | 8.316E-01 | 4.521E-01 | 3.195E-08 | 1.533E-06 | 5.877E-06 | 2.455E-05 | 9.586E-04 |
| 372.00 | 5.488E+02 | 6.676E+03 | 2.722E+02 | 7.832E+00 | 7.980E-01 | 5.067E-01 | 1.484E-07 | 1.582E-06 | 5.951E-06 | 2.733E-05 | 1.173E-03 |
| 432.00 | 5.584E+02 | 6.612E+03 | 2.892E+02 | 7.722E+00 | 8.195E-01 | 5.685E-01 | 2.320E-07 | 1.516E-06 | 5.469E-06 | 2.985E-05 | 1.226E-03 |
| 492.00 | 5.644E+02 | 6.549E+03 | 3.455E+02 | 7.600E+00 | 8.603E-01 | 6.373E-01 | 3.011E-07 | 1.494E-06 | 5.047E-06 | 3.261E-05 | 1.091E-03 |
| 552.00 | 5.684E+02 | 6.482E+03 | 4.400E+02 | 7.466E+00 | 9.384E-01 | 7.125E-01 | 3.590E-07 | 1.501E-06 | 4.669E-06 | 3.573E-05 | 8.711E-04 |
| 612.00 | 5.708E+02 | 6.411E+03 | 5.611E+02 | 7.325E+00 | 1.025E+00 | 7.945E-01 | 4.091E-07 | 1.540E-06 | 4.333E-06 | 3.924E-05 | 6.676E-04 |
| 672.00 | 5.730E+02 | 6.333E+03 | 7.024E+02 | 7.175E+00 | 1.126E+00 | 8.842E-01 | 4.565E-07 | 1.582E-06 | 3.991E-06 | 4.326E-05 | 5.133E-04 |
| 732.00 | 5.737E+02 | 6.248E+03 | 8.659E+02 | 7.020E+00 | 1.235E+00 | 9.840E-01 | 4.998E-07 | 1.657E-06 | 3.673E-06 | 4.812E-05 | 4.047E-04 |
| 792.00 | 5.729E+02 | 6.152E+03 | 1.058E+03 | 6.860E+00 | 1.350E+00 | 1.097E+00 | 5.395E-07 | 1.777E-06 | 3.366E-06 | 5.416E-05 | 3.302E-04 |
| 852.00 | 5.704E+02 | 6.038E+03 | 1.293E+03 | 6.691E+00 | 1.467E+00 | 1.228E+00 | 5.757E-07 | 1.960E-06 | 3.057E-06 | 6.202E-05 | 2.801E-04 |
| 912.00 | 5.659E+02 | 5.891E+03 | 1.589E+03 | 6.508E+00 | 1.579E+00 | 1.385E+00 | 6.077E-07 | 2.223E-06 | 2.727E-06 | 7.269E-05 | 2.481E-04 |
| 972.00 | 5.547E+02 | 5.700E+03 | 1.979E+03 | 6.321E+00 | 1.676E+00 | 1.580E+00 | 6.284E-07 | 2.979E-06 | 2.604E-06 | 8.789E-05 | 2.311E-04 |
| 1032.00 | 5.446E+02 | 5.400E+03 | 2.485E+03 | 6.079E+00 | 1.737E+00 | 1.826E+00 | 6.643E-07 | 3.609E-06 | 2.171E-06 | 1.101E-04 | 2.276E-04 |
| 1092.00 | 5.346E+02 | 4.964E+03 | 3.075E+03 | 5.792E+00 | 1.748E+00 | 2.126E+00 | 6.971E-07 | 4.497E-06 | 1.643E-06 | 1.406E-04 | 2.373E-04 |
| 1152.00 | 5.238E+02 | 4.371E+03 | 3.688E+03 | 5.455E+00 | 1.701E+00 | 2.461E+00 | 7.200E-07 | 6.040E-06 | 1.056E-06 | 1.802E-04 | 2.609E-04 |
| 1212.00 | 5.308E+02 | 3.616E+03 | 4.239E+03 | 5.053E+00 | 1.623E+00 | 2.792E+00 | 7.644E-07 | 7.424E-06 | 4.600E-07 | 2.282E-04 | 2.965E-04 |
| 1272.00 | 5.430E+02 | 2.748E+03 | 4.655E+03 | 4.595E+00 | 1.601E+00 | 3.063E+00 | 7.851E-07 | 9.368E-06 | 1.676E-06 | 2.812E-04 | 3.417E-04 |
| 1332.00 | 5.698E+02 | 2.765E+03 | 4.420E+03 | 4.150E+00 | 1.605E+00 | 3.271E+00 | 8.538E-07 | 1.151E-05 | 1.165E-06 | 3.077E-04 | 4.037E-04 |
| 1392.00 | 6.124E+02 | 3.525E+03 | 3.626E+03 | 3.877E+00 | 1.692E+00 | 3.407E+00 | 8.867E-07 | 1.230E-05 | 2.584E-06 | 3.520E-04 | 5.031E-04 |
| 1432.00 | 6.478E+02 | 3.951E+03 | 3.000E+03 | 3.722E+00 | 1.934E+00 | 3.388E+00 | 9.172E-07 | 1.167E-05 | 5.396E-06 | 4.088E-04 | 5.768E-04 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

4.945E-09 2.639E-09 3.261E-08 2.930E-02

GROUP 3 ACCELEROMETER SCALE FACTOR

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 1.446E+04 | 5.747E+03 | 1.536E+03 | 2.820E+00 | 1.606E+01 | 4.982E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 2.020E+00 | 1.206E+00 |
| 312.00 | 1.243E+04 | 1.053E+04 | 1.974E+02 | 1.009E+01 | 1.401E+01 | 5.836E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.875E+00 | 4.661E-01 |
| 312.00 | 1.176E+04 | 9.524E+03 | 6.237E+01 | 9.745E+00 | 1.285E+01 | 5.469E+00 | 3.594E-06 | 1.161E-06 | 7.350E-06 | 1.671E+00 | 1.794E-01 |
| 372.00 | 1.110E+04 | 1.021E+04 | 3.454E+02 | 1.088E+01 | 1.201E+01 | 5.491E+00 | 3.460E-06 | 1.067E-06 | 6.944E-06 | 1.401E+00 | 3.423E-01 |
| 432.00 | 1.042E+04 | 1.092E+04 | 6.763E+02 | 1.199E+01 | 1.115E+01 | 5.511E+00 | 3.101E-06 | 9.213E-07 | 6.143E-06 | 9.999E-01 | 5.617E-01 |
| 492.00 | 9.672E+03 | 1.157E+04 | 1.006E+03 | 1.302E+01 | 1.020E+01 | 5.500E+00 | 2.818E-06 | 8.113E-07 | 5.542E-06 | 5.222E-01 | 7.501E-01 |
| 552.00 | 8.861E+03 | 1.214E+04 | 1.334E+03 | 1.397E+01 | 9.173E+00 | 5.462E+00 | 2.601E-06 | 7.077E-07 | 5.094E-06 | 2.112E-01 | 9.427E-01 |
| 612.00 | 7.993E+03 | 1.265E+04 | 1.658E+03 | 1.485E+01 | 8.076E+00 | 5.401E+00 | 2.473E-06 | 5.768E-07 | 4.836E-06 | 7.278E-01 | 1.145E+00 |
| 672.00 | 7.075E+03 | 1.308E+04 | 1.978E+03 | 1.565E+01 | 6.928E+00 | 5.321E+00 | 2.417E-06 | 4.028E-07 | 4.724E-06 | 1.409E+00 | 1.355E+00 |
| 732.00 | 6.109E+03 | 1.343E+04 | 2.291E+03 | 1.638E+01 | 5.735E+00 | 5.220E+00 | 2.506E-06 | 1.475E-07 | 4.940E-06 | 2.185E+00 | 1.571E+00 |
| 792.00 | 5.099E+03 | 1.369E+04 | 2.595E+03 | 1.702E+01 | 4.509E+00 | 5.099E+00 | 2.770E-06 | 4.094E-07 | 5.605E-06 | 3.066E+00 | 1.788E+00 |
| 852.00 | 4.052E+03 | 1.385E+04 | 2.886E+03 | 1.758E+01 | 3.261E+00 | 4.956E+00 | 3.231E-06 | 1.146E-06 | 6.874E-06 | 4.076E+00 | 1.991E+00 |
| 912.00 | 2.974E+03 | 1.390E+04 | 3.159E+03 | 1.804E+01 | 2.011E+00 | 4.789E+00 | 3.894E-06 | 2.241E-06 | 8.929E-06 | 5.243E+00 | 2.172E+00 |
| 972.00 | 1.879E+03 | 1.377E+04 | 3.397E+03 | 1.833E+01 | 8.235E-01 | 4.571E+00 | 5.067E-06 | 4.212E-06 | 1.301E-05 | 6.572E+00 | 2.272E+00 |
| 1032.00 | 7.888E+02 | 1.351E+04 | 3.601E+03 | 1.850E+01 | 7.086E-01 | 4.327E+00 | 6.211E-06 | 6.489E-06 | 1.792E-05 | 8.155E+00 | 2.335E+00 |
| 1092.00 | 2.714E+02 | 1.309E+04 | 3.753E+03 | 1.849E+01 | 1.781E+00 | 4.040E+00 | 7.417E-06 | 9.322E-06 | 2.462E-05 | 9.855E+00 | 2.159E+00 |
| 1152.00 | 1.241E+03 | 1.242E+04 | 3.814E+03 | 1.809E+01 | 2.808E+00 | 3.670E+00 | 8.771E-06 | 1.315E-05 | 3.528E-05 | 1.140E+01 | 1.733E+00 |
| 1212.00 | 2.122E+03 | 1.168E+04 | 3.830E+03 | 1.763E+01 | 3.726E+00 | 3.315E+00 | 9.401E-06 | 1.589E-05 | 4.553E-05 | 1.284E+01 | 9.812E-01 |
| 1272.00 | 2.812E+03 | 1.071E+04 | 3.735E+03 | 1.666E+01 | 4.401E+00 | 2.914E+00 | 9.483E-06 | 1.786E-05 | 6.021E-05 | 1.363E+01 | 3.587E-01 |
| 1332.00 | 3.345E+03 | 9.735E+03 | 3.605E+03 | 1.548E+01 | 4.895E+00 | 2.553E+00 | 8.431E-06 | 1.743E-05 | 7.361E-05 | 1.292E+01 | 4.270E-01 |
| 1392.00 | 3.859E+03 | 8.934E+03 | 3.534E+03 | 1.467E+01 | 5.398E+00 | 2.333E+00 | 6.229E-06 | 1.326E-05 | 8.038E-05 | 1.204E+01 | 1.398E+00 |
| 1432.00 | 4.182E+03 | 8.445E+03 | 3.507E+03 | 1.428E+01 | 5.709E+00 | 2.241E+00 | 4.493E-06 | 8.695E-06 | 8.247E-05 | 1.181E+01 | 2.360E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 1.810E+03 | 1.552E+04 | 4.356E+02 | 1.699E+01 | 9.156E-01 | 1.026E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 7.835E-05 | 4.880E-04 |
| 312.00 | 1.186E+03 | 1.625E+04 | 1.326E+02 | 1.818E+01 | 2.848E-01 | 1.134E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 7.217E-05 | 2.307E-03 |
| 312.00 | 7.394E+02 | 1.511E+04 | 1.302E+02 | 1.699E+01 | 3.493E-01 | 1.045E+00 | 4.347E-08 | 2.146E-06 | 7.980E-06 | 6.406E-05 | 2.146E-03 |
| 372.00 | 6.243E+02 | 1.507E+04 | 1.460E+02 | 1.707E+01 | 4.820E-01 | 1.040E+00 | 2.076E-07 | 2.064E-06 | 7.552E-06 | 5.410E-05 | 2.615E-03 |
| 432.00 | 5.596E+02 | 1.510E+04 | 2.967E+02 | 1.724E+01 | 6.169E-01 | 1.018E+00 | 3.291E-07 | 1.891E-06 | 6.672E-06 | 3.921E-05 | 2.769E-03 |
| 492.00 | 5.143E+02 | 1.509E+04 | 5.368E+02 | 1.739E+01 | 7.794E-01 | 9.603E-01 | 4.233E-07 | 1.781E-06 | 5.997E-06 | 2.086E-05 | 2.491E-03 |
| 552.00 | 4.969E+02 | 1.506E+04 | 8.133E+02 | 1.754E+01 | 9.627E-01 | 8.626E-01 | 4.927E-07 | 1.722E-06 | 5.477E-06 | 8.658E-06 | 2.005E-03 |
| 612.00 | 5.120E+02 | 1.500E+04 | 1.116E+03 | 1.769E+01 | 1.163E+00 | 7.220E-01 | 5.383E-07 | 1.767E-06 | 5.140E-06 | 3.051E-05 | 1.544E-03 |
| 672.00 | 5.662E+02 | 1.492E+04 | 1.448E+03 | 1.786E+01 | 1.376E+00 | 5.362E-01 | 5.730E-07 | 1.923E-06 | 4.929E-06 | 6.060E-05 | 1.190E-03 |
| 732.00 | 6.621E+02 | 1.481E+04 | 1.821E+03 | 1.805E+01 | 1.598E+00 | 3.042E-01 | 5.952E-07 | 2.344E-06 | 4.986E-06 | 9.673E-05 | 9.367E-04 |
| 792.00 | 8.049E+02 | 1.465E+04 | 2.255E+03 | 1.824E+01 | 1.825E+00 | 1.156E-01 | 6.182E-07 | 3.172E-06 | 5.367E-06 | 1.404E-04 | 7.599E-04 |
| 852.00 | 9.997E+02 | 1.442E+04 | 2.781E+03 | 1.844E+01 | 2.046E+00 | 4.132E-01 | 6.639E-07 | 4.595E-06 | 6.119E-06 | 1.943E-04 | 6.384E-04 |
| 912.00 | 1.252E+03 | 1.409E+04 | 3.441E+03 | 1.862E+01 | 2.244E+00 | 8.733E-01 | 7.607E-07 | 6.857E-06 | 7.234E-06 | 2.623E-04 | 5.581E-04 |
| 972.00 | 1.554E+03 | 1.356E+04 | 4.283E+03 | 1.870E+01 | 2.384E+00 | 1.448E+00 | 9.209E-07 | 1.125E-05 | 9.231E-06 | 3.493E-04 | 5.091E-04 |
| 1032.00 | 1.923E+03 | 1.279E+04 | 5.379E+03 | 1.874E+01 | 2.413E+00 | 2.174E+00 | 1.252E-06 | 1.694E-05 | 1.064E-05 | 4.682E-04 | 4.931E-04 |
| 1092.00 | 2.350E+03 | 1.167E+04 | 6.618E+03 | 1.863E+01 | 2.253E+00 | 3.029E+00 | 1.722E-06 | 2.489E-05 | 1.120E-05 | 6.225E-04 | 5.069E-04 |
| 1152.00 | 2.784E+03 | 1.010E+04 | 7.782E+03 | 1.817E+01 | 1.821E+00 | 3.908E+00 | 2.218E-06 | 3.713E-05 | 1.053E-05 | 8.077E-04 | 5.468E-04 |
| 1212.00 | 3.259E+03 | 8.222E+03 | 8.790E+03 | 1.765E+01 | 1.095E+00 | 4.778E+00 | 2.861E-06 | 4.870E-05 | 5.827E-06 | 1.041E-03 | 6.189E-04 |
| 1272.00 | 3.649E+03 | 5.998E+03 | 9.343E+03 | 1.663E+01 | 2.681E-01 | 5.366E+00 | 3.111E-06 | 6.340E-05 | 2.207E-06 | 1.289E-03 | 7.027E-04 |
| 1332.00 | 3.976E+03 | 5.903E+03 | 8.265E+03 | 1.540E+01 | 2.647E-01 | 5.749E+00 | 2.968E-06 | 7.597E-05 | 3.617E-06 | 1.460E-03 | 8.113E-04 |
| 1392.00 | 4.303E+03 | 7.045E+03 | 5.767E+03 | 1.457E+01 | 1.641E+00 | 5.898E+00 | 2.319E-06 | 7.576E-05 | 3.049E-08 | 1.687E-03 | 9.656E-04 |
| 1432.00 | 4.515E+03 | 8.119E+03 | 3.848E+03 | 1.419E+01 | 2.852E+00 | 5.649E+00 | 1.499E-06 | 6.662E-05 | 4.956E-05 | 1.929E-03 | 1.040E-03 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

2.891E-08 1.542E-08 1.905E-07 2.009E-01

GROUP 6 ACCELEROMETER MISALIGNMENTS

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 4.622E+03 | 1.247E+03 | 2.043E+03 | 3.765E+00 | 4.295E+00 | 2.152E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.961E-01 | 2.673E+00 |
| 312.00 | 3.296E+03 | 1.052E+03 | 1.517E+03 | 4.470E+00 | 1.836E+00 | 1.833E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.106E+00 | 2.504E+00 |
| 312.00 | 4.467E+03 | 1.987E+03 | 1.393E+03 | 5.065E+00 | 3.809E+00 | 2.390E+00 | 6.187E-06 | 1.999E-06 | 1.265E-05 | 7.883E-01 | 1.752E+00 |
| 372.00 | 4.283E+03 | 2.365E+03 | 1.276E+03 | 5.333E+00 | 3.577E+00 | 2.427E+00 | 6.238E-06 | 1.942E-06 | 1.261E-05 | 9.231E-01 | 1.664E+00 |
| 432.00 | 3.956E+03 | 2.554E+03 | 1.174E+03 | 5.494E+00 | 3.125E+00 | 2.398E+00 | 5.678E-06 | 1.712E-06 | 1.140E-05 | 1.122E+00 | 1.653E+00 |
| 492.00 | 3.624E+03 | 2.725E+03 | 1.076E+03 | 5.629E+00 | 2.686E+00 | 2.375E+00 | 5.185E-06 | 1.513E-06 | 1.036E-05 | 1.334E+00 | 1.621E+00 |
| 552.00 | 3.284E+03 | 2.867E+03 | 9.837E+02 | 5.728E+00 | 2.259E+00 | 2.354E+00 | 4.726E-06 | 1.333E-06 | 9.381E-06 | 1.549E+00 | 1.580E+00 |
| 612.00 | 2.938E+03 | 2.981E+03 | 8.983E+02 | 5.795E+00 | 1.849E+00 | 2.337E+00 | 4.284E-06 | 1.181E-06 | 8.445E-06 | 1.765E+00 | 1.533E+00 |
| 672.00 | 2.589E+03 | 3.069E+03 | 8.218E+02 | 5.833E+00 | 1.463E+00 | 2.324E+00 | 3.844E-06 | 1.076E-06 | 7.520E-06 | 1.982E+00 | 1.481E+00 |
| 732.00 | 2.239E+03 | 3.128E+03 | 7.568E+02 | 5.845E+00 | 1.107E+00 | 2.313E+00 | 3.383E-06 | 1.043E-06 | 6.551E-06 | 2.201E+00 | 1.424E+00 |
| 792.00 | 1.890E+03 | 3.157E+03 | 7.063E+02 | 5.832E+00 | 7.963E-01 | 2.305E+00 | 2.896E-06 | 1.110E-06 | 5.501E-06 | 2.426E+00 | 1.365E+00 |
| 852.00 | 1.546E+03 | 3.155E+03 | 6.727E+02 | 5.797E+00 | 5.753E-01 | 2.297E+00 | 2.385E-06 | 1.307E-06 | 4.353E-06 | 2.661E+00 | 1.305E+00 |
| 912.00 | 1.211E+03 | 3.119E+03 | 6.570E+02 | 5.737E+00 | 5.291E-01 | 2.290E+00 | 1.873E-06 | 1.655E-06 | 3.173E-06 | 2.911E+00 | 1.250E+00 |
| 972.00 | 8.978E+02 | 3.053E+03 | 6.596E+02 | 5.658E+00 | 6.663E-01 | 2.287E+00 | 1.498E-06 | 2.129E-06 | 2.620E-06 | 3.184E+00 | 1.211E+00 |
| 1032.00 | 6.321E+02 | 2.942E+03 | 6.737E+02 | 5.528E+00 | 8.856E-01 | 2.291E+00 | 1.231E-06 | 2.845E-06 | 3.212E-06 | 3.470E+00 | 1.237E+00 |
| 1092.00 | 4.751E+02 | 2.795E+03 | 6.974E+02 | 5.352E+00 | 1.114E+00 | 2.312E+00 | 1.264E-06 | 3.686E-06 | 5.205E-06 | 3.743E+00 | 1.342E+00 |
| 1152.00 | 4.889E+02 | 2.607E+03 | 7.261E+02 | 5.090E+00 | 1.319E+00 | 2.349E+00 | 1.540E-06 | 4.681E-06 | 8.343E-06 | 3.936E+00 | 1.566E+00 |
| 1212.00 | 6.214E+02 | 2.407E+03 | 7.665E+02 | 4.799E+00 | 1.493E+00 | 2.410E+00 | 1.733E-06 | 5.385E-06 | 1.143E-05 | 4.054E+00 | 1.887E+00 |
| 1272.00 | 7.622E+02 | 2.184E+03 | 8.155E+02 | 4.402E+00 | 1.623E+00 | 2.475E+00 | 1.799E-06 | 5.802E-06 | 1.540E-05 | 3.999E+00 | 2.246E+00 |
| 1332.00 | 8.806E+02 | 1.972E+03 | 8.834E+02 | 3.942E+00 | 1.718E+00 | 2.448E+00 | 1.593E-06 | 5.575E-06 | 1.887E-05 | 3.632E+00 | 2.232E+00 |
| 1392.00 | 9.904E+02 | 1.809E+03 | 9.723E+02 | 3.561E+00 | 1.833E+00 | 2.366E+00 | 1.140E-06 | 4.408E-06 | 2.059E-05 | 3.241E+00 | 1.853E+00 |
| 1432.00 | 1.056E+03 | 1.717E+03 | 1.037E+03 | 3.359E+00 | 1.912E+00 | 2.328E+00 | 8.302E-07 | 3.219E-06 | 2.107E-05 | 3.063E+00 | 1.564E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 2.297E+03 | 4.427E+03 | 1.488E+03 | 5.435E+00 | 2.771E+00 | 1.720E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 8.973E-06 | 1.562E-04 |
| 312.00 | 2.123E+03 | 2.807E+03 | 1.373E+03 | 4.436E+00 | 2.571E+00 | 6.491E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 4.456E-05 | 3.803E-04 |
| 312.00 | 1.354E+03 | 4.704E+03 | 1.373E+03 | 6.477E+00 | 1.852E+00 | 7.019E-01 | 7.483E-08 | 3.590E-06 | 1.377E-05 | 3.172E-05 | 6.594E-04 |
| 372.00 | 1.228E+03 | 4.720E+03 | 1.332E+03 | 6.594E+00 | 1.723E+00 | 8.167E-01 | 3.541E-07 | 3.664E-06 | 1.371E-05 | 3.682E-05 | 8.160E-04 |
| 432.00 | 1.173E+03 | 4.528E+03 | 1.294E+03 | 6.484E+00 | 1.675E+00 | 9.230E-01 | 5.600E-07 | 3.465E-06 | 1.237E-05 | 4.493E-05 | 8.427E-04 |
| 492.00 | 1.102E+03 | 4.348E+03 | 1.260E+03 | 6.388E+00 | 1.632E+00 | 1.029E+00 | 7.313E-07 | 3.337E-06 | 1.117E-05 | 5.431E-05 | 7.497E-04 |
| 552.00 | 1.021E+03 | 4.173E+03 | 1.230E+03 | 6.296E+00 | 1.587E+00 | 1.137E+00 | 8.757E-07 | 3.212E-06 | 1.005E-05 | 6.440E-05 | 6.041E-04 |
| 612.00 | 9.296E+02 | 4.002E+03 | 1.203E+03 | 6.208E+00 | 1.539E+00 | 1.247E+00 | 9.982E-07 | 3.060E-06 | 8.983E-06 | 7.509E-05 | 4.715E-04 |
| 672.00 | 8.282E+02 | 3.836E+03 | 1.182E+03 | 6.124E+00 | 1.488E+00 | 1.359E+00 | 1.101E-06 | 2.855E-06 | 7.945E-06 | 8.651E-05 | 3.723E-04 |
| 732.00 | 7.187E+02 | 3.672E+03 | 1.170E+03 | 6.043E+00 | 1.433E+00 | 1.472E+00 | 1.184E-06 | 2.559E-06 | 6.892E-06 | 9.892E-05 | 3.030E-04 |
| 792.00 | 6.035E+02 | 3.506E+03 | 1.174E+03 | 5.962E+00 | 1.377E+00 | 1.588E+00 | 1.245E-06 | 2.151E-06 | 5.805E-06 | 1.127E-04 | 2.559E-04 |
| 852.00 | 4.887E+02 | 3.333E+03 | 1.202E+03 | 5.878E+00 | 1.321E+00 | 1.706E+00 | 1.277E-06 | 1.666E-06 | 4.684E-06 | 1.286E-04 | 2.245E-04 |
| 912.00 | 3.883E+02 | 3.143E+03 | 1.264E+03 | 5.786E+00 | 1.271E+00 | 1.829E+00 | 1.272E-06 | 1.406E-06 | 3.567E-06 | 1.474E-04 | 2.045E-04 |
| 972.00 | 3.305E+02 | 2.926E+03 | 1.374E+03 | 5.686E+00 | 1.240E+00 | 1.952E+00 | 1.221E-06 | 2.191E-06 | 2.711E-06 | 1.708E-04 | 1.937E-04 |
| 1032.00 | 3.572E+02 | 2.648E+03 | 1.538E+03 | 5.543E+00 | 1.254E+00 | 2.072E+00 | 1.136E-06 | 3.819E-06 | 2.013E-06 | 2.001E-04 | 1.906E-04 |
| 1092.00 | 4.589E+02 | 2.308E+03 | 1.728E+03 | 5.358E+00 | 1.356E+00 | 2.163E+00 | 1.011E-06 | 6.207E-06 | 1.654E-06 | 2.355E-04 | 1.933E-04 |
| 1152.00 | 5.901E+02 | 1.903E+03 | 1.896E+03 | 5.088E+00 | 1.574E+00 | 2.191E+00 | 8.760E-07 | 9.562E-06 | 1.297E-06 | 2.743E-04 | 1.991E-04 |
| 1212.00 | 7.346E+02 | 1.473E+03 | 2.015E+03 | 4.789E+00 | 1.891E+00 | 2.134E+00 | 7.637E-07 | 1.267E-05 | 1.232E-06 | 3.177E-04 | 2.057E-04 |
| 1272.00 | 8.537E+02 | 1.063E+03 | 2.039E+03 | 4.383E+00 | 2.246E+00 | 1.971E+00 | 6.978E-07 | 1.622E-05 | 3.252E-06 | 3.569E-04 | 2.086E-04 |
| 1332.00 | 9.497E+02 | 1.093E+03 | 1.830E+03 | 3.916E+00 | 2.231E+00 | 2.043E+00 | 6.685E-07 | 1.959E-05 | 2.356E-06 | 3.837E-04 | 2.382E-04 |
| 1392.00 | 1.039E+03 | 1.389E+03 | 1.480E+03 | 3.537E+00 | 1.859E+00 | 2.383E+00 | 6.443E-07 | 2.073E-05 | 3.813E-06 | 4.321E-04 | 3.266E-04 |
| 1432.00 | 1.092E+03 | 1.536E+03 | 1.259E+03 | 3.339E+00 | 1.612E+00 | 2.572E+00 | 6.672E-07 | 1.962E-05 | 8.345E-06 | 4.870E-04 | 4.083E-04 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

7.366E-09 3.900E-09 4.846E-08 4.863E-02

GROUP 5 ACCELEROMETER NONLINEARITY

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 5.267E-03 | 5.364E-03 | 5.259E-03 | 3.370E-05 | 3.474E-05 | 3.349E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 3.606E-05 | 3.318E-05 |
| 312.00 | 7.809E-03 | 4.315E-03 | 5.027E-03 | 3.258E-05 | 3.145E-05 | 3.285E-05 | 1.655E-11 | 5.346E-12 | 3.385E-11 | 3.701E-05 | 3.357E-05 |
| 372.00 | 1.047E-02 | 5.828E-03 | 7.110E-03 | 3.840E-05 | 3.724E-05 | 3.883E-05 | 1.916E-11 | 6.308E-12 | 4.041E-11 | 4.523E-05 | 3.941E-05 |
| 432.00 | 1.320E-02 | 7.758E-03 | 9.567E-03 | 4.435E-05 | 4.360E-05 | 4.476E-05 | 2.020E-11 | 6.666E-12 | 4.457E-11 | 5.370E-05 | 4.511E-05 |
| 492.00 | 1.627E-02 | 1.012E-02 | 1.237E-02 | 5.043E-05 | 5.002E-05 | 5.055E-05 | 2.232E-11 | 6.360E-12 | 5.073E-11 | 6.255E-05 | 5.064E-05 |
| 552.00 | 1.968E-02 | 1.290E-02 | 1.552E-02 | 5.676E-05 | 5.642E-05 | 5.618E-05 | 2.645E-11 | 4.484E-12 | 6.018E-11 | 7.175E-05 | 5.596E-05 |
| 612.00 | 2.348E-02 | 1.608E-02 | 1.899E-02 | 6.342E-05 | 6.272E-05 | 6.163E-05 | 3.358E-11 | 1.578E-12 | 7.496E-11 | 8.129E-05 | 6.111E-05 |
| 672.00 | 2.767E-02 | 1.961E-02 | 2.280E-02 | 7.071E-05 | 6.893E-05 | 6.691E-05 | 4.132E-11 | 7.762E-12 | 9.044E-11 | 9.112E-05 | 6.607E-05 |
| 732.00 | 3.237E-02 | 2.358E-02 | 2.689E-02 | 7.840E-05 | 7.486E-05 | 7.193E-05 | 5.276E-11 | 1.920E-11 | 1.148E-10 | 1.012E-04 | 7.090E-05 |
| 792.00 | 3.759E-02 | 2.797E-02 | 3.126E-02 | 8.645E-05 | 8.045E-05 | 7.664E-05 | 6.783E-11 | 3.625E-11 | 1.498E-10 | 1.113E-04 | 7.562E-05 |
| 852.00 | 4.333E-02 | 3.281E-02 | 3.587E-02 | 9.470E-05 | 8.565E-05 | 8.099E-05 | 8.590E-11 | 5.948E-11 | 1.968E-10 | 1.212E-04 | 8.026E-05 |
| 912.00 | 4.951E-02 | 3.813E-02 | 4.069E-02 | 1.030E-04 | 9.043E-05 | 8.494E-05 | 1.058E-10 | 8.897E-11 | 2.566E-10 | 1.307E-04 | 8.488E-05 |
| 972.00 | 5.595E-02 | 4.425E-02 | 4.560E-02 | 1.088E-04 | 9.472E-05 | 8.809E-05 | 1.378E-10 | 1.402E-10 | 3.662E-10 | 1.382E-04 | 8.949E-05 |
| 1032.00 | 6.235E-02 | 5.083E-02 | 5.071E-02 | 1.153E-04 | 9.872E-05 | 9.095E-05 | 1.606E-10 | 1.863E-10 | 4.666E-10 | 1.447E-04 | 9.372E-05 |
| 1092.00 | 6.844E-02 | 5.800E-02 | 5.596E-02 | 1.206E-04 | 1.025E-04 | 9.324E-05 | 1.603E-10 | 2.302E-10 | 5.854E-10 | 1.486E-04 | 9.753E-05 |
| 1152.00 | 7.329E-02 | 6.642E-02 | 6.127E-02 | 1.200E-04 | 1.066E-04 | 9.457E-05 | 2.013E-10 | 3.014E-10 | 7.703E-10 | 1.465E-04 | 1.003E-04 |
| 1212.00 | 7.759E-02 | 7.419E-02 | 6.685E-02 | 1.223E-04 | 1.108E-04 | 9.574E-05 | 2.051E-10 | 3.353E-10 | 9.067E-10 | 1.443E-04 | 1.012E-04 |
| 1272.00 | 7.951E-02 | 8.294E-02 | 7.253E-02 | 1.166E-04 | 1.167E-04 | 9.606E-05 | 2.006E-10 | 3.571E-10 | 1.115E-09 | 1.342E-04 | 9.974E-05 |
| 1332.00 | 8.078E-02 | 9.048E-02 | 7.837E-02 | 1.117E-04 | 1.227E-04 | 9.604E-05 | 1.800E-10 | 3.404E-10 | 1.255E-09 | 1.282E-04 | 1.034E-04 |
| 1392.00 | 8.193E-02 | 9.649E-02 | 8.410E-02 | 1.091E-04 | 1.286E-04 | 9.576E-05 | 1.437E-10 | 2.735E-10 | 1.328E-09 | 1.265E-04 | 1.161E-04 |
| 1432.00 | 8.261E-02 | 9.995E-02 | 8.783E-02 | 1.093E-04 | 1.326E-04 | 9.548E-05 | 1.155E-10 | 2.031E-10 | 1.346E-09 | 1.261E-04 | 1.282E-04 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 5.418E-03 | 5.238E-03 | 5.232E-03 | 3.557E-05 | 3.317E-05 | 3.314E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.386E-09 | 1.829E-09 |
| 312.00 | 3.420E-03 | 8.112E-03 | 5.232E-03 | 3.007E-05 | 3.357E-05 | 3.314E-05 | 2.002E-13 | 9.882E-12 | 3.675E-11 | 1.424E-09 | 2.032E-09 |
| 372.00 | 5.192E-03 | 1.050E-02 | 7.400E-03 | 3.586E-05 | 3.942E-05 | 3.910E-05 | 6.919E-13 | 1.121E-11 | 4.375E-11 | 1.753E-09 | 2.591E-09 |
| 432.00 | 7.660E-03 | 1.300E-02 | 9.920E-03 | 4.271E-05 | 4.512E-05 | 4.486E-05 | 8.626E-13 | 1.208E-11 | 4.788E-11 | 2.111E-09 | 2.899E-09 |
| 492.00 | 1.061E-02 | 1.563E-02 | 1.278E-02 | 4.999E-05 | 5.064E-05 | 5.037E-05 | 7.964E-13 | 1.475E-11 | 5.379E-11 | 2.505E-09 | 2.853E-09 |
| 552.00 | 1.406E-02 | 1.849E-02 | 1.597E-02 | 5.777E-05 | 5.596E-05 | 5.561E-05 | 6.460E-13 | 2.071E-11 | 6.255E-11 | 2.935E-09 | 2.566E-09 |
| 612.00 | 1.804E-02 | 2.159E-02 | 1.947E-02 | 6.598E-05 | 6.110E-05 | 6.056E-05 | 8.065E-13 | 3.207E-11 | 7.563E-11 | 3.403E-09 | 2.226E-09 |
| 672.00 | 2.268E-02 | 2.478E-02 | 2.326E-02 | 7.494E-05 | 6.606E-05 | 6.517E-05 | 1.110E-12 | 4.662E-11 | 8.816E-11 | 3.915E-09 | 1.913E-09 |
| 732.00 | 2.784E-02 | 2.837E-02 | 2.733E-02 | 8.413E-05 | 7.089E-05 | 6.943E-05 | 1.669E-12 | 6.988E-11 | 1.070E-10 | 4.475E-09 | 1.693E-09 |
| 792.00 | 3.351E-02 | 3.237E-02 | 3.166E-02 | 9.341E-05 | 7.560E-05 | 7.333E-05 | 2.960E-12 | 1.043E-10 | 1.322E-10 | 5.091E-09 | 1.573E-09 |
| 852.00 | 3.966E-02 | 3.681E-02 | 3.624E-02 | 1.026E-04 | 8.023E-05 | 7.683E-05 | 5.753E-12 | 1.522E-10 | 1.627E-10 | 5.772E-09 | 1.560E-09 |
| 912.00 | 4.621E-02 | 4.171E-02 | 4.106E-02 | 1.114E-04 | 8.479E-05 | 7.996E-05 | 1.071E-11 | 2.161E-10 | 1.954E-10 | 6.532E-09 | 1.669E-09 |
| 972.00 | 5.263E-02 | 4.753E-02 | 4.625E-02 | 1.172E-04 | 8.930E-05 | 8.278E-05 | 1.752E-11 | 3.332E-10 | 2.478E-10 | 7.332E-09 | 1.963E-09 |
| 1032.00 | 5.928E-02 | 5.335E-02 | 5.179E-02 | 1.235E-04 | 9.356E-05 | 8.549E-05 | 2.922E-11 | 4.543E-10 | 2.663E-10 | 8.295E-09 | 2.456E-09 |
| 1092.00 | 6.561E-02 | 5.932E-02 | 5.794E-02 | 1.282E-04 | 9.729E-05 | 8.852E-05 | 4.354E-11 | 6.028E-10 | 2.562E-10 | 9.376E-09 | 3.270E-09 |
| 1152.00 | 7.044E-02 | 6.560E-02 | 6.536E-02 | 1.268E-04 | 1.001E-04 | 9.283E-05 | 5.724E-11 | 8.208E-10 | 2.186E-10 | 1.037E-08 | 4.586E-09 |
| 1212.00 | 7.501E-02 | 7.059E-02 | 7.337E-02 | 1.283E-04 | 1.009E-04 | 9.885E-05 | 7.386E-11 | 9.805E-10 | 9.920E-11 | 1.169E-08 | 6.434E-09 |
| 1272.00 | 7.690E-02 | 7.518E-02 | 8.304E-02 | 1.219E-04 | 9.922E-05 | 1.082E-04 | 8.147E-11 | 1.183E-09 | 6.702E-11 | 1.269E-08 | 9.219E-09 |
| 1332.00 | 7.827E-02 | 8.174E-02 | 8.970E-02 | 1.167E-04 | 1.022E-04 | 1.127E-04 | 8.525E-11 | 1.310E-09 | 2.044E-11 | 1.444E-08 | 1.177E-08 |
| 1392.00 | 7.989E-02 | 9.141E-02 | 9.141E-02 | 1.133E-04 | 1.150E-04 | 1.076E-04 | 7.755E-11 | 1.282E-09 | 4.571E-10 | 1.756E-08 | 1.356E-08 |
| 1432.00 | 8.100E-02 | 9.775E-02 | 9.171E-02 | 1.128E-04 | 1.255E-04 | 1.009E-04 | 6.537E-11 | 1.131E-09 | 7.646E-10 | 2.007E-08 | 1.450E-08 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

4.107E-13 2.202E-13 2.704E-12 3.607E-06

GROUP 6 GRAVITY ANOMALY AND VERTICAL DEFLECTIONS (MULTIPLY BY 0.0390)

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | | | | | | | | | | | |
| 312.00 | THIS SEGMENT OF TABLE NOT PRINTED | | | | | | | | | | |
| 372.00 | 9.110E+01 | 4.254E+01 | 7.946E+01 | 3.295E-01 | 3.659E-01 | 4.405E-01 | 2.051E-07 | 6.693E-08 | 4.296E-07 | 4.502E-01 | 2.957E-01 |
| 432.00 | 1.167E+02 | 5.716E+01 | 1.014E+02 | 3.858E-01 | 4.087E-01 | 4.993E-01 | 2.073E-04 | 6.478E-05 | 2.723E-04 | 5.198E-01 | 3.383E-01 |
| 492.00 | 1.384E+02 | 7.296E+01 | 1.265E+02 | 4.927E-01 | 4.676E-01 | 5.808E-01 | 2.796E-04 | 8.698E-05 | 3.674E-04 | 6.231E-01 | 4.097E-01 |
| 552.00 | 1.644E+02 | 9.195E+01 | 1.554E+02 | 6.765E-01 | 5.412E-01 | 7.046E-01 | 3.271E-04 | 1.013E-04 | 4.299E-04 | 7.884E-01 | 5.329E-01 |
| 612.00 | 1.993E+02 | 1.148E+02 | 1.902E+02 | 9.399E-01 | 6.265E-01 | 8.808E-01 | 3.614E-04 | 1.115E-04 | 4.751E-04 | 1.024E+00 | 7.144E-01 |
| 672.00 | 2.495E+02 | 1.426E+02 | 2.343E+02 | 1.279E+00 | 7.226E-01 | 1.112E+00 | 3.872E-04 | 1.189E-04 | 5.092E-04 | 1.335E+00 | 9.535E-01 |
| 732.00 | 3.212E+02 | 1.768E+02 | 2.915E+02 | 1.698E+00 | 8.362E-01 | 1.399E+00 | 4.072E-04 | 1.246E-04 | 5.357E-04 | 1.728E+00 | 1.251E+00 |
| 792.00 | 4.218E+02 | 2.202E+02 | 3.658E+02 | 2.198E+00 | 9.770E-01 | 1.746E+00 | 4.228E-04 | 1.288E-04 | 5.566E-04 | 2.219E+00 | 1.615E+00 |
| 852.00 | 5.568E+02 | 2.784E+02 | 4.613E+02 | 2.794E+00 | 1.162E+00 | 2.164E+00 | 4.352E-04 | 1.321E-04 | 5.735E-04 | 2.828E+00 | 2.060E+00 |
| 912.00 | 7.317E+02 | 3.617E+02 | 5.825E+02 | 3.510E+00 | 1.409E+00 | 2.672E+00 | 4.451E-04 | 1.346E-04 | 5.873E-04 | 3.586E+00 | 2.614E+00 |
| 972.00 | 9.524E+02 | 4.956E+02 | 7.345E+02 | 4.353E+00 | 1.728E+00 | 3.302E+00 | 4.531E-04 | 1.365E-04 | 5.992E-04 | 4.517E+00 | 3.311E+00 |
| 1032.00 | 1.208E+03 | 7.055E+02 | 9.261E+02 | 5.364E+00 | 2.117E+00 | 4.112E+00 | 4.535E-04 | 1.361E-04 | 6.024E-04 | 5.645E+00 | 4.217E+00 |
| 1092.00 | 1.500E+03 | 1.005E+03 | 1.169E+03 | 6.486E+00 | 2.500E+00 | 5.060E+00 | 4.536E-04 | 1.357E-04 | 6.060E-04 | 6.900E+00 | 5.250E+00 |
| 1152.00 | 1.803E+03 | 1.436E+03 | 1.474E+03 | 7.535E+00 | 2.818E+00 | 6.083E+00 | 4.536E-04 | 1.353E-04 | 6.110E-04 | 8.074E+00 | 6.324E+00 |
| 1212.00 | 2.122E+03 | 1.910E+03 | 1.848E+03 | 8.576E+00 | 3.060E+00 | 7.099E+00 | 4.537E-04 | 1.350E-04 | 6.157E-04 | 9.138E+00 | 7.329E+00 |
| 1272.00 | 2.395E+03 | 2.499E+03 | 2.291E+03 | 9.239E+00 | 3.237E+00 | 7.996E+00 | 4.537E-04 | 1.348E-04 | 6.217E-04 | 9.729E+00 | 8.157E+00 |
| 1332.00 | 2.625E+03 | 3.090E+03 | 2.782E+03 | 8.620E+00 | 3.494E+00 | 7.985E+00 | 4.536E-04 | 1.346E-04 | 6.269E-04 | 9.215E+00 | 7.919E+00 |
| 1392.00 | 2.827E+03 | 3.563E+03 | 3.246E+03 | 7.572E+00 | 4.197E+00 | 7.412E+00 | 4.536E-04 | 1.344E-04 | 6.279E-04 | 8.408E+00 | 6.637E+00 |
| 1432.00 | 2.940E+03 | 3.843E+03 | 3.537E+03 | 7.160E+00 | 4.736E+00 | 7.137E+00 | 4.536E-04 | 1.344E-04 | 6.274E-04 | 8.081E+00 | 5.733E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | | | | | | | | | | | |
| 312.00 | THIS SEGMENT OF TABLE NOT PRINTED | | | | | | | | | | |
| 372.00 | 5.269E+01 | 8.200E+01 | 8.320E+01 | 3.863E-01 | 2.955E-01 | 4.472E-01 | 8.432E-09 | 1.203E-07 | 4.653E-07 | 1.742E-05 | 2.469E-05 |
| 432.00 | 7.088E+01 | 1.042E+02 | 1.063E+02 | 4.425E-01 | 3.382E-01 | 5.051E-01 | 1.783E-04 | 1.463E-04 | 2.610E-04 | 2.042E-05 | 2.696E-05 |
| 492.00 | 9.560E+01 | 1.179E+02 | 1.321E+02 | 5.470E-01 | 4.097E-01 | 5.759E-01 | 2.502E-04 | 1.858E-04 | 3.516E-04 | 2.494E-05 | 2.664E-05 |
| 552.00 | 1.257E+02 | 1.338E+02 | 1.610E+02 | 7.139E-01 | 5.329E-01 | 6.733E-01 | 3.025E-04 | 2.052E-04 | 4.105E-04 | 3.224E-05 | 2.728E-05 |
| 612.00 | 1.644E+02 | 1.560E+02 | 1.942E+02 | 9.453E-01 | 7.145E-01 | 8.047E-01 | 3.435E-04 | 2.152E-04 | 4.522E-04 | 4.288E-05 | 3.054E-05 |
| 672.00 | 2.162E+02 | 1.902E+02 | 2.335E+02 | 1.241E+00 | 9.536E-01 | 9.715E-01 | 3.763E-04 | 2.213E-04 | 4.826E-04 | 5.735E-05 | 3.633E-05 |
| 732.00 | 2.880E+02 | 2.402E+02 | 2.806E+02 | 1.612E+00 | 1.252E+00 | 1.172E+00 | 4.025E-04 | 2.273E-04 | 5.046E-04 | 7.646E-05 | 4.422E-05 |
| 792.00 | 3.833E+02 | 3.156E+02 | 3.371E+02 | 2.064E+00 | 1.616E+00 | 1.402E+00 | 4.234E-04 | 2.362E-04 | 5.198E-04 | 1.016E-04 | 5.418E-05 |
| 852.00 | 5.083E+02 | 4.232E+02 | 4.035E+02 | 2.615E+00 | 2.062E+00 | 1.658E+00 | 4.397E-04 | 2.511E-04 | 5.286E-04 | 1.347E-04 | 6.630E-05 |
| 912.00 | 6.693E+02 | 5.725E+02 | 4.793E+02 | 3.294E+00 | 2.618E+00 | 1.935E+00 | 4.521E-04 | 2.748E-04 | 5.304E-04 | 1.794E-04 | 8.097E-05 |
| 972.00 | 8.687E+02 | 7.864E+02 | 5.648E+02 | 4.110E+00 | 3.320E+00 | 2.219E+00 | 4.612E-04 | 3.110E-04 | 5.231E-04 | 2.401E-04 | 9.836E-05 |
| 1032.00 | 1.101E+03 | 1.077E+03 | 6.644E+02 | 5.106E+00 | 4.225E+00 | 2.498E+00 | 4.614E-04 | 3.584E-04 | 4.958E-04 | 3.242E-04 | 1.192E-04 |
| 1092.00 | 1.372E+03 | 1.444E+03 | 8.111E+02 | 6.233E+00 | 5.260E+00 | 2.719E+00 | 4.604E-04 | 4.178E-04 | 4.526E-04 | 4.361E-04 | 1.412E-04 |
| 1152.00 | 1.653E+03 | 1.884E+03 | 1.098E+03 | 7.301E+00 | 6.334E+00 | 2.881E+00 | 4.590E-04 | 4.837E-04 | 3.909E-04 | 5.726E-04 | 1.661E-04 |
| 1212.00 | 1.963E+03 | 2.298E+03 | 1.558E+03 | 8.372E+00 | 7.342E+00 | 3.051E+00 | 4.574E-04 | 5.463E-04 | 3.090E-04 | 7.422E-04 | 2.034E-04 |
| 1272.00 | 2.224E+03 | 2.663E+03 | 2.279E+03 | 9.062E+00 | 8.173E+00 | 3.294E+00 | 4.560E-04 | 5.974E-04 | 2.136E-04 | 9.231E-04 | 2.685E-04 |
| 1332.00 | 2.447E+03 | 3.242E+03 | 2.772E+03 | 8.470E+00 | 7.951E+00 | 3.914E+00 | 4.550E-04 | 5.990E-04 | 2.260E-04 | 1.047E-03 | 3.864E-04 |
| 1392.00 | 2.670E+03 | 4.040E+03 | 2.788E+03 | 7.460E+00 | 6.673E+00 | 5.450E+00 | 4.545E-04 | 5.336E-04 | 3.562E-04 | 1.182E-03 | 6.902E-04 |
| 1432.00 | 2.808E+03 | 4.469E+03 | 2.840E+03 | 7.078E+00 | 5.825E+00 | 6.373E+00 | 4.543E-04 | 4.604E-04 | 4.462E-04 | 1.324E-03 | 9.568E-04 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

4.867E-05 6.835E-05 6.111E-05 3.254E-02

GROUP 7 GYRO BIAS DRIFT

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 5.863E+03 | 1.207E+04 | 2.528E+04 | 4.268E+00 | 1.155E+01 | 3.888E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.407E+00 | 1.410E+00 |
| 312.00 | 4.098E+03 | 1.489E+04 | 2.228E+04 | 6.912E+00 | 6.223E+00 | 1.504E+01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.089E+00 | 1.859E+00 |
| 312.00 | 3.826E+03 | 1.448E+04 | 2.234E+04 | 6.778E+00 | 5.739E+00 | 1.490E+01 | 1.832E-06 | 5.917E-07 | 3.746E-06 | 9.990E-01 | 2.003E+00 |
| 372.00 | 3.396E+03 | 1.477E+04 | 2.140E+04 | 7.108E+00 | 4.456E+00 | 1.650E+01 | 1.771E-06 | 5.468E-07 | 3.557E-06 | 7.760E-01 | 2.162E+00 |
| 432.00 | 2.964E+03 | 1.500E+04 | 2.037E+04 | 7.411E+00 | 2.958E+00 | 1.779E+01 | 1.598E-06 | 4.763E-07 | 3.178E-06 | 4.467E-01 | 2.359E+00 |
| 492.00 | 2.513E+03 | 1.513E+04 | 1.927E+04 | 7.665E+00 | 1.294E+00 | 1.889E+01 | 1.473E-06 | 4.218E-07 | 2.924E-06 | 3.272E-01 | 2.571E+00 |
| 552.00 | 2.048E+03 | 1.515E+04 | 1.811E+04 | 7.883E+00 | 6.616E-01 | 1.978E+01 | 1.405E-06 | 3.590E-07 | 2.795E-06 | 7.471E-01 | 2.791E+00 |
| 612.00 | 1.576E+03 | 1.505E+04 | 1.690E+04 | 8.070E+00 | 2.284E+00 | 2.046E+01 | 1.426E-06 | 2.529E-07 | 2.844E-06 | 1.327E+00 | 3.017E+00 |
| 672.00 | 1.109E+03 | 1.485E+04 | 1.566E+04 | 8.241E+00 | 3.978E+00 | 2.092E+01 | 1.508E-06 | 9.432E-08 | 3.015E-06 | 1.992E+00 | 3.248E+00 |
| 732.00 | 6.815E+02 | 1.454E+04 | 1.441E+04 | 8.400E+00 | 5.666E+00 | 2.115E+01 | 1.736E-06 | 2.228E-07 | 3.519E-06 | 2.742E+00 | 3.486E+00 |
| 792.00 | 4.811E+02 | 1.411E+04 | 1.315E+04 | 8.559E+00 | 7.354E+00 | 2.109E+01 | 2.137E-06 | 7.252E-07 | 4.477E-06 | 3.591E+00 | 3.738E+00 |
| 852.00 | 7.548E+02 | 1.355E+04 | 1.191E+04 | 8.729E+00 | 9.061E+00 | 2.071E+01 | 2.730E-06 | 1.512E-06 | 6.042E-06 | 4.560E+00 | 4.008E+00 |
| 912.00 | 1.231E+03 | 1.287E+04 | 1.072E+04 | 8.926E+00 | 1.080E+01 | 1.993E+01 | 3.512E-06 | 2.657E-06 | 8.382E-06 | 5.672E+00 | 4.315E+00 |
| 972.00 | 1.757E+03 | 1.199E+04 | 9.626E+03 | 9.106E+00 | 1.258E+01 | 1.864E+01 | 4.793E-06 | 4.690E-06 | 1.275E-05 | 6.920E+00 | 4.661E+00 |
| 1032.00 | 2.291E+03 | 1.098E+04 | 8.658E+03 | 9.393E+00 | 1.433E+01 | 1.669E+01 | 6.005E-06 | 6.991E-06 | 1.785E-05 | 8.357E+00 | 5.138E+00 |
| 1092.00 | 2.813E+03 | 9.800E+03 | 7.880E+03 | 9.713E+00 | 1.582E+01 | 1.428E+01 | 7.243E-06 | 9.804E-06 | 2.462E-05 | 9.812E+00 | 5.640E+00 |
| 1152.00 | 3.272E+03 | 8.439E+03 | 7.357E+03 | 9.847E+00 | 1.671E+01 | 1.164E+01 | 8.583E-06 | 1.352E-05 | 3.510E-05 | 1.096E+01 | 6.155E+00 |
| 1212.00 | 3.685E+03 | 7.098E+03 | 7.075E+03 | 1.008E+01 | 1.685E+01 | 9.308E+00 | 9.162E-06 | 1.605E-05 | 4.472E-05 | 1.186E+01 | 6.648E+00 |
| 1272.00 | 3.962E+03 | 5.758E+03 | 7.082E+03 | 9.880E+00 | 1.607E+01 | 7.808E+00 | 9.201E-06 | 1.777E-05 | 5.822E-05 | 1.200E+01 | 7.083E+00 |
| 1332.00 | 4.147E+03 | 4.678E+03 | 7.259E+03 | 8.856E+00 | 1.408E+01 | 7.803E+00 | 8.212E-06 | 1.722E-05 | 6.951E-05 | 1.083E+01 | 6.929E+00 |
| 1392.00 | 4.301E+03 | 3.996E+03 | 7.302E+03 | 7.688E+00 | 1.128E+01 | 8.659E+00 | 6.249E-06 | 1.345E-05 | 7.476E-05 | 9.299E+00 | 5.949E+00 |
| 1432.00 | 4.383E+03 | 3.727E+03 | 7.269E+03 | 7.225E+00 | 9.308E+00 | 9.175E+00 | 4.774E-06 | 9.567E-06 | 7.599E-05 | 8.554E+00 | 4.936E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 9.641E+02 | 1.158E+04 | 2.615E+04 | 1.278E+01 | 1.630E+00 | 8.910E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 5.312E-05 | 1.339E-03 |
| 312.00 | 6.025E+02 | 1.230E+04 | 2.415E+04 | 1.411E+01 | 2.069E+00 | 1.046E+01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 4.076E-05 | 3.577E-04 |
| 312.00 | 3.748E+02 | 1.185E+04 | 2.414E+04 | 1.362E+01 | 2.210E+00 | 1.050E+01 | 2.216E-08 | 1.094E-06 | 4.067E-06 | 3.718E-05 | 2.875E-04 |
| 372.00 | 3.182E+02 | 1.178E+04 | 2.342E+04 | 1.366E+01 | 2.283E+00 | 1.226E+01 | 1.056E-07 | 1.056E-06 | 3.868E-06 | 2.929E-05 | 1.580E-03 |
| 432.00 | 2.950E+02 | 1.153E+04 | 2.271E+04 | 1.349E+01 | 2.404E+00 | 1.387E+01 | 1.661E-07 | 9.738E-07 | 3.450E-06 | 1.725E-05 | 2.936E-03 |
| 492.00 | 2.920E+02 | 1.113E+04 | 2.196E+04 | 1.318E+01 | 2.594E+00 | 1.538E+01 | 2.107E-07 | 9.347E-07 | 3.159E-06 | 1.309E-05 | 3.744E-03 |
| 552.00 | 3.149E+02 | 1.066E+04 | 2.116E+04 | 1.285E+01 | 2.806E+00 | 1.675E+01 | 2.392E-07 | 9.542E-07 | 2.991E-06 | 3.063E-05 | 3.576E-03 |
| 612.00 | 3.675E+02 | 1.014E+04 | 2.029E+04 | 1.253E+01 | 3.030E+00 | 1.797E+01 | 2.518E-07 | 1.093E-06 | 2.988E-06 | 5.565E-05 | 3.629E-03 |
| 672.00 | 4.573E+02 | 9.564E+03 | 1.938E+04 | 1.222E+01 | 3.261E+00 | 1.901E+01 | 2.631E-07 | 1.349E-06 | 3.080E-06 | 8.569E-05 | 3.270E-03 |
| 732.00 | 5.862E+02 | 8.919E+03 | 1.843E+04 | 1.192E+01 | 3.503E+00 | 1.988E+01 | 2.693E-07 | 1.891E-06 | 3.435E-06 | 1.215E-04 | 2.923E-03 |
| 792.00 | 7.594E+02 | 8.178E+03 | 1.746E+04 | 1.163E+01 | 3.759E+00 | 2.056E+01 | 2.854E-07 | 2.860E-06 | 4.108E-06 | 1.646E-04 | 2.628E-03 |
| 852.00 | 9.818E+02 | 7.301E+03 | 1.649E+04 | 1.134E+01 | 4.038E+00 | 2.104E+01 | 3.343E-07 | 4.441E-06 | 5.139E-06 | 2.175E-04 | 2.386E-03 |
| 912.00 | 1.258E+03 | 6.237E+03 | 1.554E+04 | 1.100E+01 | 4.352E+00 | 2.128E+01 | 4.454E-07 | 6.867E-06 | 6.504E-06 | 2.840E-04 | 2.201E-03 |
| 972.00 | 1.579E+03 | 4.888E+03 | 1.460E+04 | 1.068E+01 | 4.712E+00 | 2.127E+01 | 6.286E-07 | 1.144E-05 | 8.725E-06 | 3.683E-04 | 2.057E-03 |
| 1032.00 | 1.961E+03 | 3.267E+03 | 1.365E+04 | 1.038E+01 | 5.169E+00 | 2.092E+01 | 9.930E-07 | 1.724E-05 | 1.026E-05 | 4.802E-04 | 1.961E-03 |
| 1092.00 | 2.389E+03 | 1.784E+03 | 1.254E+04 | 1.016E+01 | 5.672E+00 | 2.033E+01 | 1.500E-06 | 2.520E-05 | 1.085E-05 | 6.203E-04 | 1.903E-03 |
| 1152.00 | 2.807E+03 | 2.267E+03 | 1.109E+04 | 9.866E+00 | 6.180E+00 | 1.940E+01 | 2.034E-06 | 3.717E-05 | 1.012E-05 | 7.774E-04 | 1.880E-03 |
| 1212.00 | 3.247E+03 | 4.145E+03 | 9.290E+03 | 9.798E+00 | 6.673E+00 | 1.821E+01 | 2.720E-06 | 4.802E-05 | 5.332E-06 | 9.632E-04 | 1.892E-03 |
| 1272.00 | 3.578E+03 | 6.041E+03 | 7.050E+03 | 9.431E+00 | 7.108E+00 | 1.665E+01 | 3.027E-06 | 6.144E-05 | 2.624E-06 | 1.138E-03 | 1.920E-03 |
| 1332.00 | 3.840E+03 | 6.425E+03 | 5.979E+03 | 8.493E+00 | 6.971E+00 | 1.473E+01 | 3.044E-06 | 7.196E-05 | 2.724E-06 | 1.230E-03 | 1.947E-03 |
| 1392.00 | 4.069E+03 | 5.763E+03 | 6.167E+03 | 7.528E+00 | 5.990E+00 | 1.299E+01 | 2.618E-06 | 7.108E-05 | 2.744E-05 | 1.307E-03 | 2.041E-03 |
| 1432.00 | 4.191E+03 | 5.268E+03 | 6.373E+03 | 7.169E+00 | 5.045E+00 | 1.209E+01 | 2.051E-06 | 6.242E-05 | 4.458E-05 | 1.401E-03 | 2.139E-03 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

2.479E-08 1.305E-08 1.626E-07 1.862E-01

GROUP 8 GYRO MASS UNBALANCE

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 2.503E+02 | 1.443E+03 | 7.561E+02 | 1.556E+00 | 4.096E-01 | 3.378E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 2.389E-01 | 1.616E+00 |
| 312.00 | 1.891E+02 | 1.730E+03 | 6.953E+02 | 7.785E-01 | 1.372E+00 | 3.415E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 7.229E-01 | 1.436E+00 |
| 312.00 | 6.028E+02 | 6.475E+02 | 5.927E+02 | 1.161E+00 | 1.274E-01 | 4.071E-01 | 3.977E-06 | 1.285E-06 | 8.135E-06 | 5.179E-01 | 9.522E-01 |
| 372.00 | 6.162E+02 | 5.444E+02 | 5.588E+02 | 1.110E+00 | 1.022E-01 | 4.246E-01 | 4.009E-06 | 1.248E-06 | 8.102E-06 | 5.290E-01 | 8.530E-01 |
| 432.00 | 5.522E+02 | 5.522E+02 | 5.340E+02 | 9.913E-01 | 1.712E-01 | 4.149E-01 | 3.650E-06 | 1.101E-06 | 7.332E-06 | 5.366E-01 | 7.993E-01 |
| 492.00 | 4.986E+02 | 5.584E+02 | 5.089E+02 | 8.687E-01 | 2.619E-01 | 4.155E-01 | 3.345E-06 | 9.739E-07 | 6.691E-06 | 5.256E-01 | 7.466E-01 |
| 552.00 | 4.529E+02 | 5.678E+02 | 4.843E+02 | 7.418E-01 | 3.419E-01 | 4.238E-01 | 3.079E-06 | 8.523E-07 | 6.129E-06 | 5.034E-01 | 6.931E-01 |
| 612.00 | 4.163E+02 | 5.796E+02 | 4.605E+02 | 6.209E-01 | 4.036E-01 | 4.371E-01 | 2.850E-06 | 7.297E-07 | 5.645E-06 | 4.752E-01 | 6.386E-01 |
| 672.00 | 3.902E+02 | 5.943E+02 | 4.380E+02 | 5.237E-01 | 4.466E-01 | 4.523E-01 | 2.637E-06 | 6.142E-07 | 5.197E-06 | 4.481E-01 | 5.840E-01 |
| 732.00 | 3.764E+02 | 6.089E+02 | 4.174E+02 | 4.824E-01 | 4.698E-01 | 4.670E-01 | 2.456E-06 | 4.976E-07 | 4.820E-06 | 4.352E-01 | 5.299E-01 |
| 792.00 | 3.767E+02 | 6.218E+02 | 3.991E+02 | 5.257E-01 | 4.746E-01 | 4.795E-01 | 2.306E-06 | 3.819E-07 | 4.525E-06 | 4.565E-01 | 4.781E-01 |
| 852.00 | 3.924E+02 | 6.311E+02 | 3.837E+02 | 6.516E-01 | 4.644E-01 | 4.899E-01 | 2.191E-06 | 2.926E-07 | 4.330E-06 | 5.330E-01 | 4.324E-01 |
| 912.00 | 4.244E+02 | 6.348E+02 | 3.717E+02 | 8.386E-01 | 4.429E-01 | 5.006E-01 | 2.115E-06 | 3.186E-07 | 4.266E-06 | 6.759E-01 | 3.973E-01 |
| 972.00 | 4.723E+02 | 6.137E+02 | 3.606E+02 | 1.050E+00 | 4.177E-01 | 5.143E-01 | 2.219E-06 | 6.359E-07 | 4.824E-06 | 8.796E-01 | 3.844E-01 |
| 1032.00 | 5.342E+02 | 5.927E+02 | 3.543E+02 | 1.318E+00 | 3.971E-01 | 5.565E-01 | 2.265E-06 | 1.038E-06 | 5.344E-06 | 1.156E+00 | 4.103E-01 |
| 1092.00 | 6.086E+02 | 5.581E+02 | 3.507E+02 | 1.605E+00 | 3.911E-01 | 6.495E-01 | 2.350E-06 | 1.554E-06 | 6.265E-06 | 1.474E+00 | 4.999E-01 |
| 1152.00 | 6.840E+02 | 4.994E+02 | 3.450E+02 | 1.848E+00 | 3.970E-01 | 8.044E-01 | 2.513E-06 | 2.310E-06 | 8.154E-06 | 1.767E+00 | 6.693E-01 |
| 1212.00 | 7.650E+02 | 4.600E+02 | 3.500E+02 | 2.116E+00 | 4.204E-01 | 1.030E+00 | 2.536E-06 | 2.821E-06 | 9.837E-06 | 2.064E+00 | 9.189E-01 |
| 1272.00 | 8.274E+02 | 4.365E+02 | 3.608E+02 | 2.282E+00 | 4.618E-01 | 1.292E+00 | 2.481E-06 | 3.219E-06 | 1.258E-05 | 2.248E+00 | 1.226E+00 |
| 1332.00 | 8.808E+02 | 4.638E+02 | 3.932E+02 | 2.166E+00 | 5.671E-01 | 1.381E+00 | 2.222E-06 | 3.147E-06 | 1.487E-05 | 2.137E+00 | 1.319E+00 |
| 1392.00 | 9.268E+02 | 5.162E+02 | 4.373E+02 | 1.986E+00 | 8.065E-01 | 1.390E+00 | 1.762E-06 | 2.406E-06 | 1.599E-05 | 1.975E+00 | 1.202E+00 |
| 1432.00 | 9.531E+02 | 5.591E+02 | 4.710E+02 | 1.979E+00 | 9.743E-01 | 1.434E+00 | 1.416E-06 | 1.638E-06 | 1.628E-05 | 1.983E+00 | 1.112E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 1.518E+03 | 2.584E+02 | 5.882E+02 | 2.766E-01 | 1.619E+00 | 7.728E-02 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.044E-05 | 3.353E-05 |
| 312.00 | 1.362E+03 | 1.162E+03 | 5.537E+02 | 7.157E-01 | 1.426E+00 | 2.425E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 2.900E-05 | 1.596E-04 |
| 312.00 | 8.672E+02 | 2.736E+02 | 5.541E+02 | 7.417E-01 | 9.633E-01 | 2.269E-01 | 4.811E-08 | 2.308E-06 | 8.849E-06 | 2.073E-05 | 2.787E-05 |
| 372.00 | 7.848E+02 | 2.851E+02 | 5.395E+02 | 7.817E-01 | 8.597E-01 | 2.687E-01 | 2.277E-07 | 2.355E-06 | 8.814E-06 | 2.106E-05 | 4.298E-05 |
| 432.00 | 7.533E+02 | 2.297E+02 | 5.242E+02 | 6.688E-01 | 8.014E-01 | 3.076E-01 | 3.597E-07 | 2.228E-06 | 7.950E-06 | 2.150E-05 | 5.862E-05 |
| 492.00 | 7.188E+02 | 2.113E+02 | 5.079E+02 | 5.622E-01 | 7.475E-01 | 3.478E-01 | 4.673E-07 | 2.156E-06 | 7.214E-06 | 2.141E-05 | 7.659E-05 |
| 552.00 | 6.857E+02 | 2.270E+02 | 4.901E+02 | 4.655E-01 | 6.936E-01 | 3.860E-01 | 5.552E-07 | 2.107E-06 | 6.559E-06 | 2.093E-05 | 8.288E-05 |
| 612.00 | 6.553E+02 | 2.648E+02 | 4.708E+02 | 3.936E-01 | 6.389E-01 | 4.198E-01 | 6.267E-07 | 2.085E-06 | 5.982E-06 | 2.023E-05 | 8.015E-05 |
| 672.00 | 6.294E+02 | 3.131E+02 | 4.507E+02 | 3.695E-01 | 5.842E-01 | 4.478E-01 | 6.883E-07 | 2.068E-06 | 5.439E-06 | 1.958E-05 | 7.383E-05 |
| 732.00 | 6.086E+02 | 3.622E+02 | 4.302E+02 | 4.133E-01 | 5.300E-01 | 4.687E-01 | 7.388E-07 | 2.086E-06 | 4.961E-06 | 1.958E-05 | 6.692E-05 |
| 792.00 | 5.945E+02 | 4.074E+02 | 4.104E+02 | 5.200E-01 | 4.782E-01 | 4.821E-01 | 7.809E-07 | 2.162E-06 | 4.546E-06 | 2.123E-05 | 6.061E-05 |
| 852.00 | 5.891E+02 | 4.457E+02 | 3.923E+02 | 6.744E-01 | 4.325E-01 | 4.882E-01 | 8.178E-07 | 2.327E-06 | 4.190E-06 | 2.576E-05 | 5.527E-05 |
| 912.00 | 5.947E+02 | 4.745E+02 | 3.776E+02 | 8.683E-01 | 3.976E-01 | 4.878E-01 | 8.532E-07 | 2.632E-06 | 3.888E-06 | 3.422E-05 | 5.092E-05 |
| 972.00 | 6.086E+02 | 4.750E+02 | 3.657E+02 | 1.076E+00 | 3.855E-01 | 4.847E-01 | 8.832E-07 | 3.575E-06 | 3.878E-06 | 4.715E-05 | 4.735E-05 |
| 1032.00 | 6.399E+02 | 4.702E+02 | 3.629E+02 | 1.342E+00 | 4.115E-01 | 4.835E-01 | 9.464E-07 | 4.573E-06 | 3.599E-06 | 6.664E-05 | 4.512E-05 |
| 1092.00 | 6.857E+02 | 4.475E+02 | 3.668E+02 | 1.629E+00 | 5.011E-01 | 4.956E-01 | 1.023E-06 | 6.013E-06 | 3.161E-06 | 9.269E-05 | 4.424E-05 |
| 1152.00 | 7.339E+02 | 4.016E+02 | 3.693E+02 | 1.871E+00 | 6.696E-01 | 5.198E-01 | 1.091E-06 | 8.409E-06 | 2.497E-06 | 1.231E-04 | 4.459E-05 |
| 1212.00 | 7.962E+02 | 3.685E+02 | 3.867E+02 | 2.136E+00 | 9.178E-01 | 5.558E-01 | 1.192E-06 | 1.042E-05 | 1.072E-06 | 1.617E-04 | 4.728E-05 |
| 1272.00 | 8.421E+02 | 3.475E+02 | 4.190E+02 | 2.294E+00 | 1.223E+00 | 5.780E-01 | 1.204E-06 | 1.311E-05 | 1.203E-06 | 2.004E-04 | 5.114E-05 |
| 1332.00 | 8.837E+02 | 3.859E+02 | 4.645E+02 | 2.160E+00 | 1.315E+00 | 7.237E-01 | 1.162E-06 | 1.530E-05 | 7.153E-07 | 2.254E-04 | 6.976E-05 |
| 1392.00 | 9.237E+02 | 4.437E+02 | 5.163E+02 | 1.965E+00 | 1.209E+00 | 1.097E+00 | 1.018E-06 | 1.576E-05 | 3.894E-06 | 2.635E-04 | 1.330E-04 |
| 1432.00 | 9.467E+02 | 4.801E+02 | 5.589E+02 | 1.954E+00 | 1.144E+00 | 1.339E+00 | 8.550E-07 | 1.472E-05 | 7.227E-06 | 3.167E-04 | 1.964E-04 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

