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Produced by the NASA Center for Aerospace Information (CASI)
LANDSAT-4 HORIZON SCANNER
FULL ORBIT DATA AVERAGES

Prepared for:
GODDARD SPACE FLIGHT CENTER

By
John P. Stanley
Stephen Bilanow

Under
Contract No. NAS5-27664

November, 1983
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SECTION 1 - INTRODUCTION

This document describes the averages taken over full orbit data spans of the pitch and roll residual measurement errors of the two Conical Earth Sensc a operating on the Landsat-4 spacecraft. The variability of these full orbit averages over representative days throughout the year is analyzed. The full orbit averages demonstrate the long term stability of the sensor measurements. In general, the orbit period systematic effects will average out over the orbits and the remaining variability of the full orbit averages represents a very low frequency noise. There is interest in the variability of these full orbit averages because consideration is being given to design of a system which uses the full orbit averages in an onboard processor in combination with gyro data for spacecraft control.

The data analyzed consists of 23 segments of sensor measurements made at 2 to 4 week intervals from August 1982 to August 1983. Each segment is roughly 24 hours in length. The variation of full orbit average as a function of orbit within a day and as a function of day of year is examined. The dependence on day of year is based on associating the start date of each segment with the mean full orbit average for the segment. In addition, the peak-to-peak and standard deviation values of the averages for each data segment are computed and their variation with day of year examined as well.
The full orbit averages were computed on data tapes containing preaveraged data, where 128 individual observations at 0.128 second intervals were averaged to represent the major frame interval. Discussion and plots of the original and the preaveraged data is presented in Reference 1. In the absence of data gaps, an orbit is represented by 362 or 363 frames at 16.384 second intervals. In general, however, gaps of varying lengths occur frequently.

The position in the orbit where data gaps occur can bias the orbit average depending on whether the gap occurs at maximum or minimum data values. For this reason, the residuals (observed-predicted) rather than the raw measurements, were selected for the present study. The predicted data takes into account the effects due to reference attitude changes, spacecraft orbit, and Earth oblateness. Raw pitch and roll exhibit significantly more variation than the corresponding residuals. This variation is largely due to earth oblateness and orbit effects present in the sensor measurements. These effects are effectively removed from the residuals and consequently, the presence of data gaps may bias the full orbit averages of the residuals significantly less than the averages of the raw uncorrected pitch and roll measurements.

Data gap length varies greatly. The number of points per orbit ranges from 1 to 363. In order not to include orbits with large data gaps in the averaging, only orbits with at least 350 points were used. Under this restriction, the number of usable orbits per 24 hour segment varies from 6
to 17. A calculation of the worst case effects due to data gaps shows that this selection criterion can introduce a maximum error of about 0.01 degree with a more likely error of less than 0.002 degree. This calculation is described as follows: Assume a complete orbit to contain 363 points let $X$ be the full orbit average for an orbit containing $N$ points, where $N < 363$. Therefore, the orbit has a data gap of $363 - N$ points. Assume that the missing points are all equal to the average $X$ plus some constant offset $D$. Then a measure of the error introduced by the missing points is given by:

$$\text{Error} = \frac{NX + (363 - N)(X + D)}{363} - X$$

This can be simplified to:

$$\text{Error} = \frac{(363 - N)D}{363}$$

If $N$ is 350 and the offset $D$ is equal to the maximum observed pitch or roll residual, about 0.36 degree, the error is roughly 0.01 degree. A more typical estimate of the error introduced is obtained by letting $D$ be the maximum standard deviation of the full orbit average pitch and roll value. This is about 0.06 degrees, giving an error of about 0.002 degrees. Also from the above formula if the number of points missing is fewer, the maximum error is reduced proportionally.
SECTION 3 - FULL ORBIT DATA AVERAGES RESULTS

Complete sets of plots of pitch and roll residual as a function of orbit phase for both sensors are provided in Appendices A through D. Each segment is plotted in a serial stacked format, that is, the data is organized vertically by orbit. This plotting format is used as it provides a clear presentation of orbit to orbit trends and indicates the location and extent of data gaps. Moreover, individual orbit peculiarities, such as sun and moon interference, are readily recognized. These plots were prepared to aid in understanding any peculiarities in the behavior of the full orbit averages. Immediately following each plot, statistical information for each orbit is presented. At the end of each appendix, a table summarizing the statistical information for each of the 23 segments is provided. This table includes the mean, peak-to-peak variation and standard deviation of the full orbit averages for each segment. The number of usable orbits per segment (orbits of at least 350 points with 363 being the maximum) is also indicated.

3.1 DAILY VARIATION OF FULL ORBIT AVERAGES

Figures 1 through 4 show full orbit average pitch and roll residual as a function of orbit on four dates for which successive orbits are well represented over a period of 24 hours. Generally, the orbit coverage per day is far less complete, as can be seen from the plots presented in the appendices. The vertical scale is in degrees and horizontal bars indicate mean full orbit average for each 24 hour segment. From these figures,
Figure 1. Orbit to Orbit Variation of Full Orbit Averages for Sensor 1 Pitch Residual on Four Sample Days in 1983.

Full Orbit Average (Degrees)
Figure 2. Orbit to Orbit Variation of Full Orbit Averages for Sensor 2 Pitch Residual on Four Sample Days in 1983.
Figure 3. Orbit to Orbit Variation of Full Orbit Averages for Sensor 1 Roll Residual on
Four Sample Days in 1983.

FULL ORBIT AVERAGE (DEGREES)
Figure 4. Orbit to Orbit Variation of Full Orbit Averages for Sensor 2 Roll Residual on Four Sample Days in 1983.
there appears to be no evidence of systematic variation of full orbit average pitch or roll residuals over the course of one day.

The variation of the full orbit averages from orbit to orbit is larger than one would expect if the only error source were simply white noise, i.e., independent random errors from one observation to the next. The expected standard deviations of averaged white noise is given by the standard deviation of the raw observations divided by the square root of the number of observations. Reference 1 provides standard deviations of the 128 point averaged data of about 0.02° and 0.01° in the width and phase channels respectively. This yields estimates of about 0.001° to 0.0005° for the standard deviation of the orbit averages if the 128 point averaged observations were corrupted by white noise alone. The actual standard deviations of the averaged orbits is around 0.01 degrees, indicating that lower frequency error sources are contributing to the variation of the orbit averages.

3.2 VARIATION OF FULL ORBIT AVERAGES OVER YEAR

The variation of mean, peak-to-peak and standard deviation of full orbit average pitch and roll residual as a function of day of year is shown graphically in Figures 5 through 7, respectively. The data represented in these figures is contained in the statistical tables found at the end of each of the four appendices. Note that the time axis runs from the date of the earliest segment to the most recent. Horizontal bars indicate overall mean values.
Figure 5. Mean Full Orbit Averages Versus Days Since Launch
Figure 6. Peak-to-Peak Variation in Orbit Averages Versus Days Since Launch
Figure 7. Standard Deviation of Orbit Averages Versus Days Since Launch.
The full orbit averages of both pitch and roll residual show only slight variation over the months January through July 1983 (Figure 5). However, with the exception of sensor 1 roll residual, the full orbit average residuals exhibit significant variation over the months September through December.

There is some evidence of a correlation between the orbit averages in the two pitch channels, particularly in the 1982 data. The correlation also appears in the peak-to-peak and standard deviations of the averages for those days. This could indicate that the orbit average variability is due to instability in the reference attitudes for pitch, because there is little reason to expect this correlation between the sensor 1 Earth width measurement and sensor 2 Earth phase measurement, without additional correlation in the other channels. There is no indication of a similar correlation in roll. The full orbit average pitch variations may result from some of the early mission problems with the reference attitudes (Reference 2).

The most significant feature in the daily variability of the orbit averages is the rather large peak-to-peak and standard deviations of the orbit averages found in the 1982 days in the sensor 2 roll measurement. This cannot be a problem with the reference attitudes because it does not show up in the sensor 1 roll measurement. This orbit to orbit variability shows up clearly in the data plots, and has been noted elsewhere (Reference 3). A reason for this variability, and its disappearance in 1983 days is not known.
In general, the peak-to-peak and standard deviation, like the orbit averages themselves, show more variability in the early part of the mission.

While moon interference in the field of view of the sensors is clearly apparent in the plots of the December 1 segment (Appendices A through D), it may not be of significance for the full orbit averages. Notice in Figure 5 that full orbit average pitch residual for sensor 2 is at a yearly peak for the December 1 segment. However, as can be seen from the plot of this segment (Figure B-8), the effect of moon interference would be to decrease rather than increase full orbit average. Similarly, from the corresponding plot of roll residual for this segment (Figure D-8), the effect of moon interference would be to produce increases in full orbit averages rather than the decreases observed in Figure 5. Moreover, July 26 data also shows moon interference, but does not show a similar effect on the orbit averages. Note that the full orbit roll residual for sensor 2 is at a yearly minimum for the December 16th segment, a data span where no moon interference is present.

Relative large peak-to-peak spreads and standard deviations for sensor 1 during January through March may have been caused by the regular occurrence of sun interference in the scanner field of view. See for example, the plots of the January 19, February 2 and March 3 segments (Figures A-11 to A-13 and C-11 to C-13, respectively).

Since the data for the months of September through December, 1983 is not yet available, it is unclear whether the observed variation of the full
orbit averages during these months reflects actual seasonal effects or is an artefact of early flight data peculiarities. Table 1 provides a comparison of the average values of mean full orbit average, peak-to-peak and standard deviation for all 23 segments, for the 1982 segments only and for the 1983 segments only.
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APPENDIX A

This appendix contains plots and statistics for sensor 1 pitch residual versus orbit phase from the ascending node for all orbits in 23 data segments. The 23 segments are presented in sequence from the earliest segment to the most recent. Figures A-1 through A-23 provide plots and Tables A-1 through A-23 provide tables of statistics computed by orbit for each segment. Tables A-1 through A-23 are organized vertically by orbit number and horizontally into the following six columns:

1. ORBIT TIME START/END: Orbit start and end times in the format YYMMDD.HHMMSSMMM, where:
   - YY... Year
   - MM... Month
   - DD... Day
   - HH... Hours
   - MM... Minutes
   - SS... Seconds
   - MMM... Milliseconds

2. (X,Y,REC) AT MIN X/Y: Provides the coordinates — orbit phase (X), residual value (Y), and record number (REC) — at which the minimum values occur. The upper line gives the minimum orbit phase (X) coordinates and the lower line gives the minimum residual value (Y) coordinates for each orbit.

3. (X,Y,REC) AT MAX X/Y: Same as (2) except maximum rather than minimum values


5. Y-RMS/STDV: For each orbit, the upper value is the root mean square of pitch residual and the lower value, the standard deviation.