5.346E-09    2.848E-09    3.522E-08    4.224E-02

GROUP 9 GYRO ANISOELASTICITY

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 3.442E+01 | 9.258E+01 | 4.201E+01 | 7.414E-02 | 6.439E-02 | 5.237E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 2.316E-02 | 8.848E-02 |
| 312.00 | 4.847E+01 | 1.208E+02 | 4.184E+01 | 1.266E-02 | 1.103E-01 | 2.806E-02 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 4.991E-02 | 7.533E-02 |
| 312.00 | 8.788E+00 | 5.940E+01 | 3.673E+01 | 3.309E-02 | 3.790E-02 | 1.602E-02 | 2.199E-07 | 7.105E-08 | 4.498E-07 | 3.732E-02 | 4.863E-02 |
| 372.00 | 7.714E+00 | 5.679E+01 | 3.551E+01 | 2.785E-02 | 3.605E-02 | 1.822E-02 | 2.156E-07 | 6.695E-08 | 4.349E-07 | 3.868E-02 | 4.391E-02 |
| 432.00 | 8.548E+00 | 5.919E+01 | 3.459E+01 | 2.042E-02 | 3.893E-02 | 2.021E-02 | 1.957E-07 | 5.881E-08 | 3.919E-07 | 4.018E-02 | 4.097E-02 |
| 492.00 | 9.060E+00 | 6.133E+01 | 3.365E+01 | 1.333E-02 | 4.039E-02 | 2.210E-02 | 1.786E-07 | 5.194E-08 | 3.555E-07 | 4.085E-02 | 3.775E-02 |
| 552.00 | 9.274E+00 | 6.349E+01 | 3.274E+01 | 7.864E-03 | 4.081E-02 | 2.370E-02 | 1.631E-07 | 4.568E-08 | 3.228E-07 | 4.083E-02 | 3.441E-02 |
| 612.00 | 9.166E+00 | 6.564E+01 | 3.187E+01 | 8.487E-03 | 4.027E-02 | 2.492E-02 | 1.491E-07 | 3.994E-08 | 2.932E-07 | 4.014E-02 | 3.102E-02 |
| 672.00 | 8.761E+00 | 6.775E+01 | 3.108E+01 | 1.445E-02 | 3.893E-02 | 2.563E-02 | 1.358E-07 | 3.503E-08 | 2.655E-07 | 3.875E-02 | 2.773E-02 |
| 732.00 | 8.143E+00 | 6.973E+01 | 3.040E+01 | 2.182E-02 | 3.703E-02 | 2.575E-02 | 1.234E-07 | 3.090E-08 | 2.397E-07 | 3.671E-02 | 2.482E-02 |
| 792.00 | 7.510E+00 | 7.152E+01 | 2.986E+01 | 2.989E-02 | 3.495E-02 | 2.514E-02 | 1.120E-07 | 2.752E-08 | 2.160E-07 | 3.428E-02 | 2.291E-02 |
| 852.00 | 7.266E+00 | 7.305E+01 | 2.951E+01 | 3.899E-02 | 3.338E-02 | 2.378E-02 | 1.017E-07 | 2.492E-08 | 1.947E-07 | 3.246E-02 | 2.307E-02 |
| 912.00 | 0.019E+00 | 7.424E+01 | 2.942E+01 | 5.018E-02 | 3.355E-02 | 2.230E-02 | 9.292E-08 | 2.348E-08 | 1.776E-07 | 3.429E-02 | 2.686E-02 |
| 972.00 | 1.025E+01 | 7.428E+01 | 2.961E+01 | 6.468E-02 | 3.705E-02 | 2.409E-02 | 9.165E-08 | 2.233E-08 | 1.845E-07 | 4.518E-02 | 3.596E-02 |
| 1032.00 | 1.412E+01 | 7.419E+01 | 3.046E+01 | 8.797E-02 | 4.618E-02 | 3.991E-02 | 9.000E-08 | 3.611E-08 | 1.966E-07 | 7.060E-02 | 5.460E-02 |
| 1092.00 | 1.970E+01 | 7.344E+01 | 3.241E+01 | 1.208E-01 | 5.960E-02 | 7.694E-02 | 9.333E-08 | 6.277E-08 | 2.426E-07 | 1.106E-01 | 8.655E-02 |
| 1152.00 | 2.660E+01 | 7.207E+01 | 3.644E+01 | 1.567E-01 | 7.379E-02 | 1.378E-01 | 1.031E-07 | 1.070E-07 | 3.539E-07 | 1.565E-01 | 1.373E-01 |
| 1212.00 | 3.453E+01 | 7.257E+01 | 4.450E+01 | 1.877E-01 | 8.394E-02 | 2.236E-01 | 1.089E-07 | 1.476E-07 | 4.870E-07 | 1.958E-01 | 2.123E-01 |
| 1272.00 | 4.159E+01 | 7.557E+01 | 5.847E+01 | 1.987E-01 | 9.171E-02 | 3.272E-01 | 1.095E-07 | 1.786E-07 | 6.807E-07 | 2.116E-01 | 3.136E-01 |
| 1332.00 | 4.686E+01 | 8.302E+01 | 7.869E+01 | 1.863E-01 | 1.267E-01 | 3.608E-01 | 9.836E-08 | 1.779E-07 | 8.559E-07 | 2.059E-01 | 3.263E-01 |
| 1392.00 | 5.036E+01 | 9.199E+01 | 9.994E+01 | 2.035E-01 | 2.083E-01 | 3.548E-01 | 8.214E-08 | 1.339E-07 | 9.319E-07 | 2.309E-01 | 2.403E-01 |
| 1432.00 | 5.209E+01 | 9.930E+01 | 1.144E+02 | 2.347E-01 | 2.657E-01 | 3.636E-01 | 7.919E-08 | 1.041E-07 | 9.484E-07 | 2.627E-01 | 1.914E-01 |

| TIME | U | V | N | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 8.480E+01 | 5.403E+01 | 3.754E+01 | 4.335E-02 | 8.774E-02 | 9.599E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 9.502E-07 | 2.799E-06 |
| 312.00 | 7.321E+01 | 1.098E+02 | 3.562E+01 | 8.586E-02 | 7.405E-02 | 1.636E-02 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.958E-06 | 1.554E-05 |
| 312.00 | 4.586E+01 | 3.979E+01 | 3.561E+01 | 1.552E-02 | 4.848E-02 | 1.401E-02 | 2.660E-09 | 1.313E-07 | 4.883E-07 | 1.460E-06 | 5.642E-06 |
| 372.00 | 4.161E+01 | 4.012E+01 | 3.471E+01 | 1.472E-02 | 4.384E-02 | 1.637E-02 | 1.242E-08 | 1.283E-07 | 4.727E-07 | 1.511E-06 | 6.835E-06 |
| 432.00 | 3.935E+01 | 4.568E+01 | 3.375E+01 | 1.791E-02 | 4.093E-02 | 1.858E-02 | 1.961E-08 | 1.191E-07 | 4.252E-07 | 1.584E-06 | 8.577E-06 |
| 492.00 | 3.686E+01 | 5.047E+01 | 3.271E+01 | 2.119E-02 | 3.772E-02 | 2.065E-02 | 2.552E-08 | 1.128E-07 | 3.842E-07 | 1.638E-06 | 9.028E-06 |
| 552.00 | 3.436E+01 | 5.485E+01 | 3.163E+01 | 2.466E-02 | 3.436E-02 | 2.234E-02 | 3.039E-08 | 1.074E-07 | 3.470E-07 | 1.671E-06 | 8.361E-06 |
| 612.00 | 3.190E+01 | 5.881E+01 | 3.054E+01 | 2.823E-02 | 3.100E-02 | 2.360E-02 | 3.438E-08 | 1.026E-07 | 3.132E-07 | 1.681E-06 | 7.263E-06 |
| 672.00 | 2.953E+01 | 6.238E+01 | 2.950E+01 | 3.193E-02 | 2.770E-02 | 2.439E-02 | 3.768E-08 | 9.760E-08 | 2.814E-07 | 1.666E-06 | 6.165E-06 |
| 732.00 | 2.729E+01 | 6.550E+01 | 2.860E+01 | 3.588E-02 | 2.478E-02 | 2.467E-02 | 4.030E-08 | 9.279E-08 | 2.518E-07 | 1.625E-06 | 5.273E-06 |
| 792.00 | 2.527E+01 | 6.813E+01 | 2.798E+01 | 4.037E-02 | 2.286E-02 | 2.438E-02 | 4.228E-08 | 8.859E-08 | 2.243E-07 | 1.570E-06 | 4.539E-06 |
| 852.00 | 2.355E+01 | 7.022E+01 | 2.784E+01 | 4.599E-02 | 2.303E-02 | 2.355E-02 | 4.368E-08 | 8.599E-08 | 1.990E-07 | 1.549E-06 | 3.963E-06 |
| 912.00 | 2.232E+01 | 7.165E+01 | 2.845E+01 | 5.394E-02 | 2.687E-02 | 2.256E-02 | 4.455E-08 | 8.742E-08 | 1.763E-07 | 1.718E-06 | 3.536E-06 |
| 972.00 | 2.166E+01 | 7.161E+01 | 3.003E+01 | 6.548E-02 | 3.609E-02 | 2.339E-02 | 4.470E-08 | 1.129E-07 | 1.678E-07 | 2.407E-06 | 3.270E-06 |
| 1032.00 | 2.230E+01 | 7.092E+01 | 3.324E+01 | 8.637E-02 | 5.476E-02 | 3.169E-02 | 4.560E-08 | 1.482E-07 | 1.550E-07 | 4.059E-06 | 3.429E-06 |
| 1092.00 | 2.468E+01 | 6.928E+01 | 3.772E+01 | 1.177E-01 | 8.678E-02 | 5.154E-02 | 4.660E-08 | 2.189E-07 | 1.462E-07 | 6.992E-06 | 4.349E-06 |
| 1152.00 | 2.876E+01 | 6.751E+01 | 4.294E+01 | 1.533E-01 | 1.375E-01 | 8.137E-02 | 4.729E-08 | 3.551E-07 | 1.378E-07 | 1.110E-05 | 6.340E-06 |
| 1212.00 | 3.476E+01 | 6.815E+01 | 5.085E+01 | 1.845E-01 | 2.125E-01 | 1.145E-01 | 4.954E-08 | 5.095E-07 | 9.362E-08 | 1.590E-05 | 9.326E-06 |
| 1272.00 | 4.044E+01 | 7.243E+01 | 6.307E+01 | 1.949E-01 | 3.136E-01 | 1.364E-01 | 4.959E-08 | 7.099E-07 | 2.830E-08 | 2.008E-05 | 1.229E-05 |
| 1332.00 | 4.479E+01 | 9.263E+01 | 6.850E+01 | 1.790E-01 | 3.272E-01 | 2.046E-01 | 5.196E-08 | 8.756E-07 | 6.742E-08 | 2.358E-05 | 2.165E-05 |
| 1392.00 | 4.780E+01 | 1.185E+02 | 6.817E+01 | 1.944E-01 | 2.428E-01 | 3.376E-01 | 5.858E-08 | 8.665E-07 | 3.728E-07 | 3.276E-05 | 4.517E-05 |
| 1432.00 | 4.944E+01 | 1.299E+02 | 7.954E+01 | 2.262E-01 | 1.993E-01 | 4.086E-01 | 6.871E-08 | 7.545E-07 | 5.854E-07 | 4.365E-05 | 6.389E-05 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)
3.759E-10 2.065E-10 2.501E-09 2.207E-03

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OF POOR QUALITY

GROUP 21 1962 STANDARD ATMOSPHERE MODELING ERROR 1-TERM MODEL

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 2.595E+03 | 3.843E+03 | 5.913E+02 | 1.317E+00 | 4.480E+00 | 1.414E+00 | 1.355E-05 | 4.376E-06 | 2.771E-05 | 7.759E-01 | 1.647E+00 |
| 372.00 | 2.894E+03 | 4.782E+03 | 7.902E+02 | 2.088E+00 | 5.170E+00 | 1.748E+00 | 1.432E-05 | 4.560E-06 | 2.943E-05 | 9.515E-01 | 1.825E+00 |
| 432.00 | 2.817E+03 | 5.252E+03 | 9.258E+02 | 2.728E+00 | 5.226E+00 | 1.897E+00 | 1.352E-05 | 4.217E-06 | 2.802E-05 | 9.729E-01 | 1.780E+00 |
| 492.00 | 2.686E+03 | 5.724E+03 | 1.070E+03 | 3.396E+00 | 5.201E+00 | 2.035E+00 | 1.294E-05 | 3.802E-06 | 2.703E-05 | 9.436E-01 | 1.730E+00 |
| 552.00 | 2.496E+03 | 6.166E+03 | 1.215E+03 | 4.075E+00 | 5.075E+00 | 2.156E+00 | 1.257E-05 | 3.205E-06 | 2.629E-05 | 8.591E-01 | 1.651E+00 |
| 612.00 | 2.259E+03 | 6.598E+03 | 1.365E+03 | 4.772E+00 | 4.870E+00 | 2.267E+00 | 1.253E-05 | 2.351E-06 | 2.612E-05 | 7.161E-01 | 1.548E+00 |
| 672.00 | 1.969E+03 | 6.975E+03 | 1.514E+03 | 5.455E+00 | 4.558E+00 | 2.352E+00 | 1.238E-05 | 1.438E-06 | 2.566E-05 | 5.054E-01 | 1.407E+00 |
| 732.00 | 1.633E+03 | 7.301E+03 | 1.664E+03 | 6.110E+00 | 4.156E+00 | 2.410E+00 | 1.196E-05 | 6.854E-07 | 2.470E-05 | 2.223E-01 | 1.239E+00 |
| 792.00 | 1.257E+03 | 7.600E+03 | 1.818E+03 | 6.757E+00 | 3.689E+00 | 2.452E+00 | 1.155E-05 | 8.070E-08 | 2.389E-05 | 1.501E-01 | 1.052E+00 |
| 852.00 | 8.400E+02 | 7.862E+03 | 1.974E+03 | 7.383E+00 | 3.159E+00 | 2.474E+00 | 1.106E-05 | 7.423E-07 | 2.299E-05 | 6.295E-01 | 8.512E-01 |
| 912.00 | 3.822E+02 | 8.070E+03 | 2.128E+03 | 7.965E+00 | 2.570E+00 | 2.467E+00 | 1.037E-05 | 1.125E-06 | 2.164E-05 | 1.235E+00 | 6.390E-01 |
| 972.00 | 1.111E+02 | 8.204E+03 | 2.275E+03 | 8.475E+00 | 1.932E+00 | 2.424E+00 | 9.423E-06 | 1.077E-06 | 1.952E-05 | 1.989E+00 | 4.379E-01 |
| 1032.00 | 6.279E+02 | 8.239E+03 | 2.403E+03 | 8.867E+00 | 1.265E+00 | 2.331E+00 | 8.188E-06 | 4.211E-07 | 1.619E-05 | 2.918E+00 | 2.242E-01 |
| 1092.00 | 1.154E+03 | 8.186E+03 | 2.509E+03 | 9.160E+00 | 5.926E-01 | 2.199E+00 | 6.917E-06 | 5.847E-07 | 1.206E-05 | 3.997E+00 | 6.751E-02 |
| 1152.00 | 1.644E+03 | 7.951E+03 | 2.555E+03 | 9.157E+00 | 3.205E-02 | 1.983E+00 | 5.338E-06 | 2.648E-06 | 4.862E-06 | 5.022E+00 | 4.304E-02 |
| 1212.00 | 2.093E+03 | 7.650E+03 | 2.568E+03 | 9.063E+00 | 5.991E-01 | 1.751E+00 | 4.130E-06 | 4.360E-06 | 2.636E-06 | 6.026E+00 | 1.366E-01 |
| 1272.00 | 2.435E+03 | 7.197E+03 | 2.508E+03 | 8.640E+00 | 1.032E+00 | 1.474E+00 | 3.203E-06 | 5.877E-06 | 1.288E-05 | 6.684E+00 | 3.943E-01 |
| 1332.00 | 2.674E+03 | 6.701E+03 | 2.411E+03 | 8.041E+00 | 1.348E+00 | 1.224E+00 | 3.056E-06 | 5.975E-06 | 2.322E-05 | 6.371E+00 | 3.955E-01 |
| 1392.00 | 2.918E+03 | 6.318E+03 | 2.353E+03 | 7.706E+00 | 1.688E+00 | 1.062E+00 | 3.601E-06 | 3.931E-06 | 2.910E-05 | 5.941E+00 | 2.542E-01 |
| 1432.00 | 3.051E+03 | 6.005E+03 | 2.315E+03 | 7.486E+00 | 1.882E+00 | 9.835E-01 | 4.294E-06 | 1.128E-06 | 3.210E-05 | 5.797E+00 | 6.055E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 1.685E+03 | 4.361E+03 | 9.321E+00 | 4.605E+00 | 1.577E+00 | 3.417E-01 | 1.639E-07 | 8.089E-06 | 3.008E-05 | 3.073E-05 | 6.198E-04 |
| 372.00 | 1.913E+03 | 5.311E+03 | 2.216E+01 | 5.552E+00 | 1.776E+00 | 4.123E-01 | 6.988E-07 | 8.461E-06 | 3.194E-05 | 3.743E-05 | 9.207E-04 |
| 432.00 | 1.929E+03 | 5.714E+03 | 8.788E+01 | 5.920E+00 | 1.760E+00 | 4.500E-01 | 1.099E-06 | 8.169E-06 | 3.030E-05 | 3.845E-05 | 1.045E-03 |
| 492.00 | 1.945E+03 | 6.107E+03 | 1.996E+02 | 6.287E+00 | 1.719E+00 | 4.851E-01 | 1.405E-06 | 8.259E-06 | 2.902E-05 | 3.789E-05 | 1.003E-03 |
| 552.00 | 1.950E+03 | 6.467E+03 | 3.390E+02 | 6.637E+00 | 1.643E+00 | 5.050E-01 | 1.660E-06 | 8.704E-06 | 2.794E-05 | 3.521E-05 | 8.545E-04 |
| 612.00 | 1.957E+03 | 6.813E+03 | 5.053E+02 | 7.000E+00 | 1.540E+00 | 5.061E-01 | 1.874E-06 | 9.676E-06 | 2.734E-05 | 3.004E-05 | 6.937E-04 |
| 672.00 | 1.953E+03 | 7.108E+03 | 6.933E+02 | 7.340E+00 | 1.399E+00 | 4.834E-01 | 2.164E-06 | 1.065E-05 | 2.638E-05 | 2.178E-05 | 5.574E-04 |
| 732.00 | 1.950E+03 | 7.356E+03 | 9.082E+02 | 7.665E+00 | 1.228E+00 | 4.371E-01 | 2.530E-06 | 1.130E-05 | 2.488E-05 | 9.916E-06 | 4.527E-04 |
| 792.00 | 1.964E+03 | 7.577E+03 | 1.170E+03 | 8.004E+00 | 1.036E+00 | 3.638E-01 | 2.897E-06 | 1.210E-05 | 2.344E-05 | 6.771E-06 | 3.765E-04 |
| 852.00 | 2.000E+03 | 7.757E+03 | 1.498E+03 | 8.358E+00 | 8.265E-01 | 2.591E-01 | 3.281E-06 | 1.286E-05 | 2.180E-05 | 2.984E-05 | 3.213E-04 |
| 912.00 | 2.064E+03 | 7.865E+03 | 1.919E+03 | 8.704E+00 | 6.049E-01 | 1.173E-01 | 3.679E-06 | 1.328E-05 | 1.968E-05 | 6.156E-05 | 2.817E-04 |
| 972.00 | 2.159E+03 | 7.855E+03 | 2.477E+03 | 9.015E+00 | 3.634E-01 | 6.942E-02 | 4.063E-06 | 1.307E-05 | 1.684E-05 | 1.054E-04 | 2.543E-04 |
| 1032.00 | 2.289E+03 | 7.649E+03 | 3.209E+03 | 9.248E+00 | 1.851E-01 | 3.090E-01 | 4.386E-06 | 1.170E-05 | 1.316E-05 | 1.673E-04 | 2.383E-04 |
| 1092.00 | 2.461E+03 | 7.207E+03 | 4.079E+03 | 9.419E+00 | 3.886E-02 | 6.191E-01 | 4.599E-06 | 9.262E-06 | 9.312E-06 | 2.522E-04 | 2.345E-04 |
| 1152.00 | 2.636E+03 | 6.412E+03 | 4.939E+03 | 9.321E+00 | 3.467E-03 | 9.491E-01 | 4.725E-06 | 3.199E-06 | 5.156E-06 | 3.556E-04 | 2.397E-04 |
| 1212.00 | 2.839E+03 | 5.345E+03 | 5.733E+03 | 9.157E+00 | 7.316E-02 | 1.309E+00 | 4.670E-06 | 3.643E-06 | 2.750E-06 | 4.884E-04 | 2.586E-04 |
| 1272.00 | 2.995E+03 | 3.975E+03 | 6.265E+03 | 8.679E+00 | 2.970E-01 | 1.575E+00 | 4.637E-06 | 1.356E-05 | 2.336E-06 | 6.322E-04 | 2.625E-04 |
| 1332.00 | 3.104E+03 | 3.970E+03 | 5.699E+03 | 8.039E+00 | 2.113E-01 | 1.818E+00 | 4.783E-06 | 2.368E-05 | 8.128E-07 | 7.193E-04 | 3.204E-04 |
| 1392.00 | 3.225E+03 | 5.131E+03 | 4.151E+03 | 7.684E+00 | 3.885E-01 | 2.041E+00 | 4.979E-06 | 2.666E-05 | 1.182E-05 | 8.317E-04 | 3.900E-04 |
| 1432.00 | 3.284E+03 | 5.681E+03 | 2.898E+03 | 7.463E+00 | 8.704E-01 | 2.023E+00 | 5.396E-06 | 2.415E-05 | 2.093E-05 | 9.434E-04 | 4.230E-04 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

1.781E-08 9.813E-09 1.189E-07 2.825E-02

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GROUP 21 1962 STANDARD ATMOSPHERE MODELING ERROR 4-TERM MODEL

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 2.341E+03 | 3.466E+03 | 5.333E+02 | 1.188E+00 | 4.041E+00 | 1.275E+00 | 1.222E-05 | 3.947E-06 | 2.499E-05 | 6.998E-01 | 1.485E+00 |
| 372.00 | 2.740E+03 | 4.531E+03 | 7.488E+02 | 1.976E+00 | 4.899E+00 | 1.656E+00 | 1.357E-05 | 4.330E-06 | 2.793E-05 | 9.015E-01 | 1.731E+00 |
| 432.00 | 2.669E+03 | 4.990E+03 | 8.780E+02 | 2.583E+00 | 4.956E+00 | 1.798E+00 | 1.282E-05 | 4.009E-06 | 2.662E-05 | 9.226E-01 | 1.690E+00 |
| 492.00 | 2.546E+03 | 5.432E+03 | 1.015E+03 | 3.219E+00 | 4.936E+00 | 1.931E+00 | 1.229E-05 | 3.616E-06 | 2.572E-05 | 8.956E-01 | 1.644E+00 |
| 552.00 | 2.367E+03 | 5.855E+03 | 1.154E+03 | 3.865E+00 | 4.819E+00 | 2.047E+00 | 1.196E-05 | 3.045E-06 | 2.505E-05 | 8.160E-01 | 1.570E+00 |
| 612.00 | 2.142E+03 | 6.269E+03 | 1.296E+03 | 4.530E+00 | 4.628E+00 | 2.154E+00 | 1.194E-05 | 2.223E-06 | 2.494E-05 | 6.806E-01 | 1.473E+00 |
| 672.00 | 1.845E+03 | 6.478E+03 | 1.413E+03 | 5.071E+00 | 4.228E+00 | 2.178E+00 | 1.097E-05 | 1.679E-06 | 2.260E-05 | 4.808E-01 | 1.299E+00 |
| 732.00 | 1.535E+03 | 6.790E+03 | 1.553E+03 | 5.690E+00 | 3.859E+00 | 2.235E+00 | 1.073E-05 | 8.680E-07 | 2.206E-05 | 2.146E-01 | 1.143E+00 |
| 792.00 | 1.186E+03 | 7.080E+03 | 1.697E+03 | 6.304E+00 | 3.429E+00 | 2.279E+00 | 1.051E-05 | 2.322E-08 | 2.168E-05 | 1.369E-01 | 9.680E-01 |
| 852.00 | 7.977E+02 | 7.337E+03 | 1.845E+03 | 6.905E+00 | 2.938E+00 | 2.306E+00 | 1.021E-05 | 7.434E-07 | 2.124E-05 | 5.910E-01 | 7.796E-01 |
| 912.00 | 3.703E+02 | 7.547E+03 | 1.992E+03 | 7.470E+00 | 2.391E+00 | 2.308E+00 | 9.715E-06 | 1.264E-06 | 2.039E-05 | 1.167E+00 | 5.803E-01 |
| 972.00 | 9.303E+01 | 7.701E+03 | 2.135E+03 | 7.990E+00 | 1.796E+00 | 2.281E+00 | 9.044E-06 | 1.507E-06 | 1.910E-05 | 1.896E+00 | 3.699E-01 |
| 1032.00 | 5.826E+02 | 7.755E+03 | 2.262E+03 | 8.394E+00 | 1.169E+00 | 2.205E+00 | 8.009E-06 | 1.079E-06 | 1.644E-05 | 2.790E+00 | 1.891E-01 |
| 1092.00 | 1.086E+03 | 7.733E+03 | 2.370E+03 | 8.719E+00 | 5.318E-01 | 2.094E+00 | 6.926E-06 | 3.351E-07 | 1.310E-05 | 3.839E+00 | 6.160E-02 |
| 1152.00 | 1.560E+03 | 7.534E+03 | 2.423E+03 | 8.761E+00 | 6.428E-02 | 1.901E+00 | 5.491E-06 | 1.481E-06 | 6.720E-06 | 4.841E+00 | 2.445E-02 |
| 1212.00 | 2.001E+03 | 7.272E+03 | 2.446E+03 | 8.726E+00 | 6.113E-01 | 1.692E+00 | 4.377E-06 | 3.006E-06 | 6.664E-08 | 5.837E+00 | 1.218E-01 |
| 1272.00 | 2.342E+03 | 6.856E+03 | 2.398E+03 | 8.363E+00 | 1.030E+00 | 1.434E+00 | 3.474E-06 | 4.466E-06 | 9.481E-06 | 6.497E+00 | 3.808E-01 |
| 1332.00 | 2.093E+03 | 5.719E+03 | 2.018E+03 | 5.867E+00 | 7.708E-01 | 9.615E-01 | 3.979E-06 | 5.987E-06 | 3.750E-05 | 4.465E+00 | 4.135E-01 |
| 1392.00 | 2.252E+03 | 5.428E+03 | 1.969E+03 | 5.565E+00 | 1.100E+00 | 8.224E-01 | 4.227E-06 | 4.286E-06 | 4.045E-05 | 4.069E+00 | 7.431E-02 |
| 1432.00 | 2.330E+03 | 5.232E+03 | 1.935E+03 | 5.359E+00 | 1.287E+00 | 7.529E-01 | 4.692E-06 | 1.936E-06 | 4.184E-05 | 3.919E+00 | 3.565E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 1.519E+03 | 3.933E+03 | 8.407E+00 | 4.153E+00 | 1.422E+00 | 3.082E-01 | 1.478E-07 | 7.296E-06 | 2.713E-05 | 2.771E-05 | 5.590E-04 |
| 372.00 | 1.814E+03 | 5.031E+03 | 2.148E+01 | 5.259E+00 | 1.685E+00 | 3.907E-01 | 6.505E-07 | 8.009E-06 | 3.030E-05 | 3.547E-05 | 8.721E-04 |
| 432.00 | 1.831E+03 | 5.416E+03 | 8.393E+01 | 5.612E+00 | 1.671E+00 | 4.268E-01 | 1.028E-06 | 7.740E-06 | 2.878E-05 | 3.646E-05 | 9.906E-04 |
| 492.00 | 1.848E+03 | 5.793E+03 | 1.902E+02 | 5.964E+00 | 1.634E+00 | 4.603E-01 | 1.317E-06 | 7.841E-06 | 2.761E-05 | 3.596E-05 | 9.516E-04 |
| 552.00 | 1.654E+03 | 6.138E+03 | 3.229E+02 | 6.299E+00 | 1.563E+00 | 4.794E-01 | 1.556E-06 | 8.285E-06 | 2.662E-05 | 3.344E-05 | 8.112E-04 |
| 612.00 | 1.862E+03 | 6.471E+03 | 4.814E+02 | 6.648E+00 | 1.466E+00 | 4.805E-01 | 1.758E-06 | 9.244E-06 | 2.609E-05 | 2.855E-05 | 6.590E-04 |
| 672.00 | 1.803E+03 | 6.612E+03 | 6.343E+02 | 6.816E+00 | 1.291E+00 | 4.537E-01 | 2.140E-06 | 9.073E-06 | 2.339E-05 | 2.072E-05 | 5.173E-04 |
| 732.00 | 1.802E+03 | 6.850E+03 | 8.368E+02 | 7.128E+00 | 1.132E+00 | 4.106E-01 | 2.402E-06 | 9.905E-06 | 2.233E-05 | 9.567E-06 | 4.206E-04 |
| 792.00 | 1.818E+03 | 7.066E+03 | 1.083E+03 | 7.461E+00 | 9.530E-01 | 3.416E-01 | 2.687E-06 | 1.091E-05 | 2.132E-05 | 6.174E-06 | 3.504E-04 |
| 852.00 | 1.855E+03 | 7.245E+03 | 1.393E+03 | 7.810E+00 | 7.565E-01 | 2.421E-01 | 3.009E-06 | 1.192E-05 | 2.012E-05 | 2.802E-05 | 2.997E-04 |
| 912.00 | 1.918E+03 | 7.360E+03 | 1.792E+03 | 8.156E+00 | 5.484E-01 | 1.065E-01 | 3.366E-06 | 1.267E-05 | 1.844E-05 | 5.817E-05 | 2.635E-04 |
| 972.00 | 2.016E+03 | 7.377E+03 | 2.323E+03 | 8.494E+00 | 3.385E-01 | 7.569E-02 | 3.726E-06 | 1.311E-05 | 1.622E-05 | 1.005E-04 | 2.393E-04 |
| 1032.00 | 2.146E+03 | 7.202E+03 | 3.021E+03 | 8.750E+00 | 1.521E-01 | 3.087E-01 | 4.066E-06 | 1.232E-05 | 1.294E-05 | 1.600E-04 | 2.253E-04 |
| 1092.00 | 2.321E+03 | 6.809E+03 | 3.853E+03 | 8.962E+00 | 1.531E-02 | 6.129E-01 | 4.317E-06 | 1.063E-05 | 9.395E-06 | 2.422E-04 | 2.233E-04 |
| 1152.00 | 2.501E+03 | 6.076E+03 | 4.678E+03 | 8.916E+00 | 2.004E-02 | 9.373E-01 | 4.500E-06 | 5.381E-06 | 5.319E-06 | 3.428E-04 | 2.298E-04 |
| 1212.00 | 2.711E+03 | 5.084E+03 | 5.447E+03 | 8.815E+00 | 6.069E-02 | 1.294E+00 | 4.507E-06 | 6.647E-07 | 2.728E-06 | 4.731E-04 | 2.499E-04 |
| 1272.00 | 2.876E+03 | 3.792E+03 | 5.966E+03 | 8.400E+00 | 2.867E-01 | 1.556E+00 | 4.536E-06 | 9.900E-06 | 1.829E-06 | 6.145E-04 | 2.742E-04 |
| 1332.00 | 2.458E+03 | 3.363E+03 | 4.880E+03 | 5.879E+00 | 2.788E-01 | 1.142E+00 | 6.617E-06 | 3.730E-05 | 4.808E-06 | 5.038E-04 | 2.281E-04 |
| 1392.00 | 2.515E+03 | 4.377E+03 | 3.595E+03 | 5.556E+00 | 1.714E-01 | 1.401E+00 | 6.105E-06 | 3.649E-05 | 1.743E-05 | 5.694E-04 | 2.870E-04 |
| 1432.00 | 2.530E+03 | 4.868E+03 | 2.540E+03 | 5.346E+00 | 5.462E-01 | 1.437E+00 | 6.141E-06 | 3.183E-05 | 2.694E-05 | 6.374E-04 | 3.163E-04 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)
1.645E-08 8.439E-09 1.170E-07 5.907E-03

GROUP 21 TIME-VARYING DENSITY DEVIATIONS-- WINTER PROFILE.

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 4.605E+03 | 6.820E+03 | 1.049E+03 | 2.338E+00 | 7.950E+00 | 2.509E+00 | 2.404E-05 | 7.766E-06 | 4.917E-05 | 1.377E+00 | 2.922E+00 |
| 372.00 | 5.357E+03 | 8.920E+03 | 1.475E+03 | 3.852E+00 | 9.637E+00 | 3.248E+00 | 2.667E-05 | 8.670E-06 | 5.568E-05 | 1.773E+00 | 3.432E+00 |
| 432.00 | 5.240E+03 | 9.839E+03 | 1.735E+03 | 5.066E+00 | 9.788E+00 | 3.542E+00 | 2.524E-05 | 8.064E-06 | 5.312E-05 | 1.824E+00 | 3.363E+00 |
| 492.00 | 4.960E+03 | 1.060E+04 | 1.984E+03 | 6.267E+00 | 9.635E+00 | 3.765E+00 | 2.370E-05 | 7.207E-06 | 4.997E-05 | 1.753E+00 | 3.221E+00 |
| 552.00 | 4.589E+03 | 1.134E+04 | 2.240E+03 | 7.481E+00 | 9.330E+00 | 3.959E+00 | 2.254E-05 | 6.177E-06 | 4.743E-05 | 1.588E+00 | 3.041E+00 |
| 612.00 | 4.135E+03 | 1.203E+04 | 2.502E+03 | 8.703E+00 | 8.879E+00 | 4.127E+00 | 2.175E-05 | 4.914E-06 | 4.553E-05 | 1.322E+00 | 2.820E+00 |
| 672.00 | 3.594E+03 | 1.264E+04 | 2.763E+03 | 9.886E+00 | 8.257E+00 | 4.248E+00 | 2.076E-05 | 3.699E-06 | 4.320E-05 | 9.417E-01 | 2.544E+00 |
| 732.00 | 2.973E+03 | 1.315E+04 | 3.024E+03 | 1.099E+01 | 7.478E+00 | 4.312E+00 | 1.923E-05 | 2.943E-06 | 3.979E-05 | 4.424E-01 | 2.224E+00 |
| 792.00 | 2.281E+03 | 1.356E+04 | 3.282E+03 | 1.202E+01 | 6.578E+00 | 4.325E+00 | 1.738E-05 | 2.646E-06 | 3.567E-05 | 1.901E-01 | 1.875E+00 |
| 852.00 | 1.521E+03 | 1.383E+04 | 3.526E+03 | 1.288E+01 | 5.564E+00 | 4.263E+00 | 1.488E-05 | 3.277E-06 | 2.986E-05 | 9.569E-01 | 1.511E+00 |
| 912.00 | 7.100E+02 | 1.386E+04 | 3.730E+03 | 1.344E+01 | 4.455E+00 | 4.080E+00 | 1.123E-05 | 5.706E-06 | 2.044E-05 | 1.822E+00 | 1.144E+00 |
| 972.00 | 1.075E+02 | 1.353E+04 | 3.848E+03 | 1.347E+01 | 3.304E+00 | 3.716E+00 | 6.072E-06 | 1.094E-05 | 5.066E-06 | 2.689E+00 | 8.231E-01 |
| 1032.00 | 8.694E+02 | 1.301E+04 | 3.894E+03 | 1.318E+01 | 2.209E+00 | 3.273E+00 | 1.321E-06 | 1.674E-05 | 1.145E-05 | 3.682E+00 | 4.781E-01 |
| 1092.00 | 1.571E+03 | 1.252E+04 | 3.915E+03 | 1.295E+01 | 1.186E+00 | 2.872E+00 | 1.732E-06 | 2.075E-05 | 2.411E-05 | 4.948E+00 | 2.053E-01 |
| 1152.00 | 2.180E+03 | 1.191E+04 | 3.868E+03 | 1.248E+01 | 2.726E-01 | 2.437E+00 | 4.029E-06 | 2.445E-05 | 3.756E-05 | 6.192E+00 | 3.485E-02 |
| 1212.00 | 2.726E+03 | 1.135E+04 | 3.808E+03 | 1.211E+01 | 5.724E-01 | 2.062E+00 | 5.102E-06 | 2.615E-05 | 4.767E-05 | 7.543E+00 | 3.518E-02 |
| 1272.00 | 3.076E+03 | 1.055E+04 | 3.630E+03 | 1.114E+01 | 1.181E+00 | 1.628E+00 | 5.590E-06 | 2.721E-05 | 6.265E-05 | 8.246E+00 | 2.839E-01 |
| 1332.00 | 3.306E+03 | 9.800E+03 | 3.440E+03 | 1.005E+01 | 1.688E+00 | 1.261E+00 | 4.898E-06 | 2.581E-05 | 7.463E-05 | 7.604E+00 | 2.363E-01 |
| 1392.00 | 3.602E+03 | 9.308E+03 | 3.347E+03 | 9.528E+00 | 2.330E+00 | 1.042E+00 | 3.415E-06 | 2.156E-05 | 7.777E-05 | 6.934E+00 | 6.718E-01 |
| 1432.00 | 3.781E+03 | 8.998E+03 | 3.295E+03 | 9.270E+00 | 2.733E+00 | 9.329E-01 | 2.170E-06 | 1.732E-05 | 7.835E-05 | 6.771E+00 | 1.232E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 2.989E+03 | 7.738E+03 | 1.654E+01 | 8.171E+00 | 2.798E+00 | 6.064E-01 | 2.908E-07 | 1.435E-05 | 5.338E-05 | 5.452E-05 | 1.100E-03 |
| 372.00 | 3.593E+03 | 9.876E+03 | 5.001E+01 | 1.032E+01 | 3.341E+00 | 7.694E-01 | 1.097E-06 | 1.565E-05 | 6.033E-05 | 6.976E-05 | 1.712E-03 |
| 432.00 | 3.640E+03 | 1.068E+04 | 1.727E+02 | 1.106E+01 | 3.327E+00 | 8.431E-01 | 1.670E-06 | 1.515E-05 | 5.736E-05 | 7.208E-05 | 1.953E-03 |
| 492.00 | 3.615E+03 | 1.130E+04 | 3.714E+02 | 1.163E+01 | 3.201E+00 | 8.991E-01 | 2.546E-06 | 1.499E-05 | 5.366E-05 | 7.040E-05 | 1.856E-03 |
| 552.00 | 3.587E+03 | 1.189E+04 | 6.180E+02 | 1.219E+01 | 3.027E+00 | 9.305E-01 | 3.103E-06 | 1.531E-05 | 5.052E-05 | 6.508E-05 | 1.570E-03 |
| 612.00 | 3.561E+03 | 1.244E+04 | 9.073E+02 | 1.276E+01 | 2.806E+00 | 9.290E-01 | 3.589E-06 | 1.616E-05 | 4.792E-05 | 5.545E-05 | 1.265E-03 |
| 672.00 | 3.520E+03 | 1.290E+04 | 1.234E+03 | 1.330E+01 | 2.528E+00 | 8.880E-01 | 4.138E-06 | 1.683E-05 | 4.484E-05 | 4.058E-05 | 1.004E-03 |
| 732.00 | 3.493E+03 | 1.327E+04 | 1.604E+03 | 1.378E+01 | 2.204E+00 | 8.076E-01 | 4.762E-06 | 1.665E-05 | 4.077E-05 | 1.972E-05 | 8.128E-04 |
| 792.00 | 3.482E+03 | 1.354E+04 | 2.044E+03 | 1.423E+01 | 1.847E+00 | 6.857E-01 | 5.359E-06 | 1.575E-05 | 3.612E-05 | 8.524E-06 | 6.677E-04 |
| 852.00 | 3.493E+03 | 1.368E+04 | 2.578E+03 | 1.458E+01 | 1.468E+00 | 5.226E-01 | 5.917E-06 | 1.325E-05 | 3.022E-05 | 4.533E-05 | 5.589E-04 |
| 912.00 | 3.514E+03 | 1.356E+04 | 3.224E+03 | 1.469E+01 | 1.086E+00 | 3.274E-01 | 6.377E-06 | 7.259E-06 | 2.198E-05 | 9.081E-05 | 4.738E-04 |
| 972.00 | 3.512E+03 | 1.302E+04 | 3.994E+03 | 1.434E+01 | 7.364E-01 | 1.281E-01 | 6.567E-06 | 4.851E-06 | 1.075E-05 | 1.424E-04 | 4.021E-04 |
| 1032.00 | 3.517E+03 | 1.217E+04 | 4.980E+03 | 1.375E+01 | 4.200E-01 | 1.075E-01 | 6.100E-06 | 1.934E-05 | 1.362E-06 | 2.110E-04 | 3.502E-04 |
| 1092.00 | 3.590E+03 | 1.112E+04 | 6.175E+03 | 1.331E+01 | 1.365E-01 | 4.623E-01 | 4.958E-06 | 3.137E-05 | 2.442E-06 | 3.121E-04 | 3.249E-04 |
| 1152.00 | 3.677E+03 | 9.685E+03 | 7.367E+03 | 1.269E+01 | 2.846E-02 | 8.820E-01 | 3.695E-06 | 4.477E-05 | 2.634E-06 | 4.385E-04 | 3.188E-04 |
| 1212.00 | 3.835E+03 | 7.979E+03 | 8.503E+03 | 1.222E+01 | 4.954E-02 | 1.422E+00 | 2.268E-06 | 5.451E-05 | 2.437E-06 | 6.115E-04 | 3.411E-04 |
| 1272.00 | 3.895E+03 | 5.831E+03 | 9.206E+03 | 1.117E+01 | 1.587E-01 | 1.816E+00 | 1.433E-06 | 6.770E-05 | 1.053E-05 | 7.802E-04 | 3.681E-04 |
| 1332.00 | 3.930E+03 | 5.767E+03 | 8.373E+03 | 1.003E+01 | 6.553E-03 | 2.202E+00 | 9.756E-07 | 7.900E-05 | 4.066E-06 | 8.591E-04 | 4.188E-04 |
| 1392.00 | 4.051E+03 | 7.495E+03 | 6.182E+03 | 9.481E+00 | 8.376E-01 | 2.590E+00 | 6.566E-07 | 7.770E-05 | 2.206E-05 | 9.718E-04 | 5.190E-04 |
| 1432.00 | 4.122E+03 | 8.357E+03 | 4.390E+03 | 9.222E+00 | 1.560E+00 | 2.607E+00 | 9.112E-07 | 6.934E-05 | 4.042E-05 | 1.105E-03 | 5.668E-04 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)
2.330E-08 1.207E-08 1.521E-07 1.337E-01

GROUP 21 TIME-VARYING DENSITY DEVIATIONS--SUMMER PROFILE

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 2.347E+03 | 3.476E+03 | 5.349E+02 | 1.192E+00 | 4.053E+00 | 1.279E+00 | 1.225E-05 | 3.959E-06 | 2.506E-05 | 7.019E-01 | 1.490E+00 |
| 372.00 | 2.662E+03 | 4.417E+03 | 7.301E+02 | 1.917E+00 | 4.774E+00 | 1.611E+00 | 1.321E-05 | 4.255E-06 | 2.739E-05 | 8.784E-01 | 1.693E+00 |
| 432.00 | 2.611E+03 | 4.896E+03 | 8.630E+02 | 2.526E+00 | 4.871E+00 | 1.764E+00 | 1.260E-05 | 3.985E-06 | 2.641E-05 | 9.070E-01 | 1.670E+00 |
| 492.00 | 2.497E+03 | 5.357E+03 | 1.000E+03 | 3.159E+00 | 4.868E+00 | 1.901E+00 | 1.214E-05 | 3.603E-06 | 2.567E-05 | 8.839E-01 | 1.632E+00 |
| 552.00 | 2.324E+03 | 5.788E+03 | 1.139E+03 | 3.804E+00 | 4.760E+00 | 2.021E+00 | 1.189E-05 | 3.021E-06 | 2.517E-05 | 8.078E-01 | 1.565E+00 |
| 612.00 | 2.106E+03 | 6.209E+03 | 1.282E+03 | 4.469E+00 | 4.588E+00 | 2.132E+00 | 1.197E-05 | 2.166E-06 | 2.523E-05 | 6.753E-01 | 1.473E+00 |
| 672.00 | 1.836E+03 | 6.577E+03 | 1.423E+03 | 5.122E+00 | 4.305E+00 | 2.218E+00 | 1.194E-05 | 1.227E-06 | 2.501E-05 | 4.775E-01 | 1.344E+00 |
| 732.00 | 1.523E+03 | 6.898E+03 | 1.567E+03 | 5.755E+00 | 3.936E+00 | 2.281E+00 | 1.167E-05 | 4.051E-07 | 2.437E-05 | 2.091E-01 | 1.188E+00 |
| 792.00 | 1.171E+03 | 7.202E+03 | 1.715E+03 | 6.390E+00 | 3.506E+00 | 2.332E+00 | 1.147E-05 | 4.902E-07 | 2.399E-05 | 1.479E-01 | 1.014E+00 |
| 852.00 | 7.787E+02 | 7.479E+03 | 1.868E+03 | 7.019E+00 | 3.014E+00 | 2.368E+00 | 1.123E-05 | 1.369E-06 | 2.369E-05 | 6.134E-01 | 8.238E-01 |
| 912.00 | 3.449E+02 | 7.717E+03 | 2.023E+03 | 7.629E+00 | 2.463E+00 | 2.383E+00 | 1.084E-05 | 2.089E-06 | 2.319E-05 | 1.212E+00 | 6.217E-01 |
| 972.00 | 1.269E+02 | 7.834E+03 | 2.162E+03 | 8.096E+00 | 1.854E+00 | 2.335E+00 | 9.756E-06 | 1.842E-06 | 2.066E-05 | 1.920E+00 | 4.344E-01 |
| 1032.00 | 6.252E+02 | 7.911E+03 | 2.297E+03 | 8.544E+00 | 1.217E+00 | 2.269E+00 | 8.780E-06 | 1.587E-06 | 1.832E-05 | 2.848E+00 | 2.280E-01 |
| 1092.00 | 1.141E+03 | 7.910E+03 | 2.414E+03 | 8.914E+00 | 5.658E-01 | 2.167E+00 | 7.719E-06 | 9.777E-07 | 1.524E-05 | 3.939E+00 | 9.614E-02 |
| 1152.00 | 1.608E+03 | 7.647E+03 | 2.450E+03 | 8.828E+00 | 2.167E-02 | 1.938E+00 | 5.981E-06 | 1.447E-06 | 7.035E-06 | 4.863E+00 | 6.768E-02 |
| 1212.00 | 2.052E+03 | 7.382E+03 | 2.473E+03 | 8.793E+00 | 5.752E-01 | 1.725E+00 | 4.807E-06 | 3.011E-06 | 2.198E-07 | 5.870E+00 | 1.564E-01 |
| 1272.00 | 2.332E+03 | 6.848E+03 | 2.378E+03 | 8.126E+00 | 9.223E-01 | 1.416E+00 | 3.756E-06 | 4.945E-06 | 1.268E-05 | 6.274E+00 | 4.117E-01 |
| 1332.00 | 2.531E+03 | 6.348E+03 | 2.273E+03 | 7.469E+00 | 1.196E+00 | 1.166E+00 | 3.554E-06 | 5.154E-06 | 2.334E-05 | 5.695E+00 | 4.109E-01 |
| 1392.00 | 2.718E+03 | 5.951E+03 | 2.200E+03 | 7.026E+00 | 1.478E+00 | 1.005E+00 | 4.116E-06 | 3.075E-06 | 2.989E-05 | 5.371E+00 | 1.666E-01 |
| 1432.00 | 2.808E+03 | 5.693E+03 | 2.153E+03 | 6.728E+00 | 1.631E+00 | 9.313E-01 | 4.857E-06 | 1.047E-07 | 3.325E-05 | 5.150E+00 | 4.686E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 1.524E+03 | 3.945E+03 | 8.432E+00 | 4.165E+00 | 1.426E+00 | 3.091E-01 | 1.482E-07 | 7.318E-06 | 2.721E-05 | 2.779E-05 | 5.607E-04 |
| 372.00 | 1.774E+03 | 4.897E+03 | 2.274E+01 | 5.119E+00 | 1.648E+00 | 3.809E-01 | 5.911E-07 | 7.780E-06 | 2.970E-05 | 3.456E-05 | 8.488E-04 |
| 432.00 | 1.808E+03 | 5.316E+03 | 8.526E+01 | 5.506E+00 | 1.652E+00 | 4.195E-01 | 9.479E-07 | 7.585E-06 | 2.852E-05 | 3.584E-05 | 9.722E-04 |
| 492.00 | 1.832E+03 | 5.704E+03 | 1.912E+02 | 5.870E+00 | 1.622E+00 | 4.537E-01 | 1.222E-06 | 7.750E-06 | 2.753E-05 | 3.550E-05 | 9.372E-04 |
| 552.00 | 1.844E+03 | 6.058E+03 | 3.236E+02 | 6.214E+00 | 1.557E+00 | 4.733E-01 | 1.452E-06 | 8.278E-06 | 2.671E-05 | 3.310E-05 | 8.010E-04 |
| 612.00 | 1.856E+03 | 6.399E+03 | 4.822E+02 | 6.572E+00 | 1.464E+00 | 4.749E-01 | 1.649E-06 | 9.352E-06 | 2.635E-05 | 2.833E-05 | 6.523E-04 |
| 672.00 | 1.857E+03 | 6.690E+03 | 6.614E+02 | 6.906E+00 | 1.336E+00 | 4.535E-01 | 1.927E-06 | 1.046E-05 | 2.563E-05 | 2.058E-05 | 5.255E-04 |
| 732.00 | 1.859E+03 | 6.939E+03 | 8.671E+02 | 7.230E+00 | 1.177E+00 | 4.093E-01 | 2.286E-06 | 1.133E-05 | 2.443E-05 | 9.327E-06 | 4.281E-04 |
| 792.00 | 1.877E+03 | 7.169E+03 | 1.119E+03 | 7.579E+00 | 9.982E-01 | 3.388E-01 | 2.655E-06 | 1.244E-05 | 2.335E-05 | 6.670E-06 | 3.574E-04 |
| 852.00 | 1.918E+03 | 7.368E+03 | 1.436E+03 | 7.954E+00 | 8.002E-01 | 2.368E-01 | 3.054E-06 | 1.370E-05 | 2.218E-05 | 2.908E-05 | 3.066E-04 |
| 912.00 | 1.989E+03 | 7.509E+03 | 1.844E+03 | 8.342E+00 | 5.890E-01 | 9.620E-02 | 3.486E-06 | 1.489E-05 | 2.065E-05 | 6.040E-05 | 2.708E-04 |
| 972.00 | 2.079E+03 | 7.489E+03 | 2.375E+03 | 8.619E+00 | 3.823E-01 | 7.848E-02 | 3.967E-06 | 1.436E-05 | 1.743E-05 | 1.017E-04 | 2.440E-04 |
| 1032.00 | 2.217E+03 | 7.333E+03 | 3.092E+03 | 8.916E+00 | 1.903E-01 | 3.170E-01 | 4.337E-06 | 1.399E-05 | 1.417E-05 | 1.633E-04 | 2.305E-04 |
| 1092.00 | 2.402E+03 | 6.952E+03 | 3.949E+03 | 9.169E+00 | 4.876E-02 | 6.292E-01 | 4.631E-06 | 1.270E-05 | 1.049E-05 | 2.465E-04 | 2.290E-04 |
| 1152.00 | 2.561E+03 | 6.156E+03 | 4.755E+03 | 8.991E+00 | 2.282E-02 | 9.230E-01 | 4.931E-06 | 5.733E-06 | 5.492E-06 | 3.444E-04 | 2.316E-04 |
| 1212.00 | 2.771E+03 | 5.150E+03 | 5.534E+03 | 8.887E+00 | 9.682E-02 | 1.276E+00 | 4.915E-06 | 4.724E-07 | 2.800E-06 | 4.758E-04 | 2.510E-04 |
| 1272.00 | 2.864E+03 | 3.772E+03 | 5.963E+03 | 8.167E+00 | 3.201E-01 | 1.442E+00 | 5.126E-06 | 1.308E-05 | 1.472E-06 | 5.934E-04 | 2.637E-04 |
| 1332.00 | 2.937E+03 | 3.750E+03 | 5.402E+03 | 7.471E+00 | 2.398E-01 | 1.643E+00 | 5.253E-06 | 2.353E-05 | 1.647E-06 | 6.655E-04 | 2.949E-04 |
| 1392.00 | 3.007E+03 | 4.821E+03 | 3.919E+03 | 7.010E+00 | 2.911E-01 | 1.828E+00 | 5.500E-06 | 2.666E-05 | 1.296E-05 | 7.519E-04 | 3.545E-04 |
| 1432.00 | 3.026E+03 | 5.320E+03 | 2.733E+03 | 6.710E+00 | 7.068E-01 | 1.806E+00 | 5.970E-06 | 2.427E-05 | 2.246E-05 | 8.378E-04 | 3.824E-04 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)
1.932E-08 1.062E-08 1.288E-07 2.614E-02

GROUP 21 FIRST-ORDER MARKOV DENSITY DEVIATIONS

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 312.00 | 1.840E-06 | 2.724E-06 | 4.192E-07 | 9.391E-10 | 3.177E-09 | 1.007E-09 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 5.050E-10 | 1.174E-09 |
| 372.00 | 2.710E+02 | 4.981E+02 | 8.298E+01 | 1.858E-01 | 5.330E-01 | 1.718E-01 | 1.456E-06 | 6.080E-07 | 3.695E-06 | 8.832E-02 | 2.121E-01 |
| 432.00 | 2.422E+02 | 5.134E+02 | 9.000E+01 | 2.308E-01 | 5.087E-01 | 1.757E-01 | 1.370E-06 | 5.438E-07 | 3.656E-06 | 8.523E-02 | 2.009E-01 |
| 492.00 | 2.085E+02 | 5.053E+02 | 9.257E+01 | 2.671E-01 | 4.610E-01 | 1.727E-01 | 1.429E-06 | 4.367E-07 | 3.699E-06 | 7.456E-02 | 1.799E-01 |
| 552.00 | 1.805E+02 | 5.012E+02 | 9.587E+01 | 3.041E-01 | 4.172E-01 | 1.718E-01 | 1.761E-06 | 6.165E-07 | 4.121E-06 | 6.180E-02 | 1.590E-01 |
| 612.00 | 1.565E+02 | 5.057E+02 | 1.009E+02 | 3.465E-01 | 3.795E-01 | 1.749E-01 | 2.312E-06 | 1.177E-06 | 4.983E-06 | 4.973E-02 | 1.393E-01 |
| 672.00 | 1.360E+02 | 5.402E+02 | 1.111E+02 | 4.097E-01 | 3.613E-01 | 1.899E-01 | 2.847E-06 | 1.780E-06 | 6.031E-06 | 4.690E-02 | 1.291E-01 |
| 732.00 | 1.138E+02 | 5.627E+02 | 1.202E+02 | 4.746E-01 | 3.275E-01 | 2.024E-01 | 3.270E-06 | 2.500E-06 | 7.032E-06 | 6.992E-02 | 1.128E-01 |
| 792.00 | 9.229E+01 | 5.993E+02 | 1.313E+02 | 5.675E-01 | 2.937E-01 | 2.251E-01 | 3.775E-06 | 3.414E-06 | 8.563E-06 | 1.255E-01 | 9.819E-02 |
| 852.00 | 6.994E+01 | 6.518E+02 | 1.464E+02 | 6.975E-01 | 2.553E-01 | 2.590E-01 | 4.250E-06 | 4.442E-06 | 1.045E-05 | 2.151E-01 | 8.806E-02 |
| 912.00 | 4.600E+01 | 7.067E+02 | 1.660E+02 | 8.458E-01 | 2.067E-01 | 2.939E-01 | 4.456E-06 | 5.308E-06 | 1.209E-05 | 3.320E-01 | 8.580E-02 |
| 972.00 | 4.376E+01 | 7.443E+02 | 1.876E+02 | 9.804E-01 | 1.511E-01 | 3.177E-01 | 4.312E-06 | 5.811E-06 | 1.309E-05 | 4.646E-01 | 8.940E-02 |
| 1032.00 | 8.478E+01 | 7.723E+02 | 2.117E+02 | 1.113E+00 | 1.107E-01 | 3.341E-01 | 3.977E-06 | 6.057E-06 | 1.378E-05 | 6.232E-01 | 9.270E-02 |
| 1092.00 | 1.450E+02 | 7.824E+02 | 2.350E+02 | 1.230E+00 | 1.245E-01 | 3.392E-01 | 3.503E-06 | 5.984E-06 | 1.413E-05 | 7.962E-01 | 8.651E-02 |
| 1152.00 | 2.075E+02 | 7.557E+02 | 2.486E+02 | 1.282E+00 | 1.776E-01 | 3.209E-01 | 2.916E-06 | 5.438E-06 | 1.368E-05 | 9.374E-01 | 6.954E-02 |
| 1212.00 | 2.667E+02 | 7.123E+02 | 2.551E+02 | 1.297E+00 | 2.344E-01 | 2.904E-01 | 2.403E-06 | 4.662E-06 | 1.283E-05 | 1.049E+00 | 6.535E-02 |
| 1272.00 | 3.074E+02 | 6.389E+02 | 2.465E+02 | 1.228E+00 | 2.673E-01 | 2.451E-01 | 2.032E-06 | 3.834E-06 | 1.127E-05 | 1.074E+00 | 1.072E-01 |
| 1332.00 | 3.487E+02 | 5.819E+02 | 2.397E+02 | 1.220E+00 | 3.053E-01 | 2.102E-01 | 1.692E-06 | 3.346E-06 | 1.036E-05 | 1.089E+00 | 1.199E-01 |
| 1392.00 | 3.726E+02 | 5.179E+02 | 2.263E+02 | 1.144E+00 | 2.976E-01 | 1.871E-01 | 1.913E-06 | 3.489E-06 | 8.522E-06 | 1.019E+00 | 1.136E-01 |
| 1432.00 | 3.871E+02 | 4.830E+02 | 2.197E+02 | 1.098E+00 | 2.900E-01 | 1.800E-01 | 1.930E-06 | 3.806E-06 | 7.463E-06 | 9.864E-01 | 1.313E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.891E-15 | 3.891E-15 |
| 312.00 | 1.194E-06 | 3.091E-06 | 1.684E-08 | 3.266E-09 | 1.124E-09 | 2.543E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 2.035E-14 | 4.396E-13 |
| 372.00 | 2.188E+02 | 5.296E+02 | 8.741E+00 | 5.508E-01 | 2.072E-01 | 4.251E-02 | 1.440E-07 | 7.712E-07 | 3.941E-06 | 3.541E-06 | 9.145E-05 |
| 432.00 | 2.130E+02 | 5.335E+02 | 2.019E+01 | 5.489E-01 | 1.991E-01 | 4.395E-02 | 2.208E-07 | 7.980E-07 | 3.854E-06 | 3.425E-06 | 9.757E-05 |
| 492.00 | 1.966E+02 | 5.174E+02 | 3.340E+01 | 5.290E-01 | 1.790E-01 | 4.303E-02 | 3.060E-07 | 1.120E-06 | 3.817E-06 | 3.043E-06 | 8.544E-05 |
| 552.00 | 1.817E+02 | 5.077E+02 | 4.727E+01 | 5.189E-01 | 1.584E-01 | 4.133E-02 | 3.899E-07 | 1.880E-06 | 4.096E-06 | 2.573E-06 | 6.786E-05 |
| 612.00 | 1.702E+02 | 5.075E+02 | 6.265E+01 | 5.233E-01 | 1.388E-01 | 3.922E-02 | 4.680E-07 | 3.027E-06 | 4.710E-06 | 2.119E-06 | 5.270E-05 |
| 672.00 | 1.721E+02 | 5.349E+02 | 8.368E+01 | 5.626E-01 | 1.285E-01 | 3.806E-02 | 4.765E-07 | 4.217E-06 | 5.445E-06 | 2.049E-06 | 4.346E-05 |
| 732.00 | 1.679E+02 | 5.523E+02 | 1.041E+02 | 5.996E-01 | 1.119E-01 | 3.746E-02 | 4.999E-07 | 5.493E-06 | 5.997E-06 | 3.140E-06 | 3.588E-05 |
| 792.00 | 1.685E+02 | 5.822E+02 | 1.324E+02 | 6.691E-01 | 9.717E-02 | 4.206E-02 | 5.672E-07 | 7.220E-06 | 6.840E-06 | 5.827E-06 | 3.155E-05 |
| 852.00 | 1.752E+02 | 6.253E+02 | 1.715E+02 | 7.796E-01 | 8.704E-02 | 5.817E-02 | 6.519E-07 | 9.308E-06 | 7.746E-06 | 1.038E-05 | 2.967E-05 |
| 912.00 | 1.876E+02 | 6.672E+02 | 2.208E+02 | 9.109E-01 | 8.569E-02 | 8.699E-02 | 7.450E-07 | 1.127E-05 | 8.167E-06 | 1.679E-05 | 2.899E-05 |
| 972.00 | 2.046E+02 | 6.867E+02 | 2.789E+02 | 1.030E+00 | 9.125E-02 | 1.257E-01 | 8.700E-07 | 1.275E-05 | 7.766E-06 | 2.490E-05 | 2.871E-05 |
| 1032.00 | 2.307E+02 | 6.853E+02 | 3.544E+02 | 1.150E+00 | 9.514E-02 | 1.754E-01 | 1.030E-06 | 1.402E-05 | 6.692E-06 | 3.591E-05 | 2.971E-05 |
| 1092.00 | 2.654E+02 | 6.515E+02 | 4.399E+02 | 1.257E+00 | 9.013E-02 | 2.352E-01 | 1.205E-06 | 1.467E-05 | 5.008E-06 | 5.006E-05 | 3.202E-05 |
| 1152.00 | 2.999E+02 | 5.688E+02 | 5.122E+02 | 1.300E+00 | 7.200E-02 | 2.878E-01 | 1.377E-06 | 1.466E-05 | 2.877E-06 | 6.531E-05 | 3.459E-05 |
| 1212.00 | 3.358E+02 | 4.566E+02 | 5.677E+02 | 1.308E+00 | 6.290E-02 | 3.300E-01 | 1.516E-06 | 1.371E-05 | 1.454E-06 | 8.213E-05 | 3.787E-05 |
| 1272.00 | 3.573E+02 | 3.162E+02 | 5.796E+02 | 1.231E+00 | 9.690E-02 | 3.382E-01 | 1.613E-06 | 1.171E-05 | 2.439E-06 | 9.576E-05 | 3.949E-05 |
| 1332.00 | 3.860E+02 | 3.092E+02 | 5.225E+02 | 1.217E+00 | 1.028E-01 | 3.670E-01 | 1.770E-06 | 1.058E-05 | 2.660E-06 | 1.148E-04 | 4.606E-05 |
| 1392.00 | 3.975E+02 | 3.842E+02 | 3.907E+02 | 1.140E+00 | 1.141E-01 | 3.457E-01 | 1.828E-06 | 8.505E-06 | 3.576E-06 | 1.356E-04 | 5.196E-05 |
| 1432.00 | 4.053E+02 | 4.207E+02 | 3.002E+02 | 1.096E+00 | 1.418E-01 | 3.207E-01 | 1.852E-06 | 7.247E-06 | 4.237E-06 | 1.562E-04 | 5.576E-05 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

5.668E-09 3.741E-09 3.952E-08 1.678E-02

GROUP 22 ZONAL (WESTERLY) WINDS

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 1.114E+01 | 1.650E+01 | 2.538E+00 | 5.655E-03 | 1.923E-02 | 6.069E-03 | 5.815E-08 | 1.879E-08 | 1.189E-07 | 2.998E-03 | 7.085E-03 |
| 372.00 | 1.608E+01 | 2.754E+01 | 4.561E+00 | 1.141E-02 | 2.967E-02 | 9.876E-03 | 8.194E-08 | 2.861E-08 | 1.809E-07 | 4.915E-03 | 1.092E-02 |
| 432.00 | 1.799E+01 | 3.586E+01 | 6.298E+00 | 1.728E-02 | 3.560E-02 | 1.261E-02 | 9.376E-08 | 3.302E-08 | 2.193E-07 | 5.941E-03 | 1.304E-02 |
| 492.00 | 1.836E+01 | 4.289E+01 | 7.903E+00 | 2.354E-02 | 3.906E-02 | 1.488E-02 | 1.045E-07 | 3.169E-08 | 2.491E-07 | 6.281E-03 | 1.426E-02 |
| 552.00 | 1.757E+01 | 4.841E+01 | 9.317E+00 | 2.981E-02 | 4.017E-02 | 1.665E-02 | 1.135E-07 | 2.466E-08 | 2.682E-07 | 5.897E-03 | 1.450E-02 |
| 612.00 | 1.608E+01 | 5.319E+01 | 1.067E+01 | 3.622E-02 | 3.982E-02 | 1.816E-02 | 1.226E-07 | 1.339E-08 | 2.840E-07 | 4.856E-03 | 1.413E-02 |
| 672.00 | 1.428E+01 | 5.867E+01 | 1.214E+01 | 4.381E-02 | 3.912E-02 | 2.002E-02 | 1.451E-07 | 1.033E-08 | 3.276E-07 | 2.942E-03 | 1.354E-02 |
| 732.00 | 1.275E+01 | 6.971E+01 | 1.443E+01 | 5.745E-02 | 4.063E-02 | 2.444E-02 | 2.264E-07 | 8.313E-08 | 5.017E-07 | 1.171E-03 | 1.334E-02 |
| 792.00 | 1.071E+01 | 8.492E+01 | 1.764E+01 | 7.759E-02 | 4.191E-02 | 3.100E-02 | 3.417E-07 | 2.015E-07 | 7.687E-07 | 8.939E-03 | 1.250E-02 |
| 852.00 | 7.371E+00 | 1.049E+02 | 2.229E+01 | 1.060E-01 | 4.184E-02 | 3.992E-02 | 4.810E-07 | 3.657E-07 | 1.125E-06 | 2.233E-02 | 1.081E-02 |
| 912.00 | 1.312E+00 | 1.206E+02 | 2.720E+01 | 1.313E-01 | 3.705E-02 | 4.651E-02 | 5.523E-07 | 4.761E-07 | 1.343E-06 | 3.810E-02 | 8.651E-03 |
| 972.00 | 7.303E+00 | 1.443E+02 | 3.476E+01 | 1.717E-01 | 2.973E-02 | 5.700E-02 | 6.594E-07 | 6.619E-07 | 1.734E-06 | 6.633E-02 | 5.591E-03 |
| 1032.00 | 2.009E+01 | 1.677E+02 | 4.378E+01 | 2.155E-01 | 1.797E-02 | 6.679E-02 | 7.338E-07 | 8.266E-07 | 2.087E-06 | 1.043E-01 | 2.732E-03 |
| 1092.00 | 3.581E+01 | 1.817E+02 | 5.162E+01 | 2.468E-01 | 3.048E-03 | 7.106E-02 | 7.332E-07 | 8.812E-07 | 2.199E-06 | 1.424E-01 | 3.674E-03 |
| 1152.00 | 4.569E+01 | 1.642E+02 | 5.000E+01 | 2.176E-01 | 4.960E-03 | 5.873E-02 | 6.033E-07 | 6.553E-07 | 1.558E-06 | 1.411E-01 | 1.020E-02 |
| 1212.00 | 3.045E+01 | 9.494E+01 | 2.799E+01 | 6.796E-02 | 1.480E-02 | 2.220E-02 | 3.751E-07 | 1.136E-07 | 3.302E-07 | 3.699E-02 | 1.717E-02 |
| 1272.00 | 3.890E+01 | 3.763E+01 | 2.508E+01 | 2.659E-01 | 9.147E-02 | 3.759E-02 | 1.618E-07 | 5.390E-07 | 3.846E-06 | 2.492E-01 | 1.111E-03 |
| 1332.00 | 4.429E+02 | 5.739E+02 | 2.667E+02 | 1.860E+00 | 5.379E-01 | 2.321E-01 | 1.224E-07 | 1.590E-06 | 1.871E-05 | 1.699E+00 | 4.642E-02 |
| 1392.00 | 5.320E+02 | 5.126E+02 | 2.671E+02 | 1.888E+00 | 5.334E-01 | 2.174E-01 | 1.747E-08 | 1.536E-06 | 1.613E-05 | 1.730E+00 | 6.913E-02 |
| 1432.00 | 5.388E+02 | 4.230E+02 | 2.455E+02 | 1.733E+00 | 4.677E-01 | 2.138E-01 | 3.823E-07 | 2.479E-06 | 1.321E-05 | 1.604E+00 | 7.590E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 312.00 | 7.232E+00 | 1.872E+01 | 1.020E-01 | 1.977E-02 | 6.779E-03 | 1.416E-03 | 7.034E-10 | 3.375E-08 | 1.294E-07 | 1.209E-07 | 2.662E-06 |
| 372.00 | 1.137E+01 | 3.014E+01 | 1.519E-01 | 3.146E-02 | 1.063E-02 | 2.343E-03 | 1.021E-09 | 4.633E-08 | 1.953E-07 | 1.968E-07 | 5.218E-06 |
| 432.00 | 1.398E+01 | 3.811E+01 | 9.441E-01 | 3.936E-02 | 1.291E-02 | 3.076E-03 | 7.203E-10 | 5.550E-08 | 2.343E-07 | 2.386E-07 | 6.970E-06 |
| 492.00 | 1.578E+01 | 4.455E+01 | 2.236E+00 | 4.568E-02 | 1.418E-02 | 3.669E-03 | 4.732E-10 | 7.009E-08 | 2.628E-07 | 2.563E-07 | 7.344E-06 |
| 552.00 | 1.676E+01 | 4.944E+01 | 3.802E+00 | 5.054E-02 | 1.444E-02 | 4.016E-03 | 1.409E-09 | 8.862E-08 | 2.785E-07 | 2.455E-07 | 6.588E-06 |
| 612.00 | 1.734E+01 | 5.356E+01 | 5.613E+00 | 5.488E-02 | 1.408E-02 | 4.131E-03 | 3.475E-09 | 1.114E-07 | 2.888E-07 | 2.070E-07 | 5.530E-06 |
| 672.00 | 1.812E+01 | 5.832E+01 | 7.970E+00 | 6.044E-02 | 1.347E-02 | 3.996E-03 | 4.235E-09 | 1.593E-07 | 3.211E-07 | 1.290E-07 | 4.681E-06 |
| 732.00 | 2.060E+01 | 6.824E+01 | 1.222E+01 | 7.323E-02 | 1.322E-02 | 3.391E-03 | 2.508E-10 | 3.154E-07 | 4.587E-07 | 5.166E-08 | 4.419E-06 |
| 792.00 | 2.410E+01 | 8.194E+01 | 1.852E+01 | 9.264E-02 | 1.231E-02 | 1.806E-03 | 4.245E-10 | 5.669E-07 | 6.534E-07 | 4.138E-07 | 4.452E-06 |
| 852.00 | 2.903E+01 | 9.968E+01 | 2.776E+01 | 1.203E-01 | 1.045E-02 | 1.336E-03 | 1.331E-08 | 9.216E-07 | 8.835E-07 | 1.076E-06 | 4.728E-06 |
| 912.00 | 3.374E+01 | 1.127E+02 | 3.809E+01 | 1.439E-01 | 8.081E-03 | 5.323E-03 | 4.974E-08 | 1.182E-06 | 9.671E-07 | 1.925E-06 | 4.798E-06 |
| 972.00 | 4.180E+01 | 1.315E+02 | 5.506E+01 | 1.829E-01 | 4.474E-03 | 1.284E-02 | 8.807E-08 | 1.635E-06 | 1.095E-06 | 3.549E-06 | 5.336E-06 |
| 1032.00 | 5.255E+01 | 1.467E+02 | 7.855E+01 | 2.252E-01 | 1.776E-03 | 2.324E-02 | 1.452E-07 | 2.096E-06 | 1.077E-06 | 6.006E-06 | 6.054E-06 |
| 1092.00 | 6.385E+01 | 1.485E+02 | 1.041E+02 | 2.546E-01 | 2.364E-03 | 3.406E-02 | 2.174E-07 | 2.331E-06 | 8.168E-07 | 8.946E-06 | 6.656E-06 |
| 1152.00 | 6.559E+01 | 1.200E+02 | 1.133E+02 | 2.229E-01 | 9.109E-03 | 3.221E-02 | 3.048E-07 | 1.746E-06 | 2.791E-07 | 9.828E-06 | 5.925E-06 |
| 1212.00 | 3.919E+01 | 5.595E+01 | 7.783E+01 | 7.091E-02 | 1.670E-02 | 4.918E-03 | 4.049E-07 | 2.135E-07 | 2.304E-07 | 2.888E-06 | 1.636E-06 |
| 1272.00 | 4.278E+01 | 2.695E+01 | 3.165E+01 | 2.636E-01 | 3.896E-03 | 1.050E-01 | 5.359E-07 | 3.848E-06 | 1.144E-07 | 2.224E-05 | 9.758E-06 |
| 1332.00 | 4.828E+02 | 3.280E+02 | 5.058E+02 | 1.846E+00 | 6.902E-03 | 6.266E-01 | 1.385E-06 | 1.866E-05 | 1.644E-06 | 1.793E-04 | 7.451E-05 |
| 1392.00 | 5.598E+02 | 4.131E+02 | 3.648E+02 | 1.877E+00 | 1.004E-01 | 6.033E-01 | 7.629E-07 | 1.548E-05 | 4.710E-06 | 2.304E-04 | 8.668E-05 |
| 1432.00 | 5.576E+02 | 4.074E+02 | 2.294E+02 | 1.726E+00 | 1.357E-01 | 5.185E-01 | 1.256E-07 | 1.256E-05 | 4.800E-06 | 2.543E-04 | 8.660E-05 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