6. POINTS: The number of points contained in each orbit.

Table A-24 provides mean, peak-to-peak and standard deviation of full orbit average pitch residual for each segment. Note that only orbits with at least 350 data points were used in compiling these statistics for each segment. The number of orbits used is provided.
FIGURE A-1. Sensor One Pitch Residuals for Consecutive Orbits
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FIGURE A-2. Sensor One Pitch Residuals for Consecutive Orbits
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<th>V.R. REC. AT MAX Y/Z</th>
<th>V.R. REC. AT MIN X/Y</th>
<th>V.R. REC. AT MIN Y/Z</th>
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<td>0.901876803</td>
<td>0.184161100</td>
<td>0.243615032</td>
<td>0.513604532</td>
<td>0.753536923</td>
</tr>
<tr>
<td>0.901876803</td>
<td>0.184161100</td>
<td>0.243615032</td>
<td>0.513604532</td>
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<td>0.243615032</td>
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<td>0.243615032</td>
<td>0.513604532</td>
<td>0.753536923</td>
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**NOTE:** For poor quality.
FIGURE A-4. Sensor One Pitch Residuals for Consecutive Orbits
FIGURE A-5. Sensor One Pitch Residuals for Consecutive Orbits
FIGURE A-6. Sensor One Pitch Residuals for Consecutive Orbits
FIGURE A-7. Sensor One Pitch Residuals for Consecutive Orbits
<table>
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<th>ORBIT TIME START/END</th>
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<th>(F,Y,REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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<td>0.15100D+00</td>
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<td>0.14758D+00</td>
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<td>0.35904E+00, 0.22233E+00, 1064</td>
<td>0.14720D+00</td>
<td>0.15865D+00</td>
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<td>0.60611E+01, 0.21032E+00, 3571</td>
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FIGURE A-8. Sensor One Pitch Residuals for Consecutive Orbits
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<th>X (K.Y.REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-AMS/STDV</th>
<th>POINTS</th>
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<td>0.20266D+00</td>
<td>0.21404D+00</td>
<td>360</td>
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<tr>
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FIGURE A-9. Sensor One Pitch Residuals for Consecutive Orbits
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<th>X,Y, REC AT MAX X/Y</th>
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FIGURE A-10. Sensor One Pitch Residuals for Consecutive Orbits
FIGURE A-11. Sensor One Pitch Residuals for Consecutive Orbits
<table>
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<tr>
<th>ORBIT TIME START/END</th>
<th>(X,Y,REC) AT WIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>V-RMS/STDEV</th>
<th>POINTS</th>
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<td>0.35932E+03, 0.26703E+00, 719</td>
<td>0.17432E+00</td>
<td>0.26703E+00, 0.83435E+01</td>
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<td>0.35932E+03, 0.26703E+00, 719</td>
<td>0.17432E+00</td>
<td>0.26703E+00, 0.83435E+01</td>
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FIGURE A-12. Sensor One Pitch Residuals for Consecutive Orbits
<table>
<thead>
<tr>
<th>ORBIT TIME START/END</th>
<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
</tr>
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<tr>
<td>1 830202.033425971</td>
<td>0.34605e-03, 0.28024e-00</td>
<td>0.39941e-03, 0.29623e-00</td>
<td>0.28202e+00</td>
<td>0.28216e+00</td>
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</tr>
<tr>
<td>2 830202.033895276</td>
<td>0.2634e-02, 0.25817e-00</td>
<td>0.35928e-03, 0.24665e-00</td>
<td>0.17876e+00</td>
<td>0.18844e+00</td>
<td>360</td>
</tr>
<tr>
<td>3 830202.050843759</td>
<td>0.32601e-01, 0.22345e-00</td>
<td>0.35915e-03, 0.26694e-00</td>
<td>0.17126e+00</td>
<td>0.18359e+00</td>
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</tr>
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<td>0.33034e-03, 0.29909e-00</td>
<td>0.16853e+00</td>
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<td>0.15968e+00</td>
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<td>0.15760e+00</td>
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<td>0.35978e-03, 0.28735e-00</td>
<td>0.17603e+00</td>
<td>0.19613e+00</td>
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<tr>
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<td>0.7725e-01, 0.29010e-00</td>
<td>0.36966e-03, 0.28875e-00</td>
<td>0.17564e+00</td>
<td>0.19764e+00</td>
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<td>0.36818e-03, 0.33040e-00</td>
<td>0.17669e+00</td>
<td>0.20394e+00</td>
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<td>0.19766e+00</td>
<td>0.21449e+00</td>
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<td>0.21980e+00</td>
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<td>0.35155e-03, 0.2943e-00</td>
<td>0.19101e+00</td>
<td>0.21664e+00</td>
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<td>0.35902e-03, 0.27442e-00</td>
<td>0.19071e+00</td>
<td>0.20526e+00</td>
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<tr>
<td>14 830202.213673615</td>
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<td>0.20970e+00</td>
<td>0.22082e+00</td>
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FIGURE A-13: Sensor One Pitch Residuals for Consecutive Orbits
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<th>ORBIT TIME START/END</th>
<th>(F.Y.,REC) AT M.I.Y</th>
<th>(F.Y.,REC) AT MAX I/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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<td>0.35561E-03, 0.24841E+00</td>
<td>0.244110</td>
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<tr>
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<td>0.35600E-03, 0.24841E+00</td>
<td>0.244110</td>
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<tr>
<td>2 830303.025850230</td>
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<td>0.35839E-03, 0.25139E+00</td>
<td>0.156410</td>
<td>0.166660</td>
<td>344</td>
</tr>
<tr>
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<td>0.35326E-02, 0.25736E+00</td>
<td>0.156410</td>
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<td>0.97844E-00, 0.25950E+00</td>
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<td>0.172860</td>
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FIGURE A-14. Sensor One Pitch Residuals for Consecutive Orbits
<table>
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<tr>
<th>ORBIT TIME START/END</th>
<th>(K, V, REC) AT MIN X/Y</th>
<th>(K, V, REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>V-RMS/STDEV</th>
<th>POINTS</th>
</tr>
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**Table A-14. Data Statistics by Orbit**

- **K, V, REC** at min and max X/Y values
- **MEAN Y** calculated from the data
- **V-RMS/STDEV** shows the variability of the data points
- **POINTS** indicates the number of points analyzed
FIGURE A-15. Sensor One Pitch Residuals for Consecutive Orbits
**TABLE A-15. Data Statistics by Orbit**

<table>
<thead>
<tr>
<th>ORBIT TIME START/END</th>
<th>(F.V,REC) AT MIN I/Y</th>
<th>(F.V,REC) AT MAX I/Y</th>
<th>MEAN I/Y</th>
<th>V-RMS/STDEV</th>
<th>POINTS</th>
</tr>
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<td>0.1883E+00</td>
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FIGURE A-16. Sensor One Pitch Residuals for Consecutive Orbits
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<th>(T.V.REC) AT MAX E/Y</th>
<th>MEAN E/Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
</tr>
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Figure A-17. Sensor One Pitch Residuals for Consecutive Orbits
### TABLE A-17. Data Statistics by Orbit

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<th>ORBIT TIME START/END</th>
<th>(F.Y.REC) AT MIN X/Y</th>
<th>(F.Y.REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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<td>0.14033D+00</td>
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**ORIGINAL PAGE 19**
FIGURE A-18. Sensor One Pitch Residuals for Consecutive Orbits
Figure A-19. Sensor One Pitch Residuals for Consecutive Orbits
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<th>I X, Y, REC AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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FIGURE A-20. Sensor One Pitch Residuals for Consecutive Orbits
FIGURE A-21. Sensor One Pitch Residuals for Consecutive Orbits
**TABLE A-21. Data Statistics by Orbit**

<table>
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<th>V-RMS/STDV</th>
<th>POINTS</th>
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<td>0.02045E+00</td>
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<td>0.35926E+03, 0.22528E+00</td>
<td>0.19217E+00</td>
<td>0.02029E+00</td>
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<td>0.02195E+00</td>
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<td>0.02195E+00</td>
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<td>0.20992E+00</td>
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FIGURE A-22. Sensor One Pitch Residuals for Consecutive Orbits
FIGURE A-23. Sensor One Pitch Residuals for Consecutive Orbits
### TABLE A-24. Summary Statistics for the Period from 8/10/82 to 8/6/83