4.163E-10 2.141E-09 1.028E-08 2.233E-02

GROUP 22 CROSSWIND AND HEADWIND

| TIME | POSITION ESTIMATE ERROR R | POSITION ESTIMATE ERROR C | POSITION ESTIMATE ERROR D | VELOCITY ESTIMATE ERROR R | VELOCITY ESTIMATE ERROR C | VELOCITY ESTIMATE ERROR D | PLATFORM TILT ESTIMATE R | PLATFORM TILT ESTIMATE C | PLATFORM TILT ESTIMATE D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 312.00 | 1.573E-06 | 2.330E-06 | 3.585E-07 | 8.049E-10 | 2.718E-09 | 8.629E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 4.809E-10 | 1.003E-09 |
| 372.00 | 4.073E+01 | 7.466E+01 | 1.243E+01 | 2.798E-02 | 7.990E-02 | 2.579E-02 | 2.185E-07 | 9.091E-08 | 5.530E-07 | 1.465E-02 | 3.170E-02 |
| 432.00 | 3.728E+01 | 8.076E+01 | 1.408E+01 | 3.552E-02 | 7.995E-02 | 2.742E-02 | 2.234E-07 | 8.729E-08 | 6.100E-07 | 1.480E-02 | 3.222E-02 |
| 492.00 | 3.108E+01 | 7.787E+01 | 1.403E+01 | 4.020E-02 | 7.109E-02 | 2.646E-02 | 2.501E-07 | 6.617E-08 | 6.460E-07 | 1.271E-02 | 2.860E-02 |
| 552.00 | 2.646E+01 | 7.638E+01 | 1.416E+01 | 4.557E-02 | 6.375E-02 | 2.626E-02 | 3.283E-07 | 1.105E-07 | 7.543E-07 | 1.040E-02 | 2.509E-02 |
| 612.00 | 2.292E+01 | 7.718E+01 | 1.467E+01 | 5.278E-02 | 5.811E-02 | 2.725E-02 | 4.413E-07 | 2.248E-07 | 9.399E-07 | 8.309E-03 | 2.175E-02 |
| 672.00 | 2.046E+01 | 8.684E+01 | 1.668E+01 | 6.642E-02 | 5.838E-02 | 3.176E-02 | 5.579E-07 | 3.462E-07 | 1.181E-06 | 8.166E-03 | 2.116E-02 |
| 732.00 | 1.748E+01 | 9.272E+01 | 1.832E+01 | 8.013E-02 | 5.409E-02 | 3.529E-02 | 6.440E-07 | 4.890E-07 | 1.392E-06 | 1.287E-02 | 1.867E-02 |
| 792.00 | 1.469E+01 | 1.018E+02 | 2.052E+01 | 1.004E-01 | 4.959E-02 | 4.101E-02 | 7.467E-07 | 6.743E-07 | 1.709E-06 | 2.376E-02 | 1.647E-02 |
| 852.00 | 1.167E+01 | 1.151E+02 | 2.383E+01 | 1.297E-01 | 4.401E-02 | 4.937E-02 | 8.517E-07 | 8.944E-07 | 2.122E-06 | 4.185E-02 | 1.535E-02 |
| 912.00 | 8.036E+00 | 1.311E+02 | 2.869E+01 | 1.668E-01 | 3.608E-02 | 5.917E-02 | 9.234E-07 | 1.113E-06 | 2.557E-06 | 6.776E-02 | 1.635E-02 |
| 972.00 | 8.451E+00 | 1.491E+02 | 3.551E+01 | 2.122E-01 | 2.605E-02 | 7.001E-02 | 9.609E-07 | 1.326E-06 | 3.021E-06 | 1.039E-01 | 1.953E-02 |
| 1032.00 | 1.873E+01 | 1.655E+02 | 4.377E+01 | 2.602E-01 | 1.979E-02 | 7.932E-02 | 9.370E-07 | 1.475E-06 | 3.413E-06 | 1.494E-01 | 2.320E-02 |
| 1092.00 | 3.628E+01 | 1.854E+02 | 5.474E+01 | 3.228E-01 | 3.130E-02 | 9.013E-02 | 9.003E-07 | 1.616E-06 | 3.922E-06 | 2.132E-01 | 2.540E-02 |
| 1152.00 | 5.730E+01 | 1.937E+02 | 6.383E+01 | 3.699E-01 | 5.325E-02 | 9.324E-02 | 7.892E-07 | 1.581E-06 | 4.168E-06 | 2.742E-01 | 2.277E-02 |
| 1212.00 | 8.256E+01 | 2.001E+02 | 7.323E+01 | 4.211E-01 | 8.027E-02 | 9.380E-02 | 6.762E-07 | 1.466E-06 | 4.418E-06 | 3.433E-01 | 1.807E-02 |
| 1272.00 | 1.098E+02 | 2.003E+02 | 8.078E+01 | 4.660E-01 | 1.078E-01 | 8.951E-02 | 5.774E-07 | 1.274E-06 | 4.566E-06 | 4.092E-01 | 2.683E-02 |
| 1332.00 | 1.430E+02 | 2.057E+02 | 8.891E+01 | 5.489E-01 | 1.516E-01 | 7.821E-02 | 5.396E-07 | 1.019E-06 | 5.096E-06 | 4.918E-01 | 3.477E-02 |
| 1392.00 | 1.912E+02 | 2.140E+02 | 1.001E+02 | 6.430E-01 | 1.860E-01 | 7.457E-02 | 6.215E-07 | 1.226E-06 | 5.234E-06 | 5.771E-01 | 7.809E-02 |
| 1432.00 | 2.198E+02 | 2.102E+02 | 1.035E+02 | 6.820E-01 | 2.018E-01 | 7.237E-02 | 7.089E-07 | 1.660E-06 | 5.020E-06 | 6.185E-01 | 1.114E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.835E-15 | 3.835E-15 |
| 312.00 | 1.021E-06 | 2.644E-06 | 5.652E-09 | 2.794E-09 | 9.611E-10 | 2.301E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.902E-14 | 3.758E-13 |
| 372.00 | 3.275E+01 | 7.945E+01 | 1.551E+00 | 8.264E-02 | 3.097E-02 | 6.475E-03 | 2.257E-08 | 1.180E-07 | 5.894E-07 | 5.773E-07 | 1.372E-05 |
| 432.00 | 3.411E+01 | 8.327E+01 | 3.438E+00 | 8.567E-02 | 3.194E-02 | 6.864E-03 | 4.069E-08 | 1.315E-07 | 6.409E-07 | 5.853E-07 | 1.524E-05 |
| 492.00 | 3.118E+01 | 7.890E+01 | 5.395E+00 | 8.074E-02 | 2.847E-02 | 6.408E-03 | 5.715E-08 | 2.037E-07 | 6.630E-07 | 5.108E-07 | 1.307E-05 |
| 552.00 | 2.862E+01 | 7.655E+01 | 7.452E+00 | 7.856E-02 | 2.500E-02 | 5.882E-03 | 7.322E-08 | 3.555E-07 | 7.464E-07 | 4.264E-07 | 1.031E-05 |
| 612.00 | 2.673E+01 | 7.673E+01 | 9.770E+00 | 8.004E-02 | 2.167E-02 | 5.360E-03 | 8.901E-08 | 5.742E-07 | 8.894E-07 | 3.485E-07 | 8.090E-06 |
| 672.00 | 2.857E+01 | 8.509E+01 | 1.345E+01 | 9.143E-02 | 2.106E-02 | 5.165E-03 | 9.277E-08 | 8.111E-07 | 1.077E-06 | 3.512E-07 | 7.103E-06 |
| 732.00 | 2.840E+01 | 9.029E+01 | 1.673E+01 | 1.011E-01 | 1.854E-02 | 5.297E-03 | 9.829E-08 | 1.057E-06 | 1.210E-06 | 5.690E-07 | 6.085E-06 |
| 792.00 | 2.913E+01 | 9.851E+01 | 2.140E+01 | 1.179E-01 | 1.631E-02 | 6.834E-03 | 1.132E-07 | 1.394E-06 | 1.406E-06 | 1.087E-06 | 5.578E-06 |
| 852.00 | 3.116E+01 | 1.104E+02 | 2.816E+01 | 1.444E-01 | 1.521E-02 | 1.087E-02 | 1.321E-07 | 1.824E-06 | 1.638E-06 | 1.992E-06 | 5.490E-06 |
| 912.00 | 3.484E+01 | 1.243E+02 | 3.742E+01 | 1.790E-01 | 1.648E-02 | 1.774E-02 | 1.527E-07 | 2.297E-06 | 1.825E-06 | 3.386E-06 | 5.667E-06 |
| 972.00 | 4.104E+01 | 1.390E+02 | 5.066E+01 | 2.223E-01 | 2.026E-02 | 2.833E-02 | 1.794E-07 | 2.833E-06 | 1.936E-06 | 5.517E-06 | 6.138E-06 |
| 1032.00 | 5.014E+01 | 1.498E+02 | 6.865E+01 | 2.683E-01 | 2.401E-02 | 4.250E-02 | 2.124E-07 | 3.346E-06 | 1.861E-06 | 8.575E-06 | 6.873E-06 |
| 1092.00 | 6.496E+01 | 1.598E+02 | 9.447E+01 | 3.294E-01 | 2.675E-02 | 6.389E-02 | 2.576E-07 | 3.990E-06 | 1.681E-06 | 1.346E-05 | 8.367E-06 |
| 1152.00 | 8.127E+01 | 1.545E+02 | 1.199E+02 | 3.747E-01 | 2.414E-02 | 8.590E-02 | 3.119E-07 | 4.342E-06 | 1.240E-06 | 1.943E-05 | 1.007E-05 |
| 1212.00 | 1.024E+02 | 1.415E+02 | 1.474E+02 | 4.239E-01 | 1.907E-02 | 1.118E-01 | 3.703E-07 | 4.626E-06 | 7.664E-07 | 2.783E-05 | 1.271E-05 |
| 1272.00 | 1.260E+02 | 1.170E+02 | 1.707E+02 | 4.665E-01 | 2.387E-02 | 1.365E-01 | 4.293E-07 | 4.718E-06 | 6.017E-07 | 3.871E-05 | 1.615E-05 |
| 1332.00 | 1.568E+02 | 1.316E+02 | 1.696E+02 | 5.457E-01 | 3.654E-02 | 1.769E-01 | 6.159E-07 | 5.009E-06 | 1.354E-06 | 5.560E-05 | 2.297E-05 |
| 1392.00 | 2.022E+02 | 1.861E+02 | 1.299E+02 | 6.387E-01 | 8.728E-02 | 1.948E-01 | 6.911E-07 | 4.477E-06 | 2.960E-06 | 8.089E-05 | 3.015E-05 |
| 1432.00 | 2.285E+02 | 2.089E+02 | 8.605E+01 | 6.781E-01 | 1.328E-01 | 1.832E-01 | 7.513E-07 | 3.604E-06 | 3.861E-06 | 1.009E-04 | 3.234E-05 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

4.671E-09 3.268E-09 3.309E-08 1.258E-02

GROUP 23 DRAG COEFFICIENT VARIATIONS (MULTIPLY BY 0.25)

| TIME | POSITION ESTIMATE ERROR R | C | D | VELOCITY ESTIMATE ERROR R | C | D | PLATFORM TILT ESTIMATE R | C | D | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 312.00 | 2.257E+03 | 3.342E+03 | 5.142E+02 | 1.145E+00 | 3.896E+00 | 1.229E+00 | 1.178E-05 | 3.805E-06 | 2.409E-05 | 6.747E-01 | 1.432E+00 |
| 372.00 | 2.240E+03 | 3.675E+03 | 6.070E+02 | 1.623E+00 | 3.976E+00 | 1.348E+00 | 1.102E-05 | 3.493E-06 | 2.252E-05 | 7.319E-01 | 1.397E+00 |
| 432.00 | 2.014E+03 | 3.665E+03 | 6.467E+02 | 1.956E+00 | 3.649E+00 | 1.336E+00 | 9.415E-06 | 2.875E-06 | 1.919E-05 | 6.795E-01 | 1.221E+00 |
| 492.00 | 1.826E+03 | 3.719E+03 | 6.993E+02 | 2.292E+00 | 3.376E+00 | 1.338E+00 | 8.385E-06 | 2.423E-06 | 1.717E-05 | 6.122E-01 | 1.084E+00 |
| 552.00 | 1.649E+03 | 3.811E+03 | 7.615E+02 | 2.627E+00 | 3.121E+00 | 1.346E+00 | 8.116E-06 | 2.620E-06 | 1.660E-05 | 5.284E-01 | 9.627E-01 |
| 612.00 | 1.467E+03 | 3.921E+03 | 8.302E+02 | 2.959E+00 | 2.866E+00 | 1.354E+00 | 8.785E-06 | 4.004E-06 | 1.781E-05 | 4.262E-01 | 8.471E-01 |
| 672.00 | 1.275E+03 | 4.064E+03 | 9.070E+02 | 3.302E+00 | 2.617E+00 | 1.371E+00 | 9.744E-06 | 5.729E-06 | 1.984E-05 | 3.120E-01 | 7.444E-01 |
| 732.00 | 1.066E+03 | 4.183E+03 | 9.825E+02 | 3.633E+00 | 2.331E+00 | 1.378E+00 | 1.078E-05 | 7.986E-06 | 2.249E-05 | 2.430E-01 | 6.305E-01 |
| 792.00 | 8.441E+02 | 4.306E+03 | 1.059E+03 | 3.984E+00 | 2.027E+00 | 1.393E+00 | 1.224E-05 | 1.093E-05 | 2.712E-05 | 3.777E-01 | 5.177E-01 |
| 852.00 | 6.088E+02 | 4.433E+03 | 1.137E+03 | 4.377E+00 | 1.701E+00 | 1.425E+00 | 1.374E-05 | 1.431E-05 | 3.319E-05 | 7.088E-01 | 4.152E-01 |
| 912.00 | 3.625E+02 | 4.565E+03 | 1.220E+03 | 4.837E+00 | 1.349E+00 | 1.477E+00 | 1.496E-05 | 1.789E-05 | 4.017E-05 | 1.198E+00 | 3.441E-01 |
| 972.00 | 1.679E+02 | 4.689E+03 | 1.310E+03 | 5.355E+00 | 9.774E-01 | 1.539E+00 | 1.547E-05 | 2.108E-05 | 4.696E-05 | 1.842E+00 | 3.313E-01 |
| 1032.00 | 3.450E+02 | 4.797E+03 | 1.409E+03 | 5.954E+00 | 6.314E-01 | 1.609E+00 | 1.537E-05 | 2.391E-05 | 5.404E-05 | 2.697E+00 | 3.739E-01 |
| 1092.00 | 6.956E+02 | 4.853E+03 | 1.510E+03 | 6.577E+00 | 5.305E-01 | 1.656E+00 | 1.441E-05 | 2.550E-05 | 6.018E-05 | 3.712E+00 | 4.068E-01 |
| 1152.00 | 1.087E+03 | 4.818E+03 | 1.598E+03 | 7.125E+00 | 8.278E-01 | 1.641E+00 | 1.266E-05 | 2.515E-05 | 6.436E-05 | 4.779E+00 | 3.812E-01 |
| 1212.00 | 1.477E+03 | 4.672E+03 | 1.655E+03 | 7.508E+00 | 1.250E+00 | 1.543E+00 | 1.058E-05 | 2.273E-05 | 6.606E-05 | 5.752E+00 | 2.998E-01 |
| 1272.00 | 1.832E+03 | 4.429E+03 | 1.668E+03 | 7.681E+00 | 1.638E+00 | 1.371E+00 | 8.851E-06 | 1.917E-05 | 6.539E-05 | 6.505E+00 | 3.915E-01 |
| 1332.00 | 2.290E+03 | 4.272E+03 | 1.712E+03 | 8.453E+00 | 2.197E+00 | 1.228E+00 | 8.586E-06 | 1.674E-05 | 7.085E-05 | 7.391E+00 | 4.917E-01 |
| 1392.00 | 2.532E+03 | 3.901E+03 | 1.641E+03 | 8.169E+00 | 2.314E+00 | 1.066E+00 | 1.000E-05 | 2.025E-05 | 6.157E-05 | 7.130E+00 | 1.001E+00 |
| 1432.00 | 2.683E+03 | 3.684E+03 | 1.600E+03 | 7.992E+00 | 2.380E+00 | 1.025E+00 | 1.103E-05 | 2.556E-05 | 5.549E-05 | 7.044E+00 | 1.362E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | | | | | | | | | | | |
| 312.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.835E-15 | 3.835E-15 |
| 312.00 | 1.465E+03 | 3.792E+03 | 8.105E+00 | 4.004E+00 | 1.371E+00 | 2.972E-01 | 1.425E-07 | 7.034E-06 | 2.616E-05 | 2.672E-05 | 5.390E-04 |
| 372.00 | 1.465E+03 | 4.092E+03 | 3.118E+01 | 4.279E+00 | 1.360E+00 | 3.168E-01 | 8.903E-07 | 6.552E-06 | 2.444E-05 | 2.879E-05 | 7.096E-04 |
| 432.00 | 1.326E+03 | 4.018E+03 | 6.954E+01 | 4.168E+00 | 1.207E+00 | 3.143E-01 | 1.414E-06 | 5.744E-06 | 2.074E-05 | 2.685E-05 | 7.348E-04 |
| 492.00 | 1.225E+03 | 4.017E+03 | 1.283E+02 | 4.145E+00 | 1.077E+00 | 3.169E-01 | 1.830E-06 | 5.548E-06 | 1.835E-05 | 2.458E-05 | 6.586E-04 |
| 552.00 | 1.150E+03 | 4.057E+03 | 1.997E+02 | 4.176E+00 | 9.579E-01 | 3.166E-01 | 2.156E-06 | 6.678E-06 | 1.730E-05 | 2.165E-05 | 5.333E-04 |
| 612.00 | 1.094E+03 | 4.116E+03 | 2.830E+02 | 4.242E+00 | 8.427E-01 | 3.103E-01 | 2.401E-06 | 9.537E-06 | 1.771E-05 | 1.788E-05 | 4.149E-04 |
| 672.00 | 1.066E+03 | 4.205E+03 | 3.834E+02 | 4.359E+00 | 7.394E-01 | 2.973E-01 | 2.444E-06 | 1.276E-05 | 1.878E-05 | 1.343E-05 | 3.252E-04 |
| 732.00 | 1.040E+03 | 4.279E+03 | 4.966E+02 | 4.480E+00 | 6.241E-01 | 2.761E-01 | 2.492E-06 | 1.603E-05 | 2.007E-05 | 1.077E-05 | 2.586E-04 |
| 792.00 | 1.030E+03 | 4.348E+03 | 6.403E+02 | 4.648E+00 | 5.092E-01 | 2.527E-01 | 2.600E-06 | 2.203E-05 | 2.265E-05 | 1.727E-05 | 2.127E-04 |
| 852.00 | 1.041E+03 | 4.421E+03 | 8.270E+02 | 4.885E+00 | 4.043E-01 | 2.471E-01 | 2.746E-06 | 2.866E-05 | 2.581E-05 | 3.373E-05 | 1.818E-04 |
| 912.00 | 1.079E+03 | 4.488E+03 | 1.075E+03 | 5.214E+00 | 3.359E-01 | 3.004E-01 | 2.968E-06 | 3.637E-05 | 2.874E-05 | 5.983E-05 | 1.629E-04 |
| 972.00 | 1.151E+03 | 4.519E+03 | 1.408E+03 | 5.630E+00 | 3.350E-01 | 4.397E-01 | 3.311E-06 | 4.443E-05 | 3.007E-05 | 9.773E-05 | 1.536E-04 |
| 1032.00 | 1.274E+03 | 4.475E+03 | 1.861E+03 | 6.151E+00 | 3.878E-01 | 6.774E-01 | 3.849E-06 | 5.342E-05 | 2.931E-05 | 1.547E-04 | 1.550E-04 |
| 1092.00 | 1.452E+03 | 4.294E+03 | 2.403E+03 | 6.714E+00 | 4.318E-01 | 1.008E+00 | 4.563E-06 | 6.172E-05 | 2.548E-05 | 2.343E-04 | 1.671E-04 |
| 1152.00 | 1.677E+03 | 3.917E+03 | 2.965E+03 | 7.215E+00 | 4.080E-01 | 1.388E+00 | 5.405E-06 | 6.747E-05 | 1.881E-05 | 3.385E-04 | 1.902E-04 |
| 1212.00 | 1.927E+03 | 3.321E+03 | 3.465E+03 | 7.554E+00 | 3.231E-01 | 1.770E+00 | 6.267E-06 | 6.944E-05 | 1.144E-05 | 4.663E-04 | 2.237E-04 |
| 1272.00 | 2.173E+03 | 2.538E+03 | 3.820E+03 | 7.686E+00 | 3.523E-01 | 2.087E+00 | 7.029E-06 | 6.765E-05 | 9.746E-06 | 6.154E-04 | 2.661E-04 |
| 1332.00 | 2.560E+03 | 2.658E+03 | 3.579E+03 | 8.412E+00 | 4.919E-01 | 2.605E+00 | 9.138E-06 | 7.061E-05 | 1.746E-05 | 8.354E-04 | 3.533E-04 |
| 1392.00 | 2.717E+03 | 3.288E+03 | 2.476E+03 | 8.122E+00 | 1.104E+00 | 2.460E+00 | 1.031E-05 | 5.479E-05 | 3.455E-05 | 9.993E-04 | 3.952E-04 |
| 1432.00 | 2.820E+03 | 3.554E+03 | 1.658E+03 | 7.951E+00 | 1.589E+00 | 2.202E+00 | 1.109E-05 | 4.345E-05 | 4.294E-05 | 1.148E-03 | 4.025E-04 |

ADDITIONAL STATE ESTIMATES AT 130,000 ft (10 TO NF)

6.004E-08 4.338E-08 4.301E-07 1.409E-01

# APPENDIX G

## SYSTEM E ERROR CONTRIBUTION TIME HISTORIES

This appendix presents the time histories associated with the error budget results summarized in Section 5.2. The data is presented in tabular form with each table indicating the rms errors in position and velocity, and the rms value of the platform alignment estimates, in both the R (runway)* and V (relative velocity) coordinate frames (see Appendix A), which result from a specific error source or group of errors. The rms errors in altitude, velocity magnitude, flight path angle ($\gamma$), and track angle ($\psi$) are also presented.

The time points in each table correspond to every minute between the end of radio blackout and MLS acquisition, and to a shorter time interval thereafter. Time points are also included just before and after each external navigation aid is activated. Thus there are two rows of data for each of the following times (see Table 2.2-1):

$$T_{TACAN} = 1432 \text{ sec}$$
$$T_{BA} = 1550 \text{ sec}$$
$$T_{MLS} = 1836 \text{ sec}$$
$$T_{DME} = 1846 \text{ sec}$$
$$T_{RA} = 1943.5 \text{ sec}$$

*Note that the order of the runway coordinate printout is (Vertical, Crossrange, Downrange) in Appendix F and (Vertical, Downrange, Crossrange) in Appendix G.

A single row of each table corresponds to the initiation of the final approach and landing sequence at an altitude of 12,000 ft:

$$T_{SW} = 1872 \text{ sec}$$

The magnitudes and mathematical description of the error sources are given in Chapter 3. Units are in feet, feet/sec, radians, and radians/sec.

## GROUP 1 TACAN RANGE MEASUREMENT NOISE

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1432.00 | 3.099E+00 | 5.394E+01 | 6.209E+01 | 4.240E-02 | 4.640E-02 | 2.199E-02 | 1.604E-06 | 1.155E-06 | 3.760E-07 | 1.958E-02 | 1.842E-02 |
| 1490.00 | 5.422E+02 | 2.060E+02 | 2.602E+02 | 1.435E+00 | 1.413E+00 | 1.306E+00 | 5.264E-05 | 3.539E-05 | 3.841E-05 | 1.437E+00 | 1.122E+00 |
| 1550.00 | 6.038E+02 | 3.365E+02 | 3.495E+02 | 1.330E+00 | 8.000E-01 | 1.391E+00 | 6.822E-05 | 3.841E-05 | 2.504E-05 | 1.357E+00 | 6.401E-01 |
| 1550.00 | 2.723E+02 | 2.942E+02 | 3.906E+02 | 4.254E-01 | 8.765E-01 | 1.333E+00 | 7.133E-05 | 4.443E-05 | 3.724E-05 | 4.351E-01 | 6.480E-01 |
| 1610.00 | 5.657E+02 | 1.301E+02 | 1.931E+02 | 1.629E+00 | 1.425E+00 | 1.161E+00 | 8.102E-05 | 4.191E-05 | 2.930E-05 | 1.644E+00 | 6.013E-01 |
| 1670.00 | 2.797E+02 | 1.177E+02 | 1.167E+02 | 9.905E-01 | 9.459E-01 | 8.927E-01 | 6.269E-05 | 3.244E-05 | 7.374E-05 | 9.986E-01 | 6.266E-01 |
| 1730.00 | 1.813E+02 | 5.492E+01 | 1.636E+02 | 3.154E-01 | 7.804E-01 | 1.195E+00 | 6.304E-05 | 8.376E-05 | 9.905E-05 | 3.157E-01 | 2.120E-01 |
| 1790.00 | 5.708E+01 | 5.663E+01 | 3.144E+01 | 2.616E-01 | 7.164E-01 | 5.922E-01 | 6.369E-05 | 4.989E-05 | 1.312E-04 | 2.632E-01 | 5.403E-01 |
| 1836.00 | 6.147E+01 | 5.011E+01 | 3.491E+01 | 3.558E-01 | 6.137E-01 | 4.993E-01 | 6.485E-05 | 5.315E-05 | 1.212E-04 | 3.580E-01 | 4.513E-01 |
| 1836.00 | 1.776E+01 | 4.440E+01 | 8.300E+00 | 3.125E-01 | 6.596E-01 | 1.860E-01 | 6.549E-05 | 6.555E-05 | 1.292E-04 | 3.141E-01 | 2.810E-01 |
| 1846.00 | 1.898E+01 | 4.908E+01 | 5.470E+00 | 2.300E-01 | 6.353E-01 | 1.986E-01 | 7.185E-05 | 6.884E-05 | 1.253E-04 | 2.320E-01 | 3.515E-01 |
| 1846.00 | 8.651E-01 | 1.188E+00 | 3.734E-01 | 1.157E-01 | 3.263E-01 | 1.124E-01 | 7.187E-05 | 6.922E-05 | 9.997E-05 | 1.167E-01 | 2.867E-01 |
| 1860.00 | 5.054E-01 | 1.405E+00 | 2.844E-01 | 4.211E-02 | 1.330E-01 | 5.037E-02 | 7.457E-05 | 7.979E-05 | 1.013E-04 | 4.247E-02 | 1.330E-01 |
| 1874.00 | 3.350E-01 | 8.894E-01 | 3.144E-01 | 2.609E-02 | 6.067E-02 | 4.644E-02 | 7.466E-05 | 8.903E-05 | 1.137E-04 | 2.626E-02 | 5.856E-02 |
| 1884.00 | 2.892E-01 | 8.709E-01 | 3.047E-01 | 3.666E-02 | 9.548E-02 | 8.387E-02 | 7.468E-05 | 8.903E-05 | 1.136E-04 | 3.692E-02 | 9.231E-02 |
| 1894.00 | 2.604E-01 | 8.744E-01 | 2.634E-01 | 4.123E-02 | 1.240E-01 | 1.171E-01 | 7.469E-05 | 8.903E-05 | 1.136E-04 | 4.152E-02 | 1.173E-01 |
| 1904.00 | 2.252E-01 | 8.814E-01 | 2.225E-01 | 4.467E-02 | 1.520E-01 | 1.523E-01 | 7.471E-05 | 8.903E-05 | 1.136E-04 | 4.497E-02 | 1.403E-01 |
| 1914.00 | 1.717E-01 | 8.911E-01 | 1.855E-01 | 4.992E-02 | 1.790E-01 | 1.893E-01 | 7.472E-05 | 8.903E-05 | 1.136E-04 | 5.021E-02 | 1.615E-01 |
| 1924.00 | 8.288E-02 | 9.035E-01 | 1.516E-01 | 5.748E-02 | 2.127E-01 | 2.344E-01 | 7.474E-05 | 8.903E-05 | 1.136E-04 | 5.779E-02 | 2.020E-01 |
| 1934.00 | 4.451E-02 | 9.172E-01 | 1.210E-01 | 7.303E-02 | 2.487E-01 | 2.847E-01 | 7.475E-05 | 8.903E-05 | 1.136E-04 | 7.326E-02 | 2.461E-01 |
| 1943.50 | 2.223E-02 | 9.313E-01 | 1.696E-01 | 9.171E-02 | 2.725E-01 | 3.255E-01 | 7.477E-05 | 8.903E-05 | 1.136E-04 | 9.189E-02 | 2.714E-01 |
| 1943.50 | 2.216E-03 | 9.313E-01 | 1.696E-01 | 9.332E-02 | 2.725E-01 | 3.255E-01 | 7.477E-05 | 8.903E-05 | 1.136E-04 | 9.351E-02 | 2.714E-01 |
| 1944.50 | 2.001E-02 | 1.003E+00 | 4.767E-01 | 5.094E-02 | 2.764E-01 | 3.285E-01 | 7.477E-05 | 8.903E-05 | 1.136E-04 | 5.112E-02 | 2.759E-01 |
| 1945.50 | 9.453E-03 | 1.141E+00 | 8.027E-01 | 1.648E-02 | 2.802E-01 | 3.314E-01 | 7.477E-05 | 8.903E-05 | 1.136E-04 | 1.661E-02 | 2.801E-01 |
| 1946.50 | 5.371E-03 | 1.326E+00 | 1.134E+00 | 5.322E-03 | 2.840E-01 | 3.343E-01 | 7.477E-05 | 8.903E-05 | 1.136E-04 | 5.277E-03 | 2.839E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000F-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.634E-14 | 1.635E-14 |
| 1432.00 | 6.477E+00 | 8.165E+01 | 8.154E+00 | 4.333E-02 | 1.686E-02 | 4.767E-02 | 1.631E-06 | 5.141E-07 | 1.060E-06 | 3.092E-06 | 8.040E-06 |
| 1490.00 | 5.401E+02 | 9.373E+01 | 3.219E+02 | 1.419E+00 | 1.177E+00 | 1.537E+00 | 5.163E-05 | 3.952E-05 | 3.564E-05 | 3.126E-04 | 3.271E-04 |
| 1550.00 | 6.016E+02 | 2.439E+02 | 4.224E+02 | 1.321E+00 | 6.828E-01 | 1.460E+00 | 6.763E-05 | 3.999E-05 | 2.414E-05 | 3.974E-04 | 4.233E-04 |
| 1550.00 | 2.714E+02 | 1.800E+02 | 4.552E+02 | 4.208E-01 | 6.497E-01 | 1.458E+00 | 7.072E-05 | 4.273E-05 | 4.026E-05 | 1.259E-04 | 4.211E-04 |
| 1610.00 | 5.643E+02 | 1.752E+02 | 1.583E+02 | 1.624E+00 | 7.763E-01 | 1.671E+00 | 8.073E-05 | 4.364E-05 | 2.752E-05 | 7.068E-04 | 6.935E-04 |
| 1670.00 | 2.794E+02 | 1.297E+02 | 1.040E+02 | 9.896E-01 | 7.732E-01 | 1.047E+00 | 6.266E-05 | 4.337E-05 | 6.791E-05 | 6.926E-04 | 6.687E-04 |
| 1730.00 | 1.811E+02 | 5.871E+01 | 1.625E+02 | 3.142E-01 | 1.691E-01 | 1.418E+00 | 6.306E-05 | 1.112E-04 | 6.676E-05 | 2.751E-04 | 1.467E-03 |
| 1790.00 | 5.690E+01 | 4.414E+01 | 4.761E+01 | 2.626E-01 | 5.892E-01 | 7.185E-01 | 6.366E-05 | 8.465E-05 | 1.119E-04 | 4.757E-04 | 1.004E-03 |
| 1836.00 | 6.151E+01 | 2.651E+01 | 5.497E+01 | 3.579E-01 | 4.807E-01 | 6.272E-01 | 6.478E-05 | 1.194E-04 | 5.716E-05 | 6.406E-04 | 1.074E-03 |
| 1836.00 | 1.795E+01 | 2.420E+01 | 3.806E+01 | 3.146E-01 | 2.564F-01 | 6.345E-01 | 6.534E-05 | 1.223E-04 | 7.790E-05 | 4.746E-04 | 1.086E-03 |
| 1846.00 | 1.919E+01 | 3.567E+01 | 3.404E+01 | 2.328E-01 | 3.064E-01 | 5.898E-01 | 7.175E-05 | 1.164E-04 | 8.304E-05 | 2.613E-04 | 1.045E-03 |
| 1846.00 | 8.707E-01 | 6.106E-01 | 1.081E+00 | 1.167E-01 | 2.759E-01 | 2.068E-01 | 7.177E-05 | 8.981E-05 | 8.206E-05 | 1.341E-04 | 3.666E-04 |
| 1860.00 | 5.095E-01 | 1.239E+00 | 7.174E-01 | 4.248E-02 | 1.327E-01 | 5.078E-02 | 7.451E-05 | 8.801E-05 | 9.429E-05 | 7.214E-05 | 9.530E-05 |
| 1874.00 | 3.373E-01 | 8.480E-01 | 4.114E-01 | 2.625E-02 | 6.072E-02 | 4.629E-02 | 7.463E-05 | 9.041E-05 | 1.126E-04 | 5.246E-05 | 8.770E-05 |
| 1884.00 | 2.916E-01 | 8.791E-01 | 2.777E-01 | 3.690E-02 | 9.544E-02 | 8.380E-02 | 7.464E-05 | 8.877E-05 | 1.139E-04 | 7.610E-05 | 1.582E-04 |
| 1894.00 | 2.629E-01 | 8.876E-01 | 2.115E-01 | 4.151E-02 | 1.241E-01 | 1.168E-01 | 7.465E-05 | 8.861E-05 | 1.140E-04 | 1.030E-04 | 2.275E-04 |
| 1904.00 | 2.277E-01 | 8.876E-01 | 1.935E-01 | 4.496E-02 | 1.522E-01 | 1.520E-01 | 7.467E-05 | 8.875E-05 | 1.139E-04 | 1.363E-04 | 3.063E-04 |
| 1914.00 | 1.741E-01 | 8.915E-01 | 1.813E-01 | 5.028E-02 | 1.791E-01 | 1.891E-01 | 7.468E-05 | 8.897E-05 | 1.137E-04 | 1.750E-04 | 3.935E-04 |
| 1924.00 | 8.459E-02 | 9.023E-01 | 1.576E-01 | 5.778E-02 | 2.127E-01 | 2.344E-01 | 7.469E-05 | 8.908E-05 | 1.136E-04 | 1.776E-04 | 4.889E-04 |
| 1934.00 | 4.609E-02 | 9.163E-01 | 1.264E-01 | 7.325E-02 | 2.487E-01 | 2.847E-01 | 7.471E-05 | 8.908E-05 | 1.136E-04 | 2.068E-04 | 7.231E-04 |
| 1943.50 | 2.205E-02 | 9.312E-01 | 1.700E-01 | 9.188E-02 | 2.725E-01 | 3.255E-01 | 7.472E-05 | 8.904E-05 | 1.136E-04 | 3.026E-04 | 1.034E-03 |
| 1943.50 | 1.960E-09 | 9.312E-01 | 1.700E-01 | 9.350E-02 | 2.725E-01 | 3.255E-01 | 7.472E-05 | 8.904E-05 | 1.136E-04 | 3.076E-04 | 1.034E-03 |
| 1944.50 | 1.910E-02 | 1.004E+00 | 4.762E-01 | 5.111E-02 | 2.764E-01 | 3.284E-01 | 7.472E-05 | 8.904E-05 | 1.136E-04 | 1.751E-04 | 1.072E-03 |
| 1945.50 | 8.412E-03 | 1.141E+00 | 8.021E-01 | 1.660E-02 | 2.802E-01 | 3.314E-01 | 7.472E-05 | 8.904E-05 | 1.136E-04 | 6.202E-05 | 1.111E-03 |
| 1946.50 | 3.485E-03 | 1.327E+00 | 1.133E+00 | 5.262E-03 | 2.839E-01 | 3.343E-01 | 7.472E-05 | 8.904E-05 | 1.136E-04 | 2.511E-05 | 1.136E-03 |

## GROUP 1 TACAN BEARING MEASUREMENT NOISE

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.000E-10 | 1.000E-10 | 1.000F-10 | 1.000E-10 | 1.000F-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1432.00 | 1.417E+02 | 1.182E+03 | 2.323E+03 | 1.554E+00 | 3.100E+00 | 8.797E-01 | 1.241E-04 | 5.852E-05 | 5.130E-05 | 1.216E+00 | 2.867E+00 |
| 1490.00 | 1.179E+02 | 3.665E+02 | 5.160E+02 | 4.874E-01 | 5.104F-01 | 1.441E+00 | 9.581E-05 | 8.067E-05 | 1.935E-05 | 4.867E-01 | 1.002E+00 |
| 1550.00 | 2.619E+02 | 2.401E+02 | 4.445E+02 | 1.052E+00 | 1.061E+00 | 2.166E+00 | 1.100E-04 | 8.436E-05 | 1.750E-05 | 1.030E+00 | 5.429E-01 |
| 1550.00 | 1.270F+02 | 2.443E+02 | 3.987E+02 | 6.925E-01 | 1.240E+00 | 2.079E+00 | 1.117E-04 | 7.679E-05 | 2.438E-05 | 6.712E-01 | 6.674E-01 |
| 1610.00 | 1.984E+02 | 1.880E+02 | 2.756E+02 | 5.768E-01 | 1.570E+00 | 1.974E+00 | 8.943E-05 | 6.359E-05 | 6.145E-05 | 5.790E-01 | 2.359E-01 |
| 1670.00 | 2.202E+02 | 1.388E+02 | 2.063E+02 | 6.337E-01 | 1.119E+00 | 1.178E+00 | 7.102E-05 | 5.518E-05 | 8.982E-05 | 6.345E-01 | 6.611E-01 |
| 1730.00 | 4.836E+02 | 8.598E+01 | 3.914E+02 | 1.632E+00 | 4.418E-01 | 1.900E+00 | 8.347E-05 | 1.270E-04 | 1.060E-04 | 1.643E+00 | 6.609E-01 |
| 1790.00 | 1.565E+02 | 3.146E+01 | 1.314E+02 | 7.575E-01 | 2.226E-01 | 1.001E+00 | 8.441E-05 | 1.147E-04 | 7.433E-05 | 7.596E-01 | 4.850E-01 |
| 1836.00 | 1.038F+02 | 3.900E+01 | 1.191E+02 | 4.287E-01 | 3.092E-01 | 1.437E+00 | 8.956E-05 | 1.795E-04 | 6.935E-05 | 4.306E-01 | 1.305E+00 |
| 1836.00 | 1.118E+01 | 2.425E+01 | 3.702E+00 | 3.930E-01 | 2.290E-01 | 6.055E-01 | 9.004E-05 | 1.266E-04 | 7.077E-05 | 3.941E-01 | 4.265E-01 |
| 1846.00 | 8.089E+00 | 2.250E+01 | 3.445E+00 | 1.981E-01 | 2.230F-01 | 2.718E-01 | 9.330E-05 | 1.272E-04 | 7.008E-05 | 1.990E-01 | 2.282E-01 |
| 1846.00 | 1.151E-01 | 6.139E-01 | 1.008E+00 | 2.245E-01 | 3.138E-01 | 1.897E-01 | 9.455E-05 | 1.313E-04 | 8.419E-05 | 2.258E-01 | 2.390E-01 |
| 1860.00 | 4.941E-01 | 3.865E-01 | 6.792E-01 | 8.420E-02 | 1.255E-01 | 5.839E-02 | 9.842E-05 | 1.473E-04 | 7.009E-05 | 8.470E-02 | 1.277E-01 |
| 1874.00 | 3.594E-01 | 9.437E-01 | 5.838E-01 | 4.555E-02 | 4.642E-02 | 8.001E-02 | 9.872E-05 | 1.650E-04 | 7.329E-05 | 4.575E-02 | 4.904E-02 |
| 1880.00 | 3.806E-01 | 1.082E+00 | 5.365E-01 | 6.606E-02 | 7.021E-02 | 1.502E-01 | 9.873E-05 | 1.682E-04 | 7.330E-05 | 6.639E-02 | 7.370E-02 |
| 1894.00 | 3.456E-01 | 1.092E+00 | 4.733E-01 | 7.646E-02 | 8.786E-02 | 2.124E-01 | 9.875E-05 | 1.713E-04 | 7.331E-05 | 7.691E-02 | 9.268E-02 |
| 1904.00 | 3.003E-01 | 1.109E+00 | 4.136E-01 | 8.333E-02 | 1.048E-01 | 2.788E-01 | 9.877E-05 | 1.744E-04 | 7.332E-05 | 8.390E-02 | 1.060E-01 |
| 1914.00 | 2.292E-01 | 1.137E+00 | 3.550E-01 | 9.167E-02 | 1.220E-01 | 3.491E-01 | 9.878E-05 | 1.775E-04 | 7.333E-05 | 9.237E-02 | 1.181E-01 |
| 1924.00 | 1.053F-01 | 1.177E+00 | 2.969E-01 | 1.029E-01 | 1.446E-01 | 4.360E-01 | 9.880E-05 | 1.804E-04 | 7.333E-05 | 1.037E-01 | 1.408E-01 |
| 1934.00 | 5.547E-02 | 1.214E+00 | 2.435E-01 | 1.202E-01 | 1.699E-01 | 5.324E-01 | 9.882E-05 | 1.834E-04 | 7.334E-05 | 1.212E-01 | 1.682E-01 |
| 1943.50 | 4.235E-02 | 1.248E+00 | 3.031E-01 | 1.390E-01 | 1.882F-01 | 6.104E-01 | 9.883E-05 | 1.861E-04 | 7.335E-05 | 1.402E-01 | 1.874E-01 |
| 1943.50 | 2.533F-03 | 1.248E+00 | 3.030E-01 | 1.427E-01 | 1.882E-01 | 6.104E-01 | 9.883E-05 | 1.861E-04 | 7.335E-05 | 1.439E-01 | 1.874E-01 |
| 1944.50 | 2.969E-02 | 1.286E+00 | 8.686E-01 | 7.696E-02 | 1.906E-01 | 6.161E-01 | 9.883E-05 | 1.864E-04 | 7.335E-05 | 7.812E-02 | 1.900E-01 |
| 1945.50 | 1.290E-02 | 1.352E+00 | 1.478E+00 | 2.367E-02 | 1.929F-01 | 6.218E-01 | 9.884E-05 | 1.867E-04 | 7.335E-05 | 2.480E-02 | 1.924E-01 |
| 1946.50 | 5.487E-03 | 1.441E+00 | 2.099E+00 | 6.189E-03 | 1.952E-01 | 6.275E-01 | 9.884E-05 | 1.870E-04 | 7.336E-05 | 7.197E-03 | 1.947E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.634E-14 | 1.635E-14 |
| 1432.00 | 1.623E+02 | 7.289E+02 | 2.502E+03 | 1.428E+00 | 2.921E+00 | 1.494E+00 | 1.207E-04 | 8.287E-05 | 3.343E-06 | 2.157E-04 | 1.588E-04 |
| 1490.00 | 1.169E+02 | 9.246E+01 | 6.264E+02 | 4.671E-01 | 1.028E+00 | 1.139E+00 | 9.414E-05 | 4.995E-05 | 6.860E-05 | 1.141E-04 | 2.279E-04 |
| 1550.00 | 2.610E+02 | 1.078E+02 | 4.940E+02 | 1.046E+00 | 5.055E-01 | 2.361E+00 | 1.087E-04 | 8.707E-05 | 1.094E-05 | 2.917E-04 | 6.683E-04 |
| 1550.00 | 1.267E+02 | 1.227E+02 | 4.512E+02 | 6.910E-01 | 6.265E-01 | 2.339E+00 | 1.105E-04 | 8.194E-05 | 7.111E-06 | 1.822E-04 | 6.626E-04 |
| 1610.00 | 1.978E+02 | 4.869E+01 | 3.303F+02 | 5.759E-01 | 2.207E-01 | 2.513E+00 | 8.891E-05 | 8.424E-05 | 2.857E-05 | 2.359E-04 | 1.033E-03 |
| 1670.00 | 2.198E+02 | 8.802E+01 | 2.329E+02 | 6.321E-01 | 6.927F-01 | 1.471E+00 | 7.096E-05 | 6.859E-05 | 8.010E-05 | 4.218E-04 | 9.336E-04 |
| 1730.00 | 4.834E+02 | 2.591E+02 | 3.059E+02 | 1.632E+00 | 1.353E+00 | 1.406E+00 | 8.360E-05 | 6.915E-05 | 1.502E-04 | 1.931E-03 | 1.454E-03 |
| 1790.00 | 1.565F+02 | 6.830E+01 | 1.166E+02 | 7.583E-01 | 6.475E-01 | 7.939E-01 | 8.442F-05 | 9.268E-05 | 1.005E-04 | 1.175E-03 | 1.106E-03 |
| 1836.00 | 1.037E+02 | 1.100E+02 | 6.019E+01 | 4.292E-01 | 1.413E+00 | 4.078E-01 | 8.963E-05 | 8.682E-05 | 1.717E-04 | 1.124E-03 | 6.996E-04 |
| 1836.00 | 1.129E+01 | 1.226E+01 | 2.119E+01 | 3.941E-01 | 5.417E-01 | 3.533E-01 | 9.009E-05 | 8.790E-05 | 1.153E-04 | 8.383E-04 | 6.047E-04 |
| 1846.00 | 8.184E+00 | 1.684E+01 | 1.526E+01 | 1.986E-01 | 2.125F-01 | 2.797E-01 | 9.342E-05 | 9.501E-05 | 1.098E-04 | 3.030E-04 | 4.959E-04 |
| 1846.00 | 1.147E-01 | 9.469E-01 | 7.041E-01 | 2.258E-01 | 1.944E-01 | 3.100E-01 | 9.470E-05 | 1.073E-04 | 1.131E-04 | 2.982E-04 | 5.494E-04 |
| 1860.00 | 4.957E-01 | 3.858E-01 | 6.784E-01 | 8.470E-02 | 1.080F-01 | 8.610E-02 | 9.863E-05 | 1.332E-04 | 9.393E-05 | 8.714E-05 | 1.616E-04 |
| 1874.00 | 3.618E-01 | 9.682E-01 | 5.406E-01 | 4.573E-02 | 4.682E-02 | 7.967E-02 | 9.894E-05 | 1.636E-04 | 7.508E-05 | 7.389E-05 | 1.509E-04 |
| 1884.00 | 3.836E-01 | 1.074E+00 | 5.505F-01 | 6.637E-02 | 7.030E-02 | 1.500E-01 | 9.895E-05 | 1.681E-04 | 7.330E-05 | 1.078E-04 | 2.831E-04 |
| 1894.00 | 3.486E-01 | 1.077E+00 | 5.035E-01 | 7.689E-02 | 8.934E-02 | 2.116E-01 | 9.895E-05 | 1.710E-04 | 7.374F-05 | 1.293E-04 | 4.121E-04 |
| 1904.00 | 3.032E-01 | 1.102E+00 | 4.302E-01 | 8.388E-02 | 1.062E-01 | 2.781E-01 | 9.895E-05 | 1.743E-04 | 7.336E-05 | 1.546E-04 | 5.604E-04 |
| 1914.00 | 2.321E-01 | 1.135E+00 | 3.573F-01 | 9.235E-02 | 1.222E-01 | 3.488E-01 | 9.896E-05 | 1.774E-04 | 7.327E-05 | 1.854E-04 | 7.258E-04 |
| 1924.00 | 1.078E-01 | 1.177E+00 | 2.939E-01 | 1.037E-01 | 1.439E-01 | 4.360E-01 | 9.896F-05 | 1.803E-04 | 7.335E-05 | 2.175E-04 | 9.096E-04 |
| 1934.00 | 5.791E-02 | 1.215E+00 | 2.408E-01 | 1.212E-01 | 1.690E-01 | 5.324E-01 | 9.897F-05 | 1.833E-04 | 7.335E-05 | 3.098E-04 | 1.352E-03 |
| 1943.50 | 4.177E-02 | 1.249E+00 | 3.006E-01 | 1.401E-01 | 1.877E-01 | 6.103E-01 | 9.898E-05 | 1.860E-04 | 7.334E-05 | 4.464E-04 | 1.940E-03 |
| 1943.50 | 5.359E-09 | 1.249E+00 | 3.006E-01 | 1.438E-01 | 1.877F-01 | 6.103E-01 | 9.898E-05 | 1.860E-04 | 7.334E-05 | 4.581E-04 | 1.940E-03 |
| 1944.50 | 2.927E-02 | 1.287E+00 | 8.669E-01 | 7.811E-02 | 1.901E-01 | 6.161E-01 | 9.898E-05 | 1.863E-04 | 7.333E-05 | 2.558E-04 | 2.011E-03 |
| 1945.50 | 1.273E-02 | 1.353E+00 | 1.477E+00 | 2.479E-02 | 1.924E-01 | 6.219E-01 | 9.898E-05 | 1.866E-04 | 7.333E-05 | 8.411E-05 | 2.085E-03 |
| 1946.50 | 5.029E-03 | 1.443E+00 | 2.098E+00 | 7.184E-03 | 1.947E-01 | 6.276E-01 | 9.898E-05 | 1.869E-04 | 7.333E-05 | 2.630E-05 | 2.133E-03 |

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## GROUP 1 MLS AZIMUTH MEASUREMENT NOISE

| TIME | POSITION ESTIMATE ERROR | | | VELOCITY ESTIMATE ERROR | | | PLATFORM TILT ESTIMATE | | | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | R | D | C | R | D | C | R | D | C | | |
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 1.874E-08 | 1.175E-07 | 1.045E-06 | 4.004E-09 | 7.174E-09 | 1.402E-08 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 4.044E-09 | 1.324E-08 |
| 1836.00 | 4.553E-01 | 1.145E+00 | 6.582E+00 | 9.834E-04 | 2.189E-02 | 5.921E-02 | 2.749E-07 | 4.337E-06 | 2.129E-06 | 8.294E-04 | 6.014E-02 |
| 1846.00 | 1.076E+00 | 3.568E+00 | 5.502E+00 | 9.159E-02 | 2.531E-02 | 5.369E-01 | 3.880E-05 | 1.092E-04 | 7.118E-06 | 9.285E-02 | 3.463E-01 |
| 1846.00 | 1.939E-01 | 3.647E-01 | 4.283E+00 | 7.365E-02 | 5.097E-02 | 5.197E-01 | 3.800E-05 | 1.061E-04 | 6.491E-06 | 7.468E-02 | 3.276E-01 |
| 1860.00 | 9.090E-02 | 2.599E-01 | 3.229E+00 | 8.005E-03 | 5.741E-02 | 2.103E-01 | 1.965E-05 | 5.748E-05 | 1.227E-05 | 8.292E-03 | 1.056E-01 |
| 1874.00 | 3.757E-01 | 1.255E+00 | 3.947E+00 | 1.283E-02 | 3.636E-02 | 1.312E-01 | 2.032E-05 | 6.759E-05 | 8.812E-06 | 1.292E-02 | 3.426E-02 |
| 1884.00 | 3.714E-01 | 1.343E+00 | 3.681E+00 | 1.396E-02 | 3.627E-02 | 1.229E-01 | 2.032E-05 | 6.759E-05 | 8.833E-06 | 1.405E-02 | 3.618E-02 |
| 1894.00 | 3.483E-01 | 1.341E+00 | 3.355E+00 | 1.524E-02 | 3.640E-02 | 1.177E-01 | 2.031E-05 | 6.759E-05 | 8.854E-06 | 1.534E-02 | 3.963E-02 |
| 1904.00 | 3.107E-01 | 1.351E+00 | 3.007E+00 | 1.671E-02 | 3.742E-02 | 1.155E-01 | 2.030E-05 | 6.759E-05 | 8.875E-06 | 1.683E-02 | 3.892E-02 |
| 1914.00 | 2.357E-01 | 1.363E+00 | 2.640E+00 | 1.874E-02 | 3.940E-02 | 1.173E-01 | 2.030E-05 | 6.759E-05 | 8.896E-06 | 1.888E-02 | 3.843E-02 |
| 1924.00 | 8.805E-02 | 1.363E+00 | 2.252E+00 | 2.130E-02 | 4.224E-02 | 1.241E-01 | 2.029E-05 | 6.759E-05 | 8.917E-06 | 2.144E-02 | 4.143E-02 |
| 1934.00 | 4.252E-02 | 1.376E+00 | 1.873E+00 | 2.329E-02 | 4.524E-02 | 1.391E-01 | 2.028E-05 | 6.759E-05 | 8.938E-06 | 2.344E-02 | 4.475E-02 |
| 1943.50 | 3.238E-02 | 1.370E+00 | 1.586E+00 | 2.524E-02 | 4.779E-02 | 1.556E-01 | 2.028E-05 | 6.759E-05 | 8.958E-06 | 2.542E-02 | 4.755E-02 |
| 1943.50 | 4.740E-03 | 1.369E+00 | 1.586E+00 | 2.719E-02 | 4.779E-02 | 1.556E-01 | 2.028E-05 | 6.759E-05 | 8.956E-06 | 2.735E-02 | 4.755E-02 |
| 1944.50 | 6.203E-03 | 1.365E+00 | 1.598E+00 | 1.463E-02 | 4.791E-02 | 1.569E-01 | 2.028E-05 | 6.759E-05 | 8.960E-06 | 1.479E-02 | 4.764E-02 |
| 1945.50 | 4.474E-03 | 1.362E+00 | 1.626E+00 | 4.484E-03 | 4.804E-02 | 1.582E-01 | 2.028E-05 | 6.759E-05 | 8.962E-06 | 4.632E-03 | 4.776E-02 |
| 1946.50 | 4.344E-03 | 1.361E+00 | 1.668E+00 | 1.172E-03 | 4.816E-02 | 1.595E-01 | 2.028E-05 | 6.759E-05 | 8.964E-06 | 1.271E-03 | 4.790E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 2.095E-08 | 9.263E-07 | 8.971E-07 | 4.037E-09 | 1.422E-08 | 6.743E-09 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.070E-11 | 1.155E-11 |
| 1836.00 | 4.714E-01 | 5.685E+00 | 3.507E+00 | 9.881E-04 | 6.310E-02 | 1.689E-03 | 2.513E-07 | 3.653E-07 | 4.819E-06 | 3.131E-05 | 3.078E-06 |
| 1846.00 | 1.084E+00 | 6.107E+00 | 2.386E+00 | 9.270E-02 | 3.976E-01 | 3.613E-01 | 3.931E-05 | 6.484E-05 | 8.799E-05 | 3.629E-04 | 6.406E-04 |
| 1846.00 | 2.032E-01 | 3.061E+00 | 3.017E+00 | 7.482E-02 | 3.715E-01 | 3.668E-01 | 3.849E-05 | 6.441E-05 | 8.434E-05 | 3.196E-04 | 6.503E-04 |
| 1860.00 | 9.217E-02 | 1.350E+00 | 2.945E+00 | 8.287E-03 | 1.134E-01 | 1.862E-01 | 1.984E-05 | 4.713E-05 | 3.502E-05 | 7.242E-05 | 3.495E-04 |
| 1874.00 | 3.799E-01 | 1.369E+00 | 3.908E+00 | 1.294E-02 | 3.865E-02 | 1.305E-01 | 2.025E-05 | 6.619E-05 | 1.640E-05 | 3.760E-05 | 2.472E-04 |
| 1884.00 | 3.754E-01 | 1.334E+00 | 3.684E+00 | 1.406E-02 | 3.820E-02 | 1.224E-01 | 2.025E-05 | 6.782E-05 | 7.071E-06 | 3.212E-05 | 2.309E-04 |
| 1894.00 | 3.527E-01 | 1.350E+00 | 3.351E+00 | 1.535E-02 | 4.181E-02 | 1.159E-01 | 2.025E-05 | 6.794E-05 | 5.764E-06 | 3.606E-05 | 2.256E-04 |
| 1904.00 | 3.153E-01 | 1.359E+00 | 3.004E+00 | 1.684E-02 | 4.081E-02 | 1.143E-01 | 2.025E-05 | 6.783E-05 | 6.961E-06 | 3.626E-05 | 2.303E-04 |
| 1914.00 | 2.402E-01 | 1.363E+00 | 2.639E+00 | 1.889E-02 | 3.989E-02 | 1.171E-01 | 2.024E-05 | 6.764E-05 | 8.620E-06 | 4.120E-05 | 2.436E-04 |
| 1924.00 | 9.218E-02 | 1.361E+00 | 2.253E+00 | 2.146E-02 | 4.145E-02 | 1.244E-01 | 2.024E-05 | 6.754E-05 | 9.365E-06 | 4.330E-05 | 2.595E-04 |
| 1934.00 | 4.616E-02 | 1.375E+00 | 1.874E+00 | 2.346E-02 | 4.450E-02 | 1.393E-01 | 2.024E-05 | 6.755E-05 | 9.348E-06 | 5.818E-05 | 3.539E-04 |
| 1943.50 | 3.290E-02 | 1.369E+00 | 1.586E+00 | 2.542E-02 | 4.743E-02 | 1.557E-01 | 2.024E-05 | 6.758E-05 | 9.147E-06 | 8.004E-05 | 4.947E-04 |
| 1943.50 | 6.346E-09 | 1.369E+00 | 1.586E+00 | 2.736E-02 | 4.743E-02 | 1.557E-01 | 2.024E-05 | 6.758E-05 | 9.147E-06 | 8.621E-05 | 4.947E-04 |
| 1944.50 | 5.559E-03 | 1.365E+00 | 1.598E+00 | 1.480E-02 | 4.759E-02 | 1.569E-01 | 2.023E-05 | 6.758E-05 | 9.131E-06 | 4.778E-05 | 5.122E-04 |
| 1945.50 | 2.404E-03 | 1.362E+00 | 1.626E+00 | 4.642E-03 | 4.776E-02 | 1.582E-01 | 2.023E-05 | 6.758E-05 | 9.116E-06 | 1.524E-05 | 5.306E-04 |
| 1946.50 | 9.107E-04 | 1.361E+00 | 1.668E+00 | 1.281E-03 | 4.790E-02 | 1.595E-01 | 2.023E-05 | 6.758E-05 | 9.109E-06 | 4.285E-06 | 5.422E-04 |

## GROUP 1 MLS ELEVATION MEASUREMENT NOISE

| TIME | POSITION ESTIMATE ERROR R | POSITION ESTIMATE ERROR D | POSITION ESTIMATE ERROR C | VELOCITY ESTIMATE ERROR R | VELOCITY ESTIMATE ERROR D | VELOCITY ESTIMATE ERROR C | PLATFORM TILT ESTIMATE R | PLATFORM TILT ESTIMATE D | PLATFORM TILT ESTIMATE C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 1.874E-08 | 1.175E-07 | 1.045E-06 | 4.004E-09 | 7.174E-09 | 1.402E-08 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 4.044E-09 | 1.324E-08 |
| 1836.00 | 5.514E+00 | 8.865E-01 | 1.807E-01 | 1.402E-02 | 2.360E-04 | 1.336E-02 | 6.552E-08 | 1.772E-06 | 2.559E-07 | 1.402E-02 | 1.629E-02 |
| 1846.00 | 7.167E+00 | 9.182E+00 | 5.422E-01 | 4.747E-01 | 4.153E-02 | 1.566E-01 | 2.400E-05 | 1.791E-05 | 1.673E-05 | 4.750E-01 | 6.600E-02 |
| 1846.00 | 3.271E+00 | 7.333E-01 | 2.841E-01 | 4.231E-01 | 3.090E-02 | 6.916E-02 | 2.545E-05 | 2.848E-05 | 9.112E-06 | 4.231E-01 | 7.067E-02 |
| 1860.00 | 2.502E+00 | 6.033E-01 | 8.803E-02 | 1.725E-01 | 3.562E-02 | 1.434E-02 | 1.505E-05 | 2.316E-05 | 4.154E-06 | 1.724E-01 | 4.025E-02 |
| 1874.00 | 2.900E+00 | 1.085E+00 | 1.997E-01 | 1.054E-01 | 2.947E-02 | 1.615E-02 | 1.884E-05 | 3.963E-05 | 1.369E-05 | 1.053E-01 | 2.503E-02 |
| 1884.00 | 2.664E+00 | 8.256E-01 | 1.798E-01 | 1.166E-01 | 3.628E-02 | 2.596E-02 | 1.885E-05 | 3.962E-05 | 1.371E-05 | 1.166E-01 | 2.477E-02 |
| 1894.00 | 2.363E+00 | 7.911E-01 | 1.609E-01 | 1.257E-01 | 4.033E-02 | 3.870E-02 | 1.886E-05 | 3.961E-05 | 1.373E-05 | 1.256E-01 | 2.695E-02 |
| 1904.00 | 2.004E+00 | 9.981E-01 | 1.440E-01 | 1.352E-01 | 4.375E-02 | 5.327E-02 | 1.887E-05 | 3.960E-05 | 1.375E-05 | 1.352E-01 | 2.900E-02 |
| 1914.00 | 1.549E+00 | 1.281E+00 | 1.266E-01 | 1.457E-01 | 4.680E-02 | 6.901E-02 | 1.888E-05 | 3.958E-05 | 1.377E-05 | 1.457E-01 | 3.096E-02 |
| 1924.00 | 9.597E-01 | 1.310E+00 | 1.080E-01 | 1.572E-01 | 4.958E-02 | 8.869E-02 | 1.889E-05 | 3.957E-05 | 1.379E-05 | 1.572E-01 | 2.326E-02 |
| 1934.00 | 4.746E-01 | 1.004E+00 | 8.995E-02 | 1.702E-01 | 5.208E-02 | 1.097E-01 | 1.890E-05 | 3.956E-05 | 1.381E-05 | 1.702E-01 | 4.326E-02 |
| 1943.50 | 1.530E-01 | 8.822E-01 | 1.333E-01 | 1.831E-01 | 5.459E-02 | 1.266E-01 | 1.891E-05 | 3.955E-05 | 1.383E-05 | 1.831E-01 | 5.164E-02 |
| 1943.50 | 1.821E-03 | 8.821E-01 | 1.334E-01 | 1.895E-01 | 5.458E-02 | 1.266E-01 | 1.891E-05 | 3.955E-05 | 1.383E-05 | 1.895E-01 | 5.154E-02 |
| 1944.50 | 3.919E-02 | 9.156E-01 | 2.564E-01 | 1.027E-01 | 5.497E-02 | 1.277E-01 | 1.891E-05 | 3.955E-05 | 1.383E-05 | 1.027E-01 | 5.395E-02 |
| 1945.50 | 1.739E-02 | 9.514E-01 | 3.832E-01 | 3.235E-02 | 5.531E-02 | 1.288E-01 | 1.891E-05 | 3.955E-05 | 1.383E-05 | 3.235E-02 | 5.526E-02 |
| 1946.50 | 7.221E-03 | 9.894E-01 | 5.119E-01 | 9.068E-03 | 5.555E-02 | 1.299E-01 | 1.891E-05 | 3.955E-05 | 1.384E-05 | 9.078E-03 | 5.569E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 2.095E-08 | 9.263E-07 | 4.971E-07 | 4.037E-09 | 1.422E-08 | 6.743E-09 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.070E-11 | 1.155E-11 |
| 1836.00 | 5.510E+00 | 4.991E-01 | 7.849E-01 | 1.400E-02 | 1.248E-02 | 8.813E-03 | 7.332E-08 | 8.961E-07 | 1.550E-06 | 1.513E-05 | 8.227E-06 |
| 1846.00 | 7.204E+00 | 6.302E+00 | 6.660E+00 | 8.752E-01 | 9.419E-02 | 1.301E-01 | 2.411E-05 | 1.439E-06 | 2.436E-05 | 8.044E-04 | 2.304E-04 |
| 1846.00 | 3.268E+00 | 6.565E-01 | 4.532E-01 | 4.231E-01 | 7.236E-02 | 2.245E-02 | 2.559E-05 | 1.157E-05 | 2.744E-05 | 7.100E-04 | 3.980E-05 |
| 1860.00 | 2.500E+00 | 5.332E-01 | 3.162E-01 | 1.724E-01 | 3.826E-02 | 6.902E-03 | 1.514E-05 | 1.977E-05 | 1.265E-05 | 2.990E-04 | 1.295E-05 |
| 1874.00 | 2.898E+00 | 1.096E+00 | 1.751E-01 | 1.053E-01 | 3.062E-02 | 1.446E-02 | 1.900E-05 | 3.777E-05 | 1.803E-05 | 1.819E-04 | 2.739E-05 |
| 1864.00 | 2.663E+00 | 8.247E-01 | 1.989E-01 | 1.166E-01 | 3.599E-02 | 2.675E-02 | 1.900E-05 | 3.995E-05 | 1.249E-05 | 2.058E-04 | 5.049E-05 |
| 1894.00 | 2.363E+00 | 7.811E-01 | 1.996E-01 | 1.256E-01 | 3.872E-02 | 4.055E-02 | 1.900E-05 | 4.027E-05 | 1.140E-05 | 2.284E-04 | 7.898E-05 |
| 1904.00 | 2.006E+00 | 9.908E-01 | 1.683E-01 | 1.352E-01 | 4.269E-02 | 5.429E-02 | 1.901E-05 | 3.997E-05 | 1.243E-05 | 2.550E-04 | 1.094E-04 |
| 1914.00 | 1.552E+00 | 1.277E+00 | 1.307E-01 | 1.457E-01 | 4.692E-02 | 6.904E-02 | 1.901E-05 | 3.960E-05 | 1.356E-05 | 2.846E-04 | 1.437E-04 |
| 1924.00 | 9.623E-01 | 1.309E+00 | 1.035E-01 | 1.572E-01 | 5.042E-02 | 8.828E-02 | 1.901E-05 | 3.943E-05 | 1.403E-05 | 3.294E-04 | 1.842E-04 |
| 1934.00 | 4.761E-01 | 1.004E+00 | 8.568E-02 | 1.702E-01 | 5.299E-02 | 1.093E-01 | 1.901E-05 | 3.943E-05 | 1.403E-05 | 4.384E-04 | 2.776E-04 |
| 1943.50 | 1.533E-01 | 8.825E-01 | 1.312E-01 | 1.831E-01 | 5.524E-02 | 1.263E-01 | 1.902E-05 | 3.947E-05 | 1.391E-05 | 5.851E-04 | 4.014E-04 |
| 1943.50 | 1.913E-09 | 8.825E-01 | 1.312E-01 | 1.895E-01 | 5.524E-02 | 1.263E-01 | 1.902E-05 | 3.947E-05 | 1.391E-05 | 6.055E-04 | 4.014E-04 |
| 1944.50 | 3.852E-02 | 9.162E-01 | 2.544E-01 | 1.027E-01 | 5.542E-02 | 1.275E-01 | 1.902E-05 | 3.947E-05 | 1.390E-05 | 3.377E-04 | 4.161E-04 |
| 1945.50 | 1.670E-02 | 9.522E-01 | 3.814E-01 | 3.235E-02 | 5.559E-02 | 1.287E-01 | 1.902E-05 | 3.948E-05 | 1.389E-05 | 1.103E-04 | 4.315E-04 |
| 1946.50 | 6.452E-03 | 9.903E-01 | 5.101E-01 | 9.071E-03 | 5.577E-02 | 1.298E-01 | 1.902E-05 | 3.948E-05 | 1.389E-05 | 3.251E-05 | 4.413E-04 |