**PITCH ESA: 1**

<table>
<thead>
<tr>
<th>SEGMENT NUMBER</th>
<th>SEGMENT DATE</th>
<th>MEAN FULL ORBIT AVERAGE</th>
<th>p-p</th>
<th>σ</th>
<th>NO. OF ORBITS</th>
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<tr>
<td>3</td>
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<td>0.1604</td>
<td>0.0308</td>
<td>0.0117</td>
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<tr>
<td>4</td>
<td>10/5/82</td>
<td>0.1342</td>
<td>0.0269</td>
<td>0.0092</td>
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</tr>
<tr>
<td>5</td>
<td>10/20/82</td>
<td>0.1494</td>
<td>0.0244</td>
<td>0.0093</td>
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<tr>
<td>6</td>
<td>11/2/82</td>
<td>0.1619</td>
<td>0.0131</td>
<td>0.0039</td>
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<tr>
<td>7</td>
<td>11/16/82</td>
<td>0.1467</td>
<td>0.0198</td>
<td>0.0059</td>
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<tr>
<td>8</td>
<td>12/1/82</td>
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<td>0.0405</td>
<td>0.0135</td>
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<tr>
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<td>0.0250</td>
<td>0.0096</td>
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<tr>
<td>10</td>
<td>12/28/82</td>
<td>0.2072</td>
<td>0.0369</td>
<td>0.0121</td>
<td>8</td>
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<tr>
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<td>0.0256</td>
<td>0.0086</td>
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</tr>
<tr>
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<td>0.1909</td>
<td>0.0412</td>
<td>0.0142</td>
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<tr>
<td>13</td>
<td>3/3/83</td>
<td>0.1721</td>
<td>0.0366</td>
<td>0.0113</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>3/14/83</td>
<td>0.1542</td>
<td>0.0095</td>
<td>0.0027</td>
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<tr>
<td>15</td>
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<td>0.0248</td>
<td>0.0075</td>
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</tr>
<tr>
<td>16</td>
<td>4/14/83</td>
<td>0.1921</td>
<td>0.0148</td>
<td>0.0044</td>
<td>16</td>
</tr>
<tr>
<td>17</td>
<td>4/26/83</td>
<td>0.1851</td>
<td>0.0129</td>
<td>0.0032</td>
<td>15</td>
</tr>
<tr>
<td>18</td>
<td>5/23/83</td>
<td>0.1918</td>
<td>0.0118</td>
<td>0.0032</td>
<td>15</td>
</tr>
<tr>
<td>19</td>
<td>6/6/83</td>
<td>0.1838</td>
<td>0.0133</td>
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<tr>
<td>20</td>
<td>6/21/83</td>
<td>0.2072</td>
<td>0.0183</td>
<td>0.0052</td>
<td>13</td>
</tr>
<tr>
<td>21</td>
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<td>0.2057</td>
<td>0.0217</td>
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<tr>
<td>22</td>
<td>7/26/83</td>
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<td>0.0208</td>
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<tr>
<td>23</td>
<td>8/6/83</td>
<td>0.2115</td>
<td>0.0148</td>
<td>0.0049</td>
<td>14</td>
</tr>
</tbody>
</table>

1 Segment date refers to the start date of each segment. Each segment is approximately 24 hours in length.
This appendix contains plots and statistics for sensor 2 pitch residual versus orbit phase from the ascending node for all orbits in 23 data segments. The 23 segments are presented in sequence from the earliest segment to the most recent. Figures B-1 through B-23 provide plots and Tables B-1 through B-23 provide tables of statistics computed by orbit for each segment. Tables B-1 through B-23 are organized vertically by orbit number and horizontally into the following six columns:

(1) ORBIT TIME START/END: Orbit start and end times in the format YYMMDD.HHMMSSMMM, where:
- YY... Year
- MM... Month
- DD... Day
- HH... Hours
- MM... Minutes
- SS... Seconds
- MMM... Milliseconds

(2) (X,Y,REC) AT MIN X/Y: Provides the coordinates — orbit phase (X), residual value (Y), and record number (REC) — at which the minimum values occur. The upper line gives the minimum orbit phase (X) coordinates and the lower line gives the minimum residual value (Y) coordinates for each orbit.

(3) (X,Y,REC) AT MAX X/Y: Same as (2) except maximum rather than minimum values

(4) MEAN Y: Full-orbit average of pitch residual.

(5) Y-RMS/STDEV: For each orbit, the upper value is the root mean square of pitch residual and the lower value, the standard deviation.

(6) POINTS: The number of points contained in each orbit.

Table B-24 provides mean, peak-to-peak and standard deviation of full orbit average pitch residual for each segment. Note that only orbits with at least 350 data points were used in compiling these statistics for each segment. The number of orbits used is provided.
FIGURE B-1. Sensor Two Pitch Residuals for Consecutive Orbits
### TABLE B-1. Data Statistics by Orbit

<table>
<thead>
<tr>
<th>ORBIT TIME START/END</th>
<th>(T,Y,REC) AT MIN T/Y</th>
<th>(T,Y,REC) AT MAX T/Y</th>
<th>MEAN Y</th>
<th>Y-ROVS/STDV</th>
<th>POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 820810.215426522</td>
<td>0.72118E+02, -0.80003E-01, 1</td>
<td>0.35933E+03, -0.54096E-01, 289</td>
<td>-0.36306E-01</td>
<td>0.4356D-01</td>
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<tr>
<td>2 820810.231337802</td>
<td>0.25411E+03, -0.89771E-01, 183</td>
<td>0.29576E+03, 0.39776E-01, 225</td>
<td>-0.54465E-01</td>
<td>0.5457D-01</td>
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<tr>
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<td>0.35921E+03, -0.49384E-01, 651</td>
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<td>0.5573D-01</td>
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<tr>
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<td>0.28759E+03, 0.49362E-01, 939</td>
<td>-0.46654E-01</td>
<td>0.3053D-01</td>
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<tr>
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<td>0.81257E+03, -0.10550E-01, 1012</td>
<td>0.27952E+03, 0.29751E-01, 1292</td>
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<td>0.21896E+03, 0.12723E-01, 1591</td>
<td>-0.44476E-01</td>
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<tr>
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<td>0.21677E+03, 0.12657E-01, 1931</td>
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<td>0.10228E+03, 0.19684E-01, 2159</td>
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<td>0.35934E+00, -0.65584E-01, 3097</td>
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<td>0.28575E+03, 0.14401E-01, 2943</td>
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FIGURE B-2. Sensor Two Pitch Residuals for Consecutive Orbits
<table>
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<th>ORBIT TIME START/END</th>
<th>(F, V, REC) AT MIN Z/Y</th>
<th>(F, V, REC) AT MAP Z/Y</th>
<th>MEAN V</th>
<th>V-RMS/STDV</th>
<th>POINTS</th>
</tr>
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FIGURE 5-3. Sensor Two Pitch Residuals for Consecutive Orbits
<table>
<thead>
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<th>ORBIT TIME START/END</th>
<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN V</th>
<th>V-RMS/STDV</th>
<th>POINTS</th>
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FIGURE B-4. Sensor Two Pitch Residuals for Consecutive Orbits
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<th>(I,Y,REC) AT MAX I/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
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FIGURE B-5. Sensor Two Pitch Residuals for Consecutive Orbits
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<th>(K.Y.REC) AT MAX X/Y</th>
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<th>Y-RMS/STDEV</th>
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FIGURE B-6. Sensor Two Pitch Residuals for Consecutive Orbits
# TABLE B-6. Data Statistics by Orbit

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<th>TIME START/END</th>
<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
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<th>MEAN Y</th>
<th>RMS/STDV</th>
<th>POINTS</th>
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FIGURE B-7. Sensor Two Pitch Residuals for Consecutive Orbits
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<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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<td>0.3594E-03, -0.3442E-01</td>
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<td>0.74424E-01</td>
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<td>0.3594E-03, -0.3442E-01</td>
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<td>0.74424E-01</td>
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<tr>
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<td>0.3593E-03, -0.4098E-01</td>
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<td>0.3593E-03, -0.7015E-02</td>
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<td>0.3511E-03, -0.1195E-01</td>
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<tr>
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<td>0.3590E-03, -0.5113E-01</td>
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**TABLE B-7. Data Statistics by Orbit**