GROUP 1 MLS DME MEASUREMENT NOISE

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1846.00 | 5.818E+00 | 1.546E+01 | 1.767E+00 | 4.286E-02 | 1.176E-01 | 9.042E-02 | 1.742E-06 | 1.150E-05 | 1.307E-05 | 4.325E-02 | 1.992E-02 |
| 1860.00 | 3.018E+00 | 8.408E+00 | 5.509E-01 | 2.556E-01 | 6.620E-01 | 7.861E-02 | 7.424E-06 | 1.029E-05 | 1.544E-04 | 2.581E-01 | 6.706E-01 |
| 1874.00 | 4.089E+00 | 1.192E+01 | 2.662E-01 | 1.613E-01 | 4.035E-01 | 5.788E-02 | 2.712E-05 | 2.118E-05 | 1.070E-04 | 1.626E-01 | 4.341E-01 |
| 1884.00 | 3.948E+00 | 1.207E+01 | 2.376E-01 | 1.515E-01 | 3.172E-01 | 8.075E-02 | 2.710E-05 | 2.123E-05 | 1.070E-04 | 1.524E-01 | 3.478E-01 |
| 1894.00 | 3.665E+00 | 1.212E+01 | 1.962E-01 | 1.514E-01 | 2.570E-01 | 9.810E-02 | 2.708E-05 | 2.128E-05 | 1.070E-04 | 1.519E-01 | 2.890E-01 |
| 1904.00 | 3.177E+00 | 1.206E+01 | 1.891E-01 | 1.543E-01 | 2.014E-01 | 1.153E-01 | 2.706E-05 | 2.133E-05 | 1.070E-04 | 1.545E-01 | 2.400E-01 |
| 1914.00 | 2.293E+00 | 1.164E+01 | 1.971E-01 | 1.596E-01 | 1.493E-01 | 1.318E-01 | 2.704E-05 | 2.138E-05 | 1.070E-04 | 1.596E-01 | 1.947E-01 |
| 1924.00 | 8.060E-01 | 1.032E+01 | 1.865E-01 | 1.657E-01 | 9.438E-02 | 1.490E-01 | 2.702E-05 | 2.142E-05 | 1.070E-04 | 1.655E-01 | 1.250E-01 |
| 1934.00 | 3.283E-01 | 9.785E+00 | 1.794E-01 | 1.819E-01 | 7.233E-02 | 1.676E-01 | 2.700E-05 | 2.147E-05 | 1.070E-04 | 1.815E-01 | 7.311E-02 |
| 1943.50 | 9.816E-01 | 9.280E+00 | 2.098E-01 | 1.994E-01 | 8.801E-02 | 1.827E-01 | 2.698E-05 | 2.152E-05 | 1.070E-04 | 1.989E-01 | 8.560E-02 |
| 1943.50 | 2.102E-02 | 9.280E+00 | 2.092E-01 | 2.237E-01 | 8.799E-02 | 1.827E-01 | 2.698E-05 | 2.152E-05 | 1.070E-04 | 2.233E-01 | 8.539E-02 |
| 1944.50 | 4.664E-02 | 9.333E+00 | 3.388E-01 | 1.221E-01 | 9.058E-02 | 1.837E-01 | 2.698E-05 | 2.152E-05 | 1.070E-04 | 1.216E-01 | 8.929E-02 |
| 1945.50 | 2.667E-02 | 9.386E+00 | 5.040E-01 | 3.949E-02 | 9.322E-02 | 1.847E-01 | 2.698E-05 | 2.153E-05 | 1.070E-04 | 3.899E-02 | 9.266E-02 |
| 1946.50 | 2.158E-02 | 9.439E+00 | 6.799E-01 | 1.223E-02 | 9.579E-02 | 1.855E-01 | 2.698E-05 | 2.153E-05 | 1.070E-04 | 1.171E-02 | 9.538E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.677E-13 | 1.772E-13 |
| 1846.00 | 5.884E+00 | 1.128E+01 | 1.069E+01 | 4.356E-02 | 6.142E-03 | 1.480E-01 | 1.769E-06 | 1.740E-05 | 4.157E-07 | 6.522E-05 | 2.621E-04 |
| 1860.00 | 3.052E+00 | 7.669E+00 | 3.460E+00 | 2.582E-01 | 6.190E-01 | 2.447E-01 | 7.410E-06 | 8.032E-05 | 1.323E-04 | 2.026E-05 | 4.590E-04 |
| 1874.00 | 4.135E+00 | 1.181E+01 | 1.507E+00 | 1.627E-01 | 4.044E-01 | 4.630E-02 | 2.715E-05 | 3.435E-05 | 1.036E-04 | 6.800E-05 | 8.749E-05 |
| 1884.00 | 3.992E+00 | 1.205E+01 | 4.132E-01 | 1.525E-01 | 3.144E-01 | 8.923E-02 | 2.714E-05 | 1.763E-05 | 1.077E-04 | 5.788E-05 | 1.684E-04 |
| 1894.00 | 3.705E+00 | 1.208E+01 | 8.505E-01 | 1.520E-01 | 2.511E-01 | 1.115E-01 | 2.712E-05 | 1.415E-05 | 1.082E-04 | 9.145E-05 | 2.172E-04 |
| 1904.00 | 3.215E+00 | 1.203E+01 | 5.715E-01 | 1.546E-01 | 1.978E-01 | 1.209E-01 | 2.710E-05 | 1.739E-05 | 1.077E-04 | 1.356E-04 | 2.435E-04 |
| 1914.00 | 2.327E+00 | 1.163E+01 | 2.466E-01 | 1.597E-01 | 1.485E-01 | 1.326E-01 | 2.709E-05 | 2.086E-05 | 1.071E-04 | 1.865E-04 | 2.759E-04 |
| 1924.00 | 8.332E-01 | 1.032E+01 | 1.362E-01 | 1.656E-01 | 9.458E-02 | 1.490E-01 | 2.707E-05 | 2.229E-05 | 1.066E-04 | 2.901E-04 | 3.106E-04 |
| 1934.00 | 3.496E-01 | 9.785E+00 | 1.276E-01 | 1.816E-01 | 7.202E-02 | 1.681E-01 | 2.705E-05 | 2.226E-05 | 1.068E-04 | 4.589E-04 | 4.270E-04 |
| 1943.50 | 9.786E-01 | 9.281E+00 | 1.878E-01 | 1.989E-01 | 8.783E-02 | 1.833E-01 | 2.704E-05 | 2.189E-05 | 1.069E-04 | 6.350E-04 | 5.826E-04 |
| 1943.50 | 6.303E-08 | 9.281E+00 | 1.878E-01 | 2.233E-01 | 8.783E-02 | 1.833E-01 | 2.704E-05 | 2.189E-05 | 1.069E-04 | 7.124E-04 | 5.626E-04 |
| 1944.50 | 4.553E-02 | 9.333E+00 | 3.278E-01 | 1.216E-01 | 9.034E-02 | 1.841E-01 | 2.703E-05 | 2.186E-05 | 1.069E-04 | 3.993E-04 | 6.009E-04 |
| 1945.50 | 1.993E-02 | 9.386E+00 | 4.978E-01 | 3.901E-02 | 9.290E-02 | 1.849E-01 | 2.703E-05 | 2.183E-05 | 1.069E-04 | 1.326E-04 | 6.201E-04 |
| 1946.50 | 7.959E-03 | 9.440E+00 | 6.760E-01 | 1.173E-02 | 9.545E-02 | 1.857E-01 | 2.703E-05 | 2.182E-05 | 1.069E-04 | 4.172E-05 | 6.311E-04 |

## GROUP I BARO ALTIMETER MEASUREMENT NOISE

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1550.00 | 2.689E+00 | 3.663E-01 | 6.155E-01 | 8.318E-03 | 3.982E-03 | 2.111E-03 | 5.587E-08 | 1.476E-07 | 1.376E-07 | 8.339E-03 | 3.930E-03 |
| 1610.00 | 2.565E+00 | 3.520E-01 | 9.595E-01 | 9.333E-03 | 3.544E-03 | 4.522E-03 | 4.793E-08 | 2.885E-07 | 3.859E-07 | 9.390E-03 | 4.544E-03 |
| 1670.00 | 1.756E+00 | 2.675E-01 | 1.001E+00 | 7.274E-03 | 2.084E-03 | 6.675E-03 | 9.832E-08 | 4.482E-07 | 4.519E-07 | 7.307E-03 | 3.761E-03 |
| 1730.00 | 1.887E+00 | 2.512E-02 | 1.254E+00 | 7.600E-03 | 4.971E-04 | 7.378E-03 | 6.647E-08 | 3.577E-07 | 2.844E-07 | 7.624E-03 | 9.742E-04 |
| 1790.00 | 1.712E+00 | 1.477E-01 | 3.547E-01 | 8.307E-03 | 1.740E-03 | 1.441E-03 | 8.406E-08 | 1.723E-07 | 2.531E-07 | 8.317E-03 | 4.917E-04 |
| 1836.00 | 3.552E+00 | 2.818E-01 | 1.105E-01 | 1.488E-02 | 3.381E-03 | 4.158E-03 | 1.311E-07 | 9.057E-07 | 4.927E-07 | 1.489E-02 | 9.554E-03 |
| 1836.00 | 5.778E-02 | 2.758E-01 | 5.470E-02 | 6.013E-03 | 3.389E-03 | 3.914E-03 | 8.821E-08 | 1.942E-07 | 6.655E-07 | 6.031E-03 | 5.702E-04 |
| 1846.00 | 1.464E-01 | 3.181E-01 | 2.914E-02 | 5.971E-03 | 3.156E-03 | 2.988E-03 | 1.647E-07 | 1.793E-07 | 6.763E-07 | 5.955E-03 | 1.698E-03 |
| 1846.00 | 1.835E-02 | 3.725E-03 | 3.081E-03 | 4.093E-03 | 8.098E-04 | 6.803E-04 | 1.704E-07 | 3.148E-07 | 4.086E-07 | 4.096E-03 | 1.335E-03 |
| 1860.00 | 6.175E-03 | 5.674E-03 | 9.979E-04 | 8.068E-04 | 1.685E-04 | 9.248E-05 | 8.011E-08 | 2.931E-07 | 2.669E-07 | 8.070E-04 | 3.686E-04 |
| 1874.00 | 1.614E-03 | 3.075E-03 | 4.003E-04 | 3.523E-04 | 1.855E-04 | 1.345E-04 | 8.950E-08 | 3.483E-07 | 3.242E-07 | 3.519E-04 | 1.148E-04 |
| 1884.00 | 1.665E-03 | 2.888E-03 | 4.209E-04 | 4.199E-04 | 3.025E-04 | 2.801E-04 | 8.955E-08 | 3.483E-07 | 3.243E-07 | 4.196E-04 | 2.080E-04 |
| 1894.00 | 1.469E-03 | 2.691E-03 | 3.645E-04 | 4.692E-04 | 3.907E-04 | 4.111E-04 | 8.961E-08 | 3.482E-07 | 3.243E-07 | 4.690E-04 | 2.759E-04 |
| 1904.00 | 1.120E-03 | 2.477E-03 | 3.110E-04 | 5.156E-04 | 4.732E-04 | 5.507E-04 | 8.966E-08 | 3.481E-07 | 3.244E-07 | 5.155E-04 | 3.375E-04 |
| 1914.00 | 8.410E-04 | 2.215E-03 | 2.626E-04 | 5.693E-04 | 5.510E-04 | 6.976E-04 | 8.971E-08 | 3.481E-07 | 3.244E-07 | 5.695E-04 | 3.948E-04 |
| 1924.00 | 6.489E-04 | 1.859E-03 | 2.174E-04 | 6.317E-04 | 6.475E-04 | 8.775E-04 | 8.976E-08 | 3.480E-07 | 3.245E-07 | 6.322E-04 | 5.370E-04 |
| 1934.00 | 3.535E-04 | 1.692E-03 | 1.769E-04 | 7.238E-04 | 7.478E-04 | 1.077E-03 | 8.982E-08 | 3.479E-07 | 3.246E-07 | 7.245E-04 | 7.199E-04 |
| 1943.50 | 1.903E-04 | 1.522E-03 | 5.732E-04 | 8.196E-04 | 8.131E-04 | 1.238E-03 | 8.987E-08 | 3.479E-07 | 3.246E-07 | 8.206E-04 | 8.038E-04 |
| 1943.50 | 4.004E-06 | 1.522E-03 | 5.728E-04 | 8.385E-04 | 8.131E-04 | 1.238E-03 | 8.987E-08 | 3.479E-07 | 3.246E-07 | 8.396E-04 | 8.036E-04 |
| 1944.50 | 1.675E-04 | 1.777E-03 | 1.804E-03 | 4.553E-04 | 8.248E-04 | 1.249E-03 | 8.987E-08 | 3.479E-07 | 3.246E-07 | 4.563E-04 | 8.218E-04 |
| 1945.50 | 7.032E-05 | 2.321E-03 | 3.056E-03 | 1.443E-04 | 8.363E-04 | 1.260E-03 | 8.988E-08 | 3.479E-07 | 3.246E-07 | 1.453E-04 | 8.365E-04 |
| 1946.50 | 2.575E-05 | 3.009E-03 | 4.320E-03 | 4.165E-05 | 8.472E-04 | 1.271E-03 | 8.988E-08 | 3.479E-07 | 3.246E-07 | 4.254E-05 | 8.480E-04 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 2.884E-14 | 2.892E-14 |
| 1550.00 | 2.678E+00 | 5.647E-01 | 5.003E-01 | 8.246E-03 | 4.540E-03 | 9.494E-04 | 5.666E-08 | 1.023E-07 | 1.736E-07 | 2.494E-06 | 2.701E-07 |
| 1610.00 | 2.558E+00 | 8.951E-01 | 5.297E-01 | 9.288E-03 | 5.661E-03 | 1.338E-03 | 4.806E-08 | 3.164E-08 | 4.808E-07 | 4.111E-06 | 5.430E-07 |
| 1670.00 | 1.753E+00 | 7.003E-01 | 7.703E-01 | 7.255E-03 | 4.914E-03 | 5.002E-03 | 9.895E-08 | 1.933E-07 | 6.063E-07 | 5.028E-06 | 3.182E-06 |
| 1730.00 | 1.886E+00 | 6.490E-01 | 1.075E+00 | 7.594E-03 | 4.205E-03 | 6.089E-03 | 6.732E-08 | 1.565E-07 | 4.292E-07 | 8.253E-06 | 6.297E-06 |
| 1790.00 | 1.711E+00 | 6.469E-02 | 3.808E-01 | 8.314E-03 | 2.164E-03 | 5.460E-04 | 8.480E-08 | 2.696E-07 | 1.447E-07 | 1.155E-05 | 7.594E-07 |
| 1836.00 | 3.551E+00 | 2.069E-01 | 2.391E-01 | 1.489E-02 | 5.101E-03 | 1.564E-03 | 1.360E-07 | 1.707E-07 | 1.016E-06 | 2.030E-05 | 2.682E-06 |
| 1836.00 | 5.896E-02 | 1.533E-01 | 2.355E-01 | 6.035E-03 | 2.419E-03 | 4.549E-03 | 8.839E-08 | 6.885E-07 | 8.151E-08 | 1.050E-05 | 7.763E-06 |
| 1846.00 | 1.477E-01 | 2.264E-01 | 2.245E-01 | 5.991E-03 | 4.660E-04 | 4.294E-03 | 1.660E-07 | 5.291E-07 | 4.574E-07 | 9.655E-06 | 7.606E-06 |
| 1846.00 | 1.837E-02 | 6.374E-04 | 4.707E-03 | 4.098E-03 | 3.089E-04 | 9.931E-04 | 1.722E-07 | 2.293E-07 | 4.613E-07 | 6.517E-06 | 1.760E-06 |
| 1860.00 | 6.196E-03 | 5.450E-03 | 1.794E-03 | 8.071E-04 | 1.581E-04 | 1.069E-04 | 8.109E-08 | 2.499E-07 | 3.250E-07 | 1.278E-06 | 2.006E-07 |
| 1874.00 | 1.603E-03 | 3.046E-03 | 6.107E-04 | 3.520E-04 | 1.910E-04 | 1.275E-04 | 9.056E-08 | 3.353E-07 | 3.374E-07 | 6.537E-07 | 2.415E-07 |
| 1884.00 | 1.855E-03 | 2.897E-03 | 4.051E-04 | 4.196E-04 | 2.997E-04 | 2.834E-04 | 9.056E-08 | 3.514E-07 | 3.206E-07 | 8.129E-07 | 5.349E-07 |
| 1894.00 | 1.460E-03 | 2.696E-03 | 3.633E-04 | 4.691E-04 | 3.807E-04 | 4.205E-04 | 9.055E-08 | 3.545E-07 | 3.171E-07 | 9.543E-07 | 8.188E-07 |
| 1904.00 | 1.114E-03 | 2.481E-03 | 3.046E-04 | 5.156E-04 | 4.664E-04 | 5.564E-04 | 9.055E-08 | 3.516E-07 | 3.204E-07 | 1.117E-06 | 1.121E-06 |
| 1914.00 | 8.357E-04 | 2.217E-03 | 2.607E-04 | 5.695E-04 | 5.507E-04 | 6.976E-04 | 9.055E-08 | 3.484E-07 | 3.236E-07 | 1.304E-06 | 1.451E-06 |
| 1924.00 | 6.449E-04 | 1.860E-03 | 2.211E-04 | 6.322E-04 | 6.510E-04 | 8.745E-04 | 9.055E-08 | 3.471E-07 | 3.253E-07 | 1.474E-06 | 1.824E-06 |
| 1934.00 | 3.505E-04 | 1.693E-03 | 1.798E-04 | 7.245E-04 | 7.516E-04 | 1.074E-03 | 9.056E-08 | 3.471E-07 | 3.253E-07 | 1.916E-06 | 2.727E-06 |
| 1943.50 | 1.931E-04 | 1.521E-03 | 5.740E-04 | 8.206E-04 | 8.157E-04 | 1.236E-03 | 9.057E-08 | 3.474E-07 | 3.249E-07 | 2.644E-06 | 3.928E-06 |
| 1943.50 | 6.729E-12 | 1.521E-03 | 5.740E-04 | 8.396E-04 | 8.157E-04 | 1.236E-03 | 9.057E-08 | 3.474E-07 | 3.249E-07 | 2.705E-06 | 3.928E-06 |
| 1944.50 | 1.710E-04 | 1.777E-03 | 1.804E-03 | 4.563E-04 | 8.267E-04 | 1.247E-03 | 9.058E-08 | 3.474E-07 | 3.249E-07 | 1.516E-06 | 4.071E-06 |
| 1945.50 | 7.451E-05 | 2.321E-03 | 3.055E-03 | 1.453E-04 | 8.376E-04 | 1.259E-03 | 9.058E-08 | 3.475E-07 | 3.248E-07 | 5.078E-07 | 4.221E-06 |
| 1946.50 | 2.947E-05 | 3.011E-03 | 4.319E-03 | 4.252E-05 | 8.483E-04 | 1.270E-03 | 9.058E-08 | 3.475E-07 | 3.248E-07 | 1.652E-07 | 4.315E-06 |

## GROUP 1 RADAR ALTIMETER MEASUREMENT NOISE

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1860.00 | | | | | | | | | | | |
| 1874.00 | | | | | | | | | | | |
| 1884.00 | | | | | | | | | | | |
| 1894.00 | | | | | | | | | | | |
| 1904.00 | | | | | | | | | | | |
| 1914.00 | | | | | | | | | | | |
| 1924.00 | | | | | | | | | | | |
| 1934.00 | | | | | | | | | | | |
| 1943.50 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1943.50 | 1.000E+00 | 2.315E-03 | 2.159E-03 | 1.000E-01 | 2.731E-04 | 1.726E-04 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-01 | 2.166E-03 |
| 1944.50 | 4.184E-01 | 9.564E-04 | 9.135E-04 | 5.127E-01 | 1.158E-03 | 1.136E-03 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 5.127E-01 | 7.953E-03 |
| 1945.50 | 4.221E-01 | 9.558E-04 | 9.272E-04 | 3.513E-01 | 7.776E-04 | 7.916E-04 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.513E-01 | 3.660E-03 |
| 1946.50 | 4.436E-01 | 1.001E-03 | 9.750E-04 | 3.088E-01 | 6.802E-04 | 6.940E-04 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.088E-01 | 2.912E-03 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1860.00 | | | | | | | | | | | |
| 1874.00 | | | | | | | | | | | |
| 1884.00 | | | | | | | | | | | |
| 1894.00 | | | | | | | | | | | |
| 1904.00 | | | | | | | | | | | |
| 1914.00 | | | | | | | | | | | |
| 1924.00 | | | | | | | | | | | |
| 1934.00 | | | | | | | | | | | |
| 1943.50 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.177E-13 | 3.178E-13 |
| 1943.50 | 1.000E+00 | 1.345E-05 | 2.154E-05 | 1.000E-01 | 4.307E-05 | 4.537E-05 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.177E-04 | 1.442E-07 |
| 1944.50 | 4.184E-01 | 8.487E-06 | 1.347E-05 | 5.127E-01 | 1.972E-05 | 2.265E-05 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.673E-03 | 7.393E-08 |
| 1945.50 | 4.221E-01 | 2.506E-05 | 3.960E-05 | 3.513E-01 | 2.701E-05 | 3.585E-05 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.178E-03 | 1.202E-07 |
| 1946.50 | 4.436E-01 | 4.649E-05 | 7.327E-05 | 3.088E-01 | 2.760E-05 | 3.798E-05 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.049E-03 | 1.291E-07 |

GROUP 1 5 PERCENT MEASUREMENT NOISE

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 9.979E+02 | 4.748E+02 | 1.020E+03 | 2.977E+00 | 3.673E-01 | 8.177E-01 | 1.944E-06 | 1.946E-05 | 6.009E-06 | 2.696E+00 | 3.650E-01 |
| 1432.00 | 9.433E+02 | 3.467E+01 | 1.332E+02 | 2.391E+00 | 1.460E-01 | 5.439E-01 | 7.458E-06 | 3.439E-05 | 5.530E-06 | 2.375E+00 | 3.435E-01 |
| 1490.00 | 7.313E+02 | 1.866E+02 | 7.472E+01 | 1.863E+00 | 5.291E-01 | 3.773E-01 | 9.796E-06 | 2.958E-05 | 9.489E-06 | 1.871E+00 | 5.449E-01 |
| 1550.00 | 5.004E+02 | 7.006E+01 | 1.115E+02 | 1.429E+00 | 8.165E-01 | 3.305E-01 | 1.124E-05 | 3.672E-05 | 2.325E-05 | 1.434E+00 | 7.307E-01 |
| 1550.00 | 2.304E+02 | 3.231E+01 | 5.504E+01 | 6.532E-01 | 4.265E-01 | 3.154E-01 | 9.704E-06 | 2.431E-05 | 1.050E-05 | 6.546E-01 | 3.423E-01 |
| 1610.00 | 7.850E+01 | 1.017E+01 | 3.822E+01 | 3.005E-01 | 1.102E-01 | 2.534E-01 | 1.785E-05 | 3.066E-05 | 1.119E-05 | 3.011E-01 | 9.254E-02 |
| 1670.00 | 1.831E+01 | 1.234E+01 | 1.058E+01 | 2.548E-01 | 5.624E-02 | 2.778E-01 | 1.880E-05 | 3.310E-05 | 1.396E-05 | 2.547E-01 | 7.414E-02 |
| 1730.00 | 1.160E+01 | 8.095E+00 | 9.481E+00 | 2.237E-01 | 6.005E-02 | 2.508E-01 | 1.841E-05 | 3.847E-05 | 1.783E-05 | 2.237E-01 | 5.763E-02 |
| 1790.00 | 9.695E+00 | 7.582E+00 | 5.193E+00 | 1.605E-01 | 5.911E-02 | 2.399E-01 | 1.776E-05 | 4.254E-05 | 2.294E-05 | 1.606E-01 | 9.917E-02 |
| 1836.00 | 1.046E+01 | 5.645E+00 | 7.450E+00 | 1.245E-01 | 6.275E-02 | 2.124E-01 | 1.722E-05 | 4.973E-05 | 2.774E-05 | 1.247E-01 | 1.766E-01 |
| 1836.00 | 1.347E+00 | 2.967E+00 | 5.653E-01 | 1.230E-01 | 5.637E-02 | 1.309E-01 | 1.704E-05 | 5.636E-05 | 2.803E-05 | 1.232E-01 | 8.354E-02 |
| 1846.00 | 1.252E+00 | 3.667E+00 | 4.704E-01 | 5.491E-02 | 6.445E-02 | 6.917E-02 | 1.801E-05 | 6.621E-05 | 2.816E-05 | 5.505E-02 | 5.647E-02 |
| 1846.00 | 6.009E-02 | 1.163E-01 | 1.059E-01 | 4.497E-02 | 4.929E-02 | 4.823E-02 | 1.832E-05 | 6.954E-05 | 2.946E-05 | 4.511E-02 | 5.042E-02 |
| 1860.00 | 7.996E-02 | 1.567E-01 | 4.701E-02 | 1.783E-02 | 3.010E-02 | 3.273E-02 | 2.007E-05 | 7.913E-05 | 3.599E-05 | 1.795E-02 | 3.029E-02 |
| 1874.00 | 1.346E-01 | 1.685E-01 | 6.425E-02 | 2.071E-02 | 2.128E-02 | 4.374E-02 | 2.025E-05 | 8.797E-05 | 4.052E-05 | 2.082E-02 | 2.136E-02 |
| 1884.00 | 1.365E-01 | 1.963E-01 | 9.405E-02 | 3.282E-02 | 3.463E-02 | 8.140E-02 | 2.028E-05 | 8.796E-05 | 4.052E-05 | 3.302E-02 | 3.715E-02 |
| 1894.00 | 1.195E-01 | 2.049E-01 | 8.019E-02 | 3.827E-02 | 4.519E-02 | 1.145E-01 | 2.031E-05 | 8.796E-05 | 4.052E-05 | 3.854E-02 | 4.907E-02 |
| 1904.00 | 1.009E-01 | 2.165E-01 | 6.726E-02 | 4.159E-02 | 5.553E-02 | 1.494E-01 | 2.034E-05 | 8.795E-05 | 4.052E-05 | 4.194E-02 | 5.759E-02 |
| 1914.00 | 7.692E-02 | 2.318E-01 | 5.594E-02 | 4.570E-02 | 6.571E-02 | 1.859E-01 | 2.036E-05 | 8.795E-05 | 4.052E-05 | 4.612E-02 | 6.510E-02 |
| 1924.00 | 4.087E-02 | 2.547E-01 | 4.568E-02 | 5.150E-02 | 7.858E-02 | 2.305E-01 | 2.039E-05 | 8.794E-05 | 4.052E-05 | 5.203E-02 | 7.776E-02 |
| 1934.00 | 2.191E-02 | 2.725E-01 | 3.702E-02 | 6.019E-02 | 9.268E-02 | 2.795E-01 | 2.042E-05 | 8.793E-05 | 4.052E-05 | 6.079E-02 | 9.216E-02 |
| 1943.50 | 2.037E-02 | 2.826E-01 | 1.310E-01 | 6.973E-02 | 1.028E-01 | 3.188E-01 | 2.045E-05 | 8.793E-05 | 4.052E-05 | 7.040E-02 | 1.025E-01 |
| 1943.50 | 4.259E-04 | 2.827E-01 | 1.310E-01 | 7.167E-02 | 1.028E-01 | 3.188E-01 | 2.045E-05 | 8.793E-05 | 4.052E-05 | 7.234E-02 | 1.025E-01 |
| 1944.50 | 1.440E-02 | 2.963E-01 | 4.507E-01 | 3.860E-02 | 1.041E-01 | 3.216E-01 | 2.045E-05 | 8.793E-05 | 4.052E-05 | 3.927E-02 | 1.038E-01 |
| 1945.50 | 5.493E-03 | 3.433E-01 | 7.736E-01 | 1.179E-02 | 1.054E-01 | 3.245E-01 | 2.045E-05 | 8.793E-05 | 4.052E-05 | 1.245E-02 | 1.051E-01 |
| 1946.50 | 1.764E-03 | 4.134E-01 | 1.099E+00 | 3.005E-03 | 1.066E-01 | 3.272E-01 | 2.045E-05 | 8.793E-05 | 4.052E-05 | 3.602E-03 | 1.064E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.038E+03 | 1.000E+03 | 4.311E+02 | 2.965E+00 | 4.627E-01 | 8.133E-01 | 2.191E-06 | 1.623E-05 | 1.226E-05 | 4.427E-04 | 1.449E-04 |
| 1432.00 | 9.447E+02 | 4.385E+01 | 1.201E+02 | 2.379E+00 | 4.195E-01 | 4.454E-01 | 8.622E-06 | 2.693E-05 | 2.167E-05 | 3.900E-04 | 7.464E-05 |
| 1490.00 | 7.276E+02 | 1.122E+02 | 1.822E+02 | 1.846E+00 | 6.486E-01 | 2.565E-01 | 1.026E-05 | 1.605E-05 | 2.642E-05 | 4.019E-04 | 4.915E-05 |
| 1550.00 | 4.985E+02 | 1.046E+02 | 9.120E+01 | 1.417E+00 | 8.323E-01 | 3.425E-01 | 1.130E-05 | 2.947E-05 | 3.192E-05 | 4.295E-04 | 9.887E-05 |
| 1550.00 | 2.296E+02 | 4.707E+01 | 4.751E+01 | 6.485E-01 | 3.826E-01 | 3.757E-01 | 9.603E-06 | 2.140E-05 | 1.566E-05 | 1.952E-04 | 1.086E-04 |
| 1610.00 | 7.829E+01 | 2.422E+01 | 3.178E+01 | 2.997E-01 | 1.205E-01 | 2.497E-01 | 1.773E-05 | 2.365E-05 | 2.257E-05 | 1.280E-04 | 1.039E-04 |
| 1670.00 | 1.828E+01 | 1.211E+01 | 1.089E+01 | 2.543E-01 | 1.026E-01 | 2.648E-01 | 1.878E-05 | 2.990E-05 | 1.992E-05 | 1.668E-04 | 1.692E-04 |
| 1730.00 | 1.159E+01 | 8.471E+00 | 9.161E+00 | 2.235E-01 | 1.105E-01 | 2.332E-01 | 1.846E-05 | 3.293E-05 | 2.667E-05 | 2.315E-04 | 2.415E-04 |
| 1790.00 | 9.664E+00 | 8.332E+00 | 3.955E+00 | 1.605E-01 | 1.232E-01 | 2.142E-01 | 1.786E-05 | 3.715E-05 | 3.086E-05 | 2.376E-04 | 2.993E-04 |
| 1836.00 | 1.043E+01 | 5.818E+00 | 7.365E+00 | 1.246E-01 | 2.040E-01 | 8.606E-02 | 1.735E-05 | 3.341E-05 | 4.607E-05 | 2.618E-04 | 1.474E-04 |
| 1836.00 | 1.360E+00 | 1.620E+00 | 2.537E+00 | 1.232E-01 | 1.186E-01 | 7.870E-02 | 1.719E-05 | 3.421E-05 | 5.279E-05 | 2.422E-04 | 1.347E-04 |
| 1846.00 | 1.268E+00 | 2.658E+00 | 2.562E+00 | 5.502E-02 | 6.153E-02 | 7.169E-02 | 1.821E-05 | 4.912E-05 | 5.251E-05 | 1.010E-04 | 1.270E-04 |
| 1846.00 | 6.006E-02 | 1.001E-01 | 1.214E-01 | 4.510E-02 | 5.101E-02 | 4.628E-02 | 1.854E-05 | 5.211E-05 | 5.459E-05 | 7.673E-05 | 8.203E-05 |
| 1860.00 | 8.045E-02 | 1.498E-01 | 6.518E-02 | 1.795E-02 | 3.043E-02 | 3.236E-02 | 2.032E-05 | 7.282E-05 | 4.738E-05 | 3.163E-05 | 6.072E-05 |
| 1874.00 | 1.353E-01 | 1.598E-01 | 8.253E-02 | 2.082E-02 | 2.153E-02 | 4.357E-02 | 2.051E-05 | 8.747E-05 | 4.146E-05 | 3.581E-05 | 8.253E-05 |
| 1884.00 | 1.372E-01 | 1.987E-01 | 8.774E-02 | 3.302E-02 | 3.478E-02 | 8.125E-02 | 2.052E-05 | 8.784E-05 | 4.068E-05 | 5.225E-05 | 1.534E-04 |
| 1894.00 | 1.203E-01 | 2.089E-01 | 6.758E-02 | 3.854E-02 | 4.625E-02 | 1.140E-01 | 2.053E-05 | 8.769E-05 | 4.099E-05 | 6.195E-05 | 2.219E-04 |
| 1904.00 | 1.016E-01 | 2.183E-01 | 5.983E-02 | 4.193E-02 | 5.644E-02 | 1.489E-01 | 2.054E-05 | 8.782E-05 | 4.069E-05 | 7.416E-05 | 3.001E-04 |
| 1914.00 | 7.764E-02 | 2.318E-01 | 5.472E-02 | 4.612E-02 | 6.587E-02 | 1.857E-01 | 2.056E-05 | 8.790E-05 | 4.053E-05 | 8.962E-05 | 3.664E-04 |
| 1924.00 | 4.156E-02 | 2.542E-01 | 4.744E-02 | 5.202E-02 | 7.818E-02 | 2.305E-01 | 2.057E-05 | 8.790E-05 | 4.051E-05 | 1.061E-04 | 4.609E-04 |
| 1934.00 | 2.259E-02 | 2.722E-01 | 3.878E-02 | 6.079E-02 | 9.217E-02 | 2.795E-01 | 2.058E-05 | 8.790E-05 | 4.051E-05 | 1.541E-04 | 7.100E-04 |
| 1943.50 | 2.008E-02 | 2.830E-01 | 1.302E-01 | 7.039E-02 | 1.025E-01 | 3.188E-01 | 2.060E-05 | 8.789E-05 | 4.052E-05 | 2.237E-04 | 1.013E-03 |
| 1943.50 | 7.277E-10 | 2.830E-01 | 1.302E-01 | 7.234E-02 | 1.025E-01 | 3.188E-01 | 2.060E-05 | 8.789E-05 | 4.052E-05 | 2.298E-04 | 1.013E-03 |
| 1944.50 | 1.472E-02 | 2.973E-01 | 4.501E-01 | 3.927E-02 | 1.038E-01 | 3.217E-01 | 2.060E-05 | 8.789E-05 | 4.052E-05 | 1.282E-04 | 1.050E-03 |
| 1945.50 | 6.396E-03 | 3.440E-01 | 7.731E-01 | 1.245E-02 | 1.051E-01 | 3.245E-01 | 2.060E-05 | 8.789E-05 | 4.052E-05 | 4.199E-05 | 1.088E-03 |
| 1946.50 | 2.521E-03 | 4.144E-01 | 1.099E+00 | 3.598E-03 | 1.064E-01 | 3.273E-01 | 2.060E-05 | 8.789E-05 | 4.052E-05 | 1.306E-05 | 1.112E-03 |

GROUP 1 QUANTIZATION ERROR

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.674E+02 | 1.579E+02 | 1.813E+02 | 1.918E-01 | 1.785E-01 | 2.470E-01 | 2.584E-07 | 2.657E-06 | 4.393E-07 | 2.143E-01 | 2.344E-01 |
| 1432.00 | 1.704E+02 | 7.522E+01 | 6.846E+01 | 2.290E-01 | 1.444E-01 | 2.550E-01 | 4.391E-06 | 4.595E-06 | 1.784E-06 | 2.406E-01 | 2.195E-01 |
| 1490.00 | 1.214E+02 | 4.424E+01 | 4.591E+01 | 2.042E-01 | 2.162E-01 | 2.316E-01 | 7.824E-06 | 5.913E-06 | 5.616E-06 | 2.052E-01 | 1.188E-01 |
| 1550.00 | 7.348E+01 | 1.620E+01 | 1.957E+01 | 1.404E-01 | 2.071E-01 | 2.086E-01 | 9.539E-06 | 7.889E-06 | 6.572E-06 | 1.408E-01 | 1.510E-01 |
| 1550.00 | 3.388E+01 | 1.154E+01 | 1.468E+01 | 1.209E-01 | 1.626E-01 | 2.181E-01 | 9.613E-06 | 9.223E-06 | 5.682E-06 | 1.202E-01 | 1.030E-01 |
| 1610.00 | 2.341E+01 | 9.225E+00 | 7.503E+00 | 1.285E-01 | 9.320E-02 | 1.533E-01 | 1.337E-05 | 1.115E-05 | 5.354E-06 | 1.280E-01 | 8.815E-02 |
| 1670.00 | 2.513E+01 | 9.692E+00 | 1.222E+01 | 1.227E-01 | 7.631E-02 | 1.473E-01 | 1.380E-05 | 1.143E-05 | 6.538E-06 | 1.225E-01 | 9.433E-02 |
| 1730.00 | 7.103E+00 | 4.896E+00 | 6.129E+00 | 1.435E-01 | 6.599E-02 | 1.030E-01 | 1.408E-05 | 1.706E-05 | 1.135E-05 | 1.434E-01 | 7.552E-02 |
| 1790.00 | 8.409E+00 | 5.959E+00 | 3.122E+00 | 1.290E-01 | 6.725E-02 | 9.341E-02 | 1.370E-05 | 1.748E-05 | 1.431E-05 | 1.288E-01 | 9.289E-02 |
| 1836.00 | 9.876E+00 | 5.893E+00 | 3.200E+00 | 1.702E-01 | 6.837E-02 | 9.556E-02 | 1.343E-05 | 1.895E-05 | 1.796E-05 | 1.200E-01 | 9.545E-02 |
| 1836.00 | 1.688E+00 | 3.805E+00 | 6.838E-01 | 9.722E-02 | 6.632E-02 | 6.086E-02 | 1.341E-05 | 2.333E-05 | 1.826E-05 | 9.715E-02 | 5.077E-02 |
| 1846.00 | 1.670E+00 | 4.961E+00 | 5.335E-01 | 4.956E-02 | 7.778E-02 | 4.513E-02 | 1.452E-05 | 2.635E-05 | 1.795E-05 | 4.949E-02 | 4.806E-02 |
| 1846.00 | 4.866E-02 | 1.575E-01 | 6.055E-02 | 4.521E-02 | 5.216E-02 | 2.745E-02 | 1.532E-05 | 2.987E-05 | 2.041E-05 | 4.522E-02 | 4.471E-02 |
| 1860.00 | 1.086E-01 | 1.784E-01 | 6.292E-02 | 2.176E-02 | 3.298E-02 | 2.386E-02 | 1.730E-05 | 3.566E-05 | 2.506E-05 | 2.178E-02 | 3.120E-02 |
| 1874.50 | 1.305E-01 | 1.164E-01 | 6.143E-02 | 2.669E-02 | 2.846E-02 | 3.177E-02 | 1.717E-05 | 3.959E-05 | 2.891E-05 | 2.670E-02 | 2.747E-02 |
| 1884.00 | 1.197E-01 | 1.303E-01 | 6.704E-02 | 3.744E-02 | 3.978E-02 | 5.073E-02 | 1.718E-05 | 3.959E-05 | 2.890E-05 | 3.747E-02 | 3.922E-02 |
| 1894.00 | 1.013E-01 | 1.339E-01 | 5.819E-02 | 4.610E-02 | 4.877E-02 | 6.724E-02 | 1.719E-05 | 3.959E-05 | 2.890E-05 | 4.613E-02 | 4.803E-02 |
| 1904.00 | 8.246E-02 | 1.397E-01 | 4.990E-02 | 5.415E-02 | 5.706E-02 | 8.410E-02 | 1.721E-05 | 3.958E-05 | 2.890E-05 | 5.417E-02 | 5.502E-02 |
| 1914.00 | 6.185E-02 | 1.498E-01 | 4.230E-02 | 6.226E-02 | 6.494E-02 | 1.014E-01 | 1.722E-05 | 3.958E-05 | 2.889E-05 | 6.229E-02 | 6.105E-02 |
| 1924.00 | 3.604E-02 | 1.711E-01 | 3.513E-02 | 7.065E-02 | 7.411E-02 | 1.219E-01 | 1.724E-05 | 3.958E-05 | 2.889E-05 | 7.068E-02 | 7.043E-02 |
| 1934.00 | 1.948E-02 | 1.885E-01 | 2.877E-02 | 7.987E-02 | 8.390E-02 | 1.438E-01 | 1.725E-05 | 3.957E-05 | 2.888E-05 | 7.991E-02 | 8.250E-02 |
| 1943.50 | 2.851E-02 | 2.220E-01 | 6.707E-02 | 8.902E-02 | 9.124E-02 | 1.616E-01 | 1.726E-05 | 3.957E-05 | 2.888E-05 | 8.906E-02 | 9.064E-02 |
| 1943.50 | 4.871E-04 | 2.220E-01 | 6.705E-02 | 9.176E-02 | 9.124E-02 | 1.616E-01 | 1.726E-05 | 3.957E-05 | 2.886E-05 | 9.181E-02 | 9.064E-02 |
| 1944.50 | 1.900E-02 | 2.752E-01 | 2.274E-01 | 5.001E-02 | 9.230E-02 | 1.629E-01 | 1.727E-05 | 3.957E-05 | 2.888E-05 | 5.006E-02 | 9.199E-02 |
| 1945.50 | 8.555E-03 | 3.457E-01 | 3.905E-01 | 1.670E-02 | 9.335E-02 | 1.641E-01 | 1.727E-05 | 3.957E-05 | 2.886E-05 | 1.673E-02 | 9.319E-02 |
| 1946.50 | 4.258E-03 | 4.257E-01 | 5.549E-01 | 7.597E-03 | 9.436E-02 | 1.653E-01 | 1.727E-05 | 3.957E-05 | 2.888E-05 | 7.604E-03 | 9.424E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.646E+02 | 1.762E+02 | 1.663E+02 | 1.966E-01 | 2.307E-01 | 1.945E-01 | 1.636E-07 | 2.238E-06 | 1.511E-06 | 3.441E-05 | 3.075E-05 |
| 1432.00 | 1.693E+02 | 4.366E+01 | 9.382E+01 | 2.315E-01 | 2.171E-01 | 1.939E-01 | 4.311E-06 | 4.245E-06 | 2.642E-06 | 3.894E-05 | 3.188E-05 |
| 1490.00 | 1.208E+02 | 1.999E+01 | 6.177E+01 | 2.020E-01 | 1.232E-01 | 2.934E-01 | 7.714E-06 | 7.153E-06 | 4.129E-06 | 4.389E-05 | 6.090E-05 |
| 1550.00 | 7.320E+01 | 1.765E+01 | 1.938E+01 | 1.393E-01 | 1.574E-01 | 2.490E-01 | 9.471E-06 | 7.605E-06 | 6.991E-06 | 4.263E-05 | 7.171E-05 |
| 1550.00 | 3.375E+01 | 9.637E+00 | 1.626E+01 | 1.208E-01 | 1.072E-01 | 2.521E-01 | 9.550E-06 | 8.680E-06 | 6.574E-06 | 3.453E-05 | 7.264E-05 |
| 1610.00 | 2.334E+01 | 9.405E+00 | 7.506E+00 | 1.282E-01 | 9.145E-02 | 1.545E-01 | 1.334E-05 | 8.162E-06 | 9.344E-06 | 5.365E-05 | 6.404E-05 |
| 1670.00 | 2.509E+01 | 1.405E+01 | 6.915E+00 | 1.225E-01 | 9.762E-02 | 1.342E-01 | 1.379E-05 | 9.955E-06 | 8.634E-06 | 7.896E-05 | 8.569E-05 |
| 1730.00 | 7.098E+00 | 5.205E+00 | 5.675E+00 | 1.434E-01 | 6.337E-02 | 1.047E-01 | 1.410E-05 | 1.256E-05 | 1.617E-05 | 1.309E-04 | 1.084E-04 |
| 1790.00 | 8.386E+00 | 4.540E+00 | 5.003E+00 | 1.289E-01 | 7.836E-02 | 8.452E-02 | 1.375E-05 | 1.436E-05 | 1.740E-05 | 1.599E-04 | 1.181E-04 |
| 1836.00 | 9.848E+00 | 3.294E+00 | 5.889E+00 | 1.200E-01 | 8.928E-02 | 7.668E-02 | 1.348E-05 | 1.989E-05 | 1.687E-05 | 1.869E-04 | 1.312E-04 |
| 1836.00 | 1.705E+00 | 2.047E+00 | 3.270E+00 | 9.711E-02 | 5.976E-02 | 6.944E-02 | 1.347E-05 | 2.100E-05 | 2.085E-05 | 1.658E-04 | 1.188E-04 |
| 1846.00 | 1.692E+00 | 3.581E+00 | 3.464E+00 | 4.943E-02 | 4.721E-02 | 7.661E-02 | 1.460E-05 | 2.374E-05 | 2.123E-05 | 8.163E-05 | 1.357E-04 |
| 1846.00 | 4.834E-02 | 8.310E-02 | 1.470E-01 | 4.521E-02 | 4.292E-02 | 4.040E-02 | 1.541E-05 | 2.830E-05 | 2.247E-05 | 7.286E-05 | 7.162E-05 |
| 1860.00 | 1.091E-01 | 1.685E-01 | 8.522E-02 | 2.178E-02 | 3.104E-02 | 2.631E-02 | 1.741E-05 | 3.610E-05 | 2.435E-05 | 3.750E-05 | 4.938E-05 |
| 1874.00 | 1.307E-01 | 1.145E-01 | 6.458E-02 | 2.670E-02 | 2.813E-02 | 3.206E-02 | 1.727E-05 | 4.012E-05 | 2.811E-05 | 4.665E-05 | 6.073E-05 |
| 1884.00 | 1.199E-01 | 1.309E-01 | 6.545E-02 | 3.747E-02 | 3.997E-02 | 5.057E-02 | 1.728E-05 | 3.933E-05 | 2.920E-05 | 6.591E-05 | 9.546E-05 |
| 1894.00 | 1.015E-01 | 1.349E-01 | 5.555E-02 | 4.613E-02 | 4.942E-02 | 6.674E-02 | 1.729E-05 | 3.910E-05 | 2.950E-05 | 8.449E-05 | 1.300E-04 |
| 1904.00 | 8.271E-02 | 1.401E-01 | 4.853E-02 | 5.417E-02 | 5.762E-02 | 8.370E-02 | 1.729E-05 | 3.931E-05 | 2.922E-05 | 1.044E-04 | 1.686E-04 |
| 1914.00 | 6.212E-02 | 1.498E-01 | 4.214E-02 | 6.229E-02 | 6.507E-02 | 1.013E-01 | 1.730E-05 | 3.951E-05 | 2.894E-05 | 1.258E-04 | 2.108E-04 |
| 1924.00 | 3.630E-02 | 1.710E-01 | 3.548E-02 | 7.068E-02 | 7.394E-02 | 1.220E-01 | 1.731E-05 | 3.959E-05 | 2.883E-05 | 1.495E-04 | 2.546E-04 |
| 1934.00 | 1.971E-02 | 1.884E-01 | 2.906E-02 | 7.991E-02 | 8.369E-02 | 1.439E-01 | 1.732E-05 | 3.958E-05 | 2.883E-05 | 2.057E-04 | 3.654E-04 |
| 1943.50 | 2.826E-02 | 2.221E-01 | 6.684E-02 | 8.906E-02 | 9.115E-02 | 1.617E-01 | 1.732E-05 | 3.956E-05 | 2.886E-05 | 2.846E-04 | 5.138E-04 |
| 1943.50 | 1.026E-09 | 2.221E-01 | 6.684E-02 | 9.180E-02 | 9.115E-02 | 1.617E-01 | 1.732E-05 | 3.956E-05 | 2.886E-05 | 2.933E-04 | 5.138E-04 |
| 1944.50 | 1.870E-02 | 2.753E-01 | 2.273E-01 | 5.005E-02 | 9.220E-02 | 1.629E-01 | 1.733E-05 | 3.956E-05 | 2.886E-05 | 1.646E-04 | 5.317E-04 |
| 1945.50 | 8.244E-03 | 3.458E-01 | 3.904E-01 | 1.673E-02 | 9.324E-02 | 1.641E-01 | 1.733E-05 | 3.956E-05 | 2.886E-05 | 5.702E-05 | 5.504E-04 |
| 1946.50 | 3.785E-03 | 4.256E-01 | 5.549E-01 | 7.602E-03 | 9.426E-02 | 1.654E-01 | 1.733E-05 | 3.955E-05 | 2.886E-05 | 2.655E-05 | 5.620E-04 |

GROUP 2 ACCELEROMETER BIAS

| TIME | POSITION ESTIMATE ERROR | | | VELOCITY ESTIMATE ERROR | | | PLATFORM TILT ESTIMATE | | | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | R | D | C | R | D | C | R | D | C | | |
| 1432.00 | 5.558E+02 | 2.231E+03 | 4.443F+03 | 3.754E+00 | 1.792E+00 | 3.431E+00 | 9.161F-07 | 1.275E-05 | 1.680E-06 | 2.507E+00 | 2.259E+00 |
| 1432.00 | 5.471E+02 | 6.233E+02 | 9.894E+02 | 1.737E+00 | 6.503E-01 | 2.646F+00 | 4.141E-05 | 6.552E-05 | 1.571E-05 | 1.566E+00 | 1.931E+00 |
| 1490.00 | 4.028E+02 | 1.681E+02 | 3.215F+02 | 1.082E+00 | 1.300E+00 | 2.185E+00 | 7.155E-05 | 7.576E-05 | 4.372E-05 | 1.087E+00 | 1.081E+00 |
| 1550.00 | 3.615E+02 | 4.620E+01 | 1.875E+02 | 7.579E-01 | 1.080F+00 | 1.725E+00 | 8.714E-05 | 8.827E-05 | 4.167E-05 | 7.583E-01 | 6.378E-01 |
| 1550.00 | 1.686E+02 | 5.372E+01 | 1.399E+02 | 2.584E-01 | 1.066E+00 | 1.650E+00 | 8.479E-05 | 9.804E-05 | 3.695E-05 | 2.591E-01 | 5.710E-01 |
| 1610.00 | 1.752F+02 | 4.560E+01 | 7.838E+01 | 1.323E-01 | 4.378E-01 | 1.134E+00 | 1.062E-04 | 1.099E-04 | 2.955E-05 | 1.290E-01 | 5.240E-01 |
| 1670.00 | 1.861F+02 | 6.410E+01 | 9.858E+01 | 2.271E-01 | 2.305F-01 | 1.139E+00 | 1.074F-04 | 1.086E-04 | 2.923E-05 | 2.286E-01 | 5.071E-01 |
| 1730.00 | 3.196E+01 | 3.477E+01 | 2.981E+01 | 4.085E-01 | 2.175E-01 | 6.030E-01 | 1.084E-04 | 1.575E-04 | 5.183E-05 | 4.075E-01 | 3.779E-01 |
| 1790.00 | 5.497E+01 | 4.168E+01 | 6.026E+00 | 4.955E-01 | 2.281E-01 | 7.734E-01 | 9.978E-05 | 1.663E-04 | 7.072E-05 | 4.942E-01 | 5.702E-01 |
| 1836.00 | 6.576E+01 | 3.767E+01 | 2.635E+01 | 5.553E-01 | 2.579F-01 | 9.185E-01 | 9.213F-05 | 1.815E-04 | 9.442E-05 | 5.541E-01 | 9.556E-01 |
| 1836.00 | 9.222E+00 | 2.026E+01 | 3.928E+00 | 3.875E-01 | 2.785E-01 | 4.746E-01 | 9.166E-05 | 2.261E-04 | 9.589E-05 | 3.874E-01 | 4.576E-01 |
| 1846.00 | 8.401E+00 | 2.438E+01 | 1.821E+00 | 2.653E-01 | 3.175E-01 | 4.074E-01 | 1.046E-04 | 2.600E-04 | 9.641E-05 | 2.653E-01 | 3.698E-01 |
| 1846.00 | 2.463E-01 | 7.864E-01 | 5.791E-01 | 2.540E-01 | 2.357E-01 | 2.332E-01 | 1.133E-04 | 2.914E-04 | 1.037E-04 | 2.542E-01 | 3.383E-01 |
| 1860.00 | 3.319E-01 | 8.069E-01 | 1.209E-01 | 7.033E-02 | 1.572F-01 | 1.732E-01 | 1.337E-04 | 3.461E-04 | 1.389E-04 | 7.076E-02 | 1.868E-01 |
| 1874.00 | 4.329E-01 | 4.470E-01 | 3.310E-01 | 8.764E-02 | 1.249E-01 | 2.375E-01 | 1.341E-04 | 3.840E-04 | 1.645F-04 | 8.811E-02 | 1.260E-01 |
| 1884.00 | 3.962F-01 | 4.989E-01 | 5.065F-01 | 1.509E-01 | 2.011F-01 | 4.342E-01 | 1.342E-04 | 3.839E-04 | 1.645E-04 | 1.517E-01 | 1.925E-01 |
| 1894.00 | 3.281E-01 | 5.172E-01 | 4.349E-01 | 1.888E-01 | 2.556E-01 | 6.091E-01 | 1.343E-04 | 3.839E-04 | 1.646E-04 | 1.899E-01 | 2.449E-01 |
| 1909.00 | 2.615E-01 | 5.580E-01 | 3.697E-01 | 2.191E-01 | 3.036E-01 | 7.938E-01 | 1.344E-04 | 3.838E-04 | 1.647E-04 | 2.206E-01 | 2.895E-01 |
| 1914.00 | 1.945E-01 | 6.341E-01 | 3.114E-01 | 2.542E-01 | 3.480E-01 | 9.876E-01 | 1.345E-04 | 3.837E-04 | 1.647E-04 | 2.560E-01 | 3.300E-01 |
| 1924.00 | 1.143E-01 | 7.846E-01 | 2.569E-01 | 2.975E-01 | 4.029E-01 | 1.221E+00 | 1.346E-04 | 3.837E-04 | 1.648E-04 | 2.998E-01 | 3.930E-01 |
| 1934.00 | 6.174E-02 | 9.124E-01 | 2.106E-01 | 3.564E-01 | 4.608E-01 | 1.474E+00 | 1.347E-04 | 3.836E-04 | 1.649E-04 | 3.592E-01 | 4.591E-01 |
| 1943.50 | 1.382E-01 | 1.094E+00 | 6.603E-01 | 4.186E-01 | 5.004E-01 | 1.680E+00 | 1.348E-04 | 3.835E-04 | 1.650E-04 | 4.218E-01 | 4.997E-01 |
| 1943.50 | 1.553E-03 | 1.094E+00 | 6.601E-01 | 4.321E-01 | 5.004F-01 | 1.680E+00 | 1.348E-04 | 3.835E-04 | 1.650E-04 | 4.353E-01 | 4.997E-01 |
| 1944.50 | 8.670E-02 | 1.335E+00 | 2.347E+00 | 2.337E-01 | 5.077E-01 | 1.695E+00 | 1.348E-04 | 3.835E-04 | 1.650E-04 | 2.369E-01 | 5.075E-01 |
| 1945.50 | 3.391E-02 | 1.703E+00 | 4.048E+00 | 7.264E-02 | 5.150E-01 | 1.709E+00 | 1.348E-04 | 3.835E-04 | 1.650E-04 | 7.583E-02 | 5.151E-01 |
| 1946.50 | 1.035E-02 | 2.138E+00 | 5.764E+00 | 1.958E-02 | 5.222E-01 | 1.723E+00 | 1.348E-04 | 3.835E-04 | 1.650E-04 | 2.264E-02 | 5.224E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 6.463E+02 | 4.395E+03 | 2.300E+03 | 3.723E+00 | 2.321E+00 | 3.136E+00 | 9.154E-07 | 1.034E-05 | 7.650E-06 | 4.156E-04 | 5.513E-04 |
| 1432.00 | 5.531E+02 | 6.575E+02 | 9.636E+02 | 1.703E+00 | 1.962E+00 | 1.921E+00 | 4.154E-05 | 5.374E-05 | 4.052E-05 | 2.615E-04 | 3.188E-04 |
| 1490.00 | 4.010E+02 | 1.265E+02 | 3.422E+02 | 1.064E+00 | 1.123E+00 | 2.289E+00 | 7.069E-05 | 7.471E-05 | 4.683E-05 | 2.386E-04 | 4.781E-04 |
| 1550.00 | 3.601E+02 | 4.909E+01 | 1.894F+02 | 7.512E-01 | 6.729E-01 | 1.923E+00 | 8.645E-05 | 8.669E-05 | 4.621E-05 | 2.274E-04 | 5.530E-04 |
| 1550.00 | 1.680F+02 | 2.235E+01 | 1.489F+02 | 2.580E-01 | 5.835E-01 | 1.876E+00 | 8.405E-05 | 9.389E-05 | 4.939E-05 | 8.253E-05 | 5.398E-04 |
| 1610.00 | 1.747E+02 | 6.811E+01 | 6.146E+01 | 1.347E-01 | 5.199F-01 | 1.098E+00 | 1.057E-04 | 8.321E-05 | 7.831E-05 | 4.736E-05 | 4.567E-04 |
| 1670.00 | 1.858E+02 | 1.006E+02 | 6.184E+01 | 2.259E-01 | 5.359F-01 | 1.032E+00 | 1.073E-04 | 9.682E-05 | 5.743E-05 | 1.823E-04 | 6.583E-04 |
| 1730.00 | 3.197F+01 | 4.269E+01 | 1.653F+01 | 4.093E-01 | 3.156F-01 | 5.574E-01 | 1.087E-04 | 1.243E-04 | 1.094E-04 | 3.346E-04 | 5.774E-04 |
| 1790.00 | 5.480F+01 | 3.757E+01 | 1.952E+01 | 4.953E-01 | 5.038E-01 | 6.297E-01 | 1.004E-04 | 1.464E-04 | 1.054E-04 | 5.605E-04 | 8.604E-04 |
| 1836.00 | 6.554E+01 | 1.258E+01 | 4.454E+01 | 5.544E-01 | 8.524F-01 | 4.298E-01 | 9.291E-05 | 1.086E-04 | 1.729E-04 | 5.634E-04 | 7.360E-04 |
| 1836.00 | 9.310E+00 | 1.117E+01 | 1.731E+01 | 3.872E-01 | 4.086F-01 | 3.690E-01 | 9.282E-05 | 1.163E-04 | 2.159E-04 | 5.319E-04 | 6.314E-04 |
| 1846.00 | 8.507E+00 | 1.695E+01 | 1.757E+01 | 2.650E-01 | 3.144E-01 | 4.100E-01 | 1.058E-04 | 1.714E-04 | 2.174E-04 | 3.018E-04 | 7.264E-04 |
| 1846.00 | 2.451E-01 | 1.983E-01 | 9.566F-01 | 2.542E-01 | 2.817E-01 | 1.746E-01 | 1.145E-04 | 2.046E-04 | 2.315E-04 | 2.882E-04 | 3.094E-04 |
| 1860.00 | 3.346E-01 | 7.365E-01 | 3.487F-01 | 7.077E-02 | 1.819F-01 | 1.469E-01 | 1.352E-04 | 3.017E-04 | 2.184E-04 | 9.823E-05 | 2.757E-04 |
| 1874.00 | 4.322E-01 | 4.063E-01 | 3.805E-01 | 8.810E-02 | 1.354E-01 | 2.315E-01 | 1.356E-04 | 3.763E-04 | 1.802E-04 | 1.723E-04 | 4.386E-04 |
| 1884.00 | 3.961E-01 | 5.111E-01 | 4.942E-01 | 1.517E-01 | 1.967E-01 | 4.359E-01 | 1.357E-04 | 3.846E-04 | 1.617E-04 | 2.705E-04 | 6.227E-04 |
| 1894.00 | 3.283F-01 | 5.375E-01 | 4.094F-01 | 1.899E-01 | 2.466F-01 | 6.124E-01 | 1.357E-04 | 3.853E-04 | 1.600E-04 | 3.412E-04 | 1.193E-03 |
| 1904.00 | 2.620E-01 | 5.677E-01 | 3.544E-01 | 2.206E-01 | 2.980F-01 | 7.956E-01 | 1.357E-04 | 3.846E-04 | 1.616E-04 | 4.256E-04 | 1.603E-03 |
| 1914.00 | 1.953E-01 | 6.351E-01 | 3.089E-01 | 2.560E-01 | 3.472E-01 | 9.874E-01 | 1.357E-04 | 3.836E-04 | 1.641E-04 | 5.276E-04 | 2.054E-03 |
| 1924.00 | 1.150E-01 | 7.829E-01 | 2.619E-01 | 2.998E-01 | 4.043E-01 | 1.220E+00 | 1.357E-04 | 3.830E-04 | 1.654E-04 | 6.336E-04 | 2.545E-03 |
| 1934.00 | 6.308E-02 | 9.110E-01 | 2.160E-01 | 3.591E-01 | 4.618E-01 | 1.473E+00 | 1.358E-04 | 3.830E-04 | 1.654E-04 | 9.191E-04 | 3.740E-03 |
| 1943.50 | 1.372E-01 | 1.096E+00 | 6.571E-01 | 4.218E-01 | 5.006E-01 | 1.679E+00 | 1.358E-04 | 3.831E-04 | 1.651E-04 | 1.344E-03 | 5.337E-03 |
| 1943.50 | 4.424E-11 | 1.096E+00 | 6.571E-01 | 4.353E-01 | 5.006E-01 | 1.679E+00 | 1.358E-04 | 3.831E-04 | 1.651E-04 | 1.387E-03 | 5.337E-03 |
| 1944.50 | 8.870E-02 | 1.340E+00 | 2.344E+00 | 2.369E-01 | 5.080F-01 | 1.694E+00 | 1.358E-04 | 3.831E-04 | 1.651E-04 | 7.762E-04 | 5.529E-03 |
| 1945.50 | 3.875E-02 | 1.709E+00 | 4.046E+00 | 7.581E-02 | 5.153E-01 | 1.709E+00 | 1.358E-04 | 3.832E-04 | 1.650E-04 | 2.569E-04 | 5.729E-03 |
| 1946.50 | 1.554E-02 | 2.145E+00 | 5.762E+00 | 2.263E-02 | 5.224E-01 | 1.723E+00 | 1.358E-04 | 3.832E-04 | 1.650E-04 | 8.104E-05 | 5.855E-03 |

GROUP 3 ACCELEROMETER SCALE FACTOR

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1032.00 | 4.182E+03 | 3.507E+03 | 8.445E+03 | 1.428E+01 | 2.241E+00 | 5.709E+00 | 4.493E-06 | 8.247E-05 | 8.695E-06 | 1.182E+01 | 2.403E+00 |
| 1432.00 | 3.799E+03 | 1.423E+02 | 1.393E+03 | 9.461E+00 | 7.848E-01 | 3.228E+00 | 4.294E-05 | 6.031E-05 | 1.896E-06 | 9.192E+00 | 1.777E+00 |
| 1490.00 | 2.867E+03 | 8.073E+02 | 3.767E+02 | 6.564E+00 | 9.963E-01 | 2.149E+00 | 3.606E-05 | 5.402E-05 | 2.411E-05 | 6.602E+00 | 1.933E+00 |
| 1550.00 | 1.425E+03 | 1.963E+02 | 3.054E+02 | 3.344E+00 | 1.813E+00 | 9.259E-01 | 2.850E-05 | 7.039E-05 | 6.667E-05 | 3.363E+00 | 1.685E+00 |
| 1550.00 | 6.525E+02 | 8.118E+01 | 1.482E+02 | 9.937E-01 | 7.580E-01 | 6.774E-01 | 2.231E-05 | 4.005E-05 | 3.100E-05 | 1.005E+00 | 6.020E-01 |
| 1610.00 | 2.322E+02 | 2.916E+01 | 1.227E+02 | 1.458E-01 | 1.460E-01 | 4.800E-01 | 4.262E-05 | 4.901E-05 | 2.121E-05 | 1.385E-01 | 2.556E-01 |
| 1670.00 | 9.179E+01 | 3.786E+01 | 5.265E+01 | 5.047E-01 | 1.124E-01 | 6.457E-01 | 4.090E-05 | 4.643E-05 | 2.505E-05 | 5.042E-01 | 2.851E-01 |
| 1730.00 | 2.465E+01 | 2.215E+01 | 1.456E+01 | 4.254E-01 | 8.155E-02 | 5.118E-01 | 4.273E-05 | 6.769E-05 | 3.792E-05 | 4.252E-01 | 1.863E-01 |
| 1790.00 | 2.800E+01 | 2.191E+01 | 8.975E+00 | 3.020E-01 | 9.170E-02 | 5.060E-01 | 4.056E-05 | 6.993E-05 | 4.559E-05 | 3.019E-01 | 2.913E-01 |
| 1836.00 | 3.142E+01 | 1.768E+01 | 1.479E+01 | 2.328E-01 | 1.207E-01 | 4.249E-01 | 3.938E-05 | 7.916E-05 | 5.679E-05 | 2.325E-01 | 3.759E-01 |
| 1836.00 | 4.335E+00 | 9.541E+00 | 1.834E+00 | 2.052E-01 | 1.520E-01 | 1.886E-01 | 3.915E-05 | 1.013E-04 | 5.406E-05 | 2.053E-01 | 1.232E-01 |
| 1846.00 | 4.086E+00 | 1.180E+01 | 1.031E+00 | 8.837E-02 | 1.689E-01 | 1.498E-01 | 4.282E-05 | 1.119E-04 | 5.381E-05 | 8.829E-02 | 8.707E-02 |
| 1846.00 | 6.526E-02 | 3.689E-01 | 2.405E-01 | 8.314E-02 | 9.924E-02 | 7.520E-02 | 4.636E-05 | 1.243E-04 | 5.932E-05 | 8.311E-02 | 8.129E-02 |
| 1860.00 | 1.957E-01 | 3.880E-01 | 6.642E-02 | 1.152E-02 | 6.468E-02 | 6.165E-02 | 5.382E-05 | 1.435E-04 | 6.867E-05 | 1.181E-02 | 5.199E-02 |
| 1874.00 | 2.089E-01 | 1.707E-01 | 8.638E-02 | 2.231E-02 | 4.463E-02 | 8.797E-02 | 5.220E-05 | 1.576E-04 | 7.620E-05 | 2.255E-02 | 3.860E-02 |
| 1884.00 | 1.661E-01 | 2.455E-01 | 1.596E-01 | 4.160E-02 | 7.025E-02 | 1.595E-01 | 5.228E-05 | 1.576E-04 | 7.615E-05 | 4.192E-02 | 7.222E-02 |
| 1894.00 | 1.373E-01 | 2.417E-01 | 1.364E-01 | 5.285E-02 | 9.326E-02 | 2.188E-01 | 5.236E-05 | 1.576E-04 | 7.611E-05 | 5.315E-02 | 9.700E-02 |
| 1904.00 | 1.068E-01 | 2.350E-01 | 1.153E-01 | 6.523E-02 | 1.183E-01 | 2.798E-01 | 5.244E-05 | 1.576E-04 | 7.606E-05 | 6.542E-02 | [illegible].131E-01 |
| 1914.00 | 7.327E-02 | 2.182E-01 | 9.704E-02 | 8.156E-02 | 1.446E-01 | 3.433E-01 | 5.252E-05 | 1.576E-04 | 7.601E-05 | 8.164E-02 | 1.267E-01 |
| 1924.00 | 4.097E-02 | 1.899E-01 | 8.055E-02 | 1.029E-01 | 1.776E-01 | 4.218E-01 | 5.260E-05 | 1.576E-04 | 7.596E-05 | 1.029E-01 | 1.606E-01 |
| 1934.00 | 1.813E-02 | 1.824E-01 | 6.674E-02 | 1.321E-01 | 2.125E-01 | 5.057E-01 | 5.268E-05 | 1.576E-04 | 7.591E-05 | 1.320E-01 | 2.057E-01 |
| 1943.50 | 5.308E-02 | 2.122E-01 | 2.282E-01 | 1.591E-01 | 2.399E-01 | 5.723E-01 | 5.276E-05 | 1.576E-04 | 7.587E-05 | 1.569E-01 | 2.369E-01 |
| 1943.50 | 5.567E-04 | 2.123E-01 | 2.281E-01 | 1.643E-01 | 2.399E-01 | 5.723E-01 | 5.276E-05 | 1.576E-04 | 7.587E-05 | 1.640E-01 | 2.369E-01 |
| 1944.50 | 3.424E-02 | 3.797E-01 | 8.030E-01 | 9.029E-02 | 2.422E-01 | 5.773E-01 | 5.277E-05 | 1.576E-04 | 7.586E-05 | 9.005E-02 | 2.404E-01 |
| 1945.50 | 1.622E-02 | 6.021E-01 | 1.383E+00 | 2.997E-02 | 2.446E-01 | 5.823E-01 | 5.278E-05 | 1.576E-04 | 7.586E-05 | 2.965E-02 | 2.434E-01 |
| 1946.50 | 9.409E-03 | 8.386E-01 | 1.967E+00 | 1.039E-02 | 2.468E-01 | 5.871E-01 | 5.278E-05 | 1.576E-04 | 7.585E-05 | 9.811E-03 | 2.457E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 4.511E+03 | 8.164E+03 | 3.757E+03 | 1.419E+01 | 2.906E+00 | 5.619E+00 | 1.544E-06 | 6.607E-05 | 5.029E-05 | 1.946E-03 | 1.042E-03 |
| 1432.00 | 3.828E+03 | 7.079E+02 | 1.115E+03 | 9.397E+00 | 2.098E+00 | 2.800E+00 | 4.486E-05 | 4.207E-05 | 4.127E-05 | 1.512E-03 | 4.936E-04 |
| 1490.00 | 2.852E+03 | 4.115E+02 | 8.414E+02 | 6.510E+00 | 2.295E+00 | 1.024E+00 | 3.682E-05 | 2.172E-05 | 5.452E-05 | 1.418E-03 | 2.335E-04 |
| 1550.00 | 1.420E+03 | 2.939E+02 | 2.463E+02 | 3.315E+00 | 1.930E+00 | 7.823E-01 | 2.845E-05 | 4.980E-05 | 8.320E-05 | 1.008E-03 | 2.247E-04 |
| 1550.00 | 6.501E+02 | 1.267E+02 | 1.248E+02 | 9.848E-01 | 6.733E-01 | 7.731E-01 | 2.200E-05 | 3.143E-05 | 3.989E-05 | 3.031E-04 | 2.228E-04 |
| 1610.00 | 2.316E+02 | 6.917E+01 | 1.068E+02 | 1.458E-01 | 2.566E-01 | 4.311E-01 | 4.243E-05 | 2.859E-05 | 4.529E-05 | 5.790E-05 | 1.792E-04 |
| 1670.00 | 9.164E+01 | 4.674E+01 | 4.525E+01 | 5.035E-01 | 3.389E-01 | 5.620E-01 | 4.090E-05 | 3.544E-05 | 3.908E-05 | 3.387E-04 | 3.59[illegible]E-04 |
| 1730.00 | 2.463E+01 | 2.037E+01 | 1.700E+01 | 4.252E-01 | 2.691E-01 | 4.432E-01 | 4.290E-05 | 4.574E-05 | 6.256E-05 | 4.458E-04 | 4.592E-04 |
| 1790.00 | 2.790E+01 | 2.173E+01 | 9.667E+00 | 3.019E-01 | 3.042E-01 | 4.147E-01 | 4.084E-05 | 5.008E-05 | 6.662E-05 | 4.230E-04 | 5.796E-04 |
| 1836.00 | 3.131E+01 | 9.405E+00 | 2.120E+01 | 2.324E-01 | 3.780E-01 | 2.289E-01 | 3.969E-05 | 7.489E-05 | 6.212E-05 | 3.829E-04 | 3.921E-04 |
| 1836.00 | 4.377E+00 | 5.244E+00 | 8.157E+00 | 2.052E-01 | 1.446E-01 | 1.943E-01 | 3.957E-05 | 7.957E-05 | 8.254E-05 | 3.551E-04 | 3.326E-04 |
| 1846.00 | 4.137E+00 | 8.323E+00 | 8.404E+00 | 8.817E-02 | 7.998E-02 | 2.112E-01 | 4.326E-05 | 1.028E-04 | 6.937E-05 | 1.363E-04 | 3.742E-04 |
| 1846.00 | 6.529E-02 | 1.486E-01 | 4.145E-01 | 8.311E-02 | 7.151E-02 | 1.020E-01 | 4.686E-05 | 1.160E-04 | 7.391E-05 | 1.234E-04 | 1.807E-04 |
| 1860.00 | 1.969E-01 | 3.382E-01 | 2.002E-01 | 1.182E-02 | 5.177E-02 | 7.278E-02 | 5.434E-05 | 1.485E-04 | 5.663E-05 | 1.883E-05 | 1.366E-04 |
| 1874.00 | 2.089E-01 | 1.598E-01 | 1.052E-01 | 2.254E-02 | 3.999E-02 | 9.011E-02 | 5.272E-05 | 1.618E-04 | 6.642E-05 | 4.234E-05 | 1.707E-04 |
| 1884.00 | 1.662E-01 | 2.501E-01 | 1.523E-01 | 4.192E-02 | 7.306E-02 | 1.581E-01 | 5.276E-05 | 1.558E-04 | 7.939E-05 | 7.469E-05 | 2.985E-04 |
| 1894.00 | 1.375E-01 | 2.491E-01 | 1.221E-01 | 5.315E-02 | 1.020E-01 | 2.148E-01 | 5.280E-05 | 1.541E-04 | 8.256E-05 | 1.097E-04 | 4.183E-04 |
| 1909.00 | 1.070E-01 | 2.386E-01 | 1.076E-01 | 6.542E-02 | 1.249E-01 | 2.769E-01 | 5.285E-05 | 1.557E-04 | 7.958E-05 | 1.548E-04 | 5.579E-04 |
| 1914.00 | 7.342E-02 | 2.166E-01 | 9.601E-02 | 8.164E-02 | 1.459E-01 | 3.428E-01 | 5.289E-05 | 1.572E-04 | 7.653E-05 | 2.070E-04 | 7.133E-04 |
| 1924.00 | 4.083E-02 | 1.893E-01 | 8.205E-02 | 1.029E-01 | 1.755E-01 | 4.227E-01 | 5.294E-05 | 1.578E-04 | 7.532E-05 | 2.513E-04 | 8.618E-04 |
| 1934.00 | 1.792E-02 | 1.820E-01 | 6.798E-02 | 1.320E-01 | 2.101E-01 | 5.068E-01 | 5.299E-05 | 1.577E-04 | 7.533E-05 | 3.515E-04 | 1.287E-03 |
| 1943.50 | 5.282E-02 | 2.126E-01 | 2.279E-01 | 1.589E-01 | 2.387E-01 | 5.729E-01 | 5.304E-05 | 1.576E-04 | 7.564E-05 | 5.133E-04 | 1.821E-03 |
| 1943.50 | 1.703E-11 | 2.126E-01 | 2.279E-01 | 1.640E-01 | 2.387E-01 | 5.729E-01 | 5.304E-05 | 1.576E-04 | 7.564E-05 | 5.296E-04 | 1.821E-03 |
| 1944.50 | 3.360E-02 | 3.792E-01 | 8.032E-01 | 9.005E-02 | 2.412E-01 | 5.778E-01 | 5.304E-05 | 1.576E-04 | 7.566E-05 | 3.004E-04 | 1.886E-03 |
| 1945.50 | 1.492E-02 | 6.005E-01 | 1.383E+00 | 2.964E-02 | 2.435E-01 | 5.827E-01 | 5.305E-05 | 1.575E-04 | 7.568E-05 | 1.043E-04 | 1.954E-03 |
| 1946.50 | 6.309E-03 | 8.360E-01 | 1.969E+00 | 9.802E-03 | 2.458E-01 | 5.875E-01 | 5.305E-05 | 1.575E-04 | 7.569E-05 | 3.876E-05 | 1.997E-03 |

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OF POOR QUALITY

## GROUP 4 ACCELEROMETER MISALIGNMENTS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.056E+03 | 1.037E+03 | 1.717E+03 | 3.359E+00 | 2.328E+00 | 1.912E+00 | 8.302E-07 | 2.107E-05 | 3.219E-06 | 3.028E+00 | 1.369E+00 |
| 1432.00 | 1.013E+03 | 4.055E+02 | 3.991E+02 | 2.697E+00 | 1.779E+00 | 1.623E+00 | 2.359E-05 | 2.157E-05 | 8.350E-06 | 2.685E+00 | 9.920E-01 |
| 1490.00 | 7.691E+02 | 2.252E+02 | 1.515E+02 | 2.079E+00 | 1.143E+00 | 1.601E+00 | 4.640E-05 | 2.552E-05 | 3.049E-05 | 2.085E+00 | 7.006E-01 |
| 1550.00 | 4.277E+02 | 8.555E+01 | 1.074E+02 | 1.469E+00 | 1.239E+00 | 1.356E+00 | 6.127E-05 | 3.327E-05 | 3.765E-05 | 1.472E+00 | 8.935E-01 |
| 1550.00 | 1.965E+02 | 5.924E+01 | 7.543E+01 | 8.804E-01 | 1.067E+00 | 1.324E+00 | 6.303E-05 | 3.828E-05 | 3.535E-05 | 8.806E-01 | 6.743E-01 |
| 1610.00 | 1.428E+02 | 4.716E+01 | 5.451E+01 | 6.149E-01 | 5.235E-01 | 1.053E+00 | 8.945E-05 | 5.413E-05 | 3.932E-05 | 6.144E-01 | 5.052E-01 |
| 1670.00 | 1.629E+02 | 5.948E+01 | 8.228E+01 | 5.599E-01 | 3.907E-01 | 1.107E+00 | 9.293E-05 | 5.934E-05 | 5.346E-05 | 5.607E-01 | 5.304E-01 |
| 1730.00 | 3.134E+01 | 3.310E+01 | 2.892E+01 | 5.401E-01 | 3.680E-01 | 6.891E-01 | 9.383E-05 | 1.065E-04 | 7.700E-05 | 5.398E-01 | 3.872E-01 |
| 1790.00 | 4.947E+01 | 3.978E+01 | 1.376E+01 | 4.931E-01 | 4.434E-01 | 8.061E-01 | 8.654E-05 | 1.194E-04 | 1.163E-04 | 4.922E-01 | 6.117E-01 |
| 1836.00 | 5.904E+01 | 3.611E+01 | 2.974E+01 | 5.083E-01 | 5.040E-01 | 9.211E-01 | 8.058E-05 | 1.399E-04 | 1.521E-04 | 5.076E-01 | 9.383E-01 |
| 1836.00 | 9.579E+00 | 2.158E+01 | 4.035E+00 | 3.862E-01 | 4.797E-01 | 5.055E-01 | 8.005E-05 | 1.807E-04 | 1.572E-04 | 3.866E-01 | 4.696E-01 |
| 1846.00 | 9.668E+00 | 2.731E+01 | 2.591E+00 | 2.713E-01 | 5.565E-01 | 3.914E-01 | 9.177E-05 | 2.174E-04 | 1.553E-04 | 2.722E-01 | 4.644E-01 |
| 1846.00 | 2.805E-01 | 8.203E-01 | 5.594E-01 | 2.472E-01 | 4.180E-01 | 2.415E-01 | 9.942E-05 | 2.463E-04 | 1.674E-04 | 2.480E-01 | 4.275E-01 |
| 1860.00 | 5.460E-01 | 1.385E+00 | 2.153E-01 | 9.139E-02 | 2.635E-01 | 1.695E-01 | 1.177E-04 | 2.986E-04 | 2.264E-04 | 9.223E-02 | 2.723E-01 |
| 1874.00 | 4.839E-01 | 5.270E-01 | 3.329E-01 | 8.150E-02 | 1.923E-01 | 2.252E-01 | 1.176E-04 | 3.362E-04 | 2.672E-04 | 8.211E-02 | 1.866E-01 |
| 1884.00 | 4.362E-01 | 6.644E-01 | 4.976E-01 | 1.320E-01 | 3.134E-01 | 4.148E-01 | 1.177E-04 | 3.362E-04 | 2.672E-04 | 1.329E-01 | 2.965E-01 |
| 1894.00 | 3.697E-01 | 6.695E-01 | 4.272E-01 | 1.559E-01 | 4.050E-01 | 5.798E-01 | 1.178E-04 | 3.361E-04 | 2.673E-04 | 1.570E-01 | 3.752E-01 |
| 1904.00 | 3.019E-01 | 6.861E-01 | 3.626E-01 | 1.739E-01 | 4.911E-01 | 7.542E-01 | 1.178E-04 | 3.361E-04 | 2.673E-04 | 1.753E-01 | 4.464E-01 |
| 1914.00 | 2.269E-01 | 7.199E-01 | 3.051E-01 | 1.991E-01 | 5.730E-01 | 9.370E-01 | 1.179E-04 | 3.360E-04 | 2.673E-04 | 2.007E-01 | 5.114E-01 |
| 1924.00 | 1.316E-01 | 8.074E-01 | 2.515E-01 | 2.346E-01 | 6.765E-01 | 1.161E+00 | 1.180E-04 | 3.359E-04 | 2.674E-04 | 2.364E-01 | 6.387E-01 |
| 1934.00 | 7.387E-02 | 9.048E-01 | 2.061E-01 | 2.944E-01 | 7.874E-01 | 1.402E+00 | 1.181E-04 | 3.359E-04 | 2.674E-04 | 2.964E-01 | 7.785E-01 |
| 1943.50 | 1.060E-01 | 1.198E+00 | 6.235E-01 | 3.623E-01 | 8.604E-01 | 1.595E+00 | 1.182E-04 | 3.358E-04 | 2.674E-04 | 3.643E-01 | 8.568E-01 |
| 1943.50 | 1.985E-03 | 1.198E+00 | 6.233E-01 | 3.720E-01 | 8.604E-01 | 1.595E+00 | 1.182E-04 | 3.358E-04 | 2.674E-04 | 3.740E-01 | 8.568E-01 |
| 1944.50 | 7.578E-02 | 1.830E+00 | 2.225E+00 | 2.017E-01 | 8.727E-01 | 1.609E+00 | 1.182E-04 | 3.358E-04 | 2.675E-04 | 2.030E-01 | 8.712E-01 |
| 1945.50 | 3.184E-02 | 2.613E+00 | 3.840E+00 | 6.353E-02 | 8.849E-01 | 1.522E+00 | 1.162E-04 | 3.358E-04 | 2.675E-04 | 6.542E-02 | 8.845E-01 |
| 1946.50 | 1.516E-02 | 3.455E+00 | 5.469E+00 | 1.861E-02 | 8.967E-01 | 1.635E+00 | 1.182E-04 | 3.358E-04 | 2.675E-04 | 1.990E-02 | 8.965E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.092E+03 | 1.679E+03 | 1.061E+03 | 3.339E+00 | 1.419E+00 | 2.683E+00 | 6.631E-07 | 1.750E-05 | 1.217E-05 | 4.983E-04 | 4.368E-04 |
| 1432.00 | 1.012E+03 | 2.440E+02 | 5.152E+02 | 2.682E+00 | 1.032E+00 | 2.194E+00 | 2.342E-05 | 1.822E-05 | 1.451E-05 | 4.412E-04 | 3.526E-04 |
| 1490.00 | 7.651E+02 | 1.155E+02 | 2.576E+02 | 2.061E+00 | 7.945E-01 | 1.820E+00 | 4.589E-05 | 3.359E-05 | 2.235E-05 | 4.473E-04 | 3.825E-04 |
| 1550.00 | 4.261E+02 | 9.866E+01 | 1.026E+02 | 1.457E+00 | 9.886E-01 | 1.559E+00 | 6.082E-05 | 3.645E-05 | 3.537E-05 | 4.419E-04 | 4.490E-04 |
| 1550.00 | 1.957E+02 | 5.212E+01 | 8.231E+01 | 8.750E-01 | 7.250E-01 | 1.541E+00 | 6.261E-05 | 4.021E-05 | 3.394E-05 | 2.655E-04 | 4.440E-04 |
| 1610.00 | 1.424E+02 | 5.511E+01 | 4.777E+01 | 6.132E-01 | 5.375E-01 | 1.047E+00 | 8.907E-05 | 5.601E-05 | 3.749E-05 | 2.642E-04 | 4.337E-04 |
| 1670.00 | 1.627E+02 | 8.945E+01 | 4.892E+01 | 5.587E-01 | 5.905E-01 | 1.016E+00 | 9.279E-05 | 6.684E-05 | 4.406E-05 | 3.904E-04 | 6.482E-04 |
| 1730.00 | 3.136E+01 | 3.984E+01 | 1.852E+01 | 5.404E-01 | 4.153E-01 | 6.614E-01 | 9.398E-05 | 9.845E-05 | 8.693E-05 | 5.343E-04 | 6.850E-04 |
| 1790.00 | 4.930E+01 | 3.603E+01 | 2.213E+01 | 4.930E-01 | 5.877E-01 | 7.078E-01 | 8.699E-05 | 1.263E-04 | 1.084E-04 | 6.226E-04 | 9.893E-04 |
| 1836.00 | 5.883E+01 | 2.183E+01 | 4.166E+01 | 5.078E-01 | 8.875E-01 | 5.615E-01 | 8.122E-05 | 1.472E-04 | 1.447E-04 | 6.596E-04 | 9.612E-04 |
| 1836.00 | 9.673E+00 | 1.175E+01 | 1.849E+01 | 3.865E-01 | 4.645E-01 | 5.192E-01 | 8.087E-05 | 1.517E-04 | 1.849E-04 | 6.174E-04 | 8.886E-04 |
| 1846.00 | 9.786E+00 | 1.936E+01 | 1.938E+01 | 2.721E-01 | 4.207E-01 | 5.342E-01 | 9.276E-05 | 1.668E-04 | 2.082E-04 | 3.157E-04 | 9.466E-04 |
| 1846.00 | 2.809E-01 | 3.947E-01 | 9.109E-01 | 2.480E-01 | 3.866E-01 | 2.884E-01 | 1.005E-04 | 1.996E-04 | 2.206E-04 | 2.817E-04 | 5.111E-04 |
| 1860.00 | 5.512E-01 | 1.307E+00 | 5.025E-01 | 9.226E-02 | 2.649E-01 | 1.670E-01 | 1.190E-04 | 2.721E-04 | 2.571E-04 | 1.169E-04 | 3.133E-04 |
| 1874.00 | 4.842E-01 | 4.871E-01 | 3.886E-01 | 8.209E-02 | 1.970E-01 | 2.209E-01 | 1.190E-04 | 3.301E-04 | 2.741E-04 | 1.766E-04 | 4.185E-04 |
| 1884.00 | 4.370E-01 | 6.752E-01 | 4.821E-01 | 1.329E-01 | 3.112E-01 | 4.162E-01 | 1.190E-04 | 3.370E-04 | 2.656E-04 | 2.812E-04 | 7.655E-04 |
| 1894.00 | 3.707E-01 | 6.879E-01 | 3.959E-01 | 1.570E-01 | 4.007E-01 | 5.825E-01 | 1.190E-04 | 3.380E-04 | 2.643E-04 | 3.744E-04 | 1.134E-03 |
| 1904.00 | 3.031E-01 | 6.951E-01 | 3.441E-01 | 1.753E-01 | 4.889E-01 | 7.554E-01 | 1.190E-04 | 3.370E-04 | 2.655E-04 | 4.877E-04 | 1.522E-03 |
| 1914.00 | 2.282E-01 | 7.207E-01 | 3.021E-01 | 2.007E-01 | 5.728E-01 | 9.368E-01 | 1.190E-04 | 3.359E-04 | 2.670E-04 | 6.206E-04 | 1.949E-03 |
| 1924.00 | 1.328E-01 | 8.055E-01 | 2.568E-01 | 2.364E-01 | 6.771E-01 | 1.161E+00 | 1.191E-04 | 3.353E-04 | 2.677E-04 | 6.573E-04 | 2.421E-03 |
| 1934.00 | 7.538E-02 | 9.034E-01 | 2.115E-01 | 2.963E-01 | 7.879E-01 | 1.402E+00 | 1.191E-04 | 3.353E-04 | 2.677E-04 | 8.117E-04 | 3.560E-03 |
| 1943.50 | 1.051E-01 | 1.200E+00 | 6.204E-01 | 3.643E-01 | 8.607E-01 | 1.595E+00 | 1.191E-04 | 3.354E-04 | 2.675E-04 | 1.187E-03 | 5.069E-03 |
| 1943.50 | 3.390E-11 | 1.200E+00 | 6.204E-01 | 3.740E-01 | 8.607E-01 | 1.595E+00 | 1.191E-04 | 3.354E-04 | 2.675E-04 | 1.217E-03 | 5.069E-03 |
| 1944.50 | 7.625E-02 | 1.833E+00 | 2.222E+00 | 2.037E-01 | 8.728E-01 | 1.609E+00 | 1.191E-04 | 3.354E-04 | 2.675E-04 | 6.874E-04 | 5.250E-03 |
| 1945.50 | 3.336E-02 | 2.617E+00 | 3.838E+00 | 6.539E-02 | 8.849E-01 | 1.622E+00 | 1.191E-04 | 3.355E-04 | 2.675E-04 | 2.368E-04 | 5.439E-03 |
| 1946.50 | 1.350E-02 | 3.458E+00 | 5.467E+00 | 1.986E-02 | 8.966E-01 | 1.635E+00 | 1.191E-04 | 3.355E-04 | 2.675E-04 | 8.802E-05 | 5.558E-03 |

GROUP 5 ACCELEROMETER NONLINEARITIES

TABLES WERE NOT PRINTED

GROUP 6 GRAVITY ANOMALY AND VERTICAL DEFLECTIONS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | THIS SEGMENT OF TABLE NOT PRINTED | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 1.477E+01 | 8.144E+00 | 4.494E+00 | 1.897E-01 | 9.601F-02 | 1.789E-01 | 2.641E-05 | 4.628E-05 | 2.450E-05 | 1.896E-01 | 1.705E-01 |
| 1836.00 | 2.250E+00 | 5.026E+00 | 9.133E-01 | 1.597E-01 | 9.603E-02 | 1.174E-01 | 2.638E-05 | 5.231E-05 | 2.496E-05 | 1.596E-01 | 9.325E-02 |
| 1846.00 | 2.251E+00 | 6.785E+00 | 6.677E-01 | 8.667E-02 | 1.078F-01 | 8.170E-02 | 2.822E-05 | 6.095E-05 | 2.501E-05 | 8.658E-02 | 7.200E-02 |
| 1846.00 | 9.631E-02 | 2.240E-01 | 1.036E-01 | 7.524E-02 | 7.199E-02 | 4.572E-02 | 2.932E-05 | 6.681E-05 | 2.748E-05 | 7.523E-02 | 6.614E-02 |
| 1860.00 | 1.373E-01 | 2.384E-01 | 5.059E-02 | 3.117E-02 | 4.304E-02 | 3.256E-02 | 3.246E-05 | 7.790E-05 | 3.544E-05 | 3.123E-02 | 3.980E-02 |
| 1874.00 | 2.198E-01 | 1.658E-01 | 1.048E-01 | 3.922E-02 | 3.217E-02 | 4.697E-02 | 3.245E-05 | 8.569E-05 | 4.108E-05 | 3.925E-02 | 3.259E-02 |
| 1884.00 | 2.167E-01 | 2.018E-01 | 1.275E-01 | 6.163E-02 | 4.919E-02 | 8.522E-02 | 3.247E-05 | 8.568E-05 | 4.108E-05 | 6.170E-02 | 5.195E-02 |
| 1894.00 | 1.834E-01 | 2.113E-01 | 1.105E-01 | 8.250E-02 | 6.318E-02 | 1.193E-01 | 3.249E-05 | 8.568E-05 | 4.108E-05 | 8.257E-02 | 6.754E-02 |
| 1904.00 | 1.511F-01 | 2.231E-01 | 9.473E-02 | 1.043E-01 | 7.697F-02 | 1.552E-01 | 3.250E-05 | 8.567E-05 | 4.108E-05 | 1.043E-01 | 8.025E-02 |
| 1914.00 | 1.169F-01 | 2.597E-01 | 8.042F-02 | 1.279E-01 | 9.096F-02 | 1.930E-01 | 3.252E-05 | 8.566E-05 | 4.107E-05 | 1.279E-01 | 9.199E-02 |
| 1924.00 | 7.122E-02 | 3.249E-01 | 6.704E-02 | 1.535E-01 | 1.074F-01 | 2.384E-01 | 3.254E-05 | 8.566E-05 | 4.107E-05 | 1.535E-01 | 1.040E-01 |
| 1934.00 | 4.132E-02 | 3.758E-01 | 5.524E-02 | 1.814E-01 | 1.251E-01 | 2.877E-01 | 3.256E-05 | 8.565E-05 | 4.107E-05 | 1.814E-01 | 1.224E-01 |
| 1943.50 | 6.371E-02 | 4.460E-01 | 1.311F-01 | 2.095E-01 | 1.396F-01 | 3.281E-01 | 3.257E-05 | 8.565E-05 | 4.107E-05 | 2.095E-01 | 1.383E-01 |
| 1943.50 | 9.389E-04 | 4.461E-01 | 1.310E-01 | 2.157E-01 | 1.396E-01 | 3.281E-01 | 3.257E-05 | 8.565E-05 | 4.107E-05 | 2.158E-01 | 1.383E-01 |
| 1944.50 | 4.492E-02 | 5.089E-01 | 4.580E-01 | 1.181E-01 | 1.414F-01 | 3.310E-01 | 3.258E-05 | 8.565E-05 | 4.107E-05 | 1.181E-01 | 1.406E-01 |
| 1945.50 | 2.032E-02 | 5.999E-01 | 7.900E-01 | 3.852E-02 | 1.431E-01 | 3.340E-01 | 3.258E-05 | 8.565E-05 | 4.107E-05 | 3.856E-02 | 1.427E-01 |
| 1946.50 | 9.269E-03 | 7.092E-01 | 1.125E+00 | 1.242E-02 | 1.448E-01 | 3.369E-01 | 3.258E-05 | 8.565E-05 | 4.107E-05 | 1.241E-02 | 1.445E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | THIS SEGMENT OF TABLE NOT PRINTED | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 1.473E+01 | 4.137E+00 | 8.399E+00 | 1.895E-01 | 1.636E-01 | 1.205E-01 | 2.648E-05 | 3.108E-05 | 4.210E-05 | 2.977E-04 | 2.063E-04 |
| 1836.00 | 2.272E+00 | 2.714E+00 | 4.317E+00 | 1.596E-01 | 1.052E-01 | 1.095E-01 | 2.646E-05 | 3.238E-05 | 4.803E-05 | 2.708E-04 | 1.873E-04 |
| 1846.00 | 2.280E+00 | 4.841E+00 | 4.787E+00 | 8.650E-02 | 6.786E-02 | 1.171E-01 | 2.834E-05 | 4.534E-05 | 4.772E-05 | 1.395E-04 | 2.075E-04 |
| 1846.00 | 9.578E-02 | 1.075E-01 | 2.224E-01 | 7.523E-02 | 6.030E-02 | 6.031E-02 | 2.947E-05 | 5.171E-05 | 5.036E-05 | 1.176E-04 | 1.069E-04 |
| 1860.00 | 1.342F-01 | 2.196E-01 | 1.046E-01 | 3.123E-02 | 3.849E-02 | 3.778E-02 | 3.265E-05 | 7.292E-05 | 4.466E-05 | 5.139E-05 | 7.089E-05 |
| 1874.00 | 2.200E-01 | 1.609E-01 | 1.118F-01 | 3.925E-02 | 3.157F-02 | 4.736E-02 | 3.264E-05 | 8.569E-05 | 4.093E-05 | 6.545E-05 | 8.971E-05 |
| 1884.00 | 2.170E-01 | 2.030E-01 | 1.251E-01 | 6.170E-02 | 4.960E-02 | 8.493E-02 | 3.265E-05 | 8.541E-05 | 4.149E-05 | 1.029E-04 | 1.603E-04 |
| 1894.00 | 1.838E-01 | 2.130E-01 | 1.065E-01 | 8.256E-02 | 6.478F-02 | 1.183E-01 | 3.266E-05 | 8.514E-05 | 4.204E-05 | 1.426E-04 | 2.305E-04 |
| 1904.00 | 1.515E-01 | 2.286E-01 | 9.285E-02 | 1.043E-01 | 7.830E-02 | 1.545E-01 | 3.266E-05 | 8.539E-05 | 4.153E-05 | 1.890E-04 | 3.113E-04 |
| 1914.00 | 1.174E-01 | 2.595E-01 | 8.026E-02 | 1.279E-01 | 9.125E-02 | 1.928E-01 | 3.267E-05 | 8.559E-05 | 4.112E-05 | 2.419E-04 | 4.011E-04 |
| 1924.00 | 7.183E-02 | 3.247E-01 | 6.737E-02 | 1.535E-01 | 1.070F-01 | 2.386E-01 | 3.268E-05 | 8.564E-05 | 4.099E-05 | 3.136E-04 | 4.977E-04 |
| 1934.00 | 4.205E-02 | 3.757E-01 | 5.543E-02 | 1.814E-01 | 1.246E-01 | 2.879E-01 | 3.268E-05 | 8.564E-05 | 4.100E-05 | 4.637E-04 | 7.312E-04 |
| 1943.50 | 6.292E-02 | 4.463E-01 | 1.304F-01 | 2.095E-01 | 1.394E-01 | 3.282E-01 | 3.269E-05 | 8.562E-05 | 4.103E-05 | 6.680E-04 | 1.043E-03 |
| 1943.50 | 1.878E-09 | 4.463E-01 | 1.304E-01 | 2.158E-01 | 1.394F-01 | 3.282E-01 | 3.269E-05 | 8.562E-05 | 4.103E-05 | 6.878E-04 | 1.043E-03 |
| 1944.50 | 4.412E-02 | 5.093E-01 | 4.576E-01 | 1.181E-01 | 1.411F-01 | 3.311E-01 | 3.269E-05 | 8.562E-05 | 4.103E-05 | 3.873E-04 | 1.081E-03 |
| 1945.50 | 1.950E-02 | 6.001E-01 | 7.899E-01 | 3.855E-02 | 1.428E-01 | 3.341E-01 | 3.270E-05 | 8.562E-05 | 4.104E-05 | 1.306E-04 | 1.120E-03 |
| 1946.50 | 8.114E-03 | 7.093E-01 | 1.125E+00 | 1.240E-02 | 1.445E-01 | 3.370E-01 | 3.270E-05 | 8.562E-05 | 4.104E-05 | 4.361E-05 | 1.145E-03 |

## GROUP 7 GYRO BIAS DRIFT

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 4.383E+03 | 7.269E+03 | 3.727E+03 | 7.225E+00 | 9.175E+00 | 9.308E+00 | 4.774E-06 | 7.599E-05 | 9.569E-06 | 8.529E+00 | 4.926E+00 |
| 1432.00 | 4.398E+03 | 3.740E+03 | 2.065E+03 | 8.029E+00 | 1.207E+01 | 9.212E+00 | 1.914E-04 | 9.697E-05 | 6.304E-05 | 8.550E+00 | 4.043E+00 |
| 1490.00 | 3.131E+03 | 1.742E+03 | 1.857E+03 | 6.979E+00 | 7.513E+00 | 8.166E+00 | 3.053E-04 | 1.153E-04 | 1.005E-04 | 7.030E+00 | 2.122E+00 |
| 1550.00 | 1.499E+03 | 5.310E+02 | 5.337E+02 | 4.593E+00 | 2.774E+00 | 7.331E+00 | 3.220E-04 | 1.381E-04 | 1.493E-04 | 4.612E+00 | 2.162E+00 |
| 1550.00 | 6.886E+02 | 4.417E+02 | 5.293E+02 | 2.183E+00 | 2.699E+00 | 6.979E+00 | 3.324E-04 | 1.661E-04 | 1.420E-04 | 2.195E+00 | 1.374E+00 |
| 1610.00 | 4.424E+02 | 2.762E+02 | 1.994E+02 | 1.525E+00 | 3.019E+00 | 4.784E+00 | 3.111E-04 | 1.647E-04 | 1.490E-04 | 1.529E+00 | 1.191E+00 |
| 1670.00 | 3.504E+02 | 1.988E+02 | 1.486E+02 | 1.371E+00 | 1.457E+00 | 3.998E+00 | 2.812E-04 | 1.609E-04 | 1.865E-04 | 1.377E+00 | 1.253E+00 |
| 1730.00 | 9.444E+01 | 1.117E+02 | 7.668E+01 | 7.350E-01 | 1.047E+00 | 2.354E+00 | 2.403E-04 | 2.452E-04 | 2.551E-04 | 7.371E-01 | 8.380E-01 |
| 1790.00 | 9.506E+01 | 1.071E+02 | 5.410E+01 | 4.944E-01 | 1.059E+00 | 2.380E+00 | 2.084E-04 | 2.799E-04 | 3.477E-04 | 4.949E-01 | 1.529E+00 |
| 1836.00 | 1.163E+02 | 8.456E+01 | 8.673E+01 | 7.681E-01 | 1.205E+00 | 2.021E+00 | 1.825E-04 | 3.335E-04 | 4.405E-04 | 7.669E-01 | 2.147E+00 |
| 1836.00 | 2.231E+01 | 5.099E+01 | 9.814E+00 | 5.985E-01 | 1.107E+00 | 1.180E+00 | 1.837E-04 | 4.336E-04 | 4.501E-04 | 6.001E-01 | 1.276E+00 |
| 1846.00 | 2.194E+01 | 5.898E+01 | 6.030E+00 | 5.938E-01 | 1.333E+00 | 8.958E-01 | 2.203E-04 | 4.912E-04 | 4.463E-04 | 5.972E-01 | 1.251E+00 |
| 1846.00 | 7.463E-01 | 1.630E+00 | 1.234E+00 | 5.171E-01 | 1.035E+00 | 6.155E-01 | 2.298E-04 | 5.506E-04 | 4.800E-04 | 5.198E-01 | 1.129E+00 |
| 1860.00 | 1.186E+00 | 3.744E+00 | 8.761E-01 | 1.967E-01 | 7.333E-01 | 4.080E-01 | 2.612E-04 | 6.634E-04 | 6.326E-04 | 1.994E-01 | 7.658E-01 |
| 1874.00 | 4.107E-01 | 1.348E+00 | 1.339E+00 | 2.009E-01 | 6.630E-01 | 5.367E-01 | 2.726E-04 | 7.515E-04 | 7.430E-04 | 2.029E-01 | 6.358E-01 |
| 1884.00 | 2.329E-01 | 1.304E+00 | 1.524E+00 | 3.423E-01 | 1.062E+00 | 1.007E+00 | 2.726E-04 | 7.514E-04 | 7.431E-04 | 3.449E-01 | 9.946E-01 |
| 1894.00 | 1.506E-01 | 1.297E+00 | 1.325E+00 | 4.123E-01 | 1.302E+00 | 1.432E+00 | 2.725E-04 | 7.513E-04 | 7.433E-04 | 4.151E-01 | 1.188E+00 |
| 1904.00 | 8.344E-02 | 1.331E+00 | 1.137E+00 | 4.675E-01 | 1.502E+00 | 1.883E+00 | 2.724E-04 | 7.512E-04 | 7.434E-04 | 4.705E-01 | 1.341E+00 |
| 1914.00 | 6.733E-02 | 1.442E+00 | 9.623E-01 | 5.454E-01 | 1.695E+00 | 2.359E+00 | 2.723E-04 | 7.511E-04 | 7.435E-04 | 5.487E-01 | 1.485E+00 |
| 1924.00 | 6.454E-02 | 1.781E+00 | 7.938E-01 | 6.490E-01 | 1.957E+00 | 2.934E+00 | 2.723E-04 | 7.510E-04 | 7.437E-04 | 6.529E-01 | 1.628E+00 |
| 1934.00 | 8.855E-02 | 2.185E+00 | 6.453E-01 | 8.448E-01 | 2.246E+00 | 3.602E+00 | 2.722E-04 | 7.509E-04 | 7.438E-04 | 8.488E-01 | 2.216E+00 |
| 1943.50 | 3.003E-01 | 3.412E+00 | 1.799E+00 | 1.059E+00 | 2.437E+00 | 4.153E+00 | 2.721E-04 | 7.508E-04 | 7.439E-04 | 1.064E+00 | 2.425E+00 |
| 1943.50 | 6.800E-03 | 3.413E+00 | 1.798E+00 | 1.087E+00 | 2.437E+00 | 4.153E+00 | 2.721E-04 | 7.508E-04 | 7.439E-04 | 1.072E+00 | 2.425E+00 |
| 1944.50 | 2.236E-01 | 5.492E+00 | 5.935E+00 | 5.918E-01 | 2.471E+00 | 4.193E+00 | 2.721E-04 | 7.508E-04 | 7.439E-04 | 5.961E-01 | 2.466E+00 |
| 1945.50 | 9.701E-02 | 7.827E+00 | 1.014E+01 | 1.888E-01 | 2.504E+00 | 4.233E+00 | 2.721E-04 | 7.508E-04 | 7.439E-04 | 1.928E-01 | 2.504E+00 |
| 1946.50 | 4.720E-02 | 1.027E+01 | 1.439E+01 | 5.731E-02 | 2.537E+00 | 4.272E+00 | 2.721E-04 | 7.507E-04 | 7.439E-04 | 5.994E-02 | 2.537E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 4.194E+03 | 5.222E+03 | 6.409E+03 | 7.169E+00 | 5.042E+00 | 1.209E+01 | 2.090E-06 | 6.193E-05 | 4.527E-05 | 1.409E-03 | 2.154E-03 |
| 1432.00 | 4.325E+03 | 1.723E+03 | 3.990E+03 | 8.069E+00 | 4.047E+00 | 1.461E+01 | 1.911E-04 | 7.277E-05 | 9.053E-05 | 1.397E-03 | 2.508E-03 |
| 1490.00 | 3.114E+03 | 3.565E+02 | 2.542E+03 | 6.978E+00 | 2.412E+00 | 1.083E+01 | 3.046E-04 | 1.193E-04 | 9.728E-05 | 1.504E-03 | 2.371E-03 |
| 1550.00 | 1.493E+03 | 4.591E+02 | 6.114E+02 | 4.541E+00 | 2.451E+00 | 7.477E+00 | 3.214E-04 | 1.339E-04 | 1.543E-04 | 1.372E-03 | 2.182E-03 |
| 1550.00 | 6.859E+02 | 3.062E+02 | 6.208E+02 | 2.149E+00 | 1.464E+00 | 7.347E+00 | 3.320E-04 | 1.548E-04 | 1.552E-04 | 6.499E-04 | 2.144E-03 |
| 1610.00 | 4.411E+02 | 1.756E+02 | 2.938E+02 | 1.514E+00 | 1.355E+00 | 5.495E+00 | 3.108E-04 | 1.454E-04 | 1.684E-04 | 6.840E-04 | 2.284E-03 |
| 1670.00 | 3.499E+02 | 2.233E+02 | 1.101E+02 | 1.363E+00 | 1.459E+00 | 4.000E+00 | 2.811E-04 | 1.654E-04 | 1.828E-04 | 9.903E-04 | 2.556E-03 |
| 1730.00 | 9.458E+01 | 1.270E+02 | 4.690E+01 | 7.344E-01 | 1.075E+00 | 2.342E+00 | 2.402E-04 | 2.320E-04 | 2.672E-04 | 9.532E-04 | 2.426E-03 |
| 1790.00 | 9.466E+01 | 1.117E+02 | 4.478E+01 | 4.955E-01 | 1.567E+00 | 2.080E+00 | 2.083E-04 | 3.153E-04 | 3.160E-04 | 8.126E-04 | 2.908E-03 |
| 1836.00 | 1.158E+02 | 6.206E+01 | 1.046E+02 | 7.678E-01 | 2.023E+00 | 1.201E+00 | 1.826E-04 | 4.214E-04 | 3.573E-04 | 4.404E-04 | 2.056E-03 |
| 1836.00 | 2.253E+01 | 2.802E+01 | 4.360E+01 | 6.003E-01 | 1.159E+00 | 1.128E+00 | 1.835E-04 | 4.320E-04 | 4.517E-04 | 4.438E-04 | 1.931E-03 |
| 1846.00 | 2.220E+01 | 4.207E+01 | 4.165E+01 | 5.976E-01 | 1.118E+00 | 1.151E+00 | 2.208E-04 | 4.296E-04 | 5.056E-04 | 3.436E-04 | 2.039E-03 |
| 1846.00 | 7.507E-01 | 8.140E-01 | 1.874E+00 | 5.199E-01 | 1.019E+00 | 6.391E-01 | 2.306E-04 | 5.008E-04 | 5.315E-04 | 3.109E-04 | 1.133E-03 |
| 1860.00 | 1.198E+00 | 3.348E+00 | 1.884E+00 | 1.995E-01 | 7.524E-01 | 3.700E-01 | 2.630E-04 | 6.145E-04 | 6.795E-04 | 2.431E-04 | 6.943E-04 |
| 1874.00 | 4.056E-01 | 1.176E+00 | 1.494E+00 | 2.028E-01 | 6.745E-01 | 5.214E-01 | 2.749E-04 | 7.339E-04 | 7.596E-04 | 5.167E-04 | 9.877E-04 |
| 1884.00 | 2.282E-01 | 1.336E+00 | 1.497E+00 | 3.449E-01 | 1.056E+00 | 1.013E+00 | 2.747E-04 | 7.556E-04 | 7.380E-04 | 8.513E-04 | 1.912E-03 |
| 1894.00 | 1.474E-01 | 1.355E+00 | 1.267E+00 | 4.151E-01 | 1.288E+00 | 1.444E+00 | 2.746E-04 | 7.600E-04 | 7.336E-04 | 1.149E-03 | 2.812E-03 |
| 1904.00 | 8.358E-02 | 1.361E+00 | 1.101E+00 | 4.705E-01 | 1.493E+00 | 1.890E+00 | 2.744E-04 | 7.559E-04 | 7.379E-04 | 1.482E-03 | 3.808E-03 |
| 1914.00 | 7.139E-02 | 1.446E+00 | 9.561E-01 | 5.487E-01 | 1.694E+00 | 2.359E+00 | 2.743E-04 | 7.515E-04 | 7.424E-04 | 1.865E-03 | 4.908E-03 |
| 1924.00 | 6.583E-02 | 1.776E+00 | 8.064E-01 | 6.529E-01 | 1.961E+00 | 2.930E+00 | 2.741E-04 | 7.496E-04 | 7.444E-04 | 1.941E-03 | 6.113E-03 |
| 1934.00 | 9.311E-02 | 2.180E+00 | 6.597E-01 | 8.488E-01 | 2.250E+00 | 3.599E+00 | 2.740E-04 | 7.496E-04 | 7.444E-04 | 2.364E-03 | 9.142E-03 |
| 1943.50 | 2.972E-01 | 3.416E+00 | 1.793E+00 | 1.064E+00 | 2.439E+00 | 4.151E+00 | 2.739E-04 | 7.501E-04 | 7.440E-04 | 3.479E-03 | 1.319E-02 |
| 1943.50 | 9.584E-11 | 3.416E+00 | 1.793E+00 | 1.092E+00 | 2.439E+00 | 4.151E+00 | 2.739E-04 | 7.501E-04 | 7.440E-04 | 3.567E-03 | 1.319E-02 |
| 1944.50 | 2.229E-01 | 5.499E+00 | 5.928E+00 | 5.961E-01 | 2.472E+00 | 4.192E+00 | 2.739E-04 | 7.501E-04 | 7.440E-04 | 2.022E-03 | 1.368E-02 |
| 1945.50 | 9.792E-02 | 7.835E+00 | 1.013E+01 | 1.927E-01 | 2.505E+00 | 4.232E+00 | 2.738E-04 | 7.501E-04 | 7.439E-04 | 7.036E-04 | 1.419E-02 |
| 1946.50 | 4.014E-02 | 1.028E+01 | 1.438E+01 | 5.983E-02 | 2.537E+00 | 4.271E+00 | 2.738E-04 | 7.502E-04 | 7.439E-04 | 2.659E-04 | 1.452E-02 |

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OF POOR QUALITY

GROUP 8 GYRO MASS UNBALANCE

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 9.531E+02 | 4.710E+02 | 5.591E+02 | 1.979E+00 | 1.434E+00 | 9.743E-01 | 1.416E-06 | 1.628E-05 | 1.638E-06 | 1.996E+00 | 9.763E-01 |
| 1432.00 | 9.592E+02 | 2.189E+02 | 2.508E+02 | 2.038E+00 | 1.182E+00 | 1.028E+00 | 1.500E-05 | 2.104E-05 | 6.494E-06 | 2.047E+00 | 9.178E-01 |
| 1490.00 | 7.399E+02 | 1.221E+02 | 1.233E+02 | 1.687E+00 | 8.348E-01 | 1.139E+00 | 3.120E-05 | 3.236E-05 | 2.237E-05 | 1.692E+00 | 9.306E-01 |
| 1550.00 | 5.163E+02 | 8.932E+01 | 1.477E+02 | 1.466E+00 | 9.603E-01 | 9.327E-01 | 4.365E-05 | 4.196E-05 | 3.024E-05 | 1.466E+00 | 8.884E-01 |
| 1550.00 | 2.388E+02 | 6.430E+01 | 1.004E+02 | 7.196E-01 | 7.390E-01 | 7.901E-01 | 4.283E-05 | 5.567E-05 | 3.187E-05 | 7.187E-01 | 6.042E-01 |
| 1610.00 | 1.963E+02 | 6.455E+01 | 7.229E+01 | 7.320E-01 | 6.325E-01 | 7.965E-01 | 6.253E-05 | 6.724E-05 | 4.010E-05 | 7.325E-01 | 7.034E-01 |
| 1670.00 | 1.870F+02 | 6.320E+01 | 9.423E+01 | 7.114E-01 | 6.420E-01 | 1.040E+00 | 6.827E-05 | 7.012E-05 | 6.238E-05 | 7.146E-01 | 6.194E-01 |
| 1730.00 | 3.188E+01 | 3.176E+01 | 2.876E+01 | 3.648E-01 | 5.841E-01 | 6.462E-01 | 6.906E-05 | 1.208E-04 | 1.164E-04 | 3.653E-01 | 5.790E-01 |
| 1790.00 | 5.097E+01 | 4.602E+01 | 1.765E+01 | 3.114E-01 | 7.907E-01 | 8.502E-01 | 6.374E-05 | 1.308E-04 | 1.804E-04 | 3.099E-01 | 9.646E-01 |
| 1836.00 | 6.235E+01 | 4.603E+01 | 2.612E+01 | 3.539E-01 | 8.964E-01 | 9.698E-01 | 5.992E-05 | 1.558E-04 | 2.477E-04 | 3.527E-01 | 9.135E-01 |
| 1836.00 | 1.423E+01 | 3.296E+01 | 5.871E+00 | 2.690E-01 | 8.794E-01 | 5.993E-01 | 5.966E-05 | 1.925E-04 | 2.532E-04 | 2.706E-01 | 5.287E-01 |
| 1846.00 | 1.589E+01 | 4.345E+01 | 4.269E+00 | 2.870E-01 | 1.015E+00 | 4.661E-01 | 7.726E-05 | 2.426E-04 | 2.481E-04 | 2.900E-01 | 6.421E-01 |
| 1846.00 | 4.088E-01 | 1.197E+00 | 5.727E-01 | 2.287E-01 | 7.179E-01 | 2.650E-01 | 8.728E-05 | 2.839E-04 | 2.777E-04 | 2.307E-01 | 5.917E-01 |
| 1860.00 | 1.012E+00 | 2.497E+00 | 2.857E-01 | 1.387E-01 | 4.615E-01 | 1.881E-01 | 1.094E-04 | 3.452E-04 | 3.739E-04 | 1.406E-01 | 4.358E-01 |
| 1874.00 | 3.932E-01 | 6.121E-01 | 4.502E-01 | 1.239E-01 | 3.391E-01 | 2.643E-01 | 1.076E-04 | 3.921E-04 | 4.417E-04 | 1.252E-01 | 3.319E-01 |
| 1884.00 | 1.880E-01 | 1.029E+00 | 6.427E-01 | 1.903E-01 | 5.502E-01 | 4.891E-01 | 1.077E-04 | 3.921E-04 | 4.417E-04 | 1.923E-01 | 5.476E-01 |
| 1894.00 | 1.517E-01 | 9.968E-01 | 5.512E-01 | 2.107E-01 | 7.146E-01 | 6.835E-01 | 1.079E-04 | 3.921E-04 | 4.417E-04 | 2.130E-01 | 6.980E-01 |
| 1904.00 | 1.252E-01 | 9.693E-01 | 4.671E-01 | 2.212E-01 | 8.728E-01 | 8.877E-01 | 1.080E-04 | 3.921E-04 | 4.416E-04 | 2.236E-01 | 8.282E-01 |
| 1914.00 | 1.023E-01 | 9.413E-01 | 3.924E-01 | 2.420E-01 | 1.026F+00 | 1.100E+00 | 1.082E-04 | 3.921E-04 | 4.416E-04 | 2.444E-01 | 9.453E-01 |
| 1924.00 | 8.128E-02 | 9.500E-01 | 3.238E-01 | 2.786E-01 | 1.218E+00 | 1.362E+00 | 1.083E-04 | 3.921E-04 | 4.415E-04 | 2.811E-01 | 1.169E+00 |
| 1934.00 | 6.574E-02 | 1.014E+00 | 2.653E-01 | 3.524E-01 | 1.427E+00 | 1.642E+00 | 1.085E-04 | 3.922E-04 | 4.415E-04 | 3.541E-01 | 1.413E+00 |
| 1943.50 | 1.297E-01 | 1.473E+00 | 7.083E-01 | 4.453E-01 | 1.568E+00 | 1.864E+00 | 1.086E-04 | 3.922E-04 | 4.415E-04 | 4.464E-01 | 1.562E+00 |
| 1943.50 | 2.880F-03 | 1.474E+00 | 7.080E-01 | 4.561E-01 | 1.568E+00 | 1.864E+00 | 1.086E-04 | 3.922E-04 | 4.415E-04 | 4.573E-01 | 1.562E+00 |
| 1944.50 | 9.479E-02 | 2.764E+00 | 2.579E+00 | 2.489E-01 | 1.590E+00 | 1.880E+00 | 1.086E-04 | 3.922E-04 | 4.415E-04 | 2.500E-01 | 1.586E+00 |
| 1945.50 | 4.367E-02 | 4.275E+00 | 4.467E+00 | 8.058E-02 | 1.611E+00 | 1.896E+00 | 1.086E-04 | 3.922E-04 | 4.415E-04 | 8.123E-02 | 1.609E+00 |
| 1946.50 | 2.697E-02 | 5.855E+00 | 6.371E+00 | 2.669E-02 | 1.632E+00 | 1.912E+00 | 1.086E-04 | 3.922E-04 | 4.415E-04 | 2.594E-02 | 1.630E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 9.487E+02 | 5.012E+02 | 5.400E+02 | 1.954E+00 | 1.021E+00 | 1.435E+00 | 8.632E-07 | 1.294E-05 | 1.007E-05 | 3.299E-04 | 2.190E-04 |
| 1432.00 | 9.553E+02 | 1.582E+02 | 3.055E+02 | 2.009E+00 | 9.750E-01 | 1.273E+00 | 1.444E-05 | 1.931E-05 | 1.134E-05 | 3.388E-04 | 1.995E-04 |
| 1490.00 | 7.363E+02 | 1.430E+02 | 1.227E+02 | 1.661E+00 | 1.024E+00 | 1.015E+00 | 3.044E-05 | 3.494E-05 | 1.932E-05 | 3.686E-04 | 2.136E-04 |
| 1550.00 | 5.143E+02 | 1.118E+02 | 1.392E+02 | 1.451E+00 | 9.811F-01 | 9.343E-01 | 4.306E-05 | 4.485E-05 | 2.674E-05 | 4.404E-04 | 2.676E-04 |
| 1550.00 | 2.379E+02 | 5.823E+01 | 1.061E+02 | 7.117E-01 | 6.387E-01 | 8.796E-01 | 4.227E-05 | 5.387E-05 | 3.552E-05 | 2.159E-04 | 2.520E-04 |
| 1610.00 | 1.957F+02 | 7.444E+01 | 6.390E+01 | 7.268E-01 | 7.784F-01 | 6.604E-01 | 6.213E-05 | 5.883E-05 | 5.214E-05 | 3.317E-04 | 2.725E-04 |
| 1670.00 | 1.867E+02 | 9.731E+01 | 5.928E+01 | 7.089E-01 | 9.275E-01 | 7.978E-01 | 6.812E-05 | 7.011E-05 | 6.256E-05 | 5.285E-04 | 5.088E-04 |
| 1730.00 | 3.189E+01 | 3.444E+01 | 2.547E+01 | 3.652E-01 | 6.774E-01 | 5.473E-01 | 6.921E-05 | 9.769E-05 | 1.363E-04 | 4.839E-04 | 5.667E-04 |
| 1790.00 | 5.079E+01 | 3.449E+01 | 3.547E+01 | 3.106E-01 | 9.650F-01 | 6.461E-01 | 6.419E-05 | 1.289E-04 | 1.616E-04 | 4.198E-04 | 9.030E-04 |
| 1836.00 | 6.213E+01 | 2.875E+01 | 4.475E+01 | 3.529E-01 | 8.669E-01 | 9.967E-01 | 6.056E-05 | 2.540E-04 | 1.450E-04 | 3.308E-04 | 1.706E-03 |
| 1836.00 | 1.437E+01 | 1.769E+01 | 2.835E+01 | 2.707E-01 | 5.010E-01 | 9.384E-01 | 6.045E-05 | 2.630E-04 | 1.786E-04 | 3.433E-04 | 1.606E-03 |
| 1846.00 | 1.608E+01 | 3.104E+01 | 3.061E+01 | 2.905E-01 | 5.831E-01 | 9.511E-01 | 7.828E-05 | 2.703E-04 | 2.172E-04 | 1.845E-04 | 1.685E-03 |
| 1846.00 | 4.133E-01 | 6.026E-01 | 1.180E+00 | 2.307E-01 | 5.535F-01 | 5.277E-01 | 8.842E-05 | 3.233E-04 | 2.302E-04 | 1.631E-04 | 9.353E-04 |
| 1860.00 | 1.021E+00 | 2.339E+00 | 9.072E-01 | 1.407E-01 | 4.170E-01 | 2.719E-01 | 1.107E-04 | 3.901E-04 | 3.262E-04 | 1.071E-04 | 5.102E-04 |
| 1874.00 | 3.915F-01 | 5.525E-01 | 5.229E-01 | 1.252E-01 | 3.318E-01 | 2.729E-01 | 1.090E-04 | 4.066E-04 | 4.281E-04 | 2.128E-04 | 5.170E-04 |
| 1884.00 | 1.868E-01 | 1.046E+00 | 6.152E-01 | 1.922E-01 | 5.530E-01 | 4.853E-01 | 1.091E-04 | 3.878E-04 | 4.451E-04 | 3.559E-04 | 9.160E-04 |
| 1894.00 | 1.517E-01 | 1.025E+00 | 4.972E-01 | 2.129E-01 | 7.239E-01 | 6.730E-01 | 1.091E-04 | 3.842E-04 | 4.483E-04 | 5.055E-04 | 1.311E-03 |
| 1904.00 | 1.262E-01 | 9.834E-01 | 4.363E-01 | 2.236E-01 | 8.805E-01 | 8.794E-01 | 1.092E-04 | 3.875E-04 | 4.454E-04 | 6.861E-04 | 1.772E-03 |
| 1914.00 | 1.035E-01 | 9.431E-01 | 3.879E-01 | 2.444E-01 | 1.027F+00 | 1.099E+00 | 1.093E-04 | 3.913E-04 | 4.421E-04 | 8.932E-04 | 2.286E-03 |
| 1924.00 | 8.108E-02 | 9.474E-01 | 3.311E-01 | 2.810E-01 | 1.216F+00 | 1.364E+00 | 1.093E-04 | 3.928E-04 | 4.407E-04 | 8.798E-04 | 2.845E-03 |
| 1934.00 | 6.651E-02 | 1.012E+00 | 2.723E-01 | 3.541E-01 | 1.424E+00 | 1.644E+00 | 1.094F-04 | 3.927E-04 | 4.408E-04 | 9.991E-04 | 4.176E-03 |
| 1943.50 | 1.287E-01 | 1.475E+00 | 7.054E-01 | 4.464E-01 | 1.567E+00 | 1.864E+00 | 1.095E-04 | 3.923E-04 | 4.411E-04 | 1.472E-03 | 5.925E-03 |
| 1943.50 | 4.151E-11 | 1.475E+00 | 7.054E-01 | 4.573E-01 | 1.567E+00 | 1.864E+00 | 1.095E-04 | 3.923E-04 | 4.411F-04 | 1.505E-03 | 5.925E-03 |
| 1944.50 | 9.341E-02 | 2.765E+00 | 2.578E+00 | 2.499E-01 | 1.588E+00 | 1.881E+00 | 1.095E-04 | 3.923E-04 | 4.412E-04 | 8.571E-04 | 6.139E-03 |
| 1945.50 | 4.114E-02 | 4.275E+00 | 4.467E+00 | 8.118E-02 | 1.610E+00 | 1.897E+00 | 1.095E-04 | 3.922E-04 | 4.412E-04 | 3.055E-04 | 6.362E-03 |
| 1946.50 | 1.706E-02 | 5.854E+00 | 6.372E+00 | 2.588E-02 | 1.630E+00 | 1.914E+00 | 1.095E-04 | 3.922E-04 | 4.412E-04 | 1.283E-04 | 6.503E-03 |

GROUP 9 GYRO ANISOPLASTICITY

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 5.209E+01 | 1.144E+02 | 9.930E+01 | 2.347E-01 | 3.636E-01 | 2.657E-01 | 7.919E-08 | 9.484E-07 | 1.041E-07 | 2.625E-01 | 1.891E-01 |
| 1432.00 | 5.459E+01 | 4.708E+01 | 3.063E+01 | 2.902E-01 | 2.938E-01 | 2.727E-01 | 2.777E-06 | 2.291E-06 | 9.309E-07 | 2.897E-01 | 1.812E-01 |
| 1490.00 | 4.767E+01 | 1.954E+01 | 3.074E+01 | 2.823E-01 | 2.293E-01 | 2.973E-01 | 6.329E-06 | 4.154E-06 | 3.448E-06 | 2.810E-01 | 1.279E-01 |
| 1550.00 | 5.844E+01 | 2.375E+01 | 2.423E+01 | 3.098E-01 | 2.961E-01 | 2.151E-01 | 1.129E-05 | 7.255E-06 | 5.577E-06 | 3.096E-01 | 2.360E-01 |
| 1550.00 | 2.722E+01 | 2.031E+01 | 2.394E+01 | 2.152E-01 | 2.629E-01 | 2.099E-01 | 1.185E-05 | 8.231E-06 | 6.969E-06 | 2.147E-01 | 2.001E-01 |
| 1610.00 | 2.765E+01 | 1.461E+01 | 1.499E+01 | 2.363E-01 | 1.817E-01 | 1.717E-01 | 1.925E-05 | 1.221E-05 | 1.001E-05 | 2.362E-01 | 1.429E-01 |
| 1670.00 | 2.942E+01 | 1.008E+01 | 1.597E+01 | 2.123E-01 | 1.751E-01 | 1.859E-01 | 2.121E-05 | 1.364E-05 | 1.696E-05 | 2.126E-01 | 1.700E-01 |
| 1730.00 | 7.916E+00 | 4.563E+00 | 7.973E+00 | 1.132E-01 | 1.649E-01 | 1.296E-01 | 2.054E-05 | 2.100E-05 | 3.034E-05 | 1.136E-01 | 1.071E-01 |
| 1790.00 | 6.467E+00 | 6.799E+00 | 4.668E+00 | 5.132E-02 | 2.077E-01 | 1.446E-01 | 1.846E-05 | 2.353E-05 | 5.007E-05 | 5.223E-02 | 1.859E-01 |
| 1836.00 | 7.857E+00 | 6.898E+00 | 7.395E+00 | 7.777E-02 | 2.368E-01 | 1.767E-01 | 1.664E-05 | 2.791E-05 | 6.854E-05 | 7.846E-02 | 2.027E-01 |
| 1836.00 | 2.510E+00 | 6.010E+00 | 1.020E+00 | 8.544E-02 | 2.207E-01 | 1.151E-01 | 1.653E-05 | 3.322E-05 | 7.052E-05 | 8.639E-02 | 1.304E-01 |
| 1846.00 | 3.151E+00 | 8.250E+00 | 9.390E-01 | 9.322E-02 | 2.579E-01 | 7.925E-02 | 1.967E-05 | 4.355E-05 | 6.971E-05 | 9.421E-02 | 1.899E-01 |
| 1846.00 | 1.222E-01 | 2.023E-01 | 1.062E-01 | 7.193E-02 | 1.988E-01 | 6.252E-02 | 2.108E-05 | 4.940E-05 | 7.614E-05 | 7.271E-02 | 1.762E-01 |
| 1860.00 | 2.311E-01 | 6.547E-01 | 8.592E-02 | 3.902E-02 | 1.268E-01 | 3.691E-02 | 2.473E-05 | 6.010E-05 | 1.042E-04 | 3.952E-02 | 1.255E-01 |
| 1874.00 | 3.540E-02 | 1.332E-01 | 8.926E-02 | 2.341E-02 | 9.358E-02 | 4.476E-02 | 2.532E-05 | 6.819E-05 | 1.235E-04 | 2.372E-02 | 9.113E-02 |
| 1884.00 | 3.126E-02 | 2.404E-01 | 1.198E-01 | 3.236E-02 | 1.526E-01 | 8.113E-02 | 2.533E-05 | 6.819E-05 | 1.235E-04 | 3.274E-02 | 1.451E-01 |
| 1894.00 | 3.197E-02 | 2.303E-01 | 1.032E-01 | 3.508E-02 | 1.975E-01 | 1.121E-01 | 2.533E-05 | 6.818E-05 | 1.235E-04 | 3.542E-02 | 1.822E-01 |
| 1904.00 | 2.921E-02 | 2.177E-01 | 8.774E-02 | 3.865E-02 | 2.397E-01 | 1.449E-01 | 2.534E-05 | 6.817E-05 | 1.235E-04 | 3.886E-02 | 2.169E-01 |
| 1914.00 | 2.169E-02 | 2.007E-01 | 7.377E-02 | 4.663E-02 | 2.798E-01 | 1.794E-01 | 2.535E-05 | 6.816E-05 | 1.235E-04 | 4.668E-02 | 2.487E-01 |
| 1924.00 | 1.244E-02 | 1.907E-01 | 6.072E-02 | 5.825E-02 | 3.304E-01 | 2.221E-01 | 2.535E-05 | 6.816E-05 | 1.235E-04 | 5.821E-02 | 3.116E-01 |
| 1934.00 | 1.454E-02 | 2.099E-01 | 4.949E-02 | 8.516E-02 | 3.844E-01 | 2.657E-01 | 2.536E-05 | 6.815E-05 | 1.235E-04 | 8.491E-02 | 3.600E-01 |
| 1943.50 | 2.467E-02 | 3.947E-01 | 1.107E-01 | 1.160E-01 | 4.196E-01 | 3.005E-01 | 2.536E-05 | 6.814E-05 | 1.235E-04 | 1.156E-01 | 4.178E-01 |
| 1943.50 | 7.726E-04 | 3.947E-01 | 1.107E-01 | 1.181E-01 | 4.196E-01 | 3.005E-01 | 2.536E-05 | 6.814E-05 | 1.235E-04 | 1.178E-01 | 4.178E-01 |
| 1944.50 | 2.524E-02 | 7.790E-01 | 4.118E-01 | 6.506E-02 | 4.256E-01 | 3.028E-01 | 2.537E-05 | 6.814E-05 | 1.235E-04 | 6.471E-02 | 4.249E-01 |
| 1945.50 | 1.240E-02 | 1.196E+00 | 7.155E-01 | 2.178E-02 | 4.316E-01 | 3.051E-01 | 2.537E-05 | 6.814E-05 | 1.235E-04 | 2.138E-02 | 4.315E-01 |
| 1946.50 | 7.338E-03 | 1.624E+00 | 1.022E+00 | 7.690E-03 | 4.374E-01 | 3.073E-01 | 2.537E-05 | 6.814E-05 | 1.235E-04 | 7.156E-03 | 4.374E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 4.947E+01 | 1.298E+02 | 7.971E+01 | 2.264E-01 | 1.971E-01 | 4.096E-01 | 6.875E-08 | 7.480E-07 | 5.936E-07 | 4.400E-05 | 6.461E-05 |
| 1432.00 | 5.387E+01 | 2.825E+01 | 4.935E+01 | 2.825E-01 | 1.911E-01 | 3.586E-01 | 2.773E-06 | 1.806E-06 | 1.697E-06 | 4.838E-05 | 5.701E-05 |
| 1490.00 | 4.744E+01 | 1.216E+01 | 3.466E+01 | 2.788E-01 | 1.415E-01 | 3.506E-01 | 6.270E-06 | 3.413E-06 | 4.270E-06 | 6.068E-05 | 7.340E-05 |
| 1550.00 | 5.820E+01 | 1.972E+01 | 2.812E+01 | 3.068E-01 | 2.542E-01 | 2.667E-01 | 1.119E-05 | 7.224E-06 | 9.804E-06 | 9.341E-05 | 7.622E-05 |
| 1550.00 | 2.709E+01 | 1.396E+01 | 2.824E+01 | 2.131E-01 | 2.112E-01 | 2.636E-01 | 1.176E-05 | 7.718E-06 | 7.673E-06 | 6.499E-05 | 7.532E-05 |
| 1610.00 | 2.757E+01 | 1.096E+01 | 1.797E+01 | 2.351E-01 | 1.701E-01 | 1.848E-01 | 1.916E-05 | 1.243E-05 | 9.919E-06 | 1.044E-04 | 7.613E-05 |
| 1670.00 | 2.937E+01 | 1.512E+01 | 1.144E+01 | 2.118E-01 | 2.046E-01 | 1.535E-01 | 2.117E-05 | 1.610E-05 | 1.470E-05 | 1.524E-04 | 9.785E-05 |
| 1730.00 | 7.914E+00 | 6.070E+00 | 6.897E+00 | 1.135E-01 | 1.641E-01 | 1.304E-01 | 2.056E-05 | 2.272E-05 | 2.905E-05 | 1.606E-04 | 1.349E-04 |
| 1790.00 | 6.443E+00 | 4.911E+00 | 6.649E+00 | 5.217E-02 | 2.059E-01 | 1.469E-01 | 1.855E-05 | 3.377E-05 | 4.378E-05 | 1.366E-04 | 2.052E-04 |
| 1836.00 | 7.828E+00 | 8.170E+00 | 5.997E+00 | 7.869E-02 | 1.928E-01 | 2.236E-01 | 1.678E-05 | 6.554E-05 | 3.430E-05 | 7.725E-05 | 3.825E-04 |
| 1836.00 | 2.536E+00 | 3.178E+00 | 5.189E+00 | 8.647E-02 | 1.188E-01 | 2.183E-01 | 1.669E-05 | 6.667E-05 | 4.033E-05 | 1.097E-04 | 3.736E-04 |
| 1846.00 | 3.186E+00 | 5.987E+00 | 5.734E+00 | 9.436E-02 | 1.690E-01 | 2.099E-01 | 1.988E-05 | 5.996E-05 | 5.615E-05 | 6.196E-05 | 3.719E-04 |
| 1846.00 | 1.230E-01 | 1.478E-01 | 1.737E-01 | 7.271E-02 | 1.614E-01 | 1.315E-01 | 2.131E-05 | 6.941E-05 | 5.840E-05 | 2.794E-05 | 2.331E-04 |
| 1860.00 | 2.336E-01 | 6.186E-01 | 2.283E-01 | 3.953E-02 | 1.200E-01 | 5.481E-02 | 2.501E-05 | 7.323E-05 | 9.535E-05 | 2.604E-05 | 1.029E-04 |
| 1874.00 | 3.535E-02 | 1.210E-01 | 1.052E-01 | 2.372E-02 | 9.382E-02 | 4.408E-02 | 2.565E-05 | 6.960E-05 | 1.225E-04 | 5.549E-05 | 8.350E-05 |
| 1884.00 | 3.225E-02 | 2.425E-01 | 1.153E-01 | 3.274E-02 | 1.521E-01 | 8.193E-02 | 2.564E-05 | 6.806E-05 | 1.235E-04 | 9.698E-05 | 1.547E-04 |
| 1894.00 | 3.288E-02 | 2.339E-01 | 9.442E-02 | 3.541E-02 | 1.962E-01 | 1.142E-01 | 2.563E-05 | 6.819E-05 | 1.234E-04 | 1.441E-04 | 2.224E-04 |
| 1904.00 | 3.001E-02 | 2.197E-01 | 8.243E-02 | 3.886E-02 | 2.391E-01 | 1.460E-01 | 2.562E-05 | 6.806E-05 | 1.235E-04 | 1.983E-04 | 2.941E-04 |
| 1914.00 | 2.237E-02 | 2.009E-01 | 7.291E-02 | 4.668E-02 | 2.798E-01 | 1.794E-01 | 2.561E-05 | 6.808E-05 | 1.235E-04 | 2.593E-04 | 3.733E-04 |
| 1924.00 | 1.279E-02 | 1.902E-01 | 6.215E-02 | 5.821E-02 | 3.306E-01 | 2.217E-01 | 2.561E-05 | 6.813E-05 | 1.235E-04 | 2.516E-04 | 4.626E-04 |
| 1934.00 | 1.491E-02 | 2.095E-01 | 5.095E-02 | 8.490E-02 | 3.847E-01 | 2.654E-01 | 2.560E-05 | 6.613E-05 | 1.235E-04 | 2.635E-04 | 6.740E-04 |
| 1943.50 | 2.409E-02 | 3.950E-01 | 1.098E-01 | 1.156E-01 | 4.195E-01 | 3.003E-01 | 2.560E-05 | 6.810E-05 | 1.235E-04 | 3.904E-04 | 9.543E-04 |
| 1943.50 | 7.770E-12 | 3.950E-01 | 1.098E-01 | 1.178E-01 | 4.198E-01 | 3.003E-01 | 2.560E-05 | 6.810E-05 | 1.235E-04 | 3.970E-04 | 9.543E-04 |
| 1944.50 | 2.413E-02 | 7.795E-01 | 4.109E-01 | 6.470E-02 | 4.258E-01 | 3.026E-01 | 2.560E-05 | 6.810E-05 | 1.235E-04 | 2.288E-04 | 9.876E-04 |
| 1945.50 | 1.073E-02 | 1.196E+00 | 7.147E-01 | 2.136E-02 | 4.317E-01 | 3.050E-01 | 2.560E-05 | 6.810E-05 | 1.235E-04 | 8.457E-05 | 1.023E-03 |
| 1946.50 | 4.585E-03 | 1.625E+00 | 1.021E+00 | 7.135E-03 | 4.375E-01 | 3.072E-01 | 2.560E-05 | 6.810E-05 | 1.235E-04 | 3.725E-05 | 1.044E-03 |

# GROUP 10 TACAN RANGE BIAS

| TIME | POSITION ESTIMATE ERROR R | POSITION ESTIMATE ERROR D | POSITION ESTIMATE ERROR C | VELOCITY ESTIMATE ERROR R | VELOCITY ESTIMATE ERROR D | VELOCITY ESTIMATE ERROR C | PLATFORM TILT ESTIMATE R | PLATFORM TILT ESTIMATE D | PLATFORM TILT ESTIMATE C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1432.00 | 1.193E+01 | 2.077E+02 | 2.391E+02 | 1.632E-01 | 1.786E-01 | 8.467E-02 | 6.174E-06 | 4.445E-06 | 1.448E-06 | 7.539E-02 | 7.091E-02 |
| 1490.00 | 9.554E+02 | 6.465E+02 | 7.432E+02 | 2.737E+00 | 3.227E+00 | 2.462E+00 | 9.147E-05 | 6.498E-05 | 7.859E-05 | 2.717E+00 | 2.991E+00 |
| 1550.00 | 1.644E+03 | 1.028E+03 | 8.857E+02 | 3.654E+00 | 3.394E+00 | 4.487E+00 | 1.924E-04 | 8.727E-05 | 1.106E-04 | 3.749E+00 | 2.815E+00 |
| 1550.00 | 7.491E+02 | 9.218E+02 | 1.013E+03 | 1.437E+00 | 4.164E+00 | 4.105E+00 | 2.083E-04 | 9.403E-05 | 1.464E-04 | 1.483E+00 | 3.390E+00 |
| 1610.00 | 1.411E+03 | 7.082E+02 | 6.273E+02 | 4.193E+00 | 5.782E+00 | 4.657E+00 | 2.875E-04 | 1.370E-04 | 1.308E-04 | 4.235E+00 | 2.694E+00 |
| 1670.00 | 1.059E+03 | 4.584E+02 | 5.783E+02 | 3.212E+00 | 3.855E+00 | 4.068E+00 | 2.301E-04 | 1.200E-04 | 2.672E-04 | 3.243E+00 | 2.280E+00 |
| 1730.00 | 7.761E+02 | 2.077E+02 | 5.004E+02 | 1.512E+00 | 2.824E+00 | 4.346E+00 | 2.189E-04 | 2.707E-04 | 4.405E-04 | 1.510E+00 | 1.267E+00 |
| 1790.00 | 5.897E+02 | 2.375E+02 | 1.778E+02 | 1.574E+00 | 2.420E+00 | 2.733E+00 | 2.156E-04 | 1.863E-04 | 5.395E-04 | 1.580E+00 | 1.622E+00 |
| 1836.00 | 5.489E+02 | 2.737E+02 | 1.545E+02 | 1.350E+00 | 2.283E+00 | 2.061E+00 | 2.173E-04 | 1.910E-04 | 5.632E-04 | 1.353E+00 | 2.070E+00 |
| 1836.00 | 1.080E+02 | 2.749E+02 | 4.970E+01 | 1.290E+00 | 2.216E+00 | 1.824E+00 | 2.204E-04 | 3.297E-04 | 5.785E-04 | 1.291E+00 | 1.874E+00 |
| 1846.00 | 1.105E+02 | 2.845E+02 | 3.202E+01 | 6.621E-01 | 2.180E+00 | 1.646E+00 | 2.591E-04 | 3.021E-04 | 5.605E-04 | 6.672E-01 | 1.540E+00 |
| 1846.00 | 5.298E+00 | 6.718E+00 | 1.670E+00 | 5.695E-01 | 1.748E+00 | 6.930E-01 | 2.661E-04 | 2.493E-04 | 4.984E-04 | 5.758E-01 | 1.515E+00 |
| 1860.00 | 2.601E+00 | 5.151E+00 | 1.811E+00 | 3.991E-01 | 7.912E-01 | 2.210E-01 | 2.649E-04 | 3.168E-04 | 5.756E-04 | 4.020E-01 | 8.081E-01 |
| 1874.00 | 2.443E+00 | 7.006E+00 | 1.958E+00 | 1.872E-01 | 3.656E-01 | 1.951E-01 | 2.797E-04 | 3.649E-04 | 6.641E-04 | 1.884E-01 | 3.614E-01 |
| 1884.00 | 2.474E+00 | 7.682E+00 | 1.842E+00 | 2.235E-01 | 5.655E-01 | 3.508E-01 | 2.820E-04 | 3.666E-04 | 6.719E-04 | 2.251E-01 | 5.619E-01 |
| 1894.00 | 2.258E+00 | 7.714E+00 | 1.608E+00 | 2.369E-01 | 7.318E-01 | 4.894E-01 | 2.843E-04 | 3.682E-04 | 6.797E-04 | 2.385E-01 | 6.990E-01 |
| 1904.00 | 1.962E+00 | 7.766E+00 | 1.384E+00 | 2.481E-01 | 8.957E-01 | 6.370E-01 | 2.866E-04 | 3.699E-04 | 6.874E-04 | 2.496E-01 | 8.325E-01 |
| 1914.00 | 1.480E+00 | 7.827E+00 | 1.175E+00 | 2.695E-01 | 1.054E+00 | 7.928E-01 | 2.888E-04 | 3.716E-04 | 6.949E-04 | 2.707E-01 | 9.575E-01 |
| 1924.00 | 6.456E-01 | 7.869E+00 | 9.744E-01 | 3.034E-01 | 1.253E+00 | 9.834E-01 | 2.911E-04 | 3.732E-04 | 7.024E-04 | 3.045E-01 | 1.195E+00 |
| 1934.00 | 3.243E-01 | 7.922E+00 | 7.919E-01 | 3.870E-01 | 1.467E+00 | 1.197E+00 | 2.933E-04 | 3.748E-04 | 7.098E-04 | 3.874E-01 | 1.453E+00 |
| 1943.50 | 1.224E-01 | 7.747E+00 | 7.849E-01 | 4.945E-01 | 1.606E+00 | 1.371E+00 | 2.954E-04 | 3.764E-04 | 7.168E-04 | 4.904E-01 | 1.601E+00 |
| 1943.50 | 1.748E-02 | 7.747E+00 | 7.848E-01 | 5.025E-01 | 1.606E+00 | 1.371E+00 | 2.954E-04 | 3.764E-04 | 7.168E-04 | 5.025E-01 | 1.600E+00 |
| 1944.50 | 1.111E-01 | 7.693E+00 | 1.954E+00 | 2.754E-01 | 1.630E+00 | 1.363E+00 | 2.956E-04 | 3.766E-04 | 7.175E-04 | 2.753E-01 | 1.628E+00 |
| 1945.50 | 5.488E-02 | 7.981E+00 | 3.300E+00 | 9.042E-02 | 1.655E+00 | 1.395E+00 | 2.959E-04 | 3.767E-04 | 7.183E-04 | 9.010E-02 | 1.654E+00 |
| 1946.50 | 3.139E-02 | 8.592E+00 | 4.683E+00 | 3.045E-02 | 1.678E+00 | 1.407E+00 | 2.961E-04 | 3.769E-04 | 7.190E-04 | 2.940E-02 | 1.678E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.634E-14 | 1.635E-14 |
| 1432.00 | 2.494E+01 | 3.143E+02 | 3.139E+01 | 1.668E-01 | 6.492E-02 | 1.835E-01 | 6.279E-06 | 1.979E-06 | 4.079E-06 | 1.191E-05 | 3.095E-05 |
| 1490.00 | 9.508E+02 | 4.329E+02 | 8.897E+02 | 2.687E+00 | 3.099E+00 | 2.673E+00 | 8.967E-05 | 7.219E-05 | 7.425E-05 | 5.986E-04 | 5.558E-04 |
| 1550.00 | 1.638E+03 | 8.181E+02 | 1.092E+03 | 3.635E+00 | 2.876E+00 | 4.878E+00 | 1.908E-04 | 9.643E-05 | 1.057E-04 | 1.084E-03 | 1.430E-03 |
| 1550.00 | 7.462E+02 | 6.735E+02 | 1.194E+03 | 1.412E+00 | 3.423E+00 | 4.748E+00 | 2.068E-04 | 9.209E-05 | 1.498E-04 | 4.485E-04 | 1.391E-03 |
| 1610.00 | 1.407E+03 | 6.505E+02 | 6.949E+02 | 4.174E+00 | 3.120E+00 | 6.749E+00 | 2.865E-04 | 1.531E-04 | 1.144E-04 | 1.862E-03 | 2.600E-03 |
| 1670.00 | 1.058E+03 | 5.987E+02 | 4.346E+02 | 3.209E+00 | 2.697E+00 | 4.914E+00 | 2.300E-04 | 1.575E-04 | 2.471E-04 | 2.241E-03 | 3.142E-03 |
| 1730.00 | 7.756E+02 | 2.280E+02 | 4.922E+02 | 1.510E+00 | 1.534E+00 | 4.952E+00 | 2.191E-04 | 3.300E-04 | 3.980E-04 | 1.657E-03 | 5.125E-03 |
| 1790.00 | 5.896E+02 | 1.747E+02 | 2.401E+02 | 1.578E+00 | 1.878E+00 | 3.129E+00 | 2.156E-04 | 3.084E-04 | 4.603E-04 | 2.480E-03 | 4.370E-03 |
| 1836.00 | 5.490E+02 | 1.756E+02 | 2.604E+02 | 1.355E+00 | 2.249E+00 | 7.095E+00 | 2.168E-04 | 5.438E-04 | 2.412E-04 | 2.622E-03 | 3.585E-03 |
| 1836.00 | 1.092E+02 | 1.482E+02 | 2.362E+02 | 1.293E+00 | 1.866E+00 | 2.179E+00 | 2.194E-04 | 5.437E-04 | 3.849E-04 | 2.074E-03 | 3.728E-03 |
| 1846.00 | 1.117E+02 | 2.070E+02 | 1.972E+02 | 6.713E-01 | 1.533E+00 | 2.259E+00 | 2.584E-04 | 5.063E-04 | 3.666E-04 | 1.086E-03 | 4.000E-03 |
| 1846.00 | 5.329E+00 | 3.856E+00 | 5.720E+00 | 5.757E-01 | 1.448E+00 | 1.196E+00 | 2.654E-04 | 4.046E-04 | 3.837E-04 | 6.138E-04 | 2.121E-03 |
| 1860.00 | 2.607E+00 | 4.676E+00 | 2.814E+00 | 4.020E-01 | 7.374E-01 | 3.589E-01 | 2.846E-04 | 3.773E-04 | 5.381E-04 | 3.976E-04 | 6.736E-04 |
| 1874.00 | 2.460E+00 | 6.896E+00 | 2.299E+00 | 1.882E-01 | 3.659E-01 | 1.934E-01 | 2.794E-04 | 3.695E-04 | 6.617E-04 | 2.636E-04 | 3.664E-04 |
| 1884.00 | 2.496E+00 | 7.686E+00 | 1.794E+00 | 2.249E-01 | 5.636E-01 | 3.530E-01 | 2.817E-04 | 3.674E-04 | 6.716E-04 | 3.950E-04 | 6.662E-04 |
| 1894.00 | 2.280E+00 | 7.714E+00 | 1.577E+00 | 2.383E-01 | 7.270E-01 | 4.958E-01 | 2.840E-04 | 3.711E-04 | 6.782E-04 | 5.525E-04 | 9.655E-04 |
| 1904.00 | 1.984E+00 | 7.764E+00 | 1.364E+00 | 2.495E-01 | 8.927E-01 | 6.407E-01 | 2.863E-04 | 3.710E-04 | 6.869E-04 | 7.494E-04 | 1.291E-03 |
| 1914.00 | 1.500E+00 | 7.824E+00 | 1.170E+00 | 2.706E-01 | 1.053E+00 | 7.930E-01 | 2.885E-04 | 3.715E-04 | 6.951E-04 | 9.783E-04 | 1.650E-03 |
| 1924.00 | 6.616E-01 | 7.867E+00 | 9.833E-01 | 3.044E-01 | 1.254E+00 | 9.818E-01 | 2.908E-04 | 3.730E-04 | 7.027E-04 | 9.843E-04 | 2.046E-03 |
| 1930.00 | 3.391E-01 | 7.921E+00 | 7.984E-01 | 3.873E-01 | 1.468E+00 | 1.195E+00 | 2.930E-04 | 3.747E-04 | 7.101E-04 | 1.118E-03 | 3.035E-03 |
| 1943.50 | 1.237E-01 | 7.748E+00 | 7.788E-01 | 4.944E-01 | 1.608E+00 | 1.370E+00 | 2.951E-04 | 3.763E-04 | 7.170E-04 | 1.641E-03 | 4.354E-03 |
| 1943.50 | 5.147E-08 | 7.748E+00 | 7.788E-01 | 5.025E-01 | 1.608E+00 | 1.370E+00 | 2.951E-04 | 3.763E-04 | 7.170E-04 | 1.667E-03 | 4.354E-03 |
| 1944.50 | 1.028E-01 | 7.695E+00 | 1.945E+00 | 2.752E-01 | 1.631E+00 | 1.382E+00 | 2.953E-04 | 3.764E-04 | 7.177E-04 | 9.535E-04 | 4.511E-03 |
| 1945.50 | 4.545E-02 | 7.985E+00 | 3.292E+00 | 9.003E-02 | 1.655E+00 | 1.395E+00 | 2.955E-04 | 3.766E-04 | 7.185E-04 | 3.438E-04 | 4.676E-03 |
| 1946.50 | 1.911E-02 | 8.596E+00 | 4.675E+00 | 2.931E-02 | 1.678E+00 | 1.407E+00 | 2.957E-04 | 3.768E-04 | 7.192E-04 | 1.453E-04 | 4.780E-03 |