**ORBIT TIME START/END**

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<th>X,Y,REC AT MIN X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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FIGURE B-8. Sensor Two Pitch Residuals for Consecutive Orbits
### Table B-8: Data Statistics by Orbit

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<th>(X, Y, REC) AT MAX R/V</th>
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<th>POINTS</th>
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FIGURE B-9. Sensor Two Pitch Residuals for Consecutive Orbits
**TABLE B-9. Data Statistics by Orbit**

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<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
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<th>POINTS</th>
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FIGURE B-10. Sensor Two Pitch Residuals for Consecutive Orbits
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**TABLE B-10. Data Statistics by Orbit**
FIGURE B-11. Sensor Two Pitch Residuals for Consecutive Orbits
<table>
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<tr>
<th>ORBIT</th>
<th>TIME START/END</th>
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<th>(X,Y,REC) AT MAX X/Y</th>
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<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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**TABLE B-11. Data Statistics by Orbit**
FIGURE B-12. Sensor Two Pitch Residuals for Consecutive Orbits
<table>
<thead>
<tr>
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FIGURE B-13. Sensor Two Pitch Residuals for Consecutive Orbits
### Table B.13: Data Statistics by Orbit

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Note: Data statistics are calculated for each orbit, with mean and standard deviation for the number of normal points (N. Normal).
FIGURE B-14. Sensor Two Pitch Residuals for Consecutive Orbits
### TABLE B-14. Data Statistics by Orbit

<table>
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<tr>
<th>ORBIT TIME START/END</th>
<th>(I, Y, REC) AT MIN X/Y</th>
<th>(I, Y, REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
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**Note:** Table entries represent statistical data for orbits with specific time starts and ends, including minimum and maximum X/Y values, mean Y values, and Y-rms/STDV values. Points column indicates the number of points used in the statistics.
FIGURE B-15. Sensor Two Pitch Residuals for Consecutive Orbits
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<th>(F,V,RECI AT MAX F/V)</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
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FIGURE B-16. Sensor Two Pitch Residuals for Consecutive Orbits
### TABLE B-16. Data Statistics by Orbit

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<th>ORBIT TIME START/END</th>
<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STUD</th>
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FIGURE B-17. Sensor Two Pitch Residuals for Consecutive Orbits
### TABLE B-17. Data Statistics by Orbit

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<th>(R,Y,REC) AT MAX R/Y</th>
<th>MEAN R/Y</th>
<th>R-M/S/STDV</th>
<th>POINTS</th>
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<td>0.4336E+02, -0.9164E+02, 832</td>
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FIGURE B-18. Sensor Two Pitch Residuals for Consecutive Orbits
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<th>(K,Y,REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>V-RMS/STDV</th>
<th>POINTS</th>
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<td>0.3951E+03, -0.4706E-01, 566</td>
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<td>0.2203E+03, 0.4489E-01, 166</td>
<td>-0.5501E-01</td>
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<td>0.3590E+03, -0.3704E-01, 667</td>
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FIGURE B-19. Sensor Two Pitch Residuals for Consecutive Orbits
FIGURE B-20. Sensor Two Pitch Residuals for Consecutive Orbits
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<th>ORBIT TIME START/END</th>
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<th>F, Y, REC AT MAX R/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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FIGURE B-21. Sensor Two Pitch Residuals for Consecutive Orbits
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<th>X, Y, REC AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
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FIGURE B-22. Sensor Two Pitch Residuals for Consecutive Orbits
FIGURE B-23. Sensor Two Pitch Residuals for Consecutive Orbits
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<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
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TABLE B-24. Summary Statistics for the Period from 8/10/82 to 8/6/83

**PITCHR ESA:** 2

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<th>p-p</th>
<th>σ</th>
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1 Segment date refers to the start date of each segment. Each segment is approximately 24 hours in length.
APPENDIX C

This appendix contains plots and statistics for sensor 1 roll residual versus orbit phase from the ascending node for all orbits in 23 data segments. The 23 segments are presented in sequence from the earliest segment to the most recent. Figures C-1 through C-23 provide plots and Tables C-1 through C-23 provide tables of statistics computed by orbit for each segment. Tables C-1 through C-23 are organized vertically by orbit number and horizontally into the following six columns:

1. **ORBIT TIME START/END:** Orbit start and end times in the format YYYYMMDD.HHMMSSMMM, where:
   - YY... Year
   - MM... Month
   - DD... Day
   - HH... Hours
   - MM... Minutes
   - SS... Seconds
   - MMM... Milliseconds

2. **(X,Y,REC) AT MIN X/Y:** Provides the coordinates — orbit phase (X), residual value (Y), and record number (REC) — at which the minimum values occur. The upper line gives the minimum orbit phase (X) coordinates and the lower line gives the minimum residual value (Y) coordinates for each orbit.

3. **(X,Y,REC) AT MAX X/Y:** Same as (2) except maximum rather than minimum values.

4. **MEAN Y:** Full-orbit average of roll residual.

5. **Y-RMS/STDV:** For each orbit, the upper value is the root mean square of roll residual and the lower value, the standard deviation.

6. **POINTS:** The number of points contained in each orbit.

Table C-24 provides mean, peak-to-peak and standard deviation of full orbit average roll residual for each segment. Note that only orbits with at least 350 data points were used in compiling these statistics for each segment. The number of orbits used is provided.
FIGURE C-1. Sensor One Roll Residuals for Consecutive Orbits
<table>
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<th>(X,Y,REC) AT MAX E/Y</th>
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<th>V-RMS/STDEV</th>
<th>POINTS</th>
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FIGURE C-2. Sensor One Roll Residuals for Consecutive Orbits
### Table C-2: Data Statistics by Orbit

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<th>(F, Y, REC) at Max K/Y</th>
<th>Mean Y</th>
<th>Y-RMS/STDV</th>
<th>Points</th>
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**C-5**

Of Poor Quality

Original Page
FIGURE C-3. Sensor One Roll Residuals for Consecutive Orbits
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<th>ORBIT</th>
<th>TIME START/END</th>
<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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<td>0.26049E-03, -0.28799E-00</td>
<td>0.35920E-03, -0.17792E-00</td>
<td>142</td>
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<td>0.23813E-00</td>
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<tr>
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<td>0.35932E-03, -0.14364E-00</td>
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<tr>
<td>4</td>
<td>B10922.0344957347</td>
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<td>0.35999E-03, -0.22607E-00</td>
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FIGURE C-4. Sensor One Roll Residuals for Consecutive Orbits
FIGURE C-5. Sensor One Roll Residuals for Consecutive Orbits
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<th>ORBIT TIME START/END</th>
<th>X,Y, REC AT MIN X/Y</th>
<th>X,Y, REC AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
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FIGURE C-6. Sensor One Roll Residuals for Consecutive Orbits
### TABLE C-6. Data Statistics by Orbit