**GROUP 11 TACAN RANGE SCALE FACTOR (MULTIPLY BY $10.^{-6}$)**

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1432.00 | 2.936E+06 | 5.110E+07 | 5.882E+07 | 4.017E+04 | 4.396E+04 | 2.083E+04 | 1.519E+00 | 1.094E+00 | 3.562E-01 | 1.855E+04 | 1.745E+04 |
| 1490.00 | 7.702E+06 | 5.403E+06 | 1.129E+08 | 1.866E+05 | 3.194E+05 | 1.434E+05 | 3.109E+00 | 3.967E+00 | 7.254E+00 | 1.584E+05 | 3.239E+05 |
| 1550.00 | 2.223E+07 | 1.846E+07 | 5.715E+07 | 1.731E+05 | 3.383E+05 | 2.162E+05 | 8.472E+00 | 9.366E+00 | 6.461E+00 | 1.611E+05 | 3.747E+05 |
| 1550.00 | 1.087E+07 | 1.760E+07 | 5.347E+07 | 2.097E+05 | 3.540E+05 | 2.286E+05 | 8.421E+00 | 1.016E+01 | 9.050E+00 | 1.977E+05 | 3.911E+05 |
| 1610.00 | 8.808E+06 | 3.040E+06 | 2.958E+07 | 2.239E+05 | 3.045E+05 | 2.460E+05 | 9.449E+00 | 9.983E+00 | 6.419E+00 | 2.185E+05 | 3.648E+05 |
| 1670.00 | 2.139E+07 | 4.567E+06 | 7.285E+06 | 1.988E+05 | 2.326E+05 | 2.682E+05 | 1.009E+01 | 9.101E+00 | 7.985E-01 | 1.980E+05 | 2.961E+05 |
| 1730.00 | 6.720E+06 | 5.921E+06 | 6.638E+06 | 9.877E+04 | 1.549E+05 | 1.866E+05 | 8.242E+00 | 3.529E+00 | 1.008E+01 | 9.902E+04 | 1.733E+05 |
| 1790.00 | 1.232E+06 | 9.847E+06 | 3.545E+06 | 4.106E+04 | 1.219E+05 | 1.440E+05 | 6.559E+00 | 2.124E+00 | 1.986E+01 | 4.184E+04 | 1.627E+05 |
| 1836.00 | 1.055E+05 | 1.001E+07 | 1.143E+06 | 2.371E+04 | 9.581E+04 | 8.994E+04 | 4.861E+00 | 1.579E+00 | 2.934E+01 | 2.417E+04 | 3.768E+04 |
| 1836.00 | 3.761E+06 | 9.271E+06 | 1.662E+06 | 3.376E+04 | 9.812E+04 | 7.464E+04 | 4.841E+00 | 3.262E+00 | 2.931E+01 | 3.419E+04 | 2.022E+04 |
| 1846.00 | 3.893E+06 | 1.017E+07 | 1.069E+06 | 2.693E+04 | 1.068E+05 | 6.148E+04 | 4.533E+00 | 4.889E+00 | 2.902E+01 | 2.733E+04 | 2.917E+04 |
| 1846.00 | 1.544E+05 | 2.508E+05 | 4.298E+04 | 1.348E+03 | 3.128E+04 | 1.111E+03 | 3.285E+00 | 1.269E+01 | 3.738E+01 | 1.209E+03 | 1.781E+04 |
| 1860.00 | 6.409E+04 | 2.783E+05 | 4.821E+04 | 7.642E+02 | 2.577E+04 | 6.831E+01 | 2.454E+00 | 1.450E+01 | 4.134E+01 | 8.661E+02 | 2.145E+04 |
| 1874.00 | 7.349E+04 | 1.628E+05 | 3.082E+04 | 2.475E+03 | 2.359E+04 | 5.722E+03 | 3.107E+00 | 1.472E+01 | 4.466E+01 | 2.575E+03 | 2.152E+04 |
| 1884.00 | 6.039E+04 | 1.223E+05 | 3.181E+04 | 3.627E+03 | 3.916E+04 | 1.090E+04 | 3.081E+00 | 1.474E+01 | 4.465E+01 | 3.790E+03 | 3.761E+04 |
| 1894.00 | 5.480E+04 | 1.281E+05 | 2.847E+04 | 1.903E+03 | 5.132E+04 | 1.523E+04 | 3.056E+00 | 1.476E+01 | 4.465E+01 | 2.107E+03 | 4.850E+04 |
| 1904.00 | 4.796E+04 | 1.359E+05 | 2.568E+04 | 8.172E+02 | 6.302E+04 | 1.951E+04 | 3.030E+00 | 1.478E+01 | 4.464E+01 | 5.802E+02 | 5.789E+04 |
| 1914.00 | 3.786E+04 | 1.463E+05 | 2.278E+04 | 4.019E+03 | 7.427E+04 | 2.372E+04 | 3.005E+00 | 1.480E+01 | 4.464E+01 | 3.755E+03 | 6.638E+04 |
| 1924.00 | 1.917E+04 | 1.694E+05 | 1.976E+04 | 6.898E+03 | 8.829E+04 | 2.886E+04 | 2.980E+00 | 1.482E+01 | 4.463E+01 | 6.603E+03 | 8.338E+04 |
| 1934.00 | 1.154E+04 | 1.915E+05 | 1.700E+04 | 1.423E+04 | 1.035E+05 | 3.468E+04 | 2.954E+00 | 1.483E+01 | 4.463E+01 | 1.391E+04 | 1.021E+05 |
| 1943.50 | 7.266E+02 | 2.669E+05 | 4.116E+03 | 2.181E+04 | 1.138E+05 | 3.884E+04 | 2.930E+00 | 1.485E+01 | 4.462E+01 | 2.147E+04 | 1.132E+05 |
| 1943.50 | 6.235E+02 | 2.669E+05 | 4.113E+03 | 2.167E+04 | 1.138E+05 | 3.884E+04 | 2.930E+00 | 1.485E+01 | 4.462E+01 | 2.133E+04 | 1.132E+05 |
| 1944.50 | 5.363E+03 | 3.815E+05 | 4.327E+04 | 1.218E+04 | 1.153E+05 | 3.941E+04 | 2.928E+00 | 1.486E+01 | 4.462E+01 | 1.184E+04 | 1.150E+05 |
| 1945.50 | 3.301E+03 | 4.976E+05 | 8.297E+04 | 4.379E+03 | 1.168E+05 | 3.997E+04 | 2.925E+00 | 1.486E+01 | 4.462E+01 | 4.034E+03 | 1.167E+05 |
| 1946.50 | 2.551E+03 | 6.152E+05 | 1.232E+05 | 1.819E+03 | 1.183E+05 | 4.050E+04 | 2.922E+00 | 1.486E+01 | 4.462E+01 | 1.473E+03 | 1.182E+05 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1432.00 | 6.136E+06 | 7.735E+07 | 7.725E+06 | 4.105E+04 | 1.597E+04 | 4.516E+04 | 1.545E+00 | 4.871E-01 | 1.004E+00 | 2.930E+00 | 7.617E+00 |
| 1490.00 | 5.931E+06 | 8.243E+07 | 7.749E+07 | 1.770E+05 | 3.343E+05 | 1.195E+05 | 3.122E+00 | 2.095E+00 | 7.993E+00 | 3.734E+01 | 2.277E+01 |
| 1550.00 | 2.150E+07 | 3.404E+07 | 4.981E+07 | 1.667E+05 | 3.879E+05 | 1.136E+05 | 8.417E+00 | 6.754E+00 | 1.071E+01 | 5.445E+01 | 3.366E+01 |
| 1550.00 | 1.018E+07 | 3.201E+07 | 4.646E+07 | 2.030E+05 | 4.069E+05 | 1.214E+05 | 8.361E+00 | 7.354E+00 | 1.149E+01 | 6.539E+01 | 3.583E+01 |
| 1610.00 | 8.986E+06 | 2.083E+07 | 2.115E+07 | 2.209E+05 | 3.931E+05 | 1.102E+03 | 9.426E+00 | 3.834E+00 | 1.125E+01 | 1.081E+02 | 9.850E-01 |
| 1670.00 | 2.140E+07 | 7.748E+05 | 8.538E+06 | 1.979E+05 | 3.301E+05 | 1.319E+05 | 1.009E+01 | 7.739E+00 | 4.866E+00 | 1.552E+02 | 8.447E+01 |
| 1730.00 | 6.738E+06 | 1.485E+06 | 8.756E+06 | 9.895E+04 | 2.302E+05 | 7.611E+04 | 8.242E+00 | 8.332E+00 | 6.689E+00 | 1.726E+02 | 7.893E+01 |
| 1790.00 | 1.271E+06 | 6.339E+06 | 8.372E+06 | 4.163E+04 | 1.804E+05 | 5.484E+04 | 6.577E+00 | 1.254E+01 | 1.554E+01 | 1.192E+02 | 7.682E+01 |
| 1836.00 | 6.089E+04 | 4.783E+06 | 8.872E+06 | 2.430E+04 | 4.790E+04 | 1.223E+05 | 4.901E+00 | 2.783E+01 | 9.414E+00 | 6.188E+01 | 2.092E+02 |
| 1836.00 | 3.801E+06 | 4.987E+06 | 7.971E+06 | 3.433E+04 | 3.284E+04 | 1.187E+05 | 4.874E+00 | 2.843E+01 | 7.841E+00 | 6.954E+01 | 2.030E+02 |
| 1846.00 | 3.937E+06 | 7.346E+06 | 7.094E+06 | 2.753E+04 | 2.140E+04 | 1.212E+05 | 4.565E+00 | 2.539E+01 | 1.487E+01 | 3.169E+01 | 2.147E+02 |
| 1846.00 | 1.556E+05 | 1.279E+05 | 2.191E+05 | 1.205E+03 | 1.924E+04 | 2.470E+04 | 3.298E+00 | 3.680E+01 | 1.426E+01 | 1.237E+01 | 4.377E+01 |
| 1860.00 | 6.516E+04 | 2.667E+05 | 8.617E+04 | 8.729E+02 | 2.279E+04 | 1.201E+04 | 2.479E+00 | 3.204E+01 | 2.986E+01 | 1.350E+01 | 2.254E+01 |
| 1874.00 | 7.405E+04 | 1.652E+05 | 1.034E+04 | 2.579E+03 | 2.267E+04 | 8.630E+03 | 3.148E+00 | 2.022E+01 | 4.245E+01 | 1.294E+01 | 1.635E+01 |
| 1884.00 | 6.077E+04 | 1.209E+05 | 3.615E+04 | 3.793E+03 | 3.950E+04 | 9.532E+03 | 3.126E+00 | 1.319E+01 | 4.513E+01 | 2.184E+01 | 1.799E+01 |
| 1894.00 | 5.516E+04 | 1.257E+05 | 3.726E+04 | 2.110E+03 | 5.224E+04 | 1.169E+04 | 3.104E+00 | 1.169E+01 | 4.554E+01 | 3.466E+01 | 2.276E+01 |
| 1904.00 | 4.833E+04 | 1.347E+05 | 3.090E+04 | 5.770E+02 | 6.371E+04 | 1.712E+04 | 3.081E+00 | 1.309E+01 | 4.516E+01 | 4.893E+01 | 3.449E+01 |
| 1914.00 | 3.825E+04 | 1.481E+05 | 2.364E+04 | 3.752E+03 | 7.441E+04 | 2.334E+04 | 3.059E+00 | 1.457E+01 | 4.471E+01 | 6.426E+01 | 4.855E+01 |
| 1924.00 | 1.958E+04 | 1.695E+05 | 1.847E+04 | 6.599E+03 | 8.808E+04 | 2.957E+04 | 3.037E+00 | 1.517E+01 | 4.451E+01 | 5.873E+01 | 6.167E+01 |
| 1934.00 | 1.198E+04 | 1.916E+05 | 1.564E+04 | 1.390E+04 | 1.032E+05 | 3.546E+04 | 3.015E+00 | 1.516E+01 | 4.451E+01 | 5.192E+01 | 9.006E+01 |
| 1943.50 | 1.350E+03 | 2.669E+05 | 4.980E+03 | 2.146E+04 | 1.137E+05 | 3.926E+04 | 2.993E+00 | 1.501E+01 | 4.457E+01 | 7.586E+01 | 1.248E+02 |
| 1943.50 | 4.354E-07 | 2.669E+05 | 4.980E+03 | 2.133E+04 | 1.137E+05 | 3.926E+04 | 2.993E+00 | 1.501E+01 | 4.457E+01 | 7.543E+01 | 1.248E+02 |
| 1944.50 | 4.396E+03 | 3.814E+05 | 4.439E+04 | 1.183E+04 | 1.152E+05 | 3.977E+04 | 2.991E+00 | 1.499E+01 | 4.457E+01 | 4.447E+01 | 1.298E+02 |
| 1945.50 | 1.989E+03 | 4.974E+05 | 8.428E+04 | 4.027E+03 | 1.168E+05 | 4.028E+04 | 2.988E+00 | 1.498E+01 | 4.458E+01 | 1.763E+01 | 1.350E+02 |
| 1946.50 | 8.992E+02 | 6.149E+05 | 1.247E+05 | 1.464E+03 | 1.182E+05 | 4.079E+04 | 2.987E+00 | 1.498E+01 | 4.458E+01 | 8.812E+00 | 1.386E+02 |

## GROUP 12 BARO ALTIMETER BIAS, SCALE FACTOR, AND STATIC DEFECT

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1550.00 | 1.885E+03 | 2.568E+02 | 4.316E+02 | 5.832E+00 | 2.792E+00 | 1.486E+00 | 3.917E-05 | 1.035E-04 | 9.647E-05 | 5.847E+00 | 2.755E+00 |
| 1610.00 | 1.242E+03 | 1.243E+02 | 4.936E+02 | 3.412E+00 | 8.792E-01 | 1.752E+00 | 4.454E-05 | 1.415E-04 | 7.843E-05 | 3.445E+00 | 1.401E+00 |
| 1670.00 | 3.457E+02 | 1.613E+01 | 2.156E+02 | 6.096E-01 | 3.941E-01 | 7.153E-01 | 4.975E-05 | 1.169E-04 | 5.135E-05 | 6.146E-01 | 1.976E-01 |
| 1730.00 | 1.527E+02 | 3.345E+01 | 1.052E+02 | 4.224E-01 | 4.546E-01 | 4.078E-01 | 3.633E-05 | 7.099E-05 | 2.778E-05 | 4.225E-01 | 3.975E-01 |
| 1790.00 | 2.458E+01 | 2.899E+01 | 1.063E+01 | 5.667E-01 | 2.311E-01 | 7.949E-01 | 3.427E-05 | 4.519E-05 | 6.095E-05 | 5.687E-01 | 4.516E-01 |
| 1836.00 | 4.717E+01 | 1.500E+01 | 1.617E+01 | 6.169E-01 | 1.914E-01 | 5.167E-01 | 3.783E-05 | 8.289E-05 | 9.082E-05 | 6.168E-01 | 2.070E-01 |
| 1836.00 | 6.162E+00 | 1.656E+01 | 3.236E+00 | 5.282E-01 | 2.422E-01 | 4.365E-01 | 3.668E-05 | 8.397E-05 | 8.403E-05 | 5.297E-01 | 1.376E-01 |
| 1846.00 | 7.212E+00 | 1.630E+01 | 1.211E+00 | 2.975E-01 | 2.445E-01 | 2.272E-01 | 3.693E-05 | 1.061E-04 | 6.743E-05 | 2.986E-01 | 8.095E-02 |
| 1846.00 | 6.664E-01 | 2.916E-01 | 2.809E-01 | 1.918E-01 | 1.237E-01 | 8.983E-02 | 3.809E-05 | 1.237E-04 | 1.015E-04 | 1.925E-01 | 7.434E-02 |
| 1860.00 | 1.146E-01 | 6.089E-01 | 4.795E-02 | 6.024E-02 | 8.283E-02 | 5.001E-02 | 3.741E-05 | 1.357E-04 | 1.179E-04 | 6.066E-02 | 6.962E-02 |
| 1874.00 | 3.337E-01 | 1.119E-01 | 9.539E-02 | 5.114E-02 | 6.278E-02 | 7.306E-02 | 3.528E-05 | 1.507E-04 | 1.264E-04 | 5.153E-02 | 6.958E-02 |
| 1884.00 | 3.595E-01 | 2.555E-01 | 1.545E-01 | 7.150E-02 | 1.038E-01 | 1.352E-01 | 3.539E-05 | 1.508E-04 | 1.264E-04 | 7.217E-02 | 1.272E-01 |
| 1894.00 | 3.053E-01 | 2.731E-01 | 1.318E-01 | 7.538E-02 | 1.403E-01 | 1.865E-01 | 3.551E-05 | 1.508E-04 | 1.263E-04 | 7.626E-02 | 1.691E-01 |
| 1904.00 | 2.480E-01 | 2.903E-01 | 1.108E-01 | 7.379E-02 | 1.783E-01 | 2.439E-01 | 3.562E-05 | 1.509E-04 | 1.262E-04 | 7.486E-02 | 2.000E-01 |
| 1914.00 | 1.822E-01 | 3.025E-01 | 9.244E-02 | 7.177E-02 | 2.165E-01 | 3.012E-01 | 3.574E-05 | 1.509E-04 | 1.261E-04 | 7.302E-02 | 2.271E-01 |
| 1924.00 | 1.010E-01 | 3.042E-01 | 7.610E-02 | 7.264E-02 | 2.634E-01 | 3.715E-01 | 3.585E-05 | 1.509E-04 | 1.261E-04 | 7.410E-02 | 2.694E-01 |
| 1934.00 | 4.805E-02 | 2.873E-01 | 6.256E-02 | 6.511E-02 | 3.146E-01 | 4.471E-01 | 3.597E-05 | 1.510E-04 | 1.260E-04 | 6.675E-02 | 3.147E-01 |
| 1943.50 | 2.272E-02 | 1.688E-01 | 1.993E-01 | 5.841E-02 | 3.525E-01 | 5.060E-01 | 3.608E-05 | 1.510E-04 | 1.259E-04 | 6.010E-02 | 3.516E-01 |
| 1943.50 | 4.252E-04 | 1.688E-01 | 1.993E-01 | 6.054E-02 | 3.525E-01 | 5.060E-01 | 3.608E-05 | 1.510E-04 | 1.259E-04 | 6.225E-02 | 3.518E-01 |
| 1944.50 | 1.075E-02 | 3.538E-01 | 7.076E-01 | 3.139E-02 | 3.567E-01 | 5.109E-01 | 3.609E-05 | 1.510E-04 | 1.259E-04 | 3.309E-02 | 3.556E-01 |
| 1945.50 | 2.809E-03 | 6.921E-01 | 1.221E+00 | 8.128E-03 | 3.609E-01 | 5.157E-01 | 3.610E-05 | 1.510E-04 | 1.259E-04 | 9.739E-03 | 3.596E-01 |
| 1946.50 | 4.814E-03 | 1.048E+00 | 1.739E+00 | 1.598E-03 | 3.650E-01 | 5.204E-01 | 3.611E-05 | 1.510E-04 | 1.259E-04 | 2.075E-03 | 3.638E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1550.00 | 1.878E+03 | 3.959E+02 | 3.508E+02 | 5.781E+00 | 3.183E+00 | 6.656E-01 | 3.973E-05 | 7.174E-05 | 1.217E-04 | 1.749E-03 | 1.894E-04 |
| 1610.00 | 1.238E+03 | 4.157E+02 | 3.079E+02 | 3.397E+00 | 1.809E+00 | 8.187E-01 | 4.413E-05 | 6.297E-05 | 1.491E-04 | 1.495E-03 | 3.320E-04 |
| 1670.00 | 3.452E+02 | 1.030E+02 | 1.911E+02 | 6.081E-01 | 2.416E-01 | 7.814E-01 | 4.975E-05 | 8.393E-05 | 9.622E-05 | 3.977E-04 | 4.953E-04 |
| 1730.00 | 1.525E+02 | 3.095E+01 | 1.062E+02 | 4.225E-01 | 5.481E-01 | 2.692E-01 | 3.649E-05 | 4.663E-05 | 6.020E-05 | 5.396E-04 | 2.786E-04 |
| 1790.00 | 2.450E+01 | 2.827E+01 | 1.258E+01 | 5.678E-01 | 6.110E-01 | 5.574E-01 | 3.443E-05 | 9.598E-06 | 7.520E-05 | 9.456E-04 | 7.792E-04 |
| 1836.00 | 4.724E+01 | 1.100E+01 | 1.896E+01 | 6.185E-01 | 4.181E-01 | 3.562E-01 | 3.807E-05 | 1.146E-04 | 4.435E-05 | 1.165E-03 | 6.101E-04 |
| 1836.00 | 6.233E+00 | 9.156E+00 | 1.414E+01 | 5.299E-01 | 3.225E-01 | 3.786E-01 | 3.693E-05 | 1.087E-04 | 4.766E-05 | 9.814E-04 | 6.479E-04 |
| 1846.00 | 7.283E+00 | 1.136E+01 | 1.170E+01 | 2.989E-01 | 5.556E-02 | 3.279E-01 | 3.726E-05 | 1.356E-04 | 3.010E-05 | 4.909E-04 | 5.809E-04 |
| 1846.00 | 6.680E-01 | 1.217E-01 | 3.833E-01 | 1.925E-01 | 4.254E-02 | 1.460E-01 | 3.646E-05 | 1.565E-04 | 3.302E-05 | 3.061E-04 | 2.588E-04 |
| 1860.00 | 1.165E-01 | 5.595E-01 | 2.442E-01 | 6.067E-02 | 5.289E-02 | 8.070E-02 | 3.774E-05 | 1.740E-04 | 4.474E-05 | 7.022E-05 | 1.514E-04 |
| 1874.00 | 3.343E-01 | 1.015E-01 | 1.045E-01 | 5.153E-02 | 5.339E-02 | 7.992E-02 | 3.559E-05 | 1.649E-04 | 1.072E-04 | 4.395E-05 | 1.514E-04 |
| 1884.00 | 3.608E-01 | 2.593E-01 | 1.451E-01 | 7.216E-02 | 1.080E-01 | 1.315E-01 | 3.567E-05 | 1.463E-04 | 1.315E-04 | 4.559E-05 | 2.462E-04 |
| 1894.00 | 3.065E-01 | 2.801E-01 | 1.129E-01 | 7.625E-02 | 1.522E-01 | 1.787E-01 | 3.575E-05 | 1.420E-04 | 1.361E-04 | 3.483E-05 | 3.480E-04 |
| 1904.00 | 2.492E-01 | 2.933E-01 | 9.962E-02 | 7.486E-02 | 1.869E-01 | 2.371E-01 | 3.583E-05 | 1.460E-04 | 1.318E-04 | 4.330E-05 | 4.776E-04 |
| 1914.00 | 1.832E-01 | 3.024E-01 | 9.055E-02 | 7.301E-02 | 2.178E-01 | 2.999E-01 | 3.591E-05 | 1.501E-04 | 1.270E-04 | 6.576E-05 | 6.240E-04 |
| 1924.00 | 1.020E-01 | 3.033E-01 | 7.814E-02 | 7.409E-02 | 2.603E-01 | 3.733E-01 | 3.599E-05 | 1.518E-04 | 1.250E-04 | 5.289E-05 | 7.789E-04 |
| 1934.00 | 4.889E-02 | 2.868E-01 | 6.434E-02 | 6.674E-02 | 3.115E-01 | 4.492E-01 | 3.607E-05 | 1.518E-04 | 1.250E-04 | 1.260E-04 | 1.141E-03 |
| 1943.50 | 2.298E-02 | 1.691E-01 | 1.990E-01 | 6.010E-02 | 3.508E-01 | 5.070E-01 | 3.616E-05 | 1.513E-04 | 1.255E-04 | 1.719E-04 | 1.611E-03 |
| 1943.50 | 7.409E-12 | 1.691E-01 | 1.990E-01 | 6.225E-02 | 3.508E-01 | 5.070E-01 | 3.616E-05 | 1.513E-04 | 1.255E-04 | 1.785E-04 | 1.611E-03 |
| 1944.50 | 1.251E-02 | 3.522E-01 | 7.084E-01 | 3.309E-02 | 3.552E-01 | 5.118E-01 | 3.617E-05 | 1.513E-04 | 1.256E-04 | 9.364E-05 | 1.670E-03 |
| 1945.50 | 5.223E-03 | 6.892E-01 | 1.222E+00 | 9.746E-03 | 3.596E-01 | 5.166E-01 | 3.618E-05 | 1.512E-04 | 1.256E-04 | 2.388E-05 | 1.732E-03 |
| 1946.50 | 1.757E-03 | 1.044E+00 | 1.741E+00 | 2.082E-03 | 3.638E-01 | 5.213E-01 | 3.618E-05 | 1.512E-04 | 1.256E-04 | 9.528E-06 | 1.772E-03 |

## GROUP 12 BARO ALTIMETER FIRST-ORDER MARKOV

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1550.00 | 1.075E+01 | 1.465E+00 | 2.462E+00 | 3.327E-02 | 1.593E-02 | 8.444E-03 | 2.235E-07 | 5.902E-07 | 5.504E-07 | 3.336E-02 | 1.572E-02 |
| 1610.00 | 9.262E+00 | 1.119E+00 | 3.561E+00 | 2.976E-02 | 9.321E-03 | 1.450E-02 | 2.513E-07 | 1.099E-06 | 1.029E-06 | 2.999E-02 | 1.291E-02 |
| 1670.00 | 5.237E+00 | 7.460E-01 | 3.026E+00 | 1.995E-02 | 5.510E-03 | 1.767E-02 | 3.629E-07 | 1.413E-06 | 1.287E-06 | 2.005E-02 | 8.847E-03 |
| 1730.00 | 5.194E+00 | 2.579E-01 | 3.525E+00 | 1.929E-02 | 5.164E-03 | 1.812E-02 | 2.675E-07 | 1.125E-06 | 7.348E-07 | 1.935E-02 | 4.585E-03 |
| 1790.00 | 4.522E+00 | 5.362E-01 | 9.798E-01 | 2.109E-02 | 4.651E-03 | 6.814E-03 | 2.855E-07 | 6.045E-07 | 7.959E-07 | 2.111E-02 | 5.674E-03 |
| 1836.00 | 8.915E+00 | 8.424E-01 | 4.155E-01 | 3.538E-02 | 6.370E-03 | 9.045E-03 | 4.405E-07 | 2.330E-06 | 1.178E-06 | 3.542E-02 | 2.030E-02 |
| 1836.00 | 1.216E-01 | 5.998E-01 | 1.214E-01 | 1.333E-02 | 6.600E-03 | 1.218E-02 | 3.472E-07 | 7.771E-07 | 1.440E-06 | 1.337E-02 | 5.021E-03 |
| 1846.00 | 3.246E-01 | 6.988E-01 | 5.722E-02 | 1.358E-02 | 6.349E-03 | 8.651E-03 | 6.323E-07 | 9.575E-07 | 1.497E-06 | 1.361E-02 | 2.731E-03 |
| 1846.00 | 4.325E-02 | 8.214E-03 | 9.859E-03 | 9.320E-03 | 2.096E-03 | 3.161E-03 | 6.809E-07 | 1.405E-06 | 1.261E-06 | 9.327E-03 | 2.220E-03 |
| 1860.00 | | | | | | | | | | | |
| 1874.00 | | | | | | | | | | | |
| 1884.00 | | | | | | | | | | | |
| 1894.00 | | | | | | | | | | | |
| 1904.00 | | | | | | | | | | | |
| 1914.00 | | | | | | | | | | | |
| 1924.00 | | | | | | | | | | | |
| 1934.00 | | | | | | | | | | | |
| 1943.50 | | | | | | | | | | | |
| 1943.50 | | | | | | | | | | | |
| 1944.50 | | | | | | | | | | | |
| 1945.50 | | | | | | | | | | | |
| 1946.50 | | | | | | | | | | | |

THIS SEGMENT OF TABLE NOT PRINTED

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 2.884E-14 | 2.892E-14 |
| 1550.00 | 1.071E+01 | 2.259E+00 | 2.001E+00 | 3.298E-02 | 1.816E-02 | 3.797E-03 | 2.267E-07 | 4.093E-07 | 6.945E-07 | 9.976E-06 | 1.081E-06 |
| 1610.00 | 9.236E+00 | 3.160E+00 | 2.104E+00 | 2.963E-02 | 1.647E-02 | 5.809E-03 | 2.492E-07 | 3.668E-07 | 1.461E-06 | 1.305E-05 | 2.359E-06 |
| 1670.00 | 5.229E+00 | 2.015E+00 | 2.397E+00 | 1.990E-02 | 1.185E-02 | 1.428E-02 | 3.642E-07 | 7.159E-07 | 1.772E-06 | 1.361E-05 | 9.079E-06 |
| 1730.00 | 5.191E+00 | 1.793E+00 | 3.050E+00 | 1.927E-02 | 1.000E-02 | 1.598E-02 | 2.700E-07 | 5.913E-07 | 1.206E-06 | 2.031E-05 | 1.653E-05 |
| 1790.00 | 4.521E+00 | 2.603E-01 | 1.092E+00 | 2.111E-02 | 7.325E-03 | 3.718E-03 | 2.878E-07 | 6.895E-07 | 7.226E-07 | 2.910E-05 | 5.190E-06 |
| 1836.00 | 8.912E+00 | 6.777E-01 | 6.939E-01 | 3.540E-02 | 1.010E-02 | 4.424E-03 | 4.506E-07 | 1.176E-06 | 2.330E-06 | 4.987E-05 | 7.579E-06 |
| 1836.00 | 1.240E-01 | 3.356E-01 | 5.112E-01 | 1.338E-02 | 9.218E-03 | 1.028E-02 | 3.477E-07 | 1.591E-06 | 3.797E-07 | 2.506E-05 | 1.758E-05 |
| 1846.00 | 3.277E-01 | 4.917E-01 | 4.978E-01 | 1.362E-02 | 3.663E-03 | 1.003E-02 | 6.362E-07 | 1.419E-06 | 1.067E-06 | 2.318E-05 | 1.777E-05 |
| 1846.00 | 4.330E-02 | 4.348E-03 | 1.190E-02 | 9.327E-03 | 2.745E-03 | 2.590E-03 | 6.864E-07 | 1.500E-06 | 1.143E-06 | 1.587E-05 | 4.590E-06 |
| 1860.00 | | | | | | | | | | | |
| 1874.00 | | | | | | | | | | | |
| 1884.00 | | | | | | | | | | | |
| 1894.00 | | | | | | | | | | | |
| 1904.00 | | | | | | | | | | | |
| 1914.00 | | | | | | | | | | | |
| 1924.00 | | | | | | | | | | | |
| 1934.00 | | | | | | | | | | | |
| 1943.50 | | | | | | | | | | | |
| 1943.50 | | | | | | | | | | | |
| 1944.50 | | | | | | | | | | | |
| 1945.50 | | | | | | | | | | | |
| 1946.50 | | | | | | | | | | | |

THIS SEGMENT OF TABLE NOT PRINTED

GROUP 13 MLS AZIMUTH BIAS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1836.00 | 1.821E+00 | 4.580E+00 | 2.633E+01 | 3.934E-03 | 8.754E-02 | 2.368E-01 | 1.099E-06 | 1.735E-05 | 8.518E-06 | 3.318E-03 | 2.406E-01 |
| 1846.00 | 1.656E+00 | 4.471E+00 | 2.496E+01 | 5.730E-02 | 8.988E-02 | 6.456E-03 | 1.488E-05 | 2.497E-05 | 5.906E-06 | 5.725E-02 | 7.790E-02 |
| 1846.00 | 9.431E-01 | 2.469E+00 | 2.476E+01 | 6.374E-02 | 1.064E-01 | 4.921E-02 | 1.846E-05 | 3.552E-05 | 6.708E-06 | 6.384E-02 | 4.968E-02 |
| 1860.00 | 3.334E-01 | 6.561E-01 | 2.198E+01 | 4.271E-02 | 1.068E-01 | 1.360E-01 | 2.688E-05 | 6.014E-05 | 2.823E-06 | 4.320E-02 | 4.538E-02 |
| 1874.00 | 8.788E-03 | 3.731E-01 | 1.906E+01 | 2.399E-02 | 8.591E-02 | 1.432E-01 | 2.734E-05 | 7.165E-05 | 3.413E-06 | 2.457E-02 | 7.116E-02 |
| 1884.00 | 1.818E-02 | 3.612E-01 | 1.694E+01 | 1.238E-02 | 7.957E-02 | 1.084E-01 | 2.737E-05 | 7.164E-05 | 3.454E-06 | 1.291E-02 | 8.124E-02 |
| 1894.00 | 6.880E-03 | 2.448E-01 | 1.491E+01 | 6.189E-03 | 6.979E-02 | 7.786E-02 | 2.739E-05 | 7.162E-05 | 3.496E-06 | 6.614E-03 | 7.102E-02 |
| 1904.00 | 2.575E-02 | 1.378E-01 | 1.295E+01 | 2.115E-03 | 5.897E-02 | 4.621E-02 | 2.742E-05 | 7.161E-05 | 3.537E-06 | 2.409E-03 | 5.633E-02 |
| 1914.00 | 2.463E-02 | 9.874E-02 | 1.106E+01 | 2.098E-03 | 4.840E-02 | 1.373E-02 | 2.745E-05 | 7.160E-05 | 3.579E-06 | 1.928E-03 | 4.346E-02 |
| 1924.00 | 1.869E-02 | 1.090E-01 | 9.203E+00 | 7.270E-03 | 3.828E-02 | 2.524E-02 | 2.748E-05 | 7.158E-05 | 3.620E-06 | 7.226E-03 | 3.532E-02 |
| 1934.00 | 7.689E-03 | 1.300E-01 | 7.487E+00 | 1.383E-02 | 2.823E-02 | 6.577E-02 | 2.751E-05 | 7.157E-05 | 3.662E-06 | 1.391E-02 | 2.779E-02 |
| 1943.50 | 7.566E-03 | 1.545E-01 | 6.289E+00 | 1.991E-02 | 1.981E-02 | 9.676E-02 | 2.753E-05 | 7.156E-05 | 3.701E-06 | 2.007E-02 | 1.974E-02 |
| 1943.50 | 1.336E-02 | 1.546E-01 | 6.289E+00 | 2.200E-02 | 1.981E-02 | 9.677E-02 | 2.753E-05 | 7.156E-05 | 3.701E-06 | 2.217E-02 | 1.969E-02 |
| 1944.50 | 9.076E-03 | 1.745E-01 | 6.387E+00 | 1.184E-02 | 1.997E-02 | 9.897E-02 | 2.754E-05 | 7.156E-05 | 3.706E-06 | 1.202E-02 | 2.009E-02 |
| 1945.50 | 1.180E-02 | 1.946E-01 | 6.487E+00 | 3.631E-03 | 2.012E-02 | 1.011E-01 | 2.754E-05 | 7.156E-05 | 3.710E-06 | 3.809E-03 | 2.035E-02 |
| 1946.50 | 1.319E-02 | 2.148E-01 | 6.589E+00 | 8.987E-04 | 2.026E-02 | 1.033E-01 | 2.754E-05 | 7.156E-05 | 3.714E-06 | 1.084E-03 | 2.051E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1836.00 | 1.885E+00 | 2.274E+01 | 1.403E+01 | 3.953E-03 | 2.524E-01 | 6.758E-03 | 1.005E-06 | 1.461E-06 | 1.927E-05 | 1.252E-04 | 1.231E-05 |
| 1846.00 | 1.723E+00 | 1.627E+01 | 1.945E+01 | 5.769E-02 | 6.259E-02 | 6.449E-02 | 1.498E-05 | 2.054E-05 | 1.520E-05 | 5.674E-05 | 1.135E-04 |
| 1846.00 | 1.001E+00 | 1.740E+01 | 1.779E+01 | 6.431E-02 | 3.050E-02 | 1.129E-01 | 1.861E-05 | 2.793E-05 | 2.284E-05 | 8.462E-05 | 1.992E-04 |
| 1860.00 | 3.822E-01 | 9.619E+00 | 1.978E+01 | 4.344E-02 | 3.135E-02 | 1.699E-01 | 2.713E-05 | 5.451E-05 | 2.530E-05 | 4.908E-05 | 3.180E-04 |
| 1874.00 | 3.174E-02 | 2.763E+00 | 1.886E+01 | 2.464E-02 | 6.717E-02 | 1.528E-01 | 2.762E-05 | 7.056E-05 | 1.231E-05 | 1.237E-05 | 2.885E-04 |
| 1884.00 | 1.795E-02 | 2.258E-01 | 1.694E+01 | 1.291E-02 | 8.323E-02 | 1.056E-01 | 2.763E-05 | 7.161E-05 | 9.125E-07 | 3.826E-05 | 1.985E-04 |
| 1894.00 | 3.879E-02 | 7.734E-01 | 1.489E+01 | 6.595E-03 | 7.491E-02 | 7.291E-02 | 2.764E-05 | 7.160E-05 | 1.454E-06 | 4.389E-05 | 1.413E-04 |
| 1904.00 | 5.358E-02 | 3.519E-01 | 1.295E+01 | 2.400E-03 | 6.067E-02 | 4.394E-02 | 2.765E-05 | 7.160E-05 | 7.712E-07 | 4.162E-05 | 8.794E-05 |
| 1914.00 | 4.842E-02 | 4.109E-02 | 1.106E+01 | 1.927E-03 | 4.848E-02 | 1.348E-02 | 2.767E-05 | 7.153E-05 | 3.145E-06 | 4.097E-05 | 2.756E-05 |
| 1924.00 | 3.845E-02 | 1.817E-01 | 9.202E+00 | 7.222E-03 | 3.850E-02 | 2.492E-02 | 2.768E-05 | 7.148E-05 | 4.124E-06 | 3.412E-05 | 5.232E-05 |
| 1934.00 | 2.369E-02 | 1.840E-01 | 7.486E+00 | 1.391E-02 | 2.874E-02 | 6.554E-02 | 2.769E-05 | 7.148E-05 | 4.117E-06 | 3.985E-05 | 1.667E-04 |
| 1943.50 | 2.092E-02 | 1.750E-01 | 6.289E+00 | 2.007E-02 | 2.017E-02 | 9.666E-02 | 2.771E-05 | 7.148E-05 | 3.873E-06 | 6.513E-05 | 3.073E-04 |
| 1943.50 | 6.748E-12 | 1.750E-01 | 6.289E+00 | 2.216E-02 | 2.017E-02 | 9.666E-02 | 2.771E-05 | 7.148E-05 | 3.873E-06 | 7.177E-05 | 3.073E-04 |
| 1944.50 | 4.453E-03 | 1.931E-01 | 6.387E+00 | 1.201E-02 | 2.028E-02 | 9.888E-02 | 2.771E-05 | 7.148E-05 | 3.854E-06 | 4.023E-05 | 3.229E-04 |
| 1945.50 | 1.904E-03 | 2.115E-01 | 6.487E+00 | 3.806E-03 | 2.039E-02 | 1.011E-01 | 2.771E-05 | 7.148E-05 | 3.836E-06 | 1.349E-05 | 3.391E-04 |
| 1946.50 | 8.367E-04 | 2.309E-01 | 6.589E+00 | 1.081E-03 | 2.052E-02 | 1.032E-01 | 2.771E-05 | 7.148E-05 | 3.829E-06 | 4.344E-06 | 3.510E-04 |

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## GROUP 13 MLS ELEVATION BIAS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1836.00 | 2.205E+01 | 3.554E+00 | 7.227E-01 | 5.609E-02 | 9.441E-04 | 5.342E-02 | 2.621E-07 | 7.088E-06 | 1.024E-06 | 5.606E-02 | 6.515E-02 |
| 1846.00 | 1.972E+01 | 5.890E+00 | 5.191E-01 | 6.981E-02 | 9.587E-03 | 7.832E-02 | 6.995E-06 | 5.275E-07 | 5.592E-06 | 6.989E-02 | 2.840E-02 |
| 1846.00 | 1.952E+01 | 5.627E+00 | 5.820E-01 | 9.737E-02 | 6.505E-03 | 7.037E-02 | 9.451E-06 | 4.697E-06 | 6.295E-06 | 9.737E-02 | 1.563E-02 |
| 1860.00 | 1.676E+01 | 4.716E+00 | 2.513E-01 | 1.643E-01 | 3.228E-02 | 4.407E-02 | 1.614E-05 | 1.838E-05 | 2.190E-06 | 1.642E-01 | 1.585E-02 |
| 1874.00 | 1.374E+01 | 3.257E+00 | 1.506E-01 | 1.790E-01 | 6.171E-02 | 3.982E-02 | 1.424E-05 | 2.270E-05 | 4.503E-06 | 1.788E-01 | 1.801E-02 |
| 1884.00 | 1.157E+01 | 2.367E+00 | 1.624E-01 | 1.783E-01 | 5.953E-02 | 5.076E-02 | 1.425E-05 | 2.269E-05 | 4.487E-06 | 1.781E-01 | 1.947E-02 |
| 1894.00 | 9.455E+00 | 1.618E+00 | 1.565E-01 | 1.763E-01 | 5.548E-02 | 6.051E-02 | 1.426E-05 | 2.269E-05 | 4.472E-06 | 1.762E-01 | 2.506E-02 |
| 1904.00 | 7.390E+00 | 9.468E-01 | 1.428E-01 | 1.741E-01 | 5.041E-02 | 7.087E-02 | 1.427E-05 | 2.269E-05 | 4.456E-06 | 1.741E-01 | 2.726E-02 |
| 1914.00 | 5.369E+00 | 3.822E-01 | 1.189E-01 | 1.725E-01 | 4.466E-02 | 8.183E-02 | 1.428E-05 | 2.268E-05 | 4.441E-06 | 1.725E-01 | 2.968E-02 |
| 1924.00 | 3.406E+00 | 1.959E-02 | 9.301E-02 | 1.721E-01 | 3.776E-02 | 9.542E-02 | 1.430E-05 | 2.268E-05 | 4.425E-06 | 1.722E-01 | 6.866E-03 |
| 1934.00 | 1.673E+00 | 1.521E-01 | 7.193E-02 | 1.742E-01 | 2.995E-02 | 1.099E-01 | 1.431E-05 | 2.267E-05 | 4.409E-06 | 1.744E-01 | 1.994E-02 |
| 1943.50 | 3.373E-01 | 2.223E-01 | 3.601E-03 | 1.786E+01 | 2.435E-02 | 1.216E-01 | 1.432E-05 | 2.267E-05 | 4.395E-06 | 1.788E-01 | 2.135E-02 |
| 1943.50 | 5.004E-04 | 2.215E-01 | 4.331E-03 | 1.449E-01 | 2.444E-02 | 1.215E-01 | 1.432E-05 | 2.267E-05 | 4.395E-06 | 1.451E-01 | 2.208E-02 |
| 1944.50 | 2.977E-02 | 2.461E-01 | 1.260E-01 | 7.835E-02 | 2.445E-02 | 1.221E-01 | 1.432E-05 | 2.267E-05 | 4.393E-06 | 7.857E-02 | 2.376E-02 |
| 1945.50 | 1.284E-02 | 2.707E-01 | 2.482E-01 | 2.449E-02 | 2.443E-02 | 1.226E-01 | 1.432E-05 | 2.267E-05 | 4.392E-06 | 2.471E-02 | 2.455E-02 |
| 1946.50 | 4.761E-03 | 2.952E-01 | 3.710E-01 | 6.660E-03 | 2.434E-02 | 1.232E-01 | 1.432E-05 | 2.267E-05 | 4.390E-06 | 6.881E-03 | 2.459E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1836.00 | 2.204E+01 | 1.996E+00 | 3.139E+00 | 5.601E-02 | 4.993E-02 | 1.925E-02 | 2.933E-07 | 3.585E-06 | 6.199E-06 | 6.051E-05 | 3.291E-05 |
| 1846.00 | 1.970E+01 | 4.209E+00 | 4.274E+00 | 7.000E-02 | 5.399E-02 | 5.732E-02 | 7.008E-06 | 3.958E-06 | 3.963E-06 | 1.402E-04 | 1.015E-04 |
| 1846.00 | 1.950E+01 | 4.088E+00 | 4.030E+00 | 9.748E-02 | 4.991E-02 | 4.972E-02 | 9.484E-06 | 1.823E-06 | 7.599E-06 | 1.816E-04 | 8.806E-05 |
| 1860.00 | 1.674E+01 | 4.341E+00 | 2.029E+00 | 1.643E-01 | 4.950E-02 | 2.343E-02 | 1.622E-05 | 1.522E-05 | 1.041E-05 | 2.970E-04 | 4.390E-05 |
| 1874.00 | 1.373E+01 | 3.300E+00 | 2.962E-01 | 1.789E-01 | 6.686E-02 | 3.128E-02 | 1.432E-05 | 2.303E-05 | 1.656E-06 | 3.238E-04 | 5.920E-05 |
| 1884.00 | 1.156E+01 | 2.402E+00 | 2.202E-01 | 1.782E-01 | 5.839E-02 | 5.242E-02 | 1.432E-05 | 2.247E-05 | 5.301E-06 | 3.212E-04 | 9.888E-05 |
| 1894.00 | 9.450E+00 | 1.637E+00 | 2.481E-01 | 1.762E-01 | 5.184E-02 | 6.381E-02 | 1.433E-05 | 2.228E-05 | 6.038E-06 | 3.231E-04 | 1.242E-04 |
| 1904.00 | 7.387E+00 | 9.645E-01 | 1.632E-01 | 1.741E-01 | 4.826E-02 | 7.236E-02 | 1.433E-05 | 2.246E-05 | 5.340E-06 | 3.282E-04 | 1.458E-04 |
| 1914.00 | 5.368E+00 | 3.973E-01 | 1.093E-01 | 1.725E-01 | 4.473E-02 | 8.169E-02 | 1.434E-05 | 2.262E-05 | 4.590E-06 | 3.337E-04 | 1.700E-04 |
| 1924.00 | 3.406E+00 | 9.810E-03 | 8.567E-02 | 1.722E-01 | 3.897E-02 | 9.475E-02 | 1.435E-05 | 2.267E-05 | 4.278E-06 | 3.556E-04 | 1.976E-04 |
| 1934.00 | 1.673E+00 | 1.475E-01 | 6.935E-02 | 1.744E-01 | 3.116E-02 | 1.093E-01 | 1.435E-05 | 2.267E-05 | 4.278E-06 | 4.462E-04 | 2.775E-04 |
| 1943.50 | 3.378E-01 | 2.215E-01 | 3.619E-03 | 1.788E-01 | 2.515E-02 | 1.211E-01 | 1.436E-05 | 2.265E-05 | 4.352E-06 | 5.698E-04 | 3.850E-04 |
| 1943.50 | 1.089E-10 | 2.215E-01 | 3.611E-03 | 1.451E-01 | 2.517E-02 | 1.212E-01 | 1.436E-05 | 2.265E-05 | 4.352E-06 | 4.625E-04 | 3.650E-04 |
| 1944.50 | 2.948E-02 | 2.466E-01 | 1.252E-01 | 7.856E-02 | 2.499E-02 | 1.218E-01 | 1.436E-05 | 2.265E-05 | 4.358E-06 | 2.576E-04 | 3.976E-04 |
| 1945.50 | 1.276E-02 | 2.714E-01 | 2.474E-01 | 2.470E-02 | 2.481E-02 | 1.225E-01 | 1.436E-05 | 2.265E-05 | 4.364E-06 | 8.370E-05 | 4.107E-04 |
| 1946.50 | 4.915E-03 | 2.961E-01 | 3.703E-01 | 6.877E-03 | 2.465E-02 | 1.231E-01 | 1.436E-05 | 2.265E-05 | 4.366E-06 | 2.418E-05 | 4.185E-04 |

GROUP 13 MLS DME BIAS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1846.00 | 2.738E+00 | 7.277E+00 | 8.316E-01 | 2.017E-02 | 5.534E-02 | 4.255E-02 | 8.197E-07 | 5.413E-06 | 6.151E-06 | 2.035E-02 | 9.375E-03 |
| 1860.00 | 2.821E+00 | 7.484E+00 | 2.172E-01 | 8.484E-03 | 2.602E-02 | 4.078E-02 | 7.059E-07 | 4.393E-06 | 1.026E-07 | 8.507E-03 | 7.066E-03 |
| 1874.00 | 2.568E+00 | 7.327E+00 | 7.224E-02 | 1.640E-03 | 1.077E-02 | 3.215E-02 | 1.041E-06 | 3.172E-07 | 2.881E-06 | 1.711E-03 | 5.316E-03 |
| 1884.00 | 2.410E+00 | 7.347E+00 | 8.185E-02 | 2.702E-04 | 1.206E-02 | 3.353E-02 | 1.039E-06 | 3.188E-07 | 2.881E-06 | 3.382E-04 | 1.200E-02 |
| 1894.00 | 2.235E+00 | 7.406E+00 | 2.863E-02 | 1.445E-03 | 1.345E-02 | 3.536E-02 | 1.038E-06 | 3.205E-07 | 2.882E-06 | 1.387E-03 | 1.507E-02 |
| 1904.00 | 1.959E+00 | 7.477E+00 | 3.479E-02 | 3.996E-03 | 1.437E-02 | 3.729E-02 | 1.036E-06 | 3.221E-07 | 2.882E-06 | 3.945E-03 | 1.607E-02 |
| 1914.00 | 1.476E+00 | 7.549E+00 | 7.322E-02 | 8.060E-03 | 1.412E-02 | 3.906E-02 | 1.035E-06 | 3.237E-07 | 2.882E-06 | 8.013E-03 | 1.640E-02 |
| 1924.00 | 5.973E-01 | 7.585E+00 | 9.007E-02 | 1.497E-02 | 1.180E-02 | 4.053E-02 | 1.034E-06 | 3.253E-07 | 2.883E-06 | 1.491E-02 | 1.495E-02 |
| 1934.00 | 2.919E-01 | 7.660E+00 | 1.015E-01 | 1.850E-02 | 1.236E-02 | 4.255E-02 | 1.032E-06 | 3.270E-07 | 2.883E-06 | 1.848E-02 | 1.317E-02 |
| 1943.50 | 1.022E-01 | 7.647E+00 | 9.409E-02 | 2.101E-02 | 1.238E-02 | 4.423E-02 | 1.031E-06 | 3.285E-07 | 2.883E-06 | 2.102E-02 | 1.264E-02 |
| 1943.50 | 1.740E-02 | 7.646E+00 | 9.435E-02 | 3.297E-02 | 1.242E-02 | 4.425E-02 | 1.031E-06 | 3.285E-07 | 2.883E-06 | 3.298E-02 | 1.290E-02 |
| 1944.50 | 1.066E-02 | 7.659E+00 | 5.015E-02 | 1.786E-02 | 1.246E-02 | 4.424E-02 | 1.031E-06 | 3.287E-07 | 2.883E-06 | 1.787E-02 | 1.257E-02 |
| 1945.50 | 1.448E-02 | 7.671E+00 | 5.941E-03 | 5.595E-03 | 1.252E-02 | 4.424E-02 | 1.031E-06 | 3.288E-07 | 2.883E-06 | 5.611E-03 | 1.245E-02 |
| 1946.50 | 1.627E-02 | 7.684E+00 | 3.829E-02 | 1.544E-03 | 1.259E-02 | 4.425E-02 | 1.031E-06 | 3.290E-07 | 2.883E-06 | 1.562E-03 | 1.249E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1846.00 | 2.769E+00 | 5.306E+00 | 5.031E+00 | 2.050E-02 | 2.890E-03 | 6.965E-02 | 8.325E-07 | 8.190E-06 | 1.956E-07 | 3.069E-05 | 1.233E-04 |
| 1860.00 | 2.852E+00 | 6.722E+00 | 3.269E+00 | 8.679E-03 | 4.107E-03 | 4.817E-02 | 7.242E-07 | 3.937E-06 | 1.945E-06 | 1.098E-05 | 9.029E-05 |
| 1874.00 | 2.596E+00 | 7.251E+00 | 9.844E-01 | 1.528E-03 | 6.654E-03 | 3.325E-02 | 1.046E-06 | 6.800E-07 | 2.816E-06 | 7.642E-06 | 6.285E-05 |
| 1884.00 | 2.437E+00 | 7.337E+00 | 1.778E-01 | 1.524E-04 | 1.322E-02 | 3.309E-02 | 1.044E-06 | 2.226E-07 | 2.889E-06 | 9.891E-06 | 6.229E-05 |
| 1894.00 | 2.260E+00 | 7.382E+00 | 4.812E-01 | 1.568E-03 | 1.583E-02 | 3.436E-02 | 1.043E-06 | 1.267E-07 | 2.895E-06 | 9.349E-06 | 6.673E-05 |
| 1904.00 | 1.982E+00 | 7.464E+00 | 3.214E-01 | 4.123E-03 | 1.576E-02 | 3.671E-02 | 1.042E-06 | 2.163E-07 | 2.890E-06 | 5.306E-06 | 7.378E-05 |
| 1914.00 | 1.498E+00 | 7.544E+00 | 1.159E-01 | 8.186E-03 | 1.430E-02 | 3.896E-02 | 1.040E-06 | 3.117E-07 | 2.882E-06 | 2.727E-06 | 8.090E-05 |
| 1924.00 | 6.174E-01 | 7.584E+00 | 3.158E-02 | 1.509E-02 | 1.144E-02 | 4.058E-02 | 1.039E-06 | 3.508E-07 | 2.878E-06 | 2.305E-05 | 8.449E-05 |
| 1934.00 | 3.106E-01 | 7.660E+00 | 4.703E-02 | 1.862E-02 | 1.201E-02 | 4.259E-02 | 1.038E-06 | 3.503E-07 | 2.878E-06 | 4.479E-05 | 1.080E-04 |
| 1943.50 | 1.196E-01 | 7.647E+00 | 6.953E-02 | 2.113E-02 | 1.219E-02 | 4.422E-02 | 1.037E-06 | 3.402E-07 | 2.880E-06 | 6.595E-05 | 1.404E-04 |
| 1943.50 | 3.858E-11 | 7.647E+00 | 6.953E-02 | 3.310E-02 | 1.220E-02 | 4.422E-02 | 1.037E-06 | 3.402E-07 | 2.880E-06 | 1.040E-04 | 1.404E-04 |
| 1944.50 | 6.744E-03 | 7.659E+00 | 2.783E-02 | 1.798E-02 | 1.229E-02 | 4.424E-02 | 1.036E-06 | 3.394E-07 | 2.880E-06 | 5.766E-05 | 1.442E-04 |
| 1945.50 | 2.943E-03 | 7.671E+00 | 1.410E-02 | 5.720E-03 | 1.239E-02 | 4.426E-02 | 1.036E-06 | 3.387E-07 | 2.880E-06 | 1.838E-05 | 1.482E-04 |
| 1946.50 | 1.062E-03 | 7.684E+00 | 5.716E-02 | 1.670E-03 | 1.248E-02 | 4.428E-02 | 1.036E-06 | 3.384E-07 | 2.880E-06 | 4.906E-06 | 1.503E-04 |

## GROUP 13 MLS DME SCALE FACTOR

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1846.00 | 8.879E+00 | 2.360E+01 | 2.697E+00 | 6.540E-02 | 1.795E-01 | 1.380E-01 | 2.658E-06 | 1.755E-05 | 1.995E-05 | 6.600E-02 | 3.040E-02 |
| 1860.00 | 8.354E+00 | 2.208E+01 | 5.907E-01 | 1.216E-02 | 1.893E-02 | 1.363E-01 | 2.092E-06 | 1.205E-05 | 2.280E-05 | 1.246E-02 | 7.859E-02 |
| 1874.00 | 6.379E+00 | 1.803E+01 | 2.299E-01 | 6.694E-02 | 1.282E-01 | 1.047E-01 | 5.554E-06 | 8.471E-06 | 4.746E-05 | 6.766E-02 | 1.554E-01 |
| 1884.00 | 5.212E+00 | 1.573E+01 | 1.904E-01 | 6.416E-02 | 1.137E-01 | 1.102E-01 | 5.530E-06 | 8.493E-06 | 4.746E-05 | 6.473E-02 | 1.263E-01 |
| 1894.00 | 4.180E+00 | 1.371E+01 | 6.951E-02 | 6.344E-02 | 1.005E-01 | 1.164E-01 | 5.506E-06 | 8.515E-06 | 4.746E-05 | 6.386E-02 | 1.100E-01 |
| 1904.00 | 3.117E+00 | 1.177E+01 | 3.805E-02 | 6.288E-02 | 8.758E-02 | 1.227E-01 | 5.482E-06 | 8.537E-06 | 4.746E-05 | 6.316E-02 | 1.012E-01 |
| 1914.00 | 1.960E+00 | 9.904E+00 | 7.991E-02 | 6.188E-02 | 7.560E-02 | 1.288E-01 | 5.458E-06 | 8.559E-06 | 4.746E-05 | 6.205E-02 | 9.348E-02 |
| 1924.00 | 6.515E-01 | 8.080E+00 | 8.105E-02 | 5.930E-02 | 6.139E-02 | 1.353E-01 | 5.434E-06 | 8.581E-06 | 4.745E-05 | 5.935E-02 | 7.548E-02 |
| 1934.00 | 2.556E-01 | 6.421E+00 | 7.215E-02 | 6.656E-02 | 4.091E-02 | 1.433E-01 | 5.410E-06 | 8.603E-06 | 4.745E-05 | 6.647E-02 | 4.594E-02 |
| 1943.50 | 4.377E-02 | 5.134E+00 | 8.212E-03 | 7.457E-02 | 2.395E-02 | 1.505E-01 | 5.388E-06 | 8.623E-06 | 4.745E-05 | 7.438E-02 | 2.584E-02 |
| 1943.50 | 1.184E-02 | 5.134E+00 | 8.092E-03 | 6.901E-02 | 2.394E-02 | 1.505E-01 | 5.388E-06 | 8.623E-06 | 4.745E-05 | 6.882E-02 | 2.572E-02 |
| 1944.50 | 2.606E-02 | 5.111E+00 | 1.589E-01 | 3.779E-02 | 2.225E-02 | 1.509E-01 | 5.385E-06 | 8.626E-06 | 4.745E-05 | 3.759E-02 | 2.319E-02 |
| 1945.50 | 1.840E-02 | 5.090E+00 | 3.101E-01 | 1.239E-02 | 2.059E-02 | 1.513E-01 | 5.383E-06 | 8.628E-06 | 4.745E-05 | 1.218E-02 | 2.109E-02 |
| 1946.50 | 1.495E-02 | 5.070E+00 | 4.616E-01 | 4.005E-03 | 1.901E-02 | 1.517E-01 | 5.380E-06 | 8.630E-06 | 4.745E-05 | 3.785E-03 | 1.941E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1846.00 | 8.980E+00 | 1.721E+01 | 1.632E+01 | 6.647E-02 | 9.373E-03 | 2.259E-01 | 2.700E-06 | 2.656E-05 | 6.343E-07 | 9.953E-05 | 4.000E-04 |
| 1860.00 | 8.445E+00 | 1.981E+01 | 9.689E+00 | 1.196E-02 | 7.995E-02 | 1.120E-01 | 2.191E-06 | 9.244E-08 | 2.578E-05 | 3.202E-05 | 2.098E-04 |
| 1874.00 | 6.449E+00 | 1.783E+01 | 2.474E+00 | 6.721E-02 | 1.401E-01 | 8.799E-02 | 5.626E-06 | 1.438E-05 | 4.601E-05 | 4.251E-07 | 1.663E-04 |
| 1884.00 | 5.270E+00 | 1.571E+01 | 3.656E-01 | 6.433E-02 | 1.096E-01 | 1.142E-01 | 5.605E-06 | 6.864E-06 | 4.771E-05 | 2.482E-05 | 2.152E-04 |
| 1894.00 | 4.227E+00 | 1.367E+01 | 8.746E-01 | 6.352E-02 | 9.206E-02 | 1.231E-01 | 5.582E-06 | 5.276E-06 | 4.792E-05 | 3.642E-05 | 2.394E-04 |
| 1904.00 | 3.154E+00 | 1.175E+01 | 4.896E-01 | 6.288E-02 | 8.268E-02 | 1.261E-01 | 5.559E-06 | 6.755E-06 | 4.773E-05 | 4.378E-05 | 2.537E-04 |
| 1914.00 | 1.988E+00 | 9.898E+00 | 1.359E-01 | 6.182E-02 | 7.475E-02 | 1.294E-01 | 5.537E-06 | 8.327E-06 | 4.749E-05 | 4.961E-05 | 2.690E-04 |
| 1924.00 | 6.729E-01 | 8.078E+00 | 1.879E-02 | 5.917E-02 | 6.230E-02 | 1.350E-01 | 5.515E-06 | 8.969E-06 | 4.737E-05 | 8.312E-05 | 2.814E-04 |
| 1934.00 | 2.712E-01 | 6.421E+00 | 2.648E-02 | 6.634E-02 | 4.178E-02 | 1.431E-01 | 5.493E-06 | 8.958E-06 | 4.738E-05 | 1.613E-04 | 3.634E-04 |
| 1943.50 | 5.560E-02 | 5.134E+00 | 2.476E-02 | 7.430E-02 | 2.427E-02 | 1.506E-01 | 5.471E-06 | 8.790E-06 | 4.741E-05 | 2.346E-04 | 4.785E-04 |
| 1943.50 | 1.793E-11 | 5.134E+00 | 2.476E-02 | 6.874E-02 | 2.427E-02 | 1.506E-01 | 5.471E-06 | 8.790E-06 | 4.741E-05 | 2.170E-04 | 4.765E-04 |
| 1944.50 | 1.403E-02 | 5.111E+00 | 1.738E-01 | 3.751E-02 | 2.261E-02 | 1.509E-01 | 5.469E-06 | 8.776E-06 | 4.741E-05 | 1.215E-04 | 4.925E-04 |
| 1945.50 | 6.160E-03 | 5.089E+00 | 3.234E-01 | 1.211E-02 | 2.096E-02 | 1.513E-01 | 5.467E-06 | 8.764E-06 | 4.742E-05 | 4.009E-05 | 5.072E-04 |
| 1946.50 | 2.557E-03 | 5.069E+00 | 4.741E-01 | 3.714E-03 | 1.938E-02 | 1.516E-01 | 5.465E-06 | 8.759E-06 | 4.742E-05 | 1.224E-05 | 5.152E-04 |

GROUP 14 MLS AZIMUTH SECOND-ORDER MARKOV (MULTIPLY BY 0.707)