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<th>ORBIT TIME START/END</th>
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<th>(F.Y.REC) AT MAP E/V</th>
<th>MEAN V</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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<td>0.25571D+00</td>
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<tr>
<td>10 821103.158545777</td>
<td>0.32327E+01, -0.20734E+00</td>
<td>0.39233E+03, -0.17611E+00</td>
<td>3439</td>
<td>0.25050D+00</td>
<td>0.25449D+00</td>
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<tr>
<td>11 821103.163455885</td>
<td>0.23220E+00, -0.17210E+00</td>
<td>0.28911E+03, -0.18611E+00</td>
<td>3789</td>
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<td>0.24354D+00</td>
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<tr>
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<td>0.30346E+02, -0.16378E+00</td>
<td>3821</td>
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<td>13 821103.201544000</td>
<td>0.29326E+02, -0.32592E+00</td>
<td>0.10927E+02, -0.16677E+00</td>
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<td>0.23839D+00</td>
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<tr>
<td>14 821103.215435005</td>
<td>0.87050E+00, -0.20123E+00</td>
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<td>0.18789D+00</td>
<td>0.18816D+00</td>
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FIGURE C-7. Sensor One Roll Residuals for Consecutive Orbits
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<th>(I.,V.REC) AT WIN X/Y</th>
<th>(I.,V.REC) AT MAX X/Y</th>
<th>MEAN V</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
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<td>0.35944E+03, -0.19270E+00</td>
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<td>0.19270E+00, 1</td>
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<td>0.35944E+03, -0.19270E+00</td>
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<td>3 821116.081301452</td>
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<td>0.19270E+00, 1</td>
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<td>12 821116.230259938</td>
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FIGURE C-8. Sensor One Roll Residuals for Consecutive Orbits
<table>
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<tr>
<th>ORBIT TIME START/END</th>
<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
</tr>
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<tbody>
<tr>
<td>1. B:1201.002896720</td>
<td>0.26704E+03, -0.32324E+00</td>
<td>0.35033E+03, -0.23980E+00</td>
<td>0.28225E+00</td>
<td>0.26914E+00</td>
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<td>2. B:1201.005436816</td>
<td>0.35282E+00, -0.22754E+00</td>
<td>0.35024E+03, -0.15519E+00</td>
<td>0.23953E+00</td>
<td>0.24360E+00</td>
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</tr>
<tr>
<td>3. B:1201.023327824</td>
<td>0.26943E+03, -0.31695E+00</td>
<td>0.35911E+03, -0.19926E+00</td>
<td>0.22900E+00</td>
<td>0.22904E+00</td>
<td>357</td>
</tr>
<tr>
<td>4. B:1201.041216532</td>
<td>0.10526E+00, -0.19641E+00</td>
<td>0.10598E+00, -0.24925E+00</td>
<td>0.25155E+00</td>
<td>0.25750E+00</td>
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</tr>
<tr>
<td>5. B:1201.055126239</td>
<td>0.25079E+03, -0.34588E+00</td>
<td>0.35808E+00, -0.22336E+00</td>
<td>0.25245E+00</td>
<td>0.26393E+00</td>
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<tr>
<td>6. B:1201.073017762</td>
<td>0.25265E+03, -0.34625E+00</td>
<td>0.35973E+03, -0.19272E+00</td>
<td>0.25227E+00</td>
<td>0.25761E+00</td>
<td>361</td>
</tr>
<tr>
<td>7. B:1201.099508270</td>
<td>0.23784E+03, -0.34703E+00</td>
<td>0.10724E+00, -0.55176E-01</td>
<td>0.25152E+00</td>
<td>0.25644E+00</td>
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</tr>
<tr>
<td>8. B:1201.104759278</td>
<td>0.22661E+03, -0.34101E+00</td>
<td>0.35615E+00, -0.22710E+00</td>
<td>0.24806E+00</td>
<td>0.25464E+00</td>
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</tr>
<tr>
<td>9. B:1201.126565301</td>
<td>0.27313E+00, -0.35696E+00</td>
<td>0.35963E+00, -0.22130E+00</td>
<td>0.25138E+00</td>
<td>0.25892E+00</td>
<td>362</td>
</tr>
<tr>
<td>10. B:1201.140541309</td>
<td>0.29506E+00, -0.36026E+00</td>
<td>0.35936E+00, -0.22130E+00</td>
<td>0.25138E+00</td>
<td>0.25892E+00</td>
<td>362</td>
</tr>
<tr>
<td>11. B:1201.163641661</td>
<td>0.29026E+03, -0.35853E+00</td>
<td>0.35910E+03, -0.22130E+00</td>
<td>0.25138E+00</td>
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<td>12. B:1201.172323325</td>
<td>0.29085E+03, -0.35888E+00</td>
<td>0.35811E+03, -0.22130E+00</td>
<td>0.25138E+00</td>
<td>0.25892E+00</td>
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<td>13. B:1201.190230817</td>
<td>0.27356E+03, -0.36736E+00</td>
<td>0.35993E+03, -0.24948E+00</td>
<td>0.24626E+00</td>
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<tr>
<td>14. B:1201.204121740</td>
<td>0.27247E+03, -0.37149E+00</td>
<td>0.35994E+03, -0.18326E+00</td>
<td>0.24644E+00</td>
<td>0.25712E+00</td>
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<td>15. B:1201.220412478</td>
<td>0.26244E+03, -0.36946E+00</td>
<td>0.35972E+03, -0.23070E+00</td>
<td>0.23301E+00</td>
<td>0.25046E+00</td>
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<tr>
<td>16. B:1201.222012748</td>
<td>0.71926E-00, -0.23036E+00</td>
<td>0.35960E+03, -0.25086E+00</td>
<td>0.24137E+00</td>
<td>0.25768E+00</td>
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<tr>
<td>17. B:1201.235903756</td>
<td>0.59057E+00, -0.29686E+00</td>
<td>0.35954E+03, -0.27183E+00</td>
<td>0.25543E+00</td>
<td>0.26407E+00</td>
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<tr>
<td>18. B:1202.013784704</td>
<td>0.46865E+00, -0.26533E+00</td>
<td>0.34245E+03, -0.23507E+00</td>
<td>0.24821E+00</td>
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<tr>
<td>19. B:1202.031160660</td>
<td>0.28016E+03, -0.37643E+00</td>
<td>0.81177E+02, -0.10627E+00</td>
<td>0.70269E+00</td>
<td>0.70269E+00</td>
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</table>
FIGURE C-9. Sensor One Roll Residuals for Consecutive Orbits
### TABLE C-9. Data Statistics by Orbit