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1836.00 | 9.106E-01 | 2.290E+00 | 1.316E+01 | 1.967E-03 | 4.377E-02 | 1.184E-01 | 5.497E-07 | 8.673E-06 | 4.259E-06 | 1.659E-03 | 1.203E-01 |
| 1846.00 | 2.572E+00 | 8.525E+00 | 1.398E+01 | 2.233E-01 | 5.909E-02 | 1.316E+00 | 9.497E-05 | 2.675E-04 | 1.729E-05 | 2.264E-01 | 8.499E-01 |
| 1846.00 | 4.866E-01 | 9.048E-01 | 1.124E+01 | 1.875E-01 | 1.235E-01 | 1.335E+00 | 9.736E-05 | 2.719E-04 | 1.553E-05 | 1.906E-01 | 8.413E-01 |
| 1860.00 | 2.547E-01 | 7.221E-01 | 8.777E+00 | 1.923E-02 | 1.571E-01 | 5.874E-01 | 5.253E-05 | 1.558E-04 | 3.523E-05 | 1.989E-02 | 3.048E-01 |
| 1874.00 | 1.062E+00 | 3.570E+00 | 9.485E+00 | 2.956E-02 | 9.905E-02 | 3.587E-01 | 5.303E-05 | 1.906E-04 | 2.561E-05 | 2.970E-02 | 9.836E-02 |
| 1884.00 | 1.061E+00 | 3.856E+00 | 1.051E+01 | 3.737E-02 | 9.659E-02 | 3.444E-01 | 5.301E-05 | 1.967E-04 | 2.567E-05 | 3.766E-02 | 9.695E-02 |
| 1894.00 | 9.994E-01 | 3.860E+00 | 9.859E+00 | 4.026E-02 | 9.574E-02 | 3.229E-01 | 5.299E-05 | 2.026E-04 | 2.573E-05 | 4.056E-02 | 1.050E-01 |
| 1904.00 | 8.901E-01 | 3.885E+00 | 9.100E+00 | 4.436E-02 | 9.826E-02 | 3.144E-01 | 5.297E-05 | 2.084E-04 | 2.580E-05 | 4.469E-02 | 1.033E-01 |
| 1914.00 | 6.737E-01 | 3.913E+00 | 8.243E+00 | 4.996E-02 | 1.036E-01 | 3.202E-01 | 5.295E-05 | 2.139E-04 | 2.586E-05 | 5.031E-02 | 1.021E-01 |
| 1924.00 | 2.517E-01 | 3.916E+00 | 7.275E+00 | 5.670E-02 | 1.111E-01 | 3.456E-01 | 5.292E-05 | 2.194E-04 | 2.592E-05 | 5.704E-02 | 1.096E-01 |
| 1934.00 | 1.221E-01 | 3.958E+00 | 6.273E+00 | 6.113E-02 | 1.193E-01 | 4.001E-01 | 5.290E-05 | 2.247E-04 | 2.599E-05 | 6.151E-02 | 1.181E-01 |
| 1943.50 | 6.734E-02 | 3.949E+00 | 5.500E+00 | 6.544E-02 | 1.266E-01 | 4.585E-01 | 5.288E-05 | 2.296E-04 | 2.604E-05 | 6.589E-02 | 1.259E-01 |
| 1943.50 | 1.514E-02 | 3.949E+00 | 5.500E+00 | 7.043E-02 | 1.266E-01 | 4.585E-01 | 5.288E-05 | 2.296E-04 | 2.604E-05 | 7.083E-02 | 1.260E-01 |
| 1944.50 | 1.798E-02 | 3.945E+00 | 5.521E+00 | 3.790E-02 | 1.269E-01 | 4.635E-01 | 5.288E-05 | 2.301E-04 | 2.605E-05 | 3.830E-02 | 1.262E-01 |
| 1945.50 | 1.433E-02 | 3.945E+00 | 5.581E+00 | 1.161E-02 | 1.273E-01 | 4.684E-01 | 5.287E-05 | 2.307E-04 | 2.606E-05 | 1.197E-02 | 1.265E-01 |
| 1946.50 | 1.415E-02 | 3.950E+00 | 5.680E+00 | 3.068E-03 | 1.276E-01 | 4.734E-01 | 5.287E-05 | 2.312E-04 | 2.606E-05 | 3.262E-03 | 1.269E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.623E-13 | 1.712E-13 |
| 1836.00 | 9.427E-01 | 1.137E+01 | 7.014E+00 | 1.976E-03 | 1.262E-01 | 3.379E-03 | 5.025E-07 | 7.305E-07 | 9.637E-06 | 6.262E-05 | 6.157E-06 |
| 1846.00 | 2.540E+00 | 1.541E+01 | 5.530E+00 | 2.260E-01 | 9.754E-01 | 8.850E-01 | 9.620E-05 | 1.587E-04 | 2.155E-04 | 8.883E-04 | 1.569E-03 |
| 1846.00 | 5.108E-01 | 8.057E+00 | 7.891E+00 | 1.904E-01 | 9.539E-01 | 9.412E-01 | 9.860E-05 | 1.649E-04 | 2.162E-04 | 8.191E-04 | 1.669E-03 |
| 1860.00 | 2.578E-01 | 3.677E+00 | 8.002E+00 | 1.987E-02 | 3.264E-01 | 5.130E-01 | 5.307E-05 | 1.262E-04 | 9.756E-05 | 2.061E-04 | 9.631E-04 |
| 1874.00 | 1.079E+00 | 3.532E+00 | 9.496E+00 | 2.976E-02 | 1.128E-01 | 3.546E-01 | 5.276E-05 | 1.864E-04 | 4.760E-05 | 1.069E-04 | 6.718E-04 |
| 1884.00 | 1.072E+00 | 3.837E+00 | 1.052E+01 | 3.769E-02 | 1.016E-01 | 3.429E-01 | 5.276E-05 | 1.974E-04 | 2.040E-05 | 8.337E-05 | 6.471E-04 |
| 1894.00 | 1.012E+00 | 3.888E+00 | 9.847E+00 | 4.058E-02 | 1.100E-01 | 3.183E-01 | 5.275E-05 | 2.036E-04 | 1.680E-05 | 9.254E-05 | 6.198E-04 |
| 1904.00 | 9.027E-01 | 3.899E+00 | 9.093E+00 | 4.473E-02 | 1.073E-01 | 3.114E-01 | 5.274E-05 | 2.090E-04 | 2.031E-05 | 9.819E-05 | 6.272E-04 |
| 1914.00 | 6.859E-01 | 3.912E+00 | 8.242E+00 | 5.036E-02 | 1.049E-01 | 3.197E-01 | 5.274E-05 | 2.141E-04 | 2.506E-05 | 1.058E-04 | 6.652E-04 |
| 1924.00 | 2.632E-01 | 3.914E+00 | 7.276E+00 | 5.709E-02 | 1.089E-01 | 3.462E-01 | 5.273E-05 | 2.193E-04 | 2.725E-05 | 1.121E-04 | 7.222E-04 |
| 1934.00 | 1.329E-01 | 3.956E+00 | 6.274E+00 | 6.155E-02 | 1.172E-01 | 4.007E-01 | 5.272E-05 | 2.246E-04 | 2.720E-05 | 1.516E-04 | 1.018E-03 |
| 1943.50 | 7.433E-02 | 3.949E+00 | 5.500E+00 | 6.592E-02 | 1.256E-01 | 4.587E-01 | 5.271E-05 | 2.296E-04 | 2.661E-05 | 2.071E-04 | 1.458E-03 |
| 1943.50 | 1.086E-08 | 3.949E+00 | 5.500E+00 | 7.087E-02 | 1.256E-01 | 4.587E-01 | 5.271E-05 | 2.296E-04 | 2.661E-05 | 2.228E-04 | 1.458E-03 |
| 1944.50 | 1.440E-02 | 3.945E+00 | 5.570E+00 | 3.833E-02 | 1.260E-01 | 4.637E-01 | 5.271E-05 | 2.301E-04 | 2.656E-05 | 1.234E-04 | 1.513E-03 |
| 1945.50 | 6.222E-03 | 3.946E+00 | 5.580E+00 | 1.200E-02 | 1.265E-01 | 4.687E-01 | 5.271E-05 | 2.306E-04 | 2.651E-05 | 3.915E-05 | 1.571E-03 |
| 1946.50 | 2.342E-03 | 3.951E+00 | 5.679E+00 | 3.291E-03 | 1.269E-01 | 4.736E-01 | 5.271E-05 | 2.312E-04 | 2.649E-05 | 1.081E-05 | 1.610E-03 |

GROUP 14 MLS ELEVATION SECOND-ORDER MARKOV (MULTIPLY BY 0.707)

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1836.00 | 1.103E+01 | 1.777E+00 | 3.614E-01 | 2.804E-02 | 4.720E-04 | 2.671E-02 | 1.310E-07 | 3.544E-06 | 5.119E-07 | 2.803E-02 | 3.257E-02 |
| 1846.00 | 1.805E+01 | 2.238E+01 | 1.315E+00 | 1.165E+00 | 1.020E-01 | 3.832E-01 | 5.879E-05 | 4.391E-05 | 4.102E-05 | 1.166E+00 | 1.618E-01 |
| 1846.00 | 8.598E+00 | 1.911E+00 | 7.364E-01 | 1.087E+00 | 7.757E-02 | 1.761E-01 | 6.523E-05 | 7.317E-05 | 2.333E-05 | 1.087E+00 | 1.816E-01 |
| 1860.00 | 6.784E+00 | 1.665E+00 | 2.532E-01 | 4.708E-01 | 9.229E-02 | 3.630E-02 | 3.921E-05 | 6.118E-05 | 1.037E-05 | 4.705E-01 | 1.158E-01 |
| 1874.00 | 7.460E+00 | 2.607E+00 | 5.616E-01 | 2.740E-01 | 7.451E-02 | 4.435E-02 | 4.987E-05 | 1.079E-04 | 3.797E-05 | 2.738E-01 | 7.023E-02 |
| 1884.00 | 7.347E+00 | 2.636E+00 | 5.136E-01 | 3.133E-01 | 9.363E-02 | 6.757E-02 | 4.990E-05 | 1.078E-04 | 3.803E-05 | 3.131E-01 | 7.069E-02 |
| 1894.00 | 6.518E+00 | 2.468E+00 | 4.626E-01 | 3.333E-01 | 1.023E-01 | 1.008E-01 | 4.993E-05 | 1.078E-04 | 3.806E-05 | 3.331E-01 | 7.565E-02 |
| 1904.00 | 5.495E+00 | 2.576E+00 | 4.162E-01 | 3.577E-01 | 1.102E-01 | 1.396E-01 | 4.996E-05 | 1.078E-04 | 3.814E-05 | 3.576E-01 | 8.012E-02 |
| 1914.00 | 4.281E+00 | 2.904E+00 | 3.664E-01 | 3.850E-01 | 1.178E-01 | 1.818E-01 | 4.999E-05 | 1.077E-04 | 3.820E-05 | 3.848E-01 | 8.459E-02 |
| 1924.00 | 2.825E+00 | 3.073E+00 | 3.124E-01 | 4.148E-01 | 1.259E-01 | 2.349E-01 | 5.001E-05 | 1.077E-04 | 3.826E-05 | 4.146E-01 | 6.090E-02 |
| 1934.00 | 1.457E+00 | 2.708E+00 | 2.607E-01 | 4.478E-01 | 1.334E-01 | 2.916E-01 | 5.004E-05 | 1.077E-04 | 3.831E-05 | 4.477E-01 | 1.105E-01 |
| 1943.50 | 4.233E-01 | 2.566E+00 | 3.753E-01 | 4.804E-01 | 1.404E-01 | 3.372E-01 | 5.007E-05 | 1.076E-04 | 3.837E-05 | 4.804E-01 | 1.327E-01 |
| 1943.50 | 5.318E-03 | 2.566E+00 | 3.754E-01 | 4.980E-01 | 1.404E-01 | 3.372E-01 | 5.007E-05 | 1.076E-04 | 3.837E-05 | 4.980E-01 | 1.324E-01 |
| 1944.50 | 1.029E-01 | 2.647E+00 | 7.036E-01 | 2.699E-01 | 1.413E-01 | 3.403E-01 | 5.007E-05 | 1.076E-04 | 3.837E-05 | 2.698E-01 | 1.386E-01 |
| 1945.50 | 4.572E-02 | 2.733E+00 | 1.042E+00 | 6.502E-02 | 1.421E-01 | 3.434E-01 | 5.007E-05 | 1.076E-04 | 3.838E-05 | 8.496E-02 | 1.420E-01 |
| 1946.50 | 1.913E-02 | 2.825E+00 | 1.385E+00 | 2.385E-02 | 1.427E-01 | 3.464E-01 | 5.008E-05 | 1.076E-04 | 3.838E-05 | 2.380E-02 | 1.430E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.623E-13 | 1.712E-13 |
| 1836.00 | 1.102E+01 | 9.982E-01 | 1.570E+00 | 2.800E-02 | 2.497E-02 | 9.626E-03 | 1.466E-07 | 1.792E-06 | 3.099E-06 | 3.026E-05 | 1.645E-05 |
| 1846.00 | 1.815E+01 | 1.536E+01 | 1.623E+01 | 1.166E+00 | 2.302E-01 | 3.187E-01 | 5.906E-05 | 3.503E-06 | 5.972E-05 | 1.974E-03 | 5.645E-04 |
| 1846.00 | 8.590E+00 | 1.730E+00 | 1.152E+00 | 1.087E+00 | 1.839E-01 | 5.680E-02 | 6.560E-05 | 2.966E-05 | 7.050E-05 | 1.823E-03 | 1.007E-04 |
| 1860.00 | 6.777E+00 | 1.460E+00 | 8.963E-01 | 4.705E-01 | 9.859E-02 | 1.936E-02 | 3.945E-05 | 5.217E-05 | 3.331E-05 | 8.116E-04 | 3.632E-05 |
| 1874.00 | 7.456E+00 | 2.630E+00 | 5.019E-01 | 2.738E-01 | 7.678E-02 | 4.169E-02 | 5.033E-05 | 1.026E-04 | 4.999E-05 | 4.695E-04 | 7.895E-05 |
| 1884.00 | 7.343E+00 | 2.634E+00 | 5.739E-01 | 3.131E-01 | 9.306E-02 | 6.941E-02 | 5.033E-05 | 1.088E-04 | 3.463E-05 | 5.494E-04 | 1.310E-04 |
| 1894.00 | 6.517E+00 | 2.445E+00 | 5.859E-01 | 3.331E-01 | 9.844E-02 | 1.052E-01 | 5.033E-05 | 1.097E-04 | 3.154E-05 | 6.020E-04 | 2.049E-04 |
| 1904.00 | 5.496E+00 | 2.562E+00 | 4.875E-01 | 3.576E-01 | 1.076E-01 | 1.421E-01 | 5.034E-05 | 1.088E-04 | 3.445E-05 | 6.703E-04 | 2.862E-04 |
| 1914.00 | 4.284E+00 | 2.899E+00 | 3.779E-01 | 3.848E-01 | 1.181E-01 | 1.819E-01 | 5.034E-05 | 1.078E-04 | 3.761E-05 | 7.473E-04 | 3.785E-04 |
| 1924.00 | 2.828E+00 | 3.072E+00 | 2.992E-01 | 4.146E-01 | 1.280E-01 | 2.340E-01 | 5.035E-05 | 1.073E-04 | 3.892E-05 | 8.658E-04 | 4.882E-04 |
| 1934.00 | 1.459E+00 | 2.709E+00 | 2.479E-01 | 4.476E-01 | 1.357E-01 | 2.907E-01 | 5.035E-05 | 1.073E-04 | 3.892E-05 | 1.152E-03 | 7.385E-04 |
| 1943.50 | 4.237E-01 | 2.567E+00 | 3.692E-01 | 4.804E-01 | 1.420E-01 | 3.366E-01 | 5.037E-05 | 1.074E-04 | 3.859E-05 | 1.535E-03 | 1.070E-03 |
| 1943.50 | 8.384E-09 | 2.567E+00 | 3.692E-01 | 4.980E-01 | 1.420E-01 | 3.366E-01 | 5.037E-05 | 1.074E-04 | 3.859E-05 | 1.591E-03 | 1.070E-03 |
| 1944.50 | 1.012E-01 | 2.648E+00 | 6.979E-01 | 2.698E-01 | 1.424E-01 | 3.399E-01 | 5.037E-05 | 1.074E-04 | 3.856E-05 | 8.868E-04 | 1.109E-03 |
| 1945.50 | 4.386E-02 | 2.735E+00 | 1.036E+00 | 8.495E-02 | 1.428E-01 | 3.431E-01 | 5.037E-05 | 1.074E-04 | 3.854E-05 | 2.894E-04 | 1.150E-03 |
| 1946.50 | 1.693E-02 | 2.828E+00 | 1.380E+00 | 2.379E-02 | 1.432E-01 | 3.462E-01 | 5.037E-05 | 1.074E-04 | 3.853E-05 | 8.511E-05 | 1.177E-03 |

GROUP 14 MLS DME SECOND-ORDER MARKOV (MULTIPLY BY 0.707)

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1846.00 | 5.818E+00 | 1.546E+01 | 1.767E+00 | 4.286E-02 | 1.176E-01 | 9.042E-02 | 1.742E-06 | 1.150E-05 | 1.307E-05 | 4.325E-02 | 1.992E-02 |
| 1860.00 | 4.030E+00 | 1.125E+01 | 7.428E-01 | 3.453E-01 | 8.946E-01 | 1.018E-01 | 9.426E-06 | 1.402E-05 | 2.079E-04 | 3.487E-01 | 9.051E-01 |
| 1874.00 | 4.830E+00 | 1.421E+01 | 3.782E-01 | 2.213E-01 | 5.633E-01 | 7.049E-02 | 3.895E-05 | 2.964E-05 | 1.452E-04 | 2.231E-01 | 6.038E-01 |
| 1884.00 | 6.004E+00 | 1.831E+01 | 3.586E-01 | 2.042E-01 | 4.307E-01 | 1.143E-01 | 3.891E-05 | 2.971E-05 | 1.452E-04 | 2.054E-01 | 4.715E-01 |
| 1894.00 | 5.890E+00 | 1.954E+01 | 2.800E-01 | 2.063E-01 | 3.621E-01 | 1.366E-01 | 3.888E-05 | 2.978E-05 | 1.452E-04 | 2.070E-01 | 4.046E-01 |
| 1904.00 | 5.430E+00 | 2.073E+01 | 2.723E-01 | 2.113E-01 | 2.949E-01 | 1.607E-01 | 3.885E-05 | 2.984E-05 | 1.452E-04 | 2.117E-01 | 3.457E-01 |
| 1914.00 | 4.264E+00 | 2.180E+01 | 3.146E-01 | 2.201E-01 | 2.353E-01 | 1.846E-01 | 3.882E-05 | 2.991E-05 | 1.452E-04 | 2.202E-01 | 2.936E-01 |
| 1924.00 | 1.749E+00 | 2.228E+01 | 3.354E-01 | 2.323E-01 | 1.780E-01 | 2.091E-01 | 3.879E-05 | 2.998E-05 | 1.452E-04 | 2.320E-01 | 2.173E-01 |
| 1934.00 | 8.687E-01 | 2.326E+01 | 3.583E-01 | 2.561E-01 | 1.622E-01 | 2.357E-01 | 3.876E-05 | 3.005E-05 | 1.452E-04 | 2.556E-01 | 1.662E-01 |
| 1943.50 | 9.623E-01 | 2.424E+01 | 4.098E-01 | 2.811E-01 | 1.807E-01 | 2.574E-01 | 3.873E-05 | 3.011E-05 | 1.452E-04 | 2.804E-01 | 1.797E-01 |
| 1943.50 | 5.503E-02 | 2.424E+01 | 4.102E-01 | 3.137E-01 | 1.808E-01 | 2.574E-01 | 3.873E-05 | 3.011E-05 | 1.452E-04 | 3.131E-01 | 1.802E-01 |
| 1944.50 | 6.406E-02 | 2.440E+01 | 5.261E-01 | 1.711E-01 | 1.828E-01 | 2.588E-01 | 3.873E-05 | 3.012E-05 | 1.452E-04 | 1.705E-01 | 1.823E-01 |
| 1945.50 | 5.053E-02 | 2.456E+01 | 7.215E-01 | 5.521E-02 | 1.850E-01 | 2.601E-01 | 3.873E-05 | 3.013E-05 | 1.452E-04 | 5.461E-02 | 1.846E-01 |
| 1946.50 | 5.207E-02 | 2.471E+01 | 9.495E-01 | 1.698E-02 | 1.873E-01 | 2.612E-01 | 3.872E-05 | 3.013E-05 | 1.452E-04 | 1.634E-02 | 1.866E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.677E-13 | 1.772E-13 |
| 1846.00 | 5.884E+00 | 1.128E+01 | 1.069E+01 | 4.356E-02 | 6.142E-03 | 1.480E-01 | 1.769E-06 | 1.740E-05 | 4.157E-07 | 6.522E-05 | 2.621E-04 |
| 1860.00 | 4.076E+00 | 1.026E+01 | 4.619E+00 | 3.489E-01 | 8.353E-01 | 3.324E-01 | 9.420E-06 | 1.084E-04 | 1.779E-04 | 2.760E-05 | 6.236E-04 |
| 1874.00 | 4.885E+00 | 1.409E+01 | 1.718E+00 | 2.233E-01 | 5.640E-01 | 5.664E-02 | 3.901E-05 | 4.752E-05 | 1.404E-04 | 9.919E-05 | 1.070E-04 |
| 1884.00 | 6.070E+00 | 1.828E+01 | 5.714E-01 | 2.055E-01 | 4.271E-01 | 1.252E-01 | 3.898E-05 | 2.484E-05 | 1.461E-04 | 8.316E-05 | 2.362E-04 |
| 1894.00 | 5.956E+00 | 1.947E+01 | 1.334E+00 | 2.072E-01 | 3.546E-01 | 1.537E-01 | 3.895E-05 | 2.012E-05 | 1.469E-04 | 1.255E-04 | 2.993E-04 |
| 1904.00 | 5.495E+00 | 2.069E+01 | 9.533E-01 | 2.118E-01 | 2.907E-01 | 1.676E-01 | 3.893E-05 | 2.451E-05 | 1.462E-04 | 1.830E-04 | 3.375E-04 |
| 1914.00 | 4.326E+00 | 2.179E+01 | 4.157E-01 | 2.204E-01 | 2.344E-01 | 1.855E-01 | 3.890E-05 | 2.923E-05 | 1.453E-04 | 2.500E-04 | 3.858E-04 |
| 1924.00 | 1.808E+00 | 2.228E+01 | 2.072E-01 | 2.322E-01 | 1.778E-01 | 2.093E-01 | 3.887E-05 | 3.116E-05 | 1.449E-04 | 3.943E-04 | 4.364E-04 |
| 1934.00 | 9.244E-01 | 2.326E+01 | 2.159E-01 | 2.558E-01 | 1.615E-01 | 2.365E-01 | 3.884E-05 | 3.113E-05 | 1.450E-04 | 6.402E-04 | 6.005E-04 |
| 1943.50 | 9.777E-01 | 2.425E+01 | 3.433E-01 | 2.806E-01 | 1.802E-01 | 2.583E-01 | 3.882E-05 | 3.062E-05 | 1.451E-04 | 8.922E-04 | 8.207E-04 |
| 1943.50 | 3.823E-08 | 2.425E+01 | 3.433E-01 | 3.133E-01 | 1.803E-01 | 2.583E-01 | 3.882E-05 | 3.062E-05 | 1.451E-04 | 9.950E-04 | 8.207E-04 |
| 1944.50 | 6.389E-02 | 2.440E+01 | 4.884E-01 | 1.707E-01 | 1.824E-01 | 2.594E-01 | 3.881E-05 | 3.058E-05 | 1.451E-04 | 5.568E-04 | 8.463E-04 |
| 1945.50 | 2.798E-02 | 2.456E+01 | 7.021E-01 | 5.476E-02 | 1.846E-01 | 2.605E-01 | 3.881E-05 | 3.055E-05 | 1.451E-04 | 1.837E-04 | 8.733E-04 |
| 1946.50 | 1.108E-02 | 2.471E+01 | 9.392E-01 | 1.649E-02 | 1.869E-01 | 2.616E-01 | 3.881E-05 | 3.053E-05 | 1.451E-04 | 5.660E-05 | 8.888E-04 |

GROUP 15 RADAR ALTIMETER BIAS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1860.00 | | | | | | | | | | | |
| 1874.00 | | | | | | | | | | | |
| 1884.00 | | | | | | | | | | | |
| 1894.00 | | | | | | | | | | | |
| 1904.00 | | | | | | | | | | | |
| 1914.00 | | | | | | | | | | | |
| 1924.00 | | | | | | | | | | | |
| 1934.00 | | | | | | | | | | | |
| 1943.50 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1943.50 | 1.000E+00 | 2.315E-03 | 2.159E-03 | 1.000E-01 | 2.731E-04 | 1.726E-04 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.000E-01 | 2.166E-03 |
| 1944.50 | 9.797E-01 | 2.228E-03 | 2.156E-03 | 5.418E-02 | 1.634E-04 | 7.770E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 5.418E-02 | 8.817E-04 |
| 1945.50 | 9.912E-01 | 2.216E-03 | 2.220E-03 | 1.707E-02 | 7.750E-05 | 1.744E-06 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.707E-02 | 2.176E-04 |
| 1946.50 | 9.966E-01 | 2.189E-03 | 2.270E-03 | 4.787E-03 | 4.937E-05 | 2.818E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 4.787E-03 | 8.409E-05 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1860.00 | | | | | | | | | | | |
| 1874.00 | | | | | | | | | | | |
| 1884.00 | | | | | | | | | | | |
| 1894.00 | | | | | | | | | | | |
| 1904.00 | | | | | | | | | | | |
| 1914.00 | | | | | | | | | | | |
| 1924.00 | | | | | | | | | | | |
| 1934.00 | | | | | | | | | | | |
| 1943.50 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1943.50 | 1.000E+00 | 1.345E-05 | 2.154E-05 | 1.000E-01 | 4.307E-05 | 4.537E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 3.177E-04 | 1.442E-07 |
| 1944.50 | 9.797E-01 | 1.249E-05 | 1.987E-05 | 5.418E-02 | 3.960E-05 | 4.034E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.768E-04 | 1.316E-07 |
| 1945.50 | 9.912E-01 | 3.704E-05 | 5.849E-05 | 1.707E-02 | 3.881E-05 | 3.886E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 5.722E-05 | 1.303E-07 |
| 1946.50 | 9.966E-01 | 4.786E-05 | 7.532E-05 | 4.787E-03 | 3.872E-05 | 3.862E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.627E-05 | 1.313E-07 |

## GROUP 15 RADAR ALTIMETER FIRST-ORDER MARKOV

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1860.00 | | | | | | | | | | | |
| 1874.00 | | | | | | | | | | | |
| 1884.00 | | | | | | | | | | | |
| 1894.00 | | | | | | | | | | | |
| 1904.00 | | | | | | | | | | | |
| 1914.00 | | | | | | | | | | | |
| 1924.00 | | | | | | | | | | | |
| 1934.00 | | | | | | | | | | | |
| 1943.50 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1943.50 | 1.000E+00 | 2.315E-03 | 2.159E-03 | 1.000E-01 | 2.731E-04 | 1.726E-04 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-01 | 2.166E-03 |
| 1944.50 | 9.276E-01 | 2.112E-03 | 2.038E-03 | 5.045E-01 | 1.142E-03 | 1.115E-03 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 5.045E-01 | 7.828E-03 |
| 1945.50 | 9.790E-01 | 2.199E-03 | 2.177E-03 | 5.477E-01 | 1.214E-03 | 1.232E-03 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 5.477E-01 | 5.708E-03 |
| 1946.50 | 1.023E+00 | 2.275E-03 | 2.290E-03 | 5.234E-01 | 1.149E-03 | 1.182E-03 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 5.234E-01 | 4.933E-03 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1846.00 | | | | | | | | | | | |
| 1860.00 | | | | | | | | | | | |
| 1874.00 | | | | | | | | | | | |
| 1884.00 | | | | | | | | | | | |
| 1894.00 | | | | | | | | | | | |
| 1904.00 | | | | | | | | | | | |
| 1914.00 | | | | | | | | | | | |
| 1924.00 | | | | | | | | | | | |
| 1934.00 | | | | | | | | | | | |
| 1943.50 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.177E-13 | 3.178E-13 |
| 1943.50 | 1.000E+00 | 1.345E-05 | 2.154E-05 | 1.000E-01 | 4.307E-05 | 4.537E-05 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 3.177E-04 | 1.442E-07 |
| 1944.50 | 9.276E-01 | 1.278E-05 | 2.031E-05 | 5.045E-01 | 3.904E-05 | 4.081E-05 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.646E-03 | 1.332E-07 |
| 1945.50 | 9.790E-01 | 3.898E-05 | 6.152E-05 | 5.477E-01 | 4.936E-05 | 5.724E-05 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.836E-03 | 1.919E-07 |
| 1946.50 | 1.023E+00 | 6.421E-05 | 1.009E-04 | 5.234E-01 | 5.432E-05 | 6.545E-05 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.779E-03 | 2.224E-07 |

## GROUP 16 TACAN SURVEY ERRORS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1432.00 | 3.398E-02 | 3.165E-01 | 5.526E-01 | 3.693E-04 | 7.909E-04 | 2.099E-04 | 3.155E-08 | 1.409E-08 | 1.292E-08 | 2.945E-04 | 7.213E-04 |
| 1490.00 | 1.216E-01 | 5.748E-01 | 6.231E-01 | 9.615E-05 | 1.885E-04 | 8.018E-05 | 5.671E-08 | 3.711E-08 | 4.310E-09 | 8.712E-05 | 1.085E-04 |
| 1550.00 | 4.938E-01 | 8.511E-01 | 9.902E-01 | 5.363E-04 | 6.294E-04 | 1.209E-04 | 7.413E-08 | 7.330E-08 | 3.367E-08 | 6.338E-04 | 6.002E-04 |
| 1550.00 | 2.341E-01 | 8.227E-01 | 1.061E+00 | 2.840E-04 | 1.016E-03 | 1.092E-04 | 7.001E-08 | 8.923E-08 | 4.752E-08 | 1.877E-04 | 9.880E-04 |
| 1610.00 | 4.477E-01 | 9.078E-01 | 1.180E+00 | 2.245E-00 | 3.294E-04 | 3.792E-04 | 1.063E-07 | 1.211E-07 | 4.959E-08 | 2.251E-04 | 5.127E-04 |
| 1670.00 | 7.237E-01 | 9.496E-01 | 1.147E+00 | 1.072E-03 | 3.451E-05 | 1.700E-04 | 1.095E-07 | 1.304E-07 | 4.811E-08 | 1.096E-03 | 2.080E-04 |
| 1730.00 | 8.751E-01 | 9.923E-01 | 1.075E+00 | 1.443E-03 | 1.324E-04 | 6.077E-04 | 9.124E-08 | 8.393E-08 | 2.636E-08 | 1.455E-03 | 1.654E-04 |
| 1790.00 | 9.259E-01 | 9.973E-01 | 9.997E-01 | 1.254E-03 | 1.105E-04 | 9.577E-04 | 7.634E-08 | 5.866E-08 | 5.419E-08 | 1.264E-03 | 7.205E-05 |
| 1836.00 | 8.445E-01 | 9.944E-01 | 9.979E-01 | 7.974E-04 | 1.827E-04 | 8.932E-04 | 6.770E-08 | 6.208E-08 | 7.079E-08 | 7.618E-04 | 5.970E-04 |
| 1836.00 | 4.738E-01 | 1.204E+00 | 2.047E-01 | 4.080E-04 | 2.885E-03 | 9.187E-03 | 9.634E-08 | 6.068E-07 | 3.121E-07 | 4.242E-04 | 9.232E-03 |
| 1846.00 | 4.497E-01 | 1.160E+00 | 1.314E-01 | 1.641E-03 | 2.917E-03 | 7.847E-03 | 9.325E-08 | 4.812E-07 | 3.339E-07 | 1.662E-03 | 7.992E-03 |
| 1846.00 | 2.051E-02 | 2.695E-02 | 1.840E-03 | 5.069E-03 | 1.152E-02 | 1.203E-03 | 2.027E-07 | 3.368E-07 | 1.299E-06 | 5.119E-03 | 9.525E-03 |
| 1860.00 | 6.917E-03 | 9.574E-04 | 7.618E-03 | 2.627E-03 | 4.684E-03 | 3.207E-04 | 2.258E-07 | 3.415E-07 | 1.508E-07 | 2.646E-03 | 4.971E-03 |
| 1874.00 | 9.947E-03 | 3.586E-02 | 7.386E-03 | 8.807E-04 | 1.237E-03 | 3.461E-04 | 3.205E-07 | 1.520E-07 | 9.337E-07 | 8.857E-04 | 1.527E-03 |
| 1884.00 | 1.228E-02 | 4.165E-02 | 6.292E-03 | 8.679E-04 | 1.445E-03 | 4.806E-04 | 3.202E-07 | 1.515E-07 | 9.339E-07 | 8.731E-04 | 1.656E-03 |
| 1894.00 | 1.153E-02 | 4.184E-02 | 5.781E-03 | 8.318E-04 | 1.598E-03 | 5.925E-04 | 3.199E-07 | 1.510E-07 | 9.341E-07 | 8.369E-04 | 1.757E-03 |
| 1904.00 | 1.019E-02 | 4.211E-02 | 5.354E-03 | 7.870E-04 | 1.731E-03 | 7.146E-04 | 3.195E-07 | 1.505E-07 | 9.343E-07 | 7.919E-04 | 1.675E-03 |
| 1914.00 | 7.699E-03 | 4.243E-02 | 4.813E-03 | 7.251E-04 | 1.858E-03 | 8.455E-04 | 3.192E-07 | 1.499E-07 | 9.345E-07 | 7.296E-04 | 1.987E-03 |
| 1924.00 | 2.980E-03 | 4.256E-02 | 4.168E-03 | 6.495E-04 | 2.053E-03 | 9.995E-04 | 3.188E-07 | 1.494E-07 | 9.347E-07 | 6.538E-04 | 2.157E-03 |
| 1934.00 | 1.444E-03 | 4.272E-02 | 3.549E-03 | 4.767E-04 | 2.252E-03 | 1.149E-03 | 3.185E-07 | 1.489E-07 | 9.349E-07 | 5.005E-04 | 2.286E-03 |
| 1943.50 | 2.561E-04 | 4.119E-02 | 2.497E-03 | 3.436E-04 | 2.359E-03 | 1.278E-03 | 3.182E-07 | 1.484E-07 | 9.351E-07 | 3.468E-04 | 2.369E-03 |
| 1943.50 | 8.936E-05 | 4.119E-02 | 2.497E-03 | 3.090E-04 | 2.359E-03 | 1.278E-03 | 3.182E-07 | 1.484E-07 | 9.351E-07 | 3.123E-04 | 2.369E-03 |
| 1944.50 | 1.481E-04 | 3.882E-02 | 1.217E-03 | 1.602E-04 | 2.391E-03 | 1.281E-03 | 3.181E-07 | 1.484E-07 | 9.351E-07 | 1.634E-04 | 2.397E-03 |
| 1945.50 | 1.079E-04 | 3.641E-02 | 6.516E-05 | 4.203E-05 | 2.423E-03 | 1.283E-03 | 3.181E-07 | 1.483E-07 | 9.351E-07 | 4.526E-05 | 2.427E-03 |
| 1946.50 | 8.657E-05 | 3.397E-02 | 1.350E-03 | 2.498E-06 | 2.454E-03 | 1.286E-03 | 3.181E-07 | 1.482E-07 | 9.352E-07 | 5.654E-06 | 2.457E-03 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1432.00 | 3.773E-02 | 1.476E-01 | 6.193E-01 | 3.374E-04 | 7.340E-04 | 3.916E-04 | 3.073E-08 | 2.042E-08 | 3.934E-10 | 5.241E-08 | 4.287E-08 |
| 1490.00 | 1.173E-01 | 1.536E-02 | 8.482E-01 | 9.057E-05 | 1.939E-04 | 7.366E-05 | 5.589E-08 | 2.524E-08 | 2.918E-08 | 2.065E-08 | 1.176E-08 |
| 1550.00 | 4.908E-01 | 5.476E-01 | 1.187E+00 | 5.436E-04 | 5.623E-04 | 2.945E-04 | 7.342E-08 | 6.208E-08 | 5.250E-08 | 1.707E-07 | 1.256E-07 |
| 1550.00 | 2.321E-01 | 4.966E-01 | 1.248E+00 | 2.695E-04 | 1.010E-03 | 1.781E-04 | 6.921E-08 | 7.344E-08 | 7.028E-08 | 7.501E-08 | 9.275E-08 |
| 1610.00 | 4.488E-01 | 2.848E-02 | 1.489E+00 | 2.284E-04 | 4.894E-04 | 9.160E-05 | 1.058E-07 | 6.418E-08 | 1.145E-07 | 6.858E-08 | 3.432E-09 |
| 1670.00 | 7.257E-01 | 3.189E-01 | 1.453E+00 | 1.072E-03 | 4.520E-05 | 1.649E-04 | 1.095E-07 | 9.403E-08 | 1.024E-07 | 6.795E-07 | 6.667E-08 |
| 1730.00 | 8.781E-01 | 2.693E-01 | 1.436E+00 | 1.443E-03 | 4.328E-04 | 4.474E-04 | 9.144E-08 | 5.702E-08 | 6.672E-08 | 1.440E-06 | 4.824E-07 |
| 1790.00 | 9.296E-01 | 2.911E-01 | 1.379E+00 | 1.254E-03 | 4.227E-04 | 8.665E-04 | 7.656E-08 | 1.955E-08 | 7.722E-08 | 1.794E-06 | 1.239E-06 |
| 1836.00 | 8.475E-01 | 1.296E+00 | 5.481E-01 | 7.980E-04 | 8.972E-04 | 1.584E-04 | 6.787E-08 | 8.878E-08 | 3.099E-08 | 1.629E-06 | 2.338E-07 |
| 1836.00 | 4.791E-01 | 6.372E-01 | 1.039E+00 | 4.064E-04 | 9.601E-03 | 7.379E-04 | 9.301E-08 | 6.425E-08 | 6.798E-07 | 4.298E-06 | 1.248E-06 |
| 1846.00 | 4.547E-01 | 8.449E-01 | 8.026E-01 | 1.639E-03 | 7.886E-03 | 2.811E-03 | 9.044E-08 | 5.314E-08 | 5.837E-07 | 1.644E-06 | 4.965E-06 |
| 1846.00 | 2.063E-02 | 1.869E-02 | 1.938E-02 | 5.119E-03 | 8.315E-03 | 8.038E-03 | 2.018E-07 | 1.213E-06 | 5.756E-07 | 3.605E-06 | 1.425E-05 |
| 1860.00 | 6.937E-03 | 2.705E-03 | 7.166E-03 | 2.646E-03 | 4.291E-03 | 1.879E-03 | 2.275E-07 | 2.319E-07 | 2.911E-07 | 1.462E-06 | 3.527E-06 |
| 1874.00 | 1.007E-02 | 3.647E-02 | 2.853E-03 | 8.848E-04 | 1.268E-03 | 1.904E-04 | 3.232E-07 | 3.248E-08 | 9.446E-07 | 4.140E-07 | 3.597E-07 |
| 1884.00 | 1.242E-02 | 4.136E-02 | 7.758E-03 | 8.721E-04 | 1.424E-03 | 5.327E-04 | 3.228E-07 | 1.826E-07 | 9.274E-07 | 3.711E-07 | 1.003E-06 |
| 1894.00 | 1.165E-02 | 4.131E-02 | 8.645E-03 | 8.359E-04 | 1.551E-03 | 7.018E-04 | 3.224E-07 | 2.133E-07 | 9.210E-07 | 2.251E-07 | 1.365E-06 |
| 1904.00 | 1.031E-02 | 4.185E-02 | 6.964E-03 | 7.909E-04 | 1.701E-03 | 7.812E-04 | 3.220E-07 | 1.846E-07 | 9.273E-07 | 4.836E-08 | 1.573E-06 |
| 1914.00 | 7.812E-03 | 4.238E-02 | 5.051E-03 | 7.287E-04 | 1.851E-03 | 8.567E-04 | 3.217E-07 | 1.539E-07 | 9.330E-07 | 1.716E-07 | 1.781E-06 |
| 1924.00 | 3.084E-03 | 4.258E-02 | 3.839E-03 | 6.528E-04 | 2.059E-03 | 9.848E-04 | 3.213E-07 | 1.412E-07 | 9.352E-07 | 2.006E-07 | 2.053E-06 |
| 1934.00 | 1.542E-03 | 4.274E-02 | 3.244E-03 | 4.997E-04 | 2.259E-03 | 1.133E-03 | 3.209E-07 | 1.414E-07 | 9.353E-07 | 8.998E-07 | 2.878E-06 |
| 1943.50 | 3.455E-04 | 4.120E-02 | 2.364E-03 | 3.462E-04 | 2.363E-03 | 1.271E-03 | 3.206E-07 | 1.446E-07 | 9.349E-07 | 9.423E-07 | 4.040E-06 |
| 1943.50 | 1.114E-13 | 4.120E-02 | 2.364E-03 | 3.116E-04 | 2.363E-03 | 1.271E-03 | 3.206E-07 | 1.446E-07 | 9.349E-07 | 8.326E-07 | 4.040E-06 |
| 1944.50 | 6.197E-05 | 3.882E-02 | 1.104E-03 | 1.628E-04 | 2.394E-03 | 1.274E-03 | 3.205E-07 | 1.449E-07 | 9.349E-07 | 4.117E-07 | 4.158E-06 |
| 1945.50 | 2.501E-05 | 3.641E-02 | 1.604E-04 | 4.474E-05 | 2.426E-03 | 1.277E-03 | 3.205E-07 | 1.451E-07 | 9.348E-07 | 6.649E-08 | 4.282E-06 |
| 1946.50 | 7.334E-06 | 3.397E-02 | 1.433E-03 | 5.175E-06 | 2.457E-03 | 1.280E-03 | 3.205E-07 | 1.452E-07 | 9.348E-07 | 5.994E-08 | 4.348E-06 |

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OF POOR QUALITY

## GROUP 17 MLS SURVEY ERRORS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1836.00 | 5.166E-01 | 2.329E-01 | 7.899E-01 | 1.577E-03 | 2.713E-03 | 6.661E-03 | 2.696E-08 | 7.168E-07 | 2.350E-07 | 1.557E-03 | 9.080E-03 |
| 1846.00 | 5.358E-01 | 2.026E-01 | 8.633E-01 | 2.029E-03 | 2.675E-03 | 7.900E-03 | 3.560E-08 | 6.386E-07 | 2.378E-07 | 2.012E-03 | 8.008E-03 |
| 1846.00 | 6.749E-01 | 1.628E-01 | 9.058E-01 | 3.187E-03 | 5.448E-03 | 5.822E-03 | 6.235E-08 | 3.924E-07 | 5.520E-07 | 3.179E-03 | 8.564E-03 |
| 1860.00 | 7.204E-01 | 2.456E-01 | 9.722E-01 | 3.196E-03 | 5.411E-03 | 4.900E-03 | 1.145E-07 | 2.036E-07 | 5.639E-07 | 3.192E-03 | 7.747E-03 |
| 1874.00 | 7.680E-01 | 3.396E-01 | 1.001E+00 | 3.244E-03 | 5.449E-03 | 3.825E-03 | 9.949E-08 | 2.716E-07 | 5.768E-07 | 3.246E-03 | 6.707E-03 |
| 1884.00 | 8.031E-01 | 4.040E-01 | 1.001E+00 | 3.188E-03 | 5.133E-03 | 4.074E-03 | 9.985E-08 | 2.718E-07 | 5.767E-07 | 3.188E-03 | 5.849E-03 |
| 1894.00 | 8.404E-01 | 4.752E-01 | 9.968E-01 | 3.181E-03 | 4.891E-03 | 4.307E-03 | 1.002E-07 | 2.720E-07 | 5.765E-07 | 3.178E-03 | 5.480E-03 |
| 1904.00 | 8.850E-01 | 5.645E-01 | 9.935E-01 | 3.212E-03 | 4.801E-03 | 4.491E-03 | 1.006E-07 | 2.722E-07 | 5.764E-07 | 3.205E-03 | 5.530E-03 |
| 1914.00 | 9.371E-01 | 6.814E-01 | 9.932E-01 | 3.310E-03 | 4.929E-03 | 4.588E-03 | 1.009E-07 | 2.724E-07 | 5.762E-07 | 3.299E-03 | 5.822E-03 |
| 1924.00 | 9.865E-01 | 8.345E-01 | 9.951E-01 | 3.561E-03 | 5.227E-03 | 4.607E-03 | 1.013E-07 | 2.726E-07 | 5.761E-07 | 3.546E-03 | 5.996E-03 |
| 1934.00 | 1.001E+00 | 1.029E+00 | 9.981E-01 | 4.270E-03 | 5.570E-03 | 4.536E-03 | 1.017E-07 | 2.728E-07 | 5.759E-07 | 4.254E-03 | 5.854E-03 |
| 1943.50 | 1.004E+00 | 1.237E+00 | 1.004E+00 | 5.146E-03 | 6.012E-03 | 4.375E-03 | 1.020E-07 | 2.730E-07 | 5.758E-07 | 5.132E-03 | 6.122E-03 |
| 1943.50 | 6.480E-04 | 1.235E+00 | 1.006E+00 | 1.056E-01 | 6.286E-03 | 4.201E-03 | 1.020E-07 | 2.730E-07 | 5.758E-07 | 1.056E-01 | 8.298E-03 |
| 1944.50 | 2.084E-02 | 1.241E+00 | 1.011E+00 | 5.723E-02 | 6.149E-03 | 4.308E-03 | 1.020E-07 | 2.730E-07 | 5.757E-07 | 5.722E-02 | 6.920E-03 |
| 1945.50 | 8.702E-03 | 1.247E+00 | 1.015E+00 | 1.805E-02 | 6.037E-03 | 4.399E-03 | 1.021E-07 | 2.730E-07 | 5.757E-07 | 1.803E-02 | 6.197E-03 |
| 1946.50 | 3.010E-03 | 1.253E+00 | 1.019E+00 | 5.084E-03 | 5.987E-03 | 4.433E-03 | 1.021E-07 | 2.730E-07 | 5.757E-07 | 5.070E-03 | 6.035E-03 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1836.00 | 5.143E-01 | 6.466E-01 | 5.123E-01 | 1.575E-03 | 9.048E-03 | 7.074E-04 | 2.325E-08 | 4.819E-08 | 7.529E-07 | 2.276E-06 | 1.233E-06 |
| 1846.00 | 5.333E-01 | 5.309E-01 | 7.122E-01 | 2.027E-03 | 7.771E-03 | 3.032E-03 | 3.228E-08 | 2.279E-07 | 6.424E-07 | 1.032E-06 | 5.402E-06 |
| 1846.00 | 6.739E-01 | 7.980E-01 | 4.600E-01 | 3.201E-03 | 7.956E-03 | 4.225E-04 | 5.955E-08 | 1.710E-07 | 6.556E-07 | 7.174E-07 | 7.162E-07 |
| 1860.00 | 7.194E-01 | 6.667E-01 | 7.500E-01 | 3.209E-03 | 7.058E-03 | 1.842E-03 | 1.125E-07 | 8.096E-08 | 5.944E-07 | 5.280E-07 | 3.501E-06 |
| 1874.00 | 7.671E-01 | 4.598E-01 | 9.520E-01 | 3.257E-03 | 5.874E-03 | 3.120E-03 | 9.927E-08 | 3.415E-07 | 5.385E-07 | 5.975E-07 | 5.963E-06 |
| 1884.00 | 8.023E-01 | 3.667E-01 | 1.016E+00 | 3.198E-03 | 4.977E-03 | 4.256E-03 | 9.956E-08 | 2.513E-07 | 5.860E-07 | 1.508E-06 | 8.089E-06 |
| 1894.00 | 8.399E-01 | 4.031E-01 | 1.029E+00 | 3.188E-03 | 4.575E-03 | 4.637E-03 | 9.986E-08 | 2.316E-07 | 5.939E-07 | 1.808E-06 | 9.087E-06 |
| 1904.00 | 8.846E-01 | 5.237E-01 | 1.016E+00 | 3.217E-03 | 4.617E-03 | 4.676E-03 | 1.002E-07 | 2.499E-07 | 5.865E-07 | 1.895E-06 | 9.478E-06 |
| 1914.00 | 9.369E-01 | 6.735E-01 | 9.988E-01 | 3.314E-03 | 4.895E-03 | 4.621E-03 | 1.005E-07 | 2.691E-07 | 5.778E-07 | 1.913E-06 | 9.676E-06 |
| 1924.00 | 9.866E-01 | 8.397E-01 | 9.907E-01 | 3.565E-03 | 5.253E-03 | 4.574E-03 | 1.008E-07 | 2.768E-07 | 5.741E-07 | 4.164E-06 | 9.597E-06 |
| 1934.00 | 1.001E+00 | 1.033E+00 | 9.929E-01 | 4.274E-03 | 5.592E-03 | 4.505E-03 | 1.011E-07 | 2.767E-07 | 5.741E-07 | 9.854E-06 | 1.149E-05 |
| 1943.50 | 1.004E+00 | 1.238E+00 | 1.002E+00 | 5.150E-03 | 6.014E-03 | 4.367E-03 | 1.014E-07 | 2.746E-07 | 5.751E-07 | 1.590E-05 | 1.393E-05 |
| 1943.50 | 3.239E-10 | 1.238E+00 | 1.002E+00 | 1.056E-01 | 6.058E-03 | 4.412E-03 | 1.014E-07 | 2.746E-07 | 5.751E-07 | 3.350E-04 | 1.408E-05 |
| 1944.50 | 2.148E-02 | 1.244E+00 | 1.007E+00 | 5.724E-02 | 6.031E-03 | 4.415E-03 | 1.014E-07 | 2.744E-07 | 5.752E-07 | 1.864E-04 | 1.446E-05 |
| 1945.50 | 9.321E-03 | 1.249E+00 | 1.012E+00 | 1.805E-02 | 6.008E-03 | 4.422E-03 | 1.014E-07 | 2.743E-07 | 5.752E-07 | 6.025E-05 | 1.488E-05 |
| 1946.50 | 3.577E-03 | 1.255E+00 | 1.016E+00 | 5.087E-03 | 5.987E-03 | 4.429E-03 | 1.015E-07 | 2.742E-07 | 5.753E-07 | 1.703E-05 | 1.511E-05 |

## GROUP 19 TACAN BEARING BIAS

| TIME | POSITION ESTIMATE ERROR R | POSITION ESTIMATE ERROR D | POSITION ESTIMATE ERROR C | VELOCITY ESTIMATE ERROR R | VELOCITY ESTIMATE ERROR D | VELOCITY ESTIMATE ERROR C | PLATFORM TILT ESTIMATE R | PLATFORM TILT ESTIMATE D | PLATFORM TILT ESTIMATE C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 |
| 1432.00 | 1.417E+02 | 1.182E+03 | 2.323E+03 | 1.554E+00 | 3.100E+00 | 8.797E-01 | 1.241E-04 | 5.852E-05 | 5.130E-05 | 1.216E+00 | 2.867E+00 |
| 1490.00 | 1.921E+02 | 5.676E+02 | 7.987E+02 | 7.352E-01 | 8.834E-01 | 2.285E+00 | 1.485E-04 | 1.247E-04 | 3.070E-05 | 7.342E-01 | 1.566E+00 |
| 1550.00 | 4.357E+02 | 3.738E+02 | 7.034F+02 | 1.674E+00 | 1.592E+00 | 3.374E+00 | 1.706E-04 | 1.319E-04 | 2.514E-05 | 1.639E+00 | 8.180E-01 |
| 1550.00 | 2.139E+02 | 3.882E+02 | 6.397F+02 | 1.105E+00 | 1.911E+00 | 3.289E+00 | 1.768E-04 | 1.217E-04 | 3.716E-05 | 1.071E+00 | 1.013E+00 |
| 1610.00 | 4.056E+02 | 3.966E+02 | 5.846E+02 | 1.232E+00 | 3.238E+00 | 4.059E+00 | 1.777E-04 | 1.218E-04 | 1.256E-04 | 1.237E+00 | 4.331E-01 |
| 1670.00 | 5.921E+02 | 3.095E+02 | 5.473E+02 | 1.641E+00 | 2.449E+00 | 2.954E+00 | 1.258E-04 | 1.056E-04 | 1.855E-04 | 1.643E+00 | 1.395E+00 |
| 1730.00 | 1.097E+03 | 2.365E+02 | 8.901E+02 | 3.601E+00 | 1.050E+00 | 3.960E+00 | 1.428E-04 | 2.663E-04 | 2.368E-04 | 3.625E+00 | 1.419E+00 |
| 1790.00 | 4.711E+02 | 9.646E+01 | 3.856E+02 | 1.968E+00 | 7.327E-01 | 2.305E+00 | 1.342E-04 | 2.364E-04 | 2.021E-04 | 1.974E+00 | 1.129E+00 |
| 1836.00 | 3.605E+02 | 1.162E+02 | 3.107E+02 | 1.251E+00 | 7.449E-01 | 3.319E+00 | 1.413E-04 | 4.196E-04 | 1.903E-04 | 1.259E+00 | 2.868E+00 |
| 1836.00 | 3.718F+01 | 7.977E+01 | 1.153E+01 | 1.166E+00 | 6.841E-01 | 1.992E+00 | 1.423E-04 | 2.936E-04 | 2.035E-04 | 1.170E+00 | 1.444E+00 |
| 1846.00 | 2.547E+01 | 6.996E+01 | 1.020E+01 | 6.252E-01 | 6.432E-01 | 7.424E-01 | 1.555E-04 | 2.741E-04 | 2.034E-04 | 6.287E-01 | 7.571E-01 |
| 1846.00 | 2.898E-01 | 1.844E+00 | 2.393E+00 | 7.369E-01 | 1.059E+00 | 4.647E-01 | 1.607E-04 | 2.796E-04 | 2.469E-04 | 7.418E-01 | 8.253E-01 |
| 1860.00 | 1.643E+00 | 8.793E-01 | 2.360E+00 | 2.873E-01 | 4.044E-01 | 1.233E-01 | 1.753E-04 | 3.216E-04 | 1.749E-04 | 2.890E-01 | 4.283E-01 |
| 1874.00 | 9.746E-01 | 3.073E+00 | 2.208E+00 | 1.287E-01 | 1.103E-01 | 1.749E-01 | 1.764E-04 | 3.621E-04 | 1.746E-04 | 1.292E-01 | 1.330E-01 |
| 1884.00 | 1.123E+00 | 3.545E+00 | 2.008E+00 | 1.703E-01 | 1.598E-01 | 3.283E-01 | 1.792E-04 | 3.701E-04 | 1.781E-04 | 1.710E-01 | 1.727E-01 |
| 1894.00 | 1.038E+00 | 3.573E+00 | 1.773E+00 | 1.936E-01 | 1.998E-01 | 4.653E-01 | 1.820E-04 | 3.779E-04 | 1.815E-04 | 1.945E-01 | 2.079E-01 |
| 1904.00 | 9.132E-01 | 3.621E+00 | 1.550E+00 | 2.103E-01 | 2.380E-01 | 6.121E-01 | 1.846E-04 | 3.856E-04 | 1.848E-04 | 2.114E-01 | 2.358E-01 |
| 1914.00 | 6.987E-01 | 3.696E+00 | 1.330E+00 | 2.304E-01 | 2.763E-01 | 7.678E-01 | 1.875E-04 | 3.931E-04 | 1.881E-04 | 2.318E-01 | 2.629E-01 |
| 1924.00 | 3.029E-01 | 3.803E+00 | 1.112E+00 | 2.563E-01 | 3.278E-01 | 9.609E-01 | 1.902E-04 | 4.004E-04 | 1.914E-04 | 2.581E-01 | 3.153E-01 |
| 1934.00 | 1.590E-01 | 3.904E+00 | 9.115E-01 | 2.991E-01 | 3.852E-01 | 1.176E+00 | 1.928E-04 | 4.076E-04 | 1.945E-04 | 3.012E-01 | 3.812E-01 |
| 1943.50 | 9.396E-02 | 3.973E+00 | 7.946E-01 | 3.461E-01 | 4.252E-01 | 1.350E+00 | 1.953E-04 | 4.144E-04 | 1.975E-04 | 3.485E-01 | 4.234E-01 |
| 1943.50 | 8.125E-03 | 3.973E+00 | 7.945E-01 | 3.539E-01 | 4.252E-01 | 1.350E+00 | 1.953E-04 | 4.144E-04 | 1.975E-04 | 3.563E-01 | 4.235E-01 |
| 1944.50 | 7.601E-02 | 4.028E+00 | 1.862E+00 | 1.912E-01 | 4.314E-01 | 1.363E+00 | 1.956E-04 | 4.151E-04 | 1.978E-04 | 1.936E-01 | 4.306E-01 |
| 1945.50 | 3.354E-02 | 4.131E+00 | 3.172E+00 | 5.927E-02 | 4.376E-01 | 1.375E+00 | 1.958E-04 | 4.158E-04 | 1.981E-04 | 6.163E-02 | 4.372E-01 |
| 1946.50 | 1.539E-02 | 4.278E+00 | 4.530E+00 | 1.591E-02 | 4.436E-01 | 1.388E+00 | 1.961E-04 | 4.165E-04 | 1.984E-04 | 1.806E-02 | 4.434E-01 |

| TIME | U (1) | V (1) | W (1) | U (2) | V (2) | W (2) | U (3) | V (3) | W (3) | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.000E-10 | 1.634E-14 | 1.635E-14 |
| 1432.00 | 1.623E+02 | 7.289E+02 | 2.502E+03 | 1.428E+00 | 2.921E+00 | 1.494E+00 | 1.207E-04 | 8.287E-05 | 3.343E-06 | 2.157E-04 | 1.588E-04 |
| 1490.00 | 1.905E+02 | 1.431E+02 | 9.697E+02 | 7.041E-01 | 1.605E+00 | 1.862E+00 | 1.459E-04 | 7.779E-05 | 1.059E-04 | 1.726E-04 | 3.754E-04 |
| 1550.00 | 4.342E+02 | 1.660E+02 | 7.799E+02 | 1.663E+00 | 7.716E-01 | 3.655E+00 | 1.687E-04 | 1.355E-04 | 1.858E-05 | 4.665E-04 | 1.035E-03 |
| 1550.00 | 2.133E+02 | 1.935E+02 | 7.230E+02 | 1.102E+00 | 9.498E-01 | 3.685E+00 | 1.749E-04 | 1.295E-04 | 1.087E-05 | 2.921E-04 | 1.044E-03 |
| 1610.00 | 4.046E+02 | 9.360E+01 | 7.008E+02 | 1.230E+00 | 3.892E-01 | 5.178E+00 | 1.766E-04 | 1.692E-04 | 4.891E-05 | 5.035E-04 | 2.128E-03 |
| 1670.00 | 5.909E+02 | 1.921E+02 | 5.998E+02 | 1.636E+00 | 1.482E+00 | 3.541E+00 | 1.256E-04 | 1.426E-04 | 1.590E-04 | 1.085E-03 | 2.247E-03 |
| 1730.00 | 1.096E+03 | 5.922E+02 | 7.062E+02 | 3.600E+00 | 2.905E+00 | 2.889E+00 | 1.432E-04 | 1.369E-04 | 3.290E-04 | 4.223E-03 | 2.988E-03 |
| 1790.00 | 4.711E+02 | 2.038E+02 | 3.413E+02 | 1.971E+00 | 1.580E+00 | 1.828E+00 | 1.342E-04 | 2.187E-04 | 2.231E-04 | 3.048E-03 | 2.551E-03 |
| 1836.00 | 3.602E+02 | 3.048E+02 | 1.316E+02 | 1.293E+00 | 3.178E+00 | 1.211E+00 | 1.413E-04 | 2.427E-04 | 3.916E-04 | 3.023E-03 | 2.075E-03 |
| 1836.00 | 3.793E+01 | 4.005E+01 | 6.975E+01 | 1.170E+00 | 1.810E+00 | 1.072E+00 | 1.422E-04 | 2.362E-04 | 2.680E-04 | 2.597E-03 | 1.835E-03 |
| 1846.00 | 2.577E+01 | 5.231E+01 | 4.739E+01 | 6.274E-01 | 6.702E-01 | 7.161E-01 | 1.558E-04 | 2.108E-04 | 2.682E-04 | 8.724E-04 | 1.270E-03 |
| 1846.00 | 2.913E-01 | 2.648E+00 | 1.454E+00 | 7.417E-01 | 6.499E-01 | 9.531E-01 | 1.611E-04 | 2.447E-04 | 2.813E-04 | 9.052E-04 | 1.689E-03 |
| 1860.00 | 1.648E+00 | 1.114E+00 | 2.255E+00 | 2.890E-01 | 3.508E-01 | 2.341E-01 | 1.760E-04 | 2.734E-04 | 2.430E-04 | 2.642E-04 | 4.393E-04 |
| 1874.00 | 9.831E-01 | 3.178E+00 | 2.051E+00 | 1.291E-01 | 1.136E-01 | 1.724E-01 | 1.771E-04 | 3.544E-04 | 1.891E-04 | 1.858E-04 | 3.266E-04 |
| 1884.00 | 1.134E+00 | 3.512E+00 | 2.059E+00 | 1.710E-01 | 1.580E-01 | 3.288E-01 | 1.799E-04 | 3.711E-04 | 1.753E-04 | 2.690E-04 | 6.206E-04 |
| 1894.00 | 1.048E+00 | 3.515E+00 | 1.880E+00 | 1.945E-01 | 1.970E-01 | 4.661E-01 | 1.826E-04 | 3.797E-04 | 1.771E-04 | 3.247E-04 | 9.077E-04 |
| 1904.00 | 9.230E-01 | 3.592E+00 | 1.609E+00 | 2.114E-01 | 2.365E-01 | 6.123E-01 | 1.853E-04 | 3.866E-04 | 1.820E-04 | 3.899E-04 | 1.234E-03 |
| 1914.00 | 7.081E-01 | 3.691E+00 | 1.338E+00 | 2.317E-01 | 2.762E-01 | 7.675E-01 | 1.880E-04 | 3.931E-04 | 1.876E-04 | 4.685E-04 | 1.597E-03 |
| 1924.00 | 3.114E-01 | 3.806E+00 | 1.101E+00 | 2.580E-01 | 3.281E-01 | 9.603E-01 | 1.907E-04 | 3.999E-04 | 1.919E-04 | 5.513E-04 | 2.003E-03 |
| 1934.00 | 1.672E-01 | 3.906E+00 | 9.013E-01 | 3.012E-01 | 3.852E-01 | 1.175E+00 | 1.933E-04 | 4.072E-04 | 1.950E-04 | 7.764E-04 | 2.985E-03 |
| 1943.50 | 9.135F-02 | 3.974E+00 | 7.862E-01 | 3.484E-01 | 4.251E-01 | 1.349E+00 | 1.957E-04 | 4.141E-04 | 1.977E-04 | 1.113E-03 | 4.289E-03 |
| 1943.50 | 9.198F-09 | 3.974E+00 | 7.862E-01 | 3.563E-01 | 4.251E-01 | 1.349E+00 | 1.957E-04 | 4.141E-04 | 1.977E-04 | 1.138E-03 | 4.289E-03 |
| 1944.50 | 7.253E-02 | 4.031E+00 | 1.856E+00 | 1.936E-01 | 4.312E-01 | 1.362E+00 | 1.960E-04 | 4.149E-04 | 1.979E-04 | 6.369E-04 | 4.446E-03 |
| 1945.50 | 3.159E-02 | 4.134E+00 | 3.167E+00 | 6.158E-02 | 4.374E-01 | 1.375E+00 | 1.962E-04 | 4.156E-04 | 1.982E-04 | 2.108E-04 | 4.611E-03 |
| 1946.50 | 1.254E-02 | 4.282E+00 | 4.526E+00 | 1.801E-02 | 4.434E-01 | 1.388E+00 | 1.965E-04 | 4.163E-04 | 1.985E-04 | 6.715E-05 | 4.716E-03 |

## GROUP 20 MLS TIMING ERROR -- AZIMUTH

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1836.00 | 1.711E+00 | 4.303E+00 | 2.474E+01 | 3.696E-03 | 8.225E-02 | 2.225E-01 | 1.033E-06 | 1.630E-05 | 8.003E-06 | 3.117E-03 | 2.260E-01 |
| 1846.00 | 1.825E+00 | 5.219E+00 | 2.017E+01 | 8.543E-02 | 8.774E-02 | 1.996E-01 | 2.795E-05 | 6.380E-05 | 2.575E-06 | 8.587E-02 | 6.363E-02 |
| 1846.00 | 7.328E-01 | 2.007E+00 | 1.960E+01 | 9.331E-02 | 1.150E-01 | 3.129E-01 | 3.574E-05 | 8.594E-05 | 3.296E-06 | 9.404E-02 | 1.266E-01 |
| 1860.00 | 2.784E-01 | 1.628E-01 | 1.053E+01 | 3.679E-02 | 9.990E-02 | 5.027E-01 | 5.475E-05 | 1.397E-04 | 9.651E-06 | 3.814E-02 | 1.199E-01 |
| 1874.00 | 1.179E-01 | 3.778E-01 | 2.552E+00 | 8.483E-04 | 7.088E-02 | 4.754E-01 | 5.450E-05 | 1.499E-04 | 1.948E-05 | 2.153E-03 | 1.052E-02 |
| 1884.00 | 1.135E-01 | 2.498E-01 | 1.613E+00 | 1.893E-02 | 7.983E-02 | 4.150E-01 | 5.455E-05 | 1.498E-04 | 1.957E-05 | 1.773E-02 | 7.877E-02 |
| 1894.00 | 8.044E-02 | 2.543E-01 | 2.537E+00 | 2.123E-02 | 9.657E-02 | 3.797E-01 | 5.461E-05 | 1.498E-04 | 1.965E-05 | 2.008E-02 | 1.033E-01 |
| 1904.00 | 5.061E-02 | 2.655E-01 | 1.815E+00 | 1.612E-02 | 1.164E-01 | 3.500E-01 | 5.466E-05 | 1.498E-04 | 1.974E-05 | 1.500E-02 | 1.121E-01 |
| 1914.00 | 3.199E-02 | 2.722E-01 | 9.961E-01 | 1.154E-02 | 1.336E-01 | 3.189E-01 | 5.471E-05 | 1.497E-04 | 1.982E-05 | 1.046E-02 | 1.192E-01 |
| 1924.00 | 2.965E-02 | 2.925E-01 | 6.136E-01 | 9.884E-03 | 1.480E-01 | 2.723E-01 | 5.477E-05 | 1.497E-04 | 1.991E-05 | 8.902E-03 | 1.386E-01 |
| 1934.00 | 1.195E-02 | 3.108E-01 | 5.312E-01 | 1.338E-02 | 1.588E-01 | 2.199E-01 | 5.482E-05 | 1.497E-04 | 2.000E-05 | 1.251E-02 | 1.561E-01 |
| 1943.50 | 9.497E-04 | 4.087E-01 | 6.160E-01 | 1.821E-02 | 1.649E-01 | 1.814E-01 | 5.487E-05 | 1.496E-04 | 2.008E-05 | 1.744E-02 | 1.640E-01 |
| 1943.50 | 2.284E-03 | 4.087E-01 | 6.159E-01 | 1.808E-02 | 1.649E-01 | 1.814E-01 | 5.487E-05 | 1.496E-04 | 2.008E-05 | 1.731E-02 | 1.640E-01 |
| 1944.50 | 6.603E-03 | 5.739E-01 | 7.951E-01 | 1.029E-02 | 1.656E-01 | 1.768E-01 | 5.488E-05 | 1.496E-04 | 2.009E-05 | 9.535E-03 | 1.650E-01 |
| 1945.50 | 5.386E-03 | 7.399E-01 | 9.696E-01 | 3.909E-03 | 1.663E-01 | 1.722E-01 | 5.488E-05 | 1.496E-04 | 2.009E-05 | 3.166E-03 | 1.658E-01 |
| 1946.50 | 5.218E-03 | 9.066E-01 | 1.139E+00 | 1.799E-03 | 1.670E-01 | 1.676E-01 | 5.489E-05 | 1.496E-04 | 2.010E-05 | 1.068E-03 | 1.665E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1836.00 | 1.771E+00 | 2.137E+01 | 1.318E+01 | 3.714E-03 | 2.371E-01 | 6.349E-03 | 9.442E-07 | 1.373E-06 | 1.811E-05 | 1.177E-04 | 1.157E-05 |
| 1846.00 | 1.886E+00 | 1.211E+01 | 1.694E+01 | 8.619E-02 | 9.677E-02 | 1.950E-01 | 2.823E-05 | 4.290E-05 | 4.712E-05 | 1.887E-04 | 3.450E-04 |
| 1846.00 | 7.785E-01 | 1.374E+01 | 1.412E+01 | 9.441E-02 | 1.661E-01 | 2.886E-01 | 3.612E-05 | 5.766E-05 | 6.360E-05 | 2.394E-04 | 5.109E-04 |
| 1860.00 | 3.012E-01 | 4.744E+00 | 9.406E+00 | 3.826E-02 | 1.449E-01 | 4.915E-01 | 5.536E-05 | 1.191E-04 | 7.315E-05 | 1.561E-04 | 9.220E-04 |
| 1874.00 | 1.271E-01 | 6.956E-01 | 2.484E+00 | 2.170E-03 | 1.064E-02 | 4.805E-01 | 5.512E-05 | 1.460E-04 | 3.799E-05 | 4.628E-06 | 9.102E-04 |
| 1884.00 | 1.091E-01 | 3.059E-01 | 1.003E+00 | 1.773E-02 | 9.423E-02 | 4.120E-01 | 5.514E-05 | 1.502E-04 | 1.425E-05 | 9.421E-05 | 7.778E-04 |
| 1894.00 | 7.401E-02 | 4.272E-01 | 2.514E+00 | 2.007E-02 | 1.223E-01 | 3.722E-01 | 5.515E-05 | 1.506E-04 | 9.276E-06 | 1.217E-04 | 7.250E-04 |
| 1904.00 | 4.582E-02 | 3.341E-01 | 1.804E+00 | 1.500E-02 | 1.296E-01 | 3.454E-01 | 5.517E-05 | 1.502E-04 | 1.395E-05 | 1.227E-04 | 6.960E-04 |
| 1914.00 | 2.903E-02 | 2.775E-01 | 9.948E-01 | 1.045E-02 | 1.353E-01 | 3.183E-01 | 5.519E-05 | 1.497E-04 | 1.892E-05 | 1.232E-04 | 6.622E-04 |
| 1924.00 | 2.753E-02 | 2.877E-01 | 6.160E-01 | 8.895E-03 | 1.459E-01 | 2.734E-01 | 5.521E-05 | 1.494E-04 | 2.097E-05 | 9.332E-05 | 5.704E-04 |
| 1934.00 | 1.003E-02 | 3.070E-01 | 5.335E-01 | 1.251E-02 | 1.572E-01 | 2.210E-01 | 5.523E-05 | 1.494E-04 | 2.095E-05 | 5.715E-05 | 5.614E-04 |
| 1943.50 | 1.294E-03 | 4.067E-01 | 6.173E-01 | 1.744E-02 | 1.644E-01 | 1.820E-01 | 5.526E-05 | 1.494E-04 | 2.044E-05 | 6.650E-05 | 5.784E-04 |
| 1943.50 | 4.173E-13 | 4.067E-01 | 6.173E-01 | 1.731E-02 | 1.644E-01 | 1.820E-01 | 5.526E-05 | 1.494E-04 | 2.044E-05 | 6.609E-05 | 5.784E-04 |
| 1944.50 | 3.557E-03 | 5.716E-01 | 7.968E-01 | 9.526E-03 | 1.651E-01 | 1.773E-01 | 5.526E-05 | 1.494E-04 | 2.040E-05 | 3.948E-05 | 5.786E-04 |
| 1945.50 | 1.590E-03 | 7.374E-01 | 9.715E-01 | 3.155E-03 | 1.659E-01 | 1.726E-01 | 5.527E-05 | 1.495E-04 | 2.036E-05 | 1.644E-05 | 5.787E-04 |
| 1946.50 | 6.736E-04 | 9.038E-01 | 1.142E+00 | 1.055E-03 | 1.666E-01 | 1.681E-01 | 5.527E-05 | 1.495E-04 | 2.035E-05 | 8.993E-06 | 5.711E-04 |