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<thead>
<tr>
<th>ORBIT TIME START/END</th>
<th>X,Y,REC AT MIN X/Y</th>
<th>X,Y,REC AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 82121.122557064</td>
<td>0.11095E+03, -0.27595E+00</td>
<td>0.35932E+03, -0.26769E+00</td>
<td>0.299040+00</td>
<td>0.299690+00</td>
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<tr>
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<td>0.31669E+00, -0.24771E+00</td>
<td>0.82949E+02, -0.16912E+00</td>
<td>0.295550+00</td>
<td>0.230690+00</td>
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<tr>
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<td>0.34033E+00, -0.28746E+00</td>
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<td>0.276690+00</td>
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<td>0.30165E+00, -0.23655E+00</td>
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<td>0.280260+00</td>
<td>0.283940+00</td>
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<td>0.27156E+00, -0.25506E+00</td>
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<td>0.35904E+03, -0.23431E+00</td>
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<td>0.282520+00</td>
<td>0.285630+00</td>
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<td>0.81090E+00, -0.25056E+00</td>
<td>0.39851E+03, -0.23036E+00</td>
<td>0.283360+00</td>
<td>0.286120+00</td>
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FIGURE C-10. Sensor One Roll Residuals for Consecutive Orbits
### Table C-10. Data Statistics by Orbit

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<tr>
<th>ORBIT</th>
<th>TIME START/END</th>
<th>(X,Y,REC) AT MIN</th>
<th>(X,Y,REC) AT MAX</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
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<tbody>
<tr>
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<td>0.7393E-02, -0.17332E-00</td>
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<td>2309</td>
<td>0.26743E-00</td>
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FIGURE C-11. Sensor One Roll Residuals for Consecutive Orbits
FIGURE C-12. Sensor One Roll Residuals for Consecutive Orbits
<table>
<thead>
<tr>
<th>ORBIT TIME START/END</th>
<th>X,Y.REC AT MIN X/Y</th>
<th>X,Y.REC AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
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<tr>
<td>1 830202.032395071</td>
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FIGURE C-13. Sensor One Roll Residuals for Consecutive Orbits
### TABLE C-13: Data Statistics by Orbit

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<th>Time Start</th>
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<th>Final Time</th>
<th>Duration</th>
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NOTE: The table continues with similar entries for orbits 3 to 15.
FIGURE C-14. Sensor One Roll Residuals for Consecutive Orbits
FIGURE C-15. Sensor One Roll Residuals for Consecutive Orbits

ORBIT PHASE

SENSOR 1 ROLL RESIDUAL VERSUS ORBIT PHASE
HORIZONTAL BARS MARK -0.25 DEGREES
THE SEPARATION BETWEEN BARS IS 0.15 DEGREES
DATA START TIME: 23550990
END TIME: 235349768

FIGURE C-15. Sensor One Roll Residuals for Consecutive Orbits
Table C-15: Data Statistics by Orbit

<table>
<thead>
<tr>
<th>ORBIT TIME START/END</th>
<th>I/F-Y</th>
<th>V. Y.</th>
<th>E. X.</th>
<th>Z. X.</th>
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C-31
FIGURE C-16. Sensor One Roll Residuals for Consecutive Orbits
<table>
<thead>
<tr>
<th>ORBIT TIME START END</th>
<th>(F.V,REC) AT MIN X/Y</th>
<th>(F.V,REC) AT MAX X/Y</th>
<th>MEAN X</th>
<th>Y-OMS/STDV</th>
<th>POINTS</th>
</tr>
</thead>
<tbody>
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<td>1 830414.0034174165</td>
<td>0.560736E-02, -0.253980E 00</td>
<td>1 0.35888E-03, -0.25617E 00</td>
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<td>2 830414.0157506469</td>
<td>0.87437E-03, -0.25212E 00</td>
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<td>0.61327E-03, -0.23653E 00</td>
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TABLE C-16. Data Statistics by Orbit
FIGURE C-17. Sensor One Roll Residuals for Consecutive Orbits
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<th>ORBIT TIME START/END</th>
<th>I.R.Y.REC1 AT MIN I/Y</th>
<th>I.R.Y.REC1 AT MAX I/Y</th>
<th>MEAN I/Y</th>
<th>V-RMS/STDEV</th>
<th>POINTS</th>
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<td>0.2322E-00</td>
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<td>0.399629E-03 -0.196596E-00</td>
<td>0.2286E-01</td>
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TABLE C-17. Data Statistics by Orbit
FIGURE C-18. Sensor One Roll Residuals for Consecutive Orbits
FIGURE C-13. Sensor One Roll Residuals for Consecutive Orbits
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C-37
FIGURE C-19. Sensor One Roll Residuals for Consecutive Orbits
### TABLE C-19. Data Statistics by Orbit

<table>
<thead>
<tr>
<th>ORBIT TIME START/END</th>
<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN V</th>
<th>V-RMS/STDV</th>
<th>POINTS</th>
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**ORIGINAL PAGE 18 OF POOR QUALITY**
FIGURE C-20. Sensor One Roll Residuals for Consecutive Orbits
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<tr>
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<th>TIME START/END</th>
<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN X</th>
<th>V-RMS/STDV</th>
<th>POINTS</th>
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FIGURE C-21. Sensor One Roll Residuals for Consecutive Orbits
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FIGURE C-22. Sensor One Roll Residuals for Consecutive Orbits
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<th>(F,Y,REC) AT MAX X/Y</th>
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TABLE C-22. Data Statistics by Orbit
FIGURE C-23. Sensor One Roll Residuals for Consecutive Orbits
### Table C-23: Data Statistics by Orbit

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**Notes:**
- The table provides statistics for various orbits, including start and end times.
- Detailed statistics are listed for each orbit.
TABLE C-24. Summary Statistics for the Period from 8/10/82 to 8/6/83

ROLLR ESA: 1

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1 Segment date refers to the start date of each segment. Each segment is approximately 24 hours in length.
APPENDIX D

This appendix contains plots and statistics for sensor 2 roll residual versus orbit phase from the ascending node for all orbits in 23 data segments. The 23 segments are presented in sequence from the earliest segment to the most recent. Figures D-1 through D-23 provide plots and Tables D-1 through D-23 provide tables of statistics computed by orbit for each segment. Tables D-1 through D-23 are organized vertically by orbit number and horizontally into the following six columns:

(1) ORBIT TIME START/END: Orbit start and end times in the format YYMMDD.HHMMSSMMM, where:
   YY... Year
   MM... Month
   DD... Day
   HH... Hours
   MM... Minutes
   SS... Seconds
   MMM... Milliseconds

(2) (X,Y,REC) AT MIN X/Y: Provides the coordinates — orbit phase (X), residual value (Y), and record number (REC) — at which the minimum values occur. The upper line gives the minimum orbit phase (X) coordinates and the lower line gives the minimum residual value (Y) coordinates for each orbit.

(3) (X,Y,REC) AT MAX X/Y: Same as (2) except maximum rather than minimum values

(4) MEAN Y: Full-orbit average of roll residual.

(5) Y-RMS/STDV: For each orbit, the upper value is the root mean square of roll residual and the lower value, the standard deviation.

(6) POINTS: The number of points contained in each orbit.

Table D-24 provides mean, peak-to-peak and standard deviation of full orbit average roll residual for each segment. Note that only orbits with at least 350 data points were used in compiling these statistics for each segment. The number of orbits used is provided.
FIGURE D-1. Sensor Two Roll Residuals for Consecutive Orbits
<table>
<thead>
<tr>
<th>ORBIT TIME START/END</th>
<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV POINTS</th>
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<td>3 820811.005228899</td>
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<td>0.35902E-03, 0.77540E-01</td>
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FIGURE D-2. Sensor Two Roll Residuals for Consecutive Orbits
TABLE D-2. Data Statistics by Orbit

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<th>(X,Y,REC) AT MAX I/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDY</th>
<th>POINTS</th>
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FIGURE D-3. Sensor Two Roll Residuals for Consecutive Orbits
FIGURE D-4. Sensor Two Roll Residuals for Consecutive Orbits
FIGURE D-5. Sensor Two Roll Residuals for Consecutive Orbits
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<th>ORBIT TIME START/END</th>
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<th>V-RMS/STDEV</th>
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FIGURE D-6. Sensor Two Roll Residuals for Consecutive Orbits
FIGURE D-7. Sensor Two Roll Residuals for Consecutive Orbits
# TABLE D-7. Data Statistics by Orbit

<table>
<thead>
<tr>
<th>ORBIT TIME START/END</th>
<th>(X,Y,REC) AT MIN F/Y</th>
<th>(X,Y,REC) AT MAX F/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
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**Notes:**
- D-15
- Original Page 13
- Poor Quality
SENSOR 2 ROLL RESIDUAL VERSUS ORBIT PHASE
HORIZONTAL BARS MARK 0.0 DEGREES
THE SEPARATION BETWEEN BARS IS 0.15 DEGREES
DATA START TIME: 021201.00286720
END TIME: 021202.031150860

FIGURE D-8. Sensor Two Roll Residuals for Consecutive Orbits
FIGURE D-9. Sensor Two Roll Residuals for Consecutive Orbits
### TABLE D-9. Data Statistics by Orbit

<table>
<thead>
<tr>
<th>ORBIT TIME START/END</th>
<th>(R, V, REC) AT MIN R/V</th>
<th>(R, V, REC) AT MAX R/V</th>
<th>MEAN V</th>
<th>y-RMS/STD DEV</th>
<th>POINTS</th>
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<td>0.72943E+00, 0.13946E-00, 0.1790</td>
<td>0.64111E-01, 361</td>
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FIGURE D-10. Sensor Two Roll Residuals for Consecutive Orbits
FIGURE D-11. Sensor Two Roll Residuals for Consecutive Orbits
TABLE D.11. Data Statistics by Orbit

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<th>Std Dev. Y</th>
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<td>0.538</td>
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<td>0.544</td>
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D-23
FIGURE D-12. Sensor Two Roll Residuals for Consecutive Orbits
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<th>ORBIT TIME START-END</th>
<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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**TABLE D-12.** Data Statistics by Orbit
FIGURE D-13. Sensor Two Roll Residuals for Consecutive Orbits
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<th>ORBIT TIME START/END</th>
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<th>T.V.REC1 AT MAX T/V</th>
<th>MEAN T</th>
<th>V-RMS/STDV POINTS</th>
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<td>0.12020E-00</td>
<td>0.35059E-03, 0.14066E-00</td>
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<td>0.12141E-00</td>
<td>0.35047E-03, 0.12206E-00</td>
<td>0.66995E-01, 0.87203E-01</td>
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<td>0.12141E-00</td>
<td>0.35047E-03, 0.12206E-00</td>
<td>0.66995E-01, 0.87203E-01</td>
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<td>0.12141E-00</td>
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<td>0.12141E-00</td>
<td>0.35047E-03, 0.12206E-00</td>
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FIGURE D-14. Sensor Two Roll Residuals for Consecutive Orbits
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<th>(X,Y,REC) AT MIN X/Y</th>
<th>(X,Y,REC) AT MAX X/Y</th>
<th>MEAN X</th>
<th>Y-RMS/STDEV</th>
<th>POINTS</th>
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<td>2</td>
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<td>0.35456E-03, 0.20171E+00</td>
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<tr>
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<td>0.35941E-03, 0.14376E+00</td>
<td>459</td>
<td>0.45311D-01</td>
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<tr>
<td>4</td>
<td>830314.173014706</td>
<td>0.36137E+02, -0.81151E-01</td>
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<td>0.17479E+00, 0.10351E+00</td>
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<td>0.35927E-03, 0.15113E+00</td>
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<td>0.35914E-03, 0.13247E+00</td>
<td>1172</td>
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<td>1068</td>
<td>0.18347E+00, 0.17354E+00</td>
<td>995</td>
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<td>0.35952E-03, 0.16322E+00</td>
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<td>11</td>
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<td>12</td>
<td>830314.064419154</td>
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<td>0.35922E-03, 0.17435E+00</td>
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<td>0.67936D-01</td>
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<td>14</td>
<td>830314.095917954</td>
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<td>0.35956E-03, 0.14396E+00</td>
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FIGURE D-15. Sensor Two Roll Residuals for Consecutive Orbits
<table>
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<tr>
<th>ORBIT TIME START/END</th>
<th>F.Y.REC AT MIN I/Y</th>
<th>F.Y.REC AT MAX I/Y</th>
<th>MEAN V</th>
<th>V-RMS/STDEV</th>
<th>POINTS</th>
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<td>0.35987E-03, 0.13589E-00</td>
<td>0.44435D-01</td>
<td>0.81189D-01</td>
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<td>0.35987E-03, 0.13589E-00</td>
<td>0.44435D-01</td>
<td>0.81189D-01</td>
<td>363</td>
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<td>0.16539E-03, 0.18402E-00</td>
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FIGURE D-16. Sensor Two Roll Residuals for Consecutive Orbits
FIGURE D-17. Sensor Two Roll Residuals for Consecutive Orbits
### TABLE D-17. Data Statistics by Orbit

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<thead>
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<th>ORBIT TIME START/END</th>
<th>(F.Y.REC) AT MIN X/Y</th>
<th>(F.Y.REC) AT MAX X/Y</th>
<th>MEAN Y</th>
<th>Y-RMS/STDV</th>
<th>POINTS</th>
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FIGURE D-18. Sensor Two Roll Residuals for Consecutive Orbits
FIGURE D-19. Sensor Two Roll Residuals for Consecutive Orbits
FIGURE D-20. Sensor Two Roll Residuals for Consecutive Orbits
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FIGURE D-21. Sensor Two Roll Residuals for Consecutive Orbits
FIGURE D-22. Sensor Two Roll Residuals for Consecutive Orbits
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FIGURE D-23. Sensor Two Roll Residuals for Consecutive Orbits
TABLE D-24. Summary Statistics for the Period from 8/10/82 to 8/6/83

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1 Segment date refers to the start date of each segment. Each segment is approximately 24 hours in length.
REFERENCES