## GROUP 20 MLS TIMING ERROR -- ELEVATION

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1836.00 | 5.181E+00 | 8.350E-01 | 1.698E-01 | 1.318E-02 | 2.218E-04 | 1.755E-02 | 6.157E-08 | 1.665E-06 | 2.405E-07 | 1.317E-02 | 1.531E-02 |
| 1846.00 | 1.748E+00 | 3.741E+00 | 2.527E-01 | 1.498E-01 | 1.375E-02 | 5.977E-02 | 8.228E-06 | 5.253E-06 | 5.866E-06 | 1.499E-01 | 1.340E-02 |
| 1846.00 | 2.502E+00 | 8.302E-01 | 3.791E-04 | 1.744E-01 | 9.554E-03 | 3.808E-02 | 1.114E-05 | 1.143E-05 | 4.417E-06 | 1.744E-01 | 2.283E-02 |
| 1860.00 | 2.903E-01 | 1.795E-01 | 1.784E-02 | 1.586E-01 | 3.419E-02 | 1.543E-02 | 1.411E-05 | 2.107E-05 | 1.531E-06 | 1.565E-01 | 2.444E-02 |
| 1874.00 | 3.853E+00 | 2.477E-01 | 1.769E-01 | 6.085E-03 | 1.904E-02 | 7.161E-03 | 1.744E-05 | 3.944E-05 | 1.248E-05 | 6.021E-03 | 1.516E-02 |
| 1884.00 | 3.446E+00 | 8.572E-02 | 1.629E-01 | 8.665E-03 | 2.315E-02 | 2.393E-02 | 1.745E-05 | 3.942E-05 | 1.250E-05 | 8.631E-03 | 1.687E-02 |
| 1894.00 | 4.034E+00 | 8.122E-02 | 1.415E-01 | 1.596E-02 | 2.779E-02 | 3.847E-02 | 1.747E-05 | 3.941E-05 | 1.252E-05 | 1.594E-02 | 1.639E-02 |
| 1904.00 | 4.807E+00 | 1.325E-02 | 1.202E-01 | 2.372E-02 | 3.250E-02 | 5.369E-02 | 1.748E-05 | 3.940E-05 | 1.255E-05 | 2.373E-02 | 1.813E-02 |
| 1914.00 | 6.207E+00 | 1.832E-01 | 9.991E-02 | 3.610E-02 | 4.033E-02 | 6.911E-02 | 1.749E-05 | 3.939E-05 | 1.257E-05 | 3.614E-02 | 2.181E-02 |
| 1924.00 | 4.561E+00 | 1.640E-01 | 8.359E-02 | 3.235E-02 | 3.089E-02 | 9.147E-02 | 1.750E-05 | 3.937E-05 | 1.260E-05 | 3.247E-02 | 2.223E-02 |
| 1934.00 | 5.627E-01 | 9.475E-01 | 8.634E-02 | 7.031E-03 | 1.979E-02 | 1.117E-01 | 1.751E-05 | 3.936E-05 | 1.262E-05 | 7.244E-03 | 2.011E-02 |
| 1943.50 | 1.609E-01 | 6.248E-01 | 1.368E-01 | 1.024E-02 | 1.434E-02 | 1.298E-01 | 1.752E-05 | 3.935E-05 | 1.264E-05 | 1.050E-02 | 1.456E-02 |
| 1943.50 | 1.138E-03 | 6.244E-01 | 1.372E-01 | 5.962E-03 | 1.439E-02 | 1.298E-01 | 1.752E-05 | 3.935E-05 | 1.264E-05 | 5.703E-03 | 1.491E-02 |
| 1944.50 | 2.659E-04 | 6.390E-01 | 2.676E-01 | 3.259E-03 | 1.483E-02 | 1.310E-01 | 1.752E-05 | 3.935E-05 | 1.265E-05 | 2.997E-03 | 1.525E-02 |
| 1945.50 | 1.442E-04 | 6.541E-01 | 3.992E-01 | 1.106E-03 | 1.528E-02 | 1.322E-01 | 1.752E-05 | 3.935E-05 | 1.265E-05 | 8.426E-04 | 1.563E-02 |
| 1946.50 | 2.047E-04 | 6.696E-01 | 5.320E-01 | 3.895E-04 | 1.571E-02 | 1.334E-01 | 1.752E-05 | 3.935E-05 | 1.265E-05 | 1.216E-04 | 1.604E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1836.00 | 5.178E+00 | 4.690E-01 | 7.375E-01 | 1.316E-02 | 1.173E-02 | 4.523E-03 | 6.890E-08 | 8.421E-07 | 1.456E-06 | 1.422E-05 | 7.731E-06 |
| 1846.00 | 1.731E+00 | 2.599E+00 | 2.714E+00 | 1.500E-01 | 3.721E-02 | 4.822E-02 | 8.262E-06 | 1.135E-06 | 7.755E-06 | 2.581E-04 | 8.543E-05 |
| 1846.00 | 2.498E+00 | 5.371E-01 | 6.478E-01 | 1.744E-01 | 3.558E-02 | 1.632E-02 | 1.120E-05 | 3.940E-06 | 1.155E-05 | 2.959E-04 | 2.892E-05 |
| 1860.00 | 2.936E-01 | 1.681E-01 | 6.861E-02 | 1.585E-01 | 3.789E-02 | 2.802E-03 | 1.420E-05 | 1.791E-05 | 1.108E-05 | 2.803E-04 | 5.262E-06 |
| 1874.00 | 3.851E+00 | 2.373E-01 | 2.169E-01 | 6.027E-03 | 1.981E-02 | 4.699E-03 | 1.762E-05 | 3.750E-05 | 1.728E-05 | 2.397E-05 | 8.906E-06 |
| 1884.00 | 3.445E+00 | 1.041E-01 | 1.670E-01 | 8.634E-03 | 2.234E-02 | 2.470E-02 | 1.762E-05 | 3.977E-05 | 1.109E-05 | 2.930E-05 | 4.662E-05 |
| 1894.00 | 4.034E+00 | 1.049E-01 | 1.435E-01 | 1.595E-02 | 2.515E-02 | 4.025E-02 | 1.763E-05 | 4.011E-05 | 9.771E-06 | 4.415E-05 | 7.838E-05 |
| 1904.00 | 4.807E+00 | 3.324E-02 | 1.295E-01 | 2.373E-02 | 3.052E-02 | 5.483E-02 | 1.763E-05 | 3.979E-05 | 1.101E-05 | 6.277E-05 | 1.105E-04 |
| 1914.00 | 6.207E+00 | 1.646E-01 | 1.143E-01 | 3.614E-02 | 4.008E-02 | 6.924E-02 | 1.763E-05 | 3.940E-05 | 1.233E-05 | 9.374E-05 | 1.441E-04 |
| 1924.00 | 4.561E+00 | 1.754E-01 | 9.491E-02 | 3.247E-02 | 3.170E-02 | 9.115E-02 | 1.763E-05 | 3.923E-05 | 1.287E-05 | 7.971E-05 | 1.901E-04 |
| 1934.00 | 5.649E-01 | 9.467E-01 | 8.076E-02 | 7.226E-03 | 2.061E-02 | 1.115E-01 | 1.763E-05 | 3.923E-05 | 1.286E-05 | 2.167E-05 | 2.633E-04 |
| 1943.50 | 1.621E-01 | 6.249E-01 | 1.351E-01 | 1.049E-02 | 1.479E-02 | 1.298E-01 | 1.764E-05 | 3.927E-05 | 1.273E-05 | 3.436E-05 | 4.124E-04 |
| 1943.50 | 5.226E-11 | 6.249E-01 | 1.351E-01 | 5.712E-03 | 1.479E-02 | 1.298E-01 | 1.764E-05 | 3.927E-05 | 1.273E-05 | 1.712E-05 | 4.125E-04 |
| 1944.50 | 1.144E-03 | 6.398E-01 | 2.657E-01 | 3.007E-03 | 1.521E-02 | 1.310E-01 | 1.764E-05 | 3.927E-05 | 1.272E-05 | 9.008E-06 | 4.275E-04 |
| 1945.50 | 4.717E-04 | 6.551E-01 | 3.975E-01 | 8.520E-04 | 1.562E-02 | 1.322E-01 | 1.764E-05 | 3.927E-05 | 1.271E-05 | 2.276E-06 | 4.432E-04 |
| 1946.50 | 1.266E-04 | 6.709E-01 | 5.304E-01 | 1.310E-04 | 1.604E-02 | 1.333E-01 | 1.764E-05 | 3.927E-05 | 1.271E-05 | 1.036E-07 | 4.532E-04 |

## GROUP 20 MLS TIMING ERROR -- DME

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1846.00 | 7.615E+00 | 2.024E+01 | 2.313E+00 | 5.609E-02 | 1.539E-01 | 1.183E-01 | 2.280E-06 | 1.506E-05 | 1.711E-05 | 5.661E-02 | 2.607E-02 |
| 1860.00 | 9.081E+00 | 2.420E+01 | 7.692E-01 | 8.004E-02 | 2.186E-01 | 1.093E-01 | 2.533E-06 | 1.546E-05 | 3.301E-05 | 8.064E-02 | 1.628E-01 |
| 1874.00 | 9.289E+00 | 2.668E+01 | 2.270E-01 | 5.987E-02 | 1.972E-01 | 9.015E-02 | 2.249E-06 | 6.697E-06 | 3.197E-05 | 6.017E-02 | 1.922E-01 |
| 1884.00 | 8.717E+00 | 2.674E+01 | 3.007E-01 | 6.159E-02 | 1.710E-01 | 8.633E-02 | 2.265E-06 | 6.709E-06 | 3.197E-05 | 6.172E-02 | 1.840E-01 |
| 1894.00 | 7.771E+00 | 2.589E+01 | 1.039E-01 | 6.534E-02 | 1.416E-01 | 8.219E-02 | 2.282E-06 | 6.721E-06 | 3.196E-05 | 6.536E-02 | 1.609E-01 |
| 1904.00 | 6.517E+00 | 2.500E+01 | 1.118E-01 | 7.252E-02 | 1.121E-01 | 7.841E-02 | 2.298E-06 | 6.734E-06 | 3.196E-05 | 7.245E-02 | 1.346E-01 |
| 1914.00 | 4.676E+00 | 2.404E+01 | 2.281E-01 | 8.463E-02 | 8.018E-02 | 7.420E-02 | 2.315E-06 | 6.746E-06 | 3.195E-05 | 8.447E-02 | 1.081E-01 |
| 1924.00 | 1.626E+00 | 2.338E+01 | 2.726E-01 | 1.060E-01 | 4.432E-02 | 7.005E-02 | 2.331E-06 | 6.758E-06 | 3.195E-05 | 1.057E-01 | 6.947E-02 |
| 1934.00 | 7.291E-01 | 1.929E+01 | 2.482E-01 | 1.074E-01 | 5.654E-03 | 5.765E-02 | 2.348E-06 | 6.771E-06 | 3.195E-05 | 1.071E-01 | 5.577E-04 |
| 1943.50 | 2.423E-01 | 1.546E+01 | 2.032E-01 | 1.065E-01 | 4.478E-02 | 4.738E-02 | 2.364E-06 | 6.782E-06 | 3.194E-05 | 1.063E-01 | 4.290E-02 |
| 1943.50 | 3.514E-02 | 1.546E+01 | 2.038E-01 | 1.343E-01 | 4.470E-02 | 4.743E-02 | 2.364E-06 | 6.782E-06 | 3.194E-05 | 1.340E-01 | 4.230E-02 |
| 1944.50 | 7.531E-03 | 1.541E+01 | 1.567E-01 | 7.310E-02 | 4.597E-02 | 4.709E-02 | 2.365E-06 | 6.783E-06 | 3.194E-05 | 7.287E-02 | 4.513E-02 |
| 1945.50 | 2.270E-02 | 1.537E+01 | 1.099E-01 | 2.341E-02 | 4.720E-02 | 4.677E-02 | 2.367E-06 | 6.785E-06 | 3.194E-05 | 2.318E-02 | 4.713E-02 |
| 1946.50 | 2.966E-02 | 1.532E+01 | 6.332E-02 | 6.994E-03 | 4.833E-02 | 4.652E-02 | 2.369E-06 | 6.786E-06 | 3.194E-05 | 6.772E-03 | 4.839E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1550.00 | | | | | | | | | | | |
| 1610.00 | | | | | | | | | | | |
| 1670.00 | | | | | | | | | | | |
| 1730.00 | | | | | | | | | | | |
| 1790.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1836.00 | | | | | | | | | | | |
| 1846.00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 1846.00 | 7.702E+00 | 1.476E+01 | 1.399E+01 | 5.701E-02 | 8.039E-03 | 1.937E-01 | 2.315E-06 | 2.278E-05 | 5.440E-07 | 8.537E-05 | 3.431E-04 |
| 1860.00 | 9.181E+00 | 2.177E+01 | 1.051E+01 | 8.119E-02 | 1.427E-01 | 1.960E-01 | 2.529E-06 | 2.901E-05 | 2.208E-05 | 3.659E-05 | 3.712E-04 |
| 1874.00 | 9.393E+00 | 2.641E+01 | 3.549E+00 | 6.084E-02 | 1.841E-01 | 1.140E-01 | 2.204E-06 | 1.065E-05 | 3.088E-05 | 4.505E-05 | 2.155E-04 |
| 1884.00 | 8.815E+00 | 2.670E+01 | 6.443E-01 | 6.240E-02 | 1.736E-01 | 8.023E-02 | 2.219E-06 | 5.589E-06 | 3.218E-05 | 2.534E-05 | 1.508E-04 |
| 1894.00 | 7.659E+00 | 2.581E+01 | 1.679E+00 | 6.600E-02 | 1.467E-01 | 7.221E-02 | 2.234E-06 | 4.516E-06 | 3.235E-05 | 1.287E-06 | 1.400E-04 |
| 1904.00 | 6.595E+00 | 2.496E+01 | 1.070E+00 | 7.304E-02 | 1.147E-01 | 7.397E-02 | 2.250E-06 | 5.514E-06 | 3.219E-05 | 3.496E-05 | 1.484E-04 |
| 1914.00 | 4.745E+00 | 2.403E+01 | 3.638E-01 | 8.502E-02 | 8.032E-02 | 7.359E-02 | 2.265E-06 | 6.572E-06 | 3.199E-05 | 8.387E-05 | 1.526E-04 |
| 1924.00 | 1.688E+00 | 2.338E+01 | 9.225E-02 | 1.063E-01 | 4.348E-02 | 7.016E-02 | 2.280E-06 | 7.004E-06 | 3.190E-05 | 1.831E-04 | 1.458E-04 |
| 1934.00 | 7.761E-01 | 1.929E+01 | 1.109E-01 | 1.075E-01 | 6.332E-03 | 5.737E-02 | 2.295E-06 | 6.995E-06 | 3.190E-05 | 2.720E-04 | 1.453E-04 |
| 1943.50 | 2.774E-01 | 1.546E+01 | 1.536E-01 | 1.065E-01 | 4.518E-02 | 4.701E-02 | 2.310E-06 | 6.880E-06 | 3.193E-05 | 3.407E-04 | 1.490E-04 |
| 1943.50 | 8.047E-11 | 1.546E+01 | 1.536E-01 | 1.343E-01 | 4.516E-02 | 4.699E-02 | 2.310E-06 | 6.880E-06 | 3.193E-05 | 4.289E-04 | 1.490E-04 |
| 1944.50 | 2.738E-02 | 1.541E+01 | 1.118E-01 | 7.309E-02 | 4.628E-02 | 4.679E-02 | 2.311E-06 | 6.871E-06 | 3.193E-05 | 2.401E-04 | 1.524E-04 |
| 1945.50 | 1.198E-02 | 1.537E+01 | 6.977E-02 | 2.340E-02 | 4.738E-02 | 4.659E-02 | 2.313E-06 | 6.863E-06 | 3.193E-05 | 7.938E-05 | 1.559E-04 |
| 1946.50 | 4.585E-03 | 1.532E+01 | 2.570E-02 | 6.988E-03 | 4.846E-02 | 4.639E-02 | 2.314E-06 | 6.859E-06 | 3.193E-05 | 2.457E-05 | 1.573E-04 |

GROUP 21 1962 STANDARD ATMOSPHERE MODELING ERROR 1-TERM MODEL

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 3.051E+03 | 2.315E+03 | 6.065E+03 | 7.486E+00 | 9.635E-01 | 1.882E+00 | 4.294E-06 | 3.210E-05 | 1.128E-06 | 5.801E+00 | 6.177E-01 |
| 1432.00 | 2.778E+03 | 1.818E+02 | 1.042E+03 | 4.054E+00 | 5.389E-02 | 6.350E-02 | 1.795E-05 | 6.992E-05 | 6.717E-06 | 3.915E+00 | 2.677E-02 |
| 1490.00 | 2.435E+03 | 7.412E+02 | 3.867E+02 | 3.452E+00 | 1.708E+00 | 1.899E-01 | 6.345E-06 | 9.356E-05 | 2.826E-05 | 3.488E+00 | 9.962E-01 |
| 1550.00 | 1.454E+03 | 2.660E+02 | 2.137E+02 | 1.667E+00 | 2.530E+00 | 7.624E-01 | 2.896E-05 | 1.325E-04 | 7.113E-05 | 1.695E+00 | 2.116E+00 |
| 1550.00 | 6.661E+02 | 1.455E+02 | 5.579E+01 | 7.364E-01 | 1.374E+00 | 1.336E+00 | 4.744E-05 | 9.240E-05 | 3.210E-05 | 7.161E-01 | 9.856E-01 |
| 1610.00 | 2.040E+02 | 1.945E+01 | 7.206E+01 | 1.601E+00 | 3.081E-01 | 1.025E+00 | 9.196E-05 | 1.098E-04 | 1.496E-05 | 1.590E+00 | 2.259E-01 |
| 1670.00 | 4.730E+01 | 2.570E-01 | 2.210E+01 | 1.797E+00 | 1.012E-01 | 1.039E+00 | 9.413E-05 | 1.112E-04 | 9.038E-06 | 1.793E+00 | 1.128E-01 |
| 1730.00 | 3.791E+01 | 3.540E+00 | 4.105E+01 | 1.717E+00 | 1.089E-01 | 1.287E+00 | 8.437E-05 | 9.293E-05 | 7.220E-06 | 1.717E+00 | 1.285E-01 |
| 1790.00 | 1.462E+01 | 2.758E+00 | 2.683E+01 | 1.278E+00 | 1.256E-01 | 1.013E+00 | 7.889E-05 | 1.130E-04 | 2.356E-05 | 1.278E+00 | 8.233E-02 |
| 1836.00 | 2.211E+01 | 1.335E+01 | 2.162E+01 | 1.014E+00 | 8.765E-02 | 7.581E-01 | 7.392E-05 | 1.485E-04 | 3.376E-05 | 1.015E+00 | 3.758E-01 |
| 1836.00 | 5.346E+00 | 1.241E+01 | 1.924E+00 | 9.500E-01 | 2.614E-02 | 6.520E-01 | 7.282E-05 | 1.525E-04 | 2.645E-05 | 9.511E-01 | 2.810E-01 |
| 1846.00 | 5.385E+00 | 1.930E+01 | 3.292E+00 | 4.248E-01 | 7.452E-02 | 1.766E-01 | 7.406E-05 | 2.072E-04 | 3.693E-05 | 4.252E-01 | 3.629E-02 |
| 1846.00 | 4.257E-01 | 7.152E-01 | 2.488E-01 | 3.510E-01 | 6.784E-02 | 1.874E-01 | 7.105E-05 | 2.020E-04 | 2.270E-05 | 3.517E-01 | 1.878E-02 |
| 1860.00 | 3.325E-01 | 1.985E-01 | 3.076E-02 | 1.080E-01 | 3.464E-02 | 1.050E-01 | 6.837E-05 | 2.214E-04 | 3.203E-05 | 1.084E-01 | 2.374E-02 |
| 1874.00 | 1.033E+00 | 9.586E-01 | 2.316E-01 | 9.052E-02 | 1.299E-02 | 1.283E-01 | 6.754E-05 | 2.508E-04 | 3.171E-05 | 9.088E-02 | 3.651E-02 |
| 1884.00 | 1.023E+00 | 1.099E+00 | 3.322E-01 | 1.278E-01 | 1.995E-02 | 2.358E-01 | 6.766E-05 | 2.508E-04 | 3.158E-05 | 1.285E-01 | 7.768E-02 |
| 1894.00 | 8.854E-01 | 1.163E+00 | 2.812E-01 | 1.443E-01 | 3.363E-02 | 3.292E-01 | 6.777E-05 | 2.508E-04 | 3.144E-05 | 1.452E-01 | 1.102E-01 |
| 1904.00 | 7.355E-01 | 1.237E+00 | 2.319E-01 | 1.540E-01 | 5.244E-02 | 4.275E-01 | 6.789E-05 | 2.508E-04 | 3.131E-05 | 1.551E-01 | 1.256E-01 |
| 1914.00 | 5.521E-01 | 1.319E+00 | 1.693E-01 | 1.649E-01 | 7.415E-02 | 5.301E-01 | 6.801E-05 | 2.507E-04 | 3.118E-05 | 1.663E-01 | 1.377E-01 |
| 1924.00 | 2.969E-01 | 1.416E+00 | 1.519E-01 | 1.803E-01 | 1.003E-01 | 6.561E-01 | 6.813E-05 | 2.507E-04 | 3.104E-05 | 1.820E-01 | 1.385E-01 |
| 1934.00 | 1.517E-01 | 1.477E+00 | 1.205E-01 | 1.986E-01 | 1.306E-01 | 7.920E-01 | 6.824E-05 | 2.507E-04 | 3.091E-05 | 2.006E-01 | 1.370E-01 |
| 1943.50 | 4.305E-02 | 1.445E+00 | 3.513E-01 | 2.177E-01 | 1.574E-01 | 9.004E-01 | 6.836E-05 | 2.507E-04 | 3.078E-05 | 2.200E-01 | 1.587E-01 |
| 1943.50 | 2.560E-03 | 1.445E+00 | 3.512E-01 | 2.217E-01 | 1.575E-01 | 9.004E-01 | 6.836E-05 | 2.507E-04 | 3.078E-05 | 2.241E-01 | 1.587E-01 |
| 1944.50 | 4.569E-02 | 1.267E+00 | 1.255E+00 | 1.189E-01 | 1.582E-01 | 9.062E-01 | 6.837E-05 | 2.507E-04 | 3.077E-05 | 1.212E-01 | 1.571E-01 |
| 1945.50 | 1.748E-02 | 1.129E+00 | 2.167E+00 | 3.560E-02 | 1.589E-01 | 9.160E-01 | 6.838E-05 | 2.507E-04 | 3.076E-05 | 3.798E-02 | 1.569E-01 |
| 1946.50 | 2.921E-03 | 9.695E-01 | 3.087E+00 | 8.015E-03 | 1.598E-01 | 9.238E-01 | 6.839E-05 | 2.507E-04 | 3.074E-05 | 1.042E-02 | 1.576E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 3.281E+03 | 5.714E+03 | 2.835E+03 | 7.463E+00 | 8.883E-01 | 2.014E+00 | 5.380E-06 | 2.392E-05 | 2.119E-05 | 9.520E-04 | 4.241E-04 |
| 1432.00 | 2.797E+03 | 4.664E+02 | 8.932E+02 | 4.050E+00 | 1.734E-01 | 6.721E-02 | 2.042E-05 | 5.466E-05 | 4.303E-05 | 6.401E-04 | 4.139E-05 |
| 1490.00 | 2.423E+03 | 3.304E+02 | 8.066E+02 | 3.414E+00 | 1.190E+00 | 1.341E+00 | 8.105E-06 | 4.755E-05 | 8.524E-05 | 7.492E-04 | 2.575E-04 |
| 1550.00 | 1.448E+03 | 3.373E+02 | 1.371E+02 | 1.640E+00 | 2.241E+00 | 1.432E+00 | 2.779E-05 | 1.078E-04 | 1.052E-04 | 5.307E-04 | 4.126E-04 |
| 1550.00 | 6.636E+02 | 1.654E+02 | 1.581E+01 | 7.433E-01 | 9.341E-01 | 1.670E+00 | 4.647E-05 | 8.045E-05 | 5.646E-05 | 1.864E-04 | 4.808E-04 |
| 1610.00 | 2.035E+02 | 6.191E+01 | 4.410E+01 | 1.597E+00 | 4.147E-01 | 9.930E-01 | 9.141E-05 | 7.689E-05 | 8.038E-05 | 6.700E-04 | 4.126E-04 |
| 1670.00 | 4.725E+01 | 1.001E+01 | 1.984E+01 | 1.794E+00 | 3.906E-01 | 9.730E-01 | 9.405E-05 | 9.481E-05 | 5.886E-05 | 1.156E-03 | 6.216E-04 |
| 1730.00 | 3.786E+01 | 2.074E+01 | 3.298E+01 | 1.716E+00 | 5.886E-01 | 1.152E+00 | 8.458E-05 | 7.481E-05 | 5.529E-05 | 1.725E-03 | 1.192E-03 |
| 1790.00 | 1.462E+01 | 1.220E+01 | 2.406E+01 | 1.278E+00 | 4.399E-01 | 8.211E-01 | 7.934E-05 | 8.180E-05 | 8.100E-05 | 1.817E-03 | 1.287E-03 |
| 1836.00 | [illegible] | [illegible] | 4.467E+00 | 1.015E+00 | 7.366E-01 | 1.954E-01 | 7.455E-05 | 8.651E-05 | 1.249E-04 | 1.942E-03 | 3.352E-04 |
| 1836.00 | 5.401E+00 | 6.397E+00 | 1.078E+01 | 9.509E-01 | 6.152E-01 | 2.134E-01 | 7.349E-05 | 8.121E-05 | 1.314E-04 | 1.781E-03 | 3.654E-04 |
| 1846.00 | 5.465E+00 | 1.484E+01 | 1.271E+01 | 4.248E-01 | 1.838E-01 | 5.430E-02 | 7.493E-05 | 1.612E-04 | 1.347E-04 | 7.745E-04 | 9.655E-05 |
| 1846.00 | 4.229E-01 | 6.506E-01 | 3.905E-01 | 3.517E-01 | 1.006E-01 | 1.707E-01 | 7.191E-05 | 1.470E-04 | 1.399E-04 | 6.126E-04 | 3.025E-04 |
| 1860.00 | 3.334E-01 | 1.606E-01 | 1.181E-01 | 1.084E-01 | 1.831E-02 | 1.086E-01 | 6.924E-05 | 2.108E-04 | 7.408E-05 | 1.867E-04 | 2.039E-04 |
| 1874.00 | 1.037E+00 | 9.183E-01 | 3.474E-01 | 9.086E-02 | 3.539E-03 | 1.267E-01 | 6.844E-05 | 2.526E-04 | 1.605E-07 | 1.419E-04 | 2.437E-04 |
| 1884.00 | 1.028E+00 | 1.106E+00 | 2.918E-01 | 1.284E-01 | 2.763E-02 | 2.347E-01 | 6.849E-05 | 2.493E-04 | 4.039E-05 | 1.826E-04 | 4.430E-04 |
| 1894.00 | 8.899E-01 | 1.177E+00 | 1.994E-01 | 1.452E-01 | 5.551E-02 | 3.258E-01 | 6.855E-05 | 2.478E-04 | 4.862E-05 | 1.947E-04 | 6.345E-04 |
| 1904.00 | 7.399E-01 | 1.242E+00 | 1.834E-01 | 1.551E-01 | 6.806E-02 | 4.249E-01 | 6.861E-05 | 2.492E-04 | 4.091E-05 | 2.089E-04 | 8.560E-04 |
| 1914.00 | 5.563E-01 | 1.318E+00 | 1.812E-01 | 1.663E-01 | 7.643E-02 | 5.294E-01 | 6.867E-05 | 2.504E-04 | 3.263E-05 | 2.289E-04 | 1.101E-03 |
| 1924.00 | 3.010E-01 | 1.414E+00 | 1.624E-01 | 1.820E-01 | 9.469E-02 | 6.564E-01 | 6.873E-05 | 2.508E-04 | 2.921E-05 | 3.050E-04 | 1.369E-03 |
| 1930.00 | 1.556E-01 | 1.476E+00 | 1.308E-01 | 2.006E-01 | 1.244E-01 | 7.925E-01 | 6.879E-05 | 2.508E-04 | 2.925E-05 | 4.873E-04 | 2.013E-03 |
| 1943.50 | 4.049E-02 | 1.446E+00 | 3.465E-01 | 2.200E-01 | 1.540E-01 | 9.004E-01 | 6.887E-05 | 2.506E-04 | 3.012E-05 | 6.885E-04 | 2.862E-03 |
| 1943.50 | 1.306E-11 | 1.446E+00 | 3.465E-01 | 2.241E-01 | 1.540E-01 | 9.004E-01 | 6.887E-05 | 2.506E-04 | 3.012E-05 | 7.014E-04 | 2.662E-03 |
| 1944.50 | 4.549E-02 | 1.291E+00 | 1.251E+00 | 1.212E-01 | 1.553E-01 | 9.084E-01 | 6.887E-05 | 2.506E-04 | 3.019E-05 | 3.876E-04 | 2.965E-03 |
| 1945.50 | 1.964E-02 | 1.134E+00 | 2.160E+00 | 3.796E-02 | 1.565E-01 | 9.164E-01 | 6.888E-05 | 2.506E-04 | 3.025E-05 | 1.218E-04 | 3.073E-03 |
| 1946.50 | 7.543E-03 | 9.770E-01 | 3.085E+00 | 1.041E-02 | 1.575E-01 | 9.241E-01 | 6.889E-05 | 2.506E-04 | 3.028E-05 | 3.034E-05 | 3.141E-03 |

GROUP 21 TIME-VARYING DENSITY DEVIATIONS--WINTER PROFILE

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 3.781E+03 | 3.295E+03 | 8.998E+03 | 9.270E+00 | 9.329E-01 | 2.733E+00 | 2.170E-06 | 7.835E-05 | 1.732E-05 | 6.777E+00 | 1.248E+00 |
| 1432.00 | 3.382E+03 | 2.861E+02 | 1.629E+03 | 4.243E+00 | 3.104E-01 | 6.532E-02 | 3.022E-05 | 7.173E-05 | 4.212E-06 | 4.003E+00 | 2.940E-01 |
| 1490.00 | 2.614E+03 | 8.595E+02 | 5.110E+02 | 2.362E+00 | 1.690E+00 | 5.862E-01 | 1.378E-06 | 9.287E-05 | 2.604E-05 | 2.406E+00 | 7.408E-01 |
| 1550.00 | 1.421E+03 | 3.029E+02 | 1.447E+02 | 3.265E-01 | 2.458E+00 | 1.070E+00 | 4.712E-05 | 1.390E-04 | 6.833E-05 | 3.607E-01 | 2.038E+00 |
| 1550.00 | 6.507E+02 | 1.830E+02 | 6.560E+00 | 2.021E+00 | 1.323E+00 | 1.621E+00 | 6.576E-05 | 1.003E-04 | 3.016E-05 | 1.995E+00 | 9.307E-01 |
| 1610.00 | 2.108E+02 | 4.620E+01 | 4.873E+01 | 2.572E+00 | 2.657E-01 | 1.158E+00 | 1.128E-04 | 1.237E-04 | 1.379E-05 | 2.540E+00 | 2.360E-01 |
| 1670.00 | 9.300E+01 | 2.767E+01 | 3.645E+01 | 2.505E+00 | 9.858E-02 | 1.043E+00 | 1.154E-04 | 1.286E-04 | 8.112E-06 | 2.500E+00 | 1.033E-02 |
| 1730.00 | 6.012E+01 | 1.248E+01 | 5.972E+01 | 2.480E+00 | 1.078E-01 | 1.540E+00 | 9.961E-05 | 8.936E-05 | 1.533E-07 | 2.480E+00 | 2.995E-01 |
| 1790.00 | 4.110E+01 | 2.047E+01 | 3.306E+01 | 1.875E+00 | 1.611E-01 | 1.120E+00 | 9.290E-05 | 1.173E-04 | 2.615E-05 | 1.875E+00 | 5.230E-02 |
| 1836.00 | 5.378E+01 | 3.135E+01 | 1.860E+01 | 1.517E+00 | 1.105E-01 | 7.807E-01 | 8.626E-05 | 1.607E-04 | 3.713E-05 | 1.519E+00 | 2.438E-01 |
| 1836.00 | 1.028E+01 | 2.336E+01 | 3.918E+00 | 1.359E+00 | 7.132E-02 | 8.204E-01 | 8.498E-05 | 1.487E-04 | 3.012E-05 | 1.360E+00 | 3.152E-01 |
| 1846.00 | 9.766E+00 | 3.331E+01 | 4.902E+00 | 6.270E-01 | 1.383E-01 | 1.558E-01 | 8.580E-05 | 2.222E-04 | 4.503E-05 | 6.274E-01 | 5.163E-03 |
| 1846.00 | 5.910E-01 | 1.700E+00 | 1.803E-01 | 5.348E-01 | 1.079E-01 | 2.171E-01 | 7.967E-05 | 2.077E-04 | 2.034E-05 | 5.357E-01 | 8.091E-02 |
| 1860.00 | 4.818E-01 | 3.544E-01 | 1.192E-01 | 1.534E-01 | 4.984E-02 | 1.118E-01 | 7.166E-05 | 2.244E-04 | 3.815E-05 | 1.538E-01 | 5.021E-02 |
| 1874.00 | 1.490E+00 | 1.312E+00 | 3.089E-01 | 1.120E-01 | 1.601E-02 | 1.319E-01 | 7.076E-05 | 2.581E-04 | 3.979E-05 | 1.123E-01 | 4.810E-02 |
| 1884.00 | 1.458E+00 | 1.499E+00 | 4.076E-01 | 1.514E-01 | 2.443E-02 | 2.422E-01 | 7.069E-05 | 2.581E-04 | 3.965E-05 | 1.520E-01 | 9.153E-02 |
| 1894.00 | 1.258E+00 | 1.587E+00 | 3.451E-01 | 1.690E-01 | 3.960E-02 | 3.380E-01 | 7.101E-05 | 2.581E-04 | 3.952E-05 | 1.699E-01 | 1.262E-01 |
| 1904.00 | 1.041E+00 | 1.685E+00 | 2.837E-01 | 1.795E-01 | 6.001E-02 | 4.388E-01 | 7.114E-05 | 2.581E-04 | 3.938E-05 | 1.807E-01 | 1.433E-01 |
| 1914.00 | 7.787E-01 | 1.790E+00 | 2.307E-01 | 1.913E-01 | 8.334E-02 | 5.440E-01 | 7.126E-05 | 2.581E-04 | 3.924E-05 | 1.928E-01 | 1.569E-01 |
| 1924.00 | 4.199E-01 | 1.909E+00 | 1.843E-01 | 2.077E-01 | 1.118E-01 | 6.732E-01 | 7.138E-05 | 2.580E-04 | 3.910E-05 | 2.095E-01 | 1.565E-01 |
| 1934.00 | 2.128E-01 | 1.981E+00 | 1.450E-01 | 2.266E-01 | 1.444E-01 | 8.125E-01 | 7.151E-05 | 2.560E-04 | 3.896E-05 | 2.288E-01 | 1.523E-01 |
| 1943.50 | 3.773E-02 | 1.944E+00 | 3.444E-01 | 2.465E-01 | 1.727E-01 | 9.234E-01 | 7.163E-05 | 2.580E-04 | 3.883E-05 | 2.489E-01 | 1.744E-01 |
| 1943.50 | 3.724E-03 | 1.944E+00 | 3.443E-01 | 2.499E-01 | 1.728E-01 | 9.234E-01 | 7.163E-05 | 2.580E-04 | 3.883E-05 | 2.523E-01 | 1.745E-01 |
| 1944.50 | 5.250E-02 | 1.771E+00 | 1.271E+00 | 1.340E-01 | 1.737E-01 | 9.315E-01 | 7.164E-05 | 2.580E-04 | 3.882E-05 | 1.365E-01 | 1.726E-01 |
| 1945.50 | 2.093E-02 | 1.597E+00 | 2.207E+00 | 4.027E-02 | 1.747E-01 | 9.395E-01 | 7.165E-05 | 2.580E-04 | 3.881E-05 | 4.274E-02 | 1.726E-01 |
| 1946.50 | 4.739E-03 | 1.422E+00 | 3.150E+00 | 9.210E-03 | 1.758E-01 | 9.474E-01 | 7.166E-05 | 2.580E-04 | 3.879E-05 | 1.171E-02 | 1.736E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 4.118E+03 | 8.407E+03 | 4.297E+03 | 9.223E+00 | 1.583E+00 | 2.591E+00 | 8.659E-07 | 6.889E-05 | 4.118E-05 | 1.115E-03 | 5.674E-04 |
| 1432.00 | 3.411E+03 | 7.686E+02 | 1.395E+03 | 4.227E+00 | 4.472E-01 | 1.822E-01 | 3.245E-05 | 4.797E-05 | 5.217E-05 | 6.562E-04 | 1.767E-05 |
| 1490.00 | 2.601E+03 | 3.341E+02 | 9.791E+02 | 2.330E+00 | 8.729E-01 | 1.608E+00 | 3.156E-06 | 4.873E-05 | 8.318E-05 | 5.173E-04 | 3.084E-04 |
| 1550.00 | 1.416E+03 | 3.529E+02 | 6.046E+01 | 3.026E-01 | 2.065E+00 | 1.714E+00 | 4.584E-05 | 1.151E-04 | 1.043E-04 | 1.471E-04 | 4.917E-04 |
| 1550.00 | 6.483E+02 | 1.837E+02 | 5.460E+01 | 2.025E+00 | 7.859E-01 | 1.935E+00 | 6.467E-05 | 8.887E-05 | 5.673E-05 | 5.574E-04 | 5.553E-04 |
| 1610.00 | 2.103E+02 | 6.820E+01 | 9.165E+00 | 2.568E+00 | 5.385E-01 | 1.070E+00 | 1.121E-04 | 8.864E-05 | 8.617E-05 | 1.072E-03 | 4.437E-04 |
| 1670.00 | 9.288E+01 | 4.150E+01 | 1.986E+01 | 2.503E+00 | 3.962E-01 | 9.766E-01 | 1.153E-04 | 1.108E-04 | 6.602E-05 | 1.597E-03 | 6.236E-04 |
| 1730.00 | 6.005E+01 | 2.104E+01 | 5.735E+01 | 2.479E+00 | 7.266E-01 | 1.364E+00 | 9.960E-05 | 7.551E-05 | 4.738E-05 | 2.446E-03 | 1.412E-03 |
| 1790.00 | 4.103E+01 | 6.141E-01 | 3.895E+01 | 1.875E+00 | 4.658E-01 | 1.031E+00 | 9.337E-05 | 8.398E-05 | 8.551E-05 | 2.600E-03 | 1.440E-03 |
| 1836.00 | 5.366E+01 | 2.893E+01 | 2.246E+01 | 1.518E+00 | 7.662E-01 | 1.801E-01 | 8.694E-05 | 9.416E-05 | 1.349E-04 | 2.733E-03 | 3.090E-04 |
| 1836.00 | 1.038E+01 | 1.232E+01 | 2.018E+01 | 1.360E+00 | 7.884E-01 | 2.320E-01 | 8.562E-05 | 8.319E-05 | 1.264E-04 | 2.500E-03 | 3.974E-04 |
| 1846.00 | 9.907E+00 | 2.513E+01 | 2.234E+01 | 6.267E-01 | 2.091E-01 | 8.833E-03 | 8.671E-05 | 1.771E-04 | 1.410E-04 | 1.109E-03 | 1.515E-05 |
| 1846.00 | 5.859E-01 | 9.099E-01 | 8.071E-01 | 5.357E-01 | 9.792E-02 | 2.197E-01 | 8.057E-05 | 1.489E-04 | 1.458E-04 | 9.031E-04 | 3.893E-04 |
| 1860.00 | 4.836E-01 | 2.573E-01 | 2.682E-01 | 1.538E-01 | 8.171E-03 | 1.216E-01 | 7.253E-05 | 2.162E-04 | 7.002E-05 | 2.533E-04 | 2.282E-04 |
| 1874.00 | 1.495E+00 | 1.257E+00 | 4.672E-01 | 1.123E-01 | 1.075E-03 | 1.326E-01 | 7.167E-05 | 2.608E-04 | 7.271E-06 | 1.730E-04 | 2.511E-04 |
| 1884.00 | 1.465E+00 | 1.507E+00 | 3.524E-01 | 1.520E-01 | 3.225E-02 | 2.409E-01 | 7.173E-05 | 2.563E-04 | 4.872E-05 | 2.164E-04 | 4.547E-04 |
| 1894.00 | 1.265E+00 | 1.603E+00 | 2.335E-01 | 1.699E-01 | 6.198E-02 | 3.342E-01 | 7.180E-05 | 2.545E-04 | 5.718E-05 | 2.300E-04 | 6.508E-04 |
| 1904.00 | 1.047E+00 | 1.691E+00 | 2.177E-01 | 1.807E-01 | 7.597E-02 | 4.358E-01 | 7.186E-05 | 2.562E-04 | 4.925E-05 | 2.459E-04 | 8.780E-04 |
| 1914.00 | 7.844E-01 | 1.789E+00 | 2.196E-01 | 1.928E-01 | 8.562E-02 | 5.431E-01 | 7.192E-05 | 2.576E-04 | 4.074E-05 | 2.677E-04 | 1.130E-03 |
| 1924.00 | 4.254E-01 | 1.906E+00 | 1.984E-01 | 2.094E-01 | 1.059E-01 | 6.736E-01 | 7.199E-05 | 2.582E-04 | 3.722E-05 | 3.526E-04 | 1.405E-03 |
| 1934.00 | 2.180E-01 | 1.979E+00 | 1.588E-01 | 2.287E-01 | 1.380E-01 | 8.130E-01 | 7.206E-05 | 2.581E-04 | 3.726E-05 | 5.563E-04 | 2.065E-03 |
| 1943.50 | 3.400E-02 | 1.945E+00 | 3.380E-01 | 2.489E-01 | 1.692E-01 | 9.235E-01 | 7.214E-05 | 2.580E-04 | 3.815E-05 | 7.793E-04 | 2.935E-03 |
| 1943.50 | 1.097E-11 | 1.945E+00 | 3.380E-01 | 2.523E-01 | 1.692E-01 | 9.235E-01 | 7.214E-05 | 2.580E-04 | 3.815E-05 | 7.901E-04 | 2.935E-03 |
| 1944.50 | 5.122E-02 | 1.775E+00 | 1.266E+00 | 1.365E-01 | 1.707E-01 | 9.317E-01 | 7.214E-05 | 2.580E-04 | 3.822E-05 | 4.367E-04 | 3.041E-03 |
| 1945.50 | 2.211E-02 | 1.603E+00 | 2.202E+00 | 4.272E-02 | 1.722E-01 | 9.398E-01 | 7.215E-05 | 2.579E-04 | 3.829E-05 | 1.373E-04 | 3.151E-03 |
| 1946.50 | 8.484E-03 | 1.430E+00 | 3.147E+00 | 1.169E-02 | 1.735E-01 | 9.478E-01 | 7.216E-05 | 2.579E-04 | 3.832E-05 | 3.421E-05 | 3.221E-03 |

GROUP 22 - WESTERLY WINDS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 5.388E+02 | 2.455E+02 | 4.230E+02 | 1.733E+00 | 2.138E-01 | 4.677E-01 | 3.823E-07 | 1.321E-05 | 2.479E-06 | 1.597E+00 | 1.751E-01 |
| 1432.00 | 5.060E+02 | 6.118E+00 | 2.948E+01 | 1.429E+00 | 7.732E-02 | 3.156E-01 | 3.779E-06 | 2.041E-05 | 2.394E-06 | 1.422E+00 | 1.683E-01 |
| 1490.00 | 5.897E+01 | 1.288E+01 | 3.758E+01 | 1.558E-01 | 2.432E-02 | 1.822E-01 | 8.856E-07 | 3.295E-06 | 9.590E-06 | 1.566E-01 | 1.393E-01 |
| 1550.00 | 4.566E+01 | 1.420E+01 | 2.400E+00 | 2.009E-01 | 1.208E-01 | 2.546E-02 | 2.620E-06 | 6.257E-06 | 3.017E-06 | 2.017E-01 | 9.711E-02 |
| 1550.00 | 2.074E+01 | 9.982E+00 | 6.746E+00 | 1.257E-01 | 8.393E-02 | 4.190E-02 | 3.292E-06 | 5.084E-06 | 4.232E-06 | 1.262E-01 | 6.152E-02 |
| 1610.00 | 1.382E+00 | 3.924E-01 | 7.571E-01 | 7.493E-02 | 1.954E-02 | 1.264E-02 | 6.550E-06 | 6.591E-06 | 4.893E-06 | 7.486E-02 | 8.664E-04 |
| 1670.00 | 5.780E+00 | 2.754E+00 | 3.484E+00 | 3.876E-02 | 6.642E-03 | 2.202E-02 | 6.528E-06 | 6.176E-06 | 5.543E-06 | 3.854E-02 | 9.990E-03 |
| 1730.00 | 6.562E-01 | 1.348E+00 | 1.783E-01 | 4.836E-02 | 1.066E-02 | 3.382E-03 | 6.501E-06 | 8.131E-06 | 5.055E-06 | 4.833E-02 | 1.230E-02 |
| 1790.00 | 3.260E+00 | 1.599E+00 | 8.601E-02 | 4.013E-02 | 9.031E-03 | 1.860E-02 | 5.885E-06 | 7.831E-06 | 6.856E-06 | 4.011E-02 | 1.330E-02 |
| 1836.00 | 3.733E+00 | 1.493E+00 | 1.233E+00 | 3.969E-02 | 1.053E-02 | 3.238E-02 | 5.397E-06 | 7.730E-06 | 7.707E-06 | 3.967E-02 | 4.482E-02 |
| 1836.00 | 2.905E-01 | 5.699E-01 | 1.168E-01 | 2.898E-02 | 5.416E-03 | 9.030E-03 | 5.384E-06 | 1.003E-05 | 7.995E-06 | 2.900E-02 | 1.907E-02 |
| 1846.00 | 1.888E-01 | 6.866E-01 | 3.513E-02 | 1.938E-02 | 7.697E-03 | 1.423E-02 | 5.934E-06 | 1.064E-05 | 8.250E-06 | 1.940E-02 | 2.125E-02 |
| 1846.00 | 1.927E-02 | 2.951E-02 | 2.346E-02 | 1.754E-02 | 1.285E-02 | 9.108E-03 | 6.358E-06 | 1.174E-05 | 7.824E-06 | 1.756E-02 | 2.008E-02 |
| 1860.00 | 2.379E-03 | 2.828E-02 | 9.648E-03 | 3.671E-03 | 8.273E-03 | 6.681E-03 | 7.337E-06 | 1.390E-05 | 1.030E-05 | 3.691E-03 | 1.104E-02 |
| 1874.00 | 2.363E-02 | 5.614E-03 | 1.032E-02 | 9.329E-04 | 6.441E-03 | 8.317E-03 | 7.420E-06 | 1.503E-05 | 1.176E-05 | 9.262E-04 | 6.321E-03 |
| 1884.00 | 2.235E-02 | 7.038E-03 | 1.633E-02 | 3.181E-03 | 1.072E-02 | 1.517E-02 | 7.421E-06 | 1.502E-05 | 1.177E-05 | 3.176E-03 | 8.012E-03 |
| 1894.00 | 1.815E-02 | 6.554E-03 | 1.412E-02 | 4.742E-03 | 1.330E-02 | 2.115E-02 | 7.422E-06 | 1.501E-05 | 1.178E-05 | 4.744E-03 | 8.856E-03 |
| 1904.00 | 1.366E-02 | 4.849E-03 | 1.215E-02 | 6.064E-03 | 1.531E-02 | 2.753E-02 | 7.423E-06 | 1.500E-05 | 1.179E-05 | 6.076E-03 | 1.053E-02 |
| 1914.00 | 8.983E-03 | 1.075E-03 | 1.033E-02 | 7.637E-03 | 1.696E-02 | 3.427E-02 | 7.424E-06 | 1.500E-05 | 1.180E-05 | 7.663E-03 | 1.220E-02 |
| 1924.00 | 4.793E-03 | 7.022E-03 | 8.552E-03 | 9.477E-03 | 1.919E-02 | 4.255E-02 | 7.425E-06 | 1.499E-05 | 1.181E-05 | 9.518E-03 | 1.643E-02 |
| 1934.00 | 1.451E-03 | 1.494E-02 | 7.041E-03 | 1.289E-02 | 2.143E-02 | 5.130E-02 | 7.427E-06 | 1.498E-05 | 1.182E-05 | 1.290E-02 | 2.096E-02 |
| 1943.50 | 5.075E-03 | 3.414E-02 | 2.313E-02 | 1.633E-02 | 2.240E-02 | 5.840E-02 | 7.428E-06 | 1.497E-05 | 1.183E-05 | 1.640E-02 | 2.228E-02 |
| 1943.50 | 2.821E-05 | 3.415E-02 | 2.312E-02 | 1.683E-02 | 2.240E-02 | 5.840E-02 | 7.428E-06 | 1.497E-05 | 1.183E-05 | 1.691E-02 | 2.227E-02 |
| 1944.50 | 3.403E-03 | 5.679E-02 | 8.172E-02 | 9.155E-03 | 2.283E-02 | 5.883E-02 | 7.428E-06 | 1.497E-05 | 1.183E-05 | 9.232E-03 | 2.288E-02 |
| 1945.50 | 1.391E-03 | 7.986E-02 | 1.407E-01 | 2.908E-03 | 2.325E-02 | 5.927E-02 | 7.428E-06 | 1.497E-05 | 1.183E-05 | 2.986E-03 | 2.338E-02 |
| 1946.50 | 4.124E-04 | 1.033E-01 | 2.002E-01 | 8.452E-04 | 2.366E-02 | 5.970E-02 | 7.428E-06 | 1.497E-05 | 1.183E-05 | 9.250E-04 | 2.380E-02 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 5.573E+02 | 4.460E+02 | 1.413E+02 | 1.726E+00 | 2.377E-01 | 4.801E-01 | 1.181E-07 | 1.131E-05 | 7.264E-06 | 2.621E-04 | 8.314E-05 |
| 1432.00 | 5.065E+02 | 3.562E+00 | 1.923E+01 | 1.423E+00 | 2.199E-01 | 2.770E-01 | 4.511E-06 | 1.632E-05 | 1.225E-05 | 2.334E-04 | 4.594E-05 |
| 1490.00 | 5.871E+01 | 1.839E+01 | 3.566E+01 | 1.525E-01 | 1.481E-01 | 1.134E-01 | 8.223E-07 | 4.306E-06 | 9.187E-06 | 3.477E-05 | 2.283E-05 |
| 1550.00 | 4.548E+01 | 1.365E+01 | 6.073E+00 | 1.994E-01 | 1.119E-01 | 5.734E-02 | 2.510E-06 | 6.890E-06 | 1.157E-06 | 6.037E-05 | 1.620E-05 |
| 1550.00 | 2.066E+01 | 8.012E+00 | 9.177E+00 | 1.249E-01 | 7.077E-02 | 6.315E-02 | 3.187E-06 | 6.114E-06 | 2.655E-06 | 3.779E-05 | 1.789E-05 |
| 1610.00 | 1.384E+00 | 1.576E-01 | 8.351E-01 | 7.488E-02 | 7.902E-03 | 2.206E-02 | 6.485E-06 | 8.254E-06 | 3.119E-07 | 3.099E-05 | 9.119E-06 |
| 1670.00 | 5.769E+00 | 3.614E+00 | 2.071E+00 | 3.801E-02 | 4.127E-03 | 2.254E-02 | 6.508E-06 | 8.044E-06 | 2.102E-06 | 2.364E-05 | 1.437E-05 |
| 1730.00 | 6.534E-01 | 1.238E+00 | 5.697E-01 | 4.839E-02 | 7.176E-03 | 8.439E-03 | 6.514E-06 | 9.565E-06 | 1.969E-08 | 4.507E-05 | 8.754E-06 |
| 1790.00 | 3.253E+00 | 1.402E+00 | 8.022E-01 | 4.016E-02 | 2.666E-03 | 2.045E-02 | 5.920E-06 | 1.028E-05 | 1.515E-06 | 5.108E-05 | 2.860E-05 |
| 1836.00 | 3.724E+00 | 5.888E-01 | 1.863E+00 | 3.969E-02 | 3.397E-02 | 2.453E-03 | 5.446E-06 | 4.283E-06 | 1.001E-05 | 4.352E-05 | 4.224E-06 |
| 1836.00 | 2.930E-01 | 3.202E-01 | 4.842E-01 | 2.899E-02 | 1.039E-02 | 1.530E-03 | 5.444E-06 | 3.695E-06 | 1.226E-05 | 3.926E-05 | 2.627E-06 |
| 1846.00 | 1.918E-01 | 4.676E-01 | 5.029E-01 | 1.939E-02 | 1.583E-02 | 3.331E-03 | 5.997E-06 | 4.978E-07 | 1.342E-05 | 2.219E-05 | 5.696E-06 |
| 1846.00 | 1.909E-02 | 9.970E-04 | 3.778E-02 | 1.758E-02 | 1.521E-02 | 3.918E-03 | 6.425E-06 | 1.529E-06 | 1.399E-05 | 1.963E-05 | 6.944E-06 |
| 1860.00 | 2.280E-03 | 2.954E-02 | 4.584E-03 | 3.692E-03 | 1.042E-02 | 2.093E-03 | 7.417E-06 | 7.512E-06 | 1.554E-05 | 8.576E-07 | 3.930E-06 |
| 1874.00 | 2.358E-02 | 4.359E-03 | 1.100E-02 | 9.261E-04 | 7.477E-03 | 7.435E-03 | 7.504E-06 | 1.341E-05 | 1.353E-05 | 6.986E-06 | 1.409E-05 |
| 1884.00 | 2.234E-02 | 6.385E-03 | 1.661E-02 | 3.176E-03 | 1.020E-02 | 1.553E-02 | 7.501E-06 | 1.539E-05 | 1.123E-05 | 1.217E-05 | 2.931E-05 |
| 1894.00 | 1.815E-02 | 5.511E-03 | 1.457E-02 | 4.744E-03 | 1.185E-02 | 2.200E-02 | 7.498E-06 | 1.575E-05 | 1.071E-05 | 1.632E-05 | 4.285E-05 |
| 1904.00 | 1.365E-02 | 4.342E-03 | 1.235E-02 | 6.076E-03 | 1.427E-02 | 2.808E-02 | 7.496E-06 | 1.541E-05 | 1.120E-05 | 2.093E-05 | 5.657E-05 |
| 1914.00 | 8.963E-03 | 9.951E-04 | 1.035E-02 | 7.663E-03 | 1.680E-02 | 3.434E-02 | 7.493E-06 | 1.503E-05 | 1.170E-05 | 2.632E-05 | 7.146E-05 |
| 1924.00 | 4.755E-03 | 6.968E-03 | 8.610E-03 | 9.518E-03 | 1.955E-02 | 4.238E-02 | 7.491E-06 | 1.487E-05 | 1.191E-05 | 2.871E-05 | 8.840E-05 |
| 1934.00 | 1.398E-03 | 1.489E-02 | 7.152E-03 | 1.290E-02 | 2.183E-02 | 5.111E-02 | 7.489E-06 | 1.488E-05 | 1.191E-05 | 3.618E-05 | 1.298E-04 |
| 1943.50 | 5.046E-03 | 3.423E-02 | 2.301E-02 | 1.640E-02 | 2.263E-02 | 5.829E-02 | 7.488E-06 | 1.492E-05 | 1.186E-05 | 5.363E-05 | 1.853E-04 |
| 1943.50 | 1.627E-12 | 3.423E-02 | 2.301E-02 | 1.691E-02 | 2.263E-02 | 5.829E-02 | 7.488E-06 | 1.492E-05 | 1.186E-05 | 5.523E-05 | 1.853E-04 |
| 1944.50 | 3.451E-03 | 5.704E-02 | 8.154E-02 | 9.231E-03 | 2.302E-02 | 5.875E-02 | 7.488E-06 | 1.492E-05 | 1.185E-05 | 3.129E-05 | 1.917E-04 |
| 1945.50 | 1.517E-03 | 8.023E-02 | 1.405E-01 | 2.985E-03 | 2.342E-02 | 5.920E-02 | 7.488E-06 | 1.492E-05 | 1.185E-05 | 1.083E-05 | 1.985E-04 |
| 1946.50 | 6.214E-04 | 1.038E-01 | 2.000E-01 | 9.236E-04 | 2.381E-02 | 5.964E-02 | 7.488E-06 | 1.492E-05 | 1.185E-05 | 3.910E-06 | 2.027E-04 |

GROUPS 21-23 MARKOVS (DENSITY DEVIATION – HEADWINDS AND CROSSWINDS – CD)

THIS SEGMENT OF TABLE PRINTED ON PAGE G-43 (rows 1432.00, 1432.00, 1490.00)

| TIME | POSITION ESTIMATE ERROR R | POSITION ESTIMATE ERROR D | POSITION ESTIMATE ERROR C | VELOCITY ESTIMATE ERROR R | VELOCITY ESTIMATE ERROR D | VELOCITY ESTIMATE ERROR C | PLATFORM TILT ESTIMATE R | PLATFORM TILT ESTIMATE D | PLATFORM TILT ESTIMATE C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | 6.475E+02 | 8.014E+01 | 1.593E+02 | 1.807E+00 | 9.673E-01 | 3.541E-01 | 1.462E-05 | 4.322E-05 | 3.415E-05 | 1.813E+00 | 8.781E-01 |
| 1550.00 | 2.976E+02 | 3.177E+01 | 8.624E+01 | 7.864E-01 | 4.662E-01 | 2.865E-01 | 1.065E-05 | 2.607E-05 | 1.732E-05 | 7.884E-01 | 3.788E-01 |
| 1610.00 | 1.018E+02 | 1.150E+01 | 5.701E+01 | 3.125E-01 | 1.125E-01 | 2.307E-01 | 1.744E-05 | 3.245E-05 | 1.830E-05 | 3.133E-01 | 6.563E-02 |
| 1670.00 | 1.750E+01 | 1.580E+01 | 1.332E+01 | 2.875E-01 | 5.798E-02 | 3.019E-01 | 1.860E-05 | 3.549E-05 | 2.239E-05 | 2.871E-01 | 9.932E-02 |
| 1730.00 | 1.254E+01 | 1.072E+01 | 9.735E+00 | 2.646E-01 | 6.382E-02 | 2.887E-01 | 1.830E-05 | 4.179E-05 | 2.852E-05 | 2.646E-01 | 8.052E-02 |
| 1790.00 | 1.185E+01 | 9.980E+00 | 5.886E+00 | 1.959E-01 | 7.587E-02 | 2.838E-01 | 1.795E-05 | 4.612E-05 | 3.603E-05 | 1.960E-01 | 1.313E-01 |
| 1836.00 | 1.276E+01 | 7.494E+00 | 8.457E+00 | 1.547E-01 | 8.413E-02 | 2.396E-01 | 1.767E-05 | 5.445E-05 | 4.368E-05 | 1.550E-01 | 1.941E-01 |
| 1836.00 | 1.886E+00 | 4.194E+00 | 7.942E-01 | 1.539E-01 | 8.219E-02 | 1.446E-01 | 1.750E-05 | 6.201E-05 | 4.356E-05 | 1.541E-01 | 8.979E-02 |
| 1846.00 | 1.792E+00 | 5.111E+00 | 6.039E-01 | 7.087E-02 | 9.451E-02 | 7.616E-02 | 1.835E-05 | 7.239E-05 | 4.400E-05 | 7.107E-02 | 6.964E-02 |
| 1846.00 | 8.196E-02 | 1.563E-01 | 1.169E-01 | 5.701E-02 | 6.931E-02 | 5.138E-02 | 1.863E-05 | 7.630E-05 | 4.638E-05 | 5.716E-02 | 6.335E-02 |
| 1860.00 | 1.068E-01 | 2.358E-01 | 5.336E-02 | 2.220E-02 | 4.414E-02 | 3.495E-02 | 2.031E-05 | 8.651E-05 | 5.561E-05 | 2.237E-02 | 4.239E-02 |
| 1874.00 | 1.637E-01 | 1.824E-01 | 6.958E-02 | 2.341E-02 | 3.253E-02 | 4.731E-02 | 2.043E-05 | 9.608E-05 | 6.210E-05 | 2.356E-02 | 3.252E-02 |
| 1884.00 | 1.634E-01 | 2.220E-01 | 1.005E-01 | 3.635E-02 | 5.316E-02 | 8.819E-02 | 2.046E-05 | 9.608E-05 | 6.210E-05 | 3.660E-02 | 5.585E-02 |
| 1894.00 | 1.421E-01 | 2.305E-01 | 8.573E-02 | 4.174E-02 | 6.967E-02 | 1.241E-01 | 2.049E-05 | 9.608E-05 | 6.209E-05 | 4.207E-02 | 7.276E-02 |
| 1904.00 | 1.189E-01 | 2.418E-01 | 7.194E-02 | 4.487E-02 | 8.579E-02 | 1.620E-01 | 2.052E-05 | 9.607E-05 | 6.209E-05 | 4.527E-02 | 8.586E-02 |
| 1914.00 | 8.990E-02 | 2.563E-01 | 5.985E-02 | 4.898E-02 | 1.015E-01 | 2.016E-01 | 2.055E-05 | 9.607E-05 | 6.208E-05 | 4.945E-02 | 9.756E-02 |
| 1924.00 | 4.818E-02 | 2.777E-01 | 4.891E-02 | 5.510E-02 | 1.212E-01 | 2.499E-01 | 2.057E-05 | 9.607E-05 | 6.207E-05 | 5.567E-02 | 1.184E-01 |
| 1934.00 | 2.543E-02 | 2.949E-01 | 3.966E-02 | 6.471E-02 | 1.427E-01 | 3.037E-01 | 2.060E-05 | 9.607E-05 | 6.207E-05 | 6.532E-02 | 1.416E-01 |
| 1943.50 | 2.187E-02 | 3.103E-01 | 1.432E-01 | 7.579E-02 | 1.576E-01 | 3.460E-01 | 2.063E-05 | 9.607E-05 | 6.206E-05 | 7.643E-02 | 1.571E-01 |
| 1943.50 | 5.042E-04 | 3.103E-01 | 1.431E-01 | 7.782E-02 | 1.576E-01 | 3.460E-01 | 2.063E-05 | 9.607E-05 | 6.206E-05 | 7.847E-02 | 1.571E-01 |
| 1944.50 | 1.573E-02 | 3.622E-01 | 4.901E-01 | 4.200E-02 | 1.597E-01 | 3.491E-01 | 2.063E-05 | 9.606E-05 | 6.206E-05 | 4.264E-02 | 1.593E-01 |
| 1945.50 | 6.255E-03 | 4.672E-01 | 8.405E-01 | 1.296E-02 | 1.617E-01 | 3.522E-01 | 2.063E-05 | 9.606E-05 | 6.206E-05 | 1.357E-02 | 1.614E-01 |
| 1946.50 | 2.683E-03 | 5.994E-01 | 1.194E+00 | 3.521E-03 | 1.637E-01 | 3.552E-01 | 2.064E-05 | 9.606E-05 | 6.206E-05 | 4.000E-03 | 1.635E-01 |

THIS SEGMENT OF TABLE PRINTED ON PAGE G-43 (rows 1432.00, 1432.00, 1490.00)

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | | | | | | | | | | | |
| 1432.00 | | | | | | | | | | | |
| 1490.00 | | | | | | | | | | | |
| 1550.00 | 6.450E+02 | 1.293E+02 | 1.351E+02 | 1.792E+00 | 1.007E+00 | 3.152E-01 | 1.475E-05 | 3.260E-05 | 4.436E-05 | 5.422E-04 | 9.079E-05 |
| 1550.00 | 2.965E+02 | 5.467E+01 | 7.820E+01 | 7.810E-01 | 4.284E-01 | 3.526E-01 | 1.060E-05 | 2.138E-05 | 2.288E-05 | 2.347E-04 | 1.020E-04 |
| 1610.00 | 1.015E+02 | 3.032E+01 | 5.016E+01 | 3.120E-01 | 8.981E-02 | 2.412E-01 | 1.734E-05 | 2.444E-05 | 2.818E-05 | 1.314E-04 | 1.007E-04 |
| 1670.00 | 1.747E+01 | 1.209E+01 | 1.679E+01 | 2.869E-01 | 1.279E-01 | 2.802E-01 | 1.858E-05 | 3.176E-05 | 2.745E-05 | 1.882E-04 | 1.792E-04 |
| 1730.00 | 1.251E+01 | 8.411E+00 | 1.182E+01 | 2.644E-01 | 1.399E-01 | 2.607E-01 | 1.834E-05 | 3.375E-05 | 3.577E-05 | 2.749E-04 | 2.700E-04 |
| 1790.00 | 1.181E+01 | 1.042E+01 | 5.154E+00 | 1.959E-01 | 1.584E-01 | 2.474E-01 | 1.803E-05 | 4.103E-05 | 4.170E-05 | 2.897E-04 | 3.457E-04 |
| 1836.00 | 1.272E+01 | 6.540E+00 | 9.275E+00 | 1.549E-01 | 2.272E-01 | 1.132E-01 | 1.778E-05 | 4.871E-05 | 4.996E-05 | 3.165E-04 | 1.938E-04 |
| 1836.00 | 1.904E+00 | 2.291E+00 | 3.592E+00 | 1.541E-01 | 1.302E-01 | 1.031E-01 | 1.763E-05 | 4.992E-05 | 5.697E-05 | 2.932E-04 | 1.765E-04 |
| 1846.00 | 1.814E+00 | 3.693E+00 | 3.573E+00 | 7.105E-02 | 7.223E-02 | 9.742E-02 | 1.853E-05 | 6.213E-05 | 5.753E-05 | 1.235E-04 | 1.726E-04 |
| 1846.00 | 8.201E-02 | 1.168E-01 | 1.564E-01 | 5.718E-02 | 6.215E-02 | 5.967E-02 | 1.883E-05 | 6.639E-05 | 5.965E-05 | 9.366E-05 | 1.058E-04 |
| 1860.00 | 1.076E-01 | 2.172E-01 | 1.053E-01 | 2.237E-02 | 4.118E-02 | 3.829E-02 | 2.055E-05 | 8.477E-05 | 5.814E-05 | 3.475E-05 | 7.185E-05 |
| 1874.00 | 1.644E-01 | 1.734E-01 | 8.854E-02 | 2.356E-02 | 3.183E-02 | 4.770E-02 | 2.068E-05 | 9.670E-05 | 6.106E-05 | 3.852E-05 | 9.037E-05 |
| 1884.00 | 1.642E-01 | 2.243E-01 | 9.389E-02 | 3.659E-02 | 5.363E-02 | 8.782E-02 | 2.069E-05 | 9.569E-05 | 6.263E-05 | 5.703E-05 | 1.656E-04 |
| 1894.00 | 1.429E-01 | 2.345E-01 | 7.261E-02 | 4.207E-02 | 7.137E-02 | 1.230E-01 | 2.070E-05 | 9.529E-05 | 6.322E-05 | 7.034E-05 | 2.396E-04 |
| 1904.00 | 1.197E-01 | 2.436E-01 | 6.421E-02 | 4.527E-02 | 8.712E-02 | 1.612E-01 | 2.072E-05 | 9.566E-05 | 6.266E-05 | 8.752E-05 | 3.247E-04 |
| 1914.00 | 9.067E-02 | 2.563E-01 | 5.859E-02 | 4.945E-02 | 1.017E-01 | 2.013E-01 | 2.073E-05 | 9.598E-05 | 6.215E-05 | 1.087E-04 | 4.189E-04 |
| 1924.00 | 4.891E-02 | 2.773E-01 | 5.075E-02 | 5.566E-02 | 1.207E-01 | 2.501E-01 | 2.074E-05 | 9.610E-05 | 6.197E-05 | 1.216E-04 | 5.217E-04 |
| 1934.00 | 2.614E-02 | 2.946E-01 | 4.149E-02 | 6.532E-02 | 1.420E-01 | 3.034E-01 | 2.076E-05 | 9.609E-05 | 6.198E-05 | 1.679E-04 | 7.705E-04 |
| 1943.50 | 2.159E-02 | 3.107E-01 | 1.423E-01 | 7.643E-02 | 1.573E-01 | 3.460E-01 | 2.077E-05 | 9.606E-05 | 6.202E-05 | 2.442E-04 | 1.100E-03 |
| 1943.50 | 5.411E-10 | 3.107E-01 | 1.423E-01 | 7.847E-02 | 1.573E-01 | 3.460E-01 | 2.077E-05 | 9.606E-05 | 6.202E-05 | 2.506E-04 | 1.100E-03 |
| 1944.50 | 1.597E-02 | 3.631E-01 | 4.694E-01 | 4.264E-02 | 1.594E-01 | 3.491E-01 | 2.077E-05 | 9.606E-05 | 6.203E-05 | 1.403E-04 | 1.139E-03 |
| 1945.50 | 6.957E-03 | 4.679E-01 | 8.401E-01 | 1.357E-02 | 1.615E-01 | 3.523E-01 | 2.078E-05 | 9.606E-05 | 6.203E-05 | 4.670E-05 | 1.181E-03 |
| 1946.50 | 2.766E-03 | 5.999E-01 | 1.194E+00 | 3.994E-03 | 1.635E-01 | 3.553E-01 | 2.078E-05 | 9.605E-05 | 6.203E-05 | 1.580E-05 | 1.208E-03 |

GROUP 21 FIRST-ORDER MARKOV DENSITY DEVIATIONS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 3.871E+02 | 2.197E+02 | 4.830E+02 | 1.098E+00 | 1.801E-01 | 2.901E-01 | 1.930E-06 | 7.462E-06 | 3.806E-06 | 9.787E-01 | 1.568E-01 |
| 1432.00 | 3.660E+02 | 1.851E+01 | 7.319E+01 | 8.627E-01 | 9.037E-02 | 2.016E-01 | 3.040E-06 | 1.246E-05 | 3.657E-06 | 8.562E-01 | 1.554E-01 |
| 1490.00 | 3.675E+02 | 9.161E+01 | 3.683E+01 | 9.222E-01 | 2.773E-01 | 2.040E-01 | 5.225E-06 | 1.494E-05 | 6.120E-06 | 9.261E-01 | 2.788E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 4.051E+02 | 4.724E+02 | 2.103E+02 | 1.096E+00 | 1.804E-01 | 3.006E-01 | 1.853E-06 | 6.739E-06 | 5.004E-06 | 1.605E-04 | 5.432E-05 |
| 1432.00 | 3.669E+02 | 3.156E+01 | 6.344E+01 | 8.595E-01 | 1.731E-01 | 1.562E-01 | 3.390E-06 | 1.028E-05 | 7.797E-06 | 1.404E-04 | 2.580E-05 |
| 1490.00 | 3.656E+02 | 5.729E+01 | 8.848E+01 | 9.134E-01 | 3.303E-01 | 1.603E-01 | 5.424E-06 | 7.145E-06 | 1.441E-05 | 1.991E-04 | 3.149E-05 |

GROUP 22 CROSSWIND AND HEADWIND

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 2.198E+02 | 1.035E+02 | 2.102E+02 | 6.820E-01 | 7.243E-02 | 2.018E-01 | 7.086E-07 | 5.020E-06 | 1.660E-06 | 6.188E-01 | 1.123E-01 |
| 1432.00 | 2.101E+02 | 5.137E+00 | 2.382E+01 | 5.585E-01 | 3.552E-02 | 1.406E-01 | 1.836E-06 | 8.567E-06 | 1.620E-06 | 5.535E-01 | 1.066E-01 |
| 1490.00 | 2.499E+02 | 5.283E+01 | 1.401E+01 | 6.799E-01 | 1.792E-01 | 1.752E-01 | 3.459E-06 | 1.069E-05 | 6.008E-06 | 6.825E-01 | 2.252E-01 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 2.284E+02 | 2.099E+02 | 8.374E+01 | 6.782E-01 | 1.342E-01 | 1.819E-01 | 7.503E-07 | 3.569E-06 | 3.893E-06 | 1.017E-04 | 3.237E-05 |
| 1432.00 | 2.104E+02 | 6.341E+00 | 2.074E+01 | 5.546E-01 | 1.245E-01 | 9.907E-02 | 2.097E-06 | 6.068E-06 | 6.178E-06 | 9.104E-05 | 1.676E-05 |
| 1490.00 | 2.487E+02 | 4.192E+01 | 4.307E+01 | 6.731E-01 | 2.632E-01 | 5.257E-02 | 3.617E-06 | 4.216E-06 | 1.146E-05 | 1.469E-04 | 1.044E-05 |

GROUP 23 DRAG COEFFICIENT VARIATIONS

| TIME | POSITION ESTIMATE ERROR R | D | C | VELOCITY ESTIMATE ERROR R | D | C | PLATFORM TILT ESTIMATE R | D | C | ALTITUDE RATE ERROR | VELOCITY MAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 2.683E+03 | 1.600E+03 | 3.684E+03 | 7.992E+00 | 1.026E+00 | 2.381E+00 | 1.103E-05 | 5.549E-05 | 2.556E-05 | 7.047E+00 | 1.373E+00 |
| 1432.00 | 2.524E+03 | 1.019E+02 | 5.701E+02 | 6.154E+00 | 5.656E-01 | 1.535E+00 | 2.309E-05 | 9.127E-05 | 2.454E-05 | 6.082E+00 | 1.242E+00 |
| 1490.00 | 2.630E+03 | 6.136E+02 | 2.199E+02 | 6.748E+00 | 1.880E+00 | 1.680E+00 | 3.694E-05 | 1.091E-04 | 5.320E-05 | 6.775E+00 | 2.179E+00 |

| TIME | U | V | W | U | V | W | U | V | W | GAMMA ERROR | PSI ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1432.00 | 2.818E+03 | 3.573E+03 | 1.619E+03 | 7.951E+00 | 1.605E+00 | 2.188E+00 | 1.108E-05 | 4.315E-05 | 4.325E-05 | 1.158E-03 | 4.031E-04 |
| 1432.00 | 2.531E+03 | 2.590E+02 | 4.796E+02 | 6.115E+00 | 1.416E+00 | 1.070E+00 | 2.575E-05 | 6.715E-05 | 6.553E-05 | 9.999E-04 | 1.814E-04 |
| 1490.00 | 2.617E+03 | 4.242E+02 | 5.607E+02 | 6.681E+00 | 2.555E+00 | 8.503E-01 | 3.854E-05 | 4.823E-05 | 1.109E-04 | 1.458E-03 | 1.670E-04 |

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