#### SAO ISAGEX EXPERIENCE. I. DATA ACQUISITION

Edited by E. M. Gaposchkin

(NASA-CR-128396)ISAGEX (INTERNATIONALN73-10825SATELLITE GEODESY EXPERIMENT)EXPERIENCE.1:DATA ACQUISITION E.M. Gaposchkin(Smithsonian Astrophysical Observatory)UnclasMay 1972150 pCSCL 22C G3/3015689



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Smithsonian Institution Astrophysical Observatory Cambridge, Massachusetts 02138

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The work reported in these papers has been supported in part by grant NGR 09-015-002 from the National Aeronautics and Space Administration.

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#### ABSTRACT

The International Satellite Geodesy Experiment (ISAGEX) has completed the data acquisition phase. This report describes the contributions and methods of the Smithsonian Astrophysical Observatory to the program. The report will provide users of the data with necessary supporting information. A sequel will be prepared when the analysis of the ISAGEX is completed.

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#### INTRODUCTION

#### E. M. Gaposchkin

The ISAGEX program is the third in a series of cooperative satellite-tracking campaigns. The first in 1967 and the second in 1968, organized by SAO, were primarily camera tracking programs. There were, respectively, four and five laser tracking instruments operating during those intervals. Where possible, the tracking schedules were established to accommodate these systems. In 1967, there were five satellites and in 1968, there were six satellites suitably equipped with corner reflectors. However, three of them were in almost identical orbital configurations, so for some purposes the number was, in reality, three and four.

ISAGEX was initiated in 1969 by the French CNES with its "Proposition for an International Laser and Photographic Observation Campaign on Satellites Equipped with Laser Reflectors." ISAGEX took on added importance with the increased number of laser systems (10) and of precision satellite-tracking cameras (30) and the launch of a seventh retroreflector satellite (Peole), by France.

There are many purposes of a tracking campaign, and the archives of data will be useful for applications not envisaged at the inception of the program. The cooperating groups proposed the following three broad objectives, which gave shape to the program:

A. To organize a well-coordinated tracking campaign of the seven satellites equipped with laser retroreflectors in such a way that its contribution to our knowledge of the gravity field of the earth and other geodetic parameters will be significant.

B. To collect the set of observations made by the different participating agencies and to make those data available to the scientific community with all information necessary for use in computations.

C. To further research and development of instrumentation and operations of high-precision tracking systems for future space experiments.

ISAGEX is primarily a program of coordinated observations and data exchange. The data are to be distributed to all participants as per the operations plan, and subsequent analysis is largely at the option of the individual agencies. The analysis objectives of the participants and others are given in the International Satellite Geodesy Experiment Plan, published by CNES on November 10, 1970.

The planning and execution of the program has been documented in several CNES reports. The program ran from January through August 1971 and, broadly speaking, all the objectives were met. The data reduction has been completed for the laser data, which have been forwarded to the CNES data bank. The reduction of photographic observations is now under way. Therefore, the first objective and part of the second have been achieved.

The purpose of this report is to describe SAO's experience and methods. Included are the information necessary to use the laser data and descriptions of the observing system, the calibration methods, the reduction methods, and the process of data validation. In addition, there is a discussion of the various aspects of data acquisition. We hope that with such a document, improvement of the data systems will be furthered. We have concentrated on the technological and operations aspects of ISAGEX and on laser tracking in general. Within the next year, a sequel will be prepared, on the scientific results to come from the ISAGEX data. Some results already in hand are reported here and elsewhere (Gaposchkin, Kozai, Veis, and Weiffenbach, 1971).

There were substantial objectives for camera observations during the campaign. Since the SAO Baker-Nunn data have already been discussed in considerable detail, this report is restricted to the SAO laser systems.

In addition to the above objectives, ISAGEX was a test bed. We have seen how successfully a multinational observing program can be carried out. This success, in the absence of any more than informal agreements, is due to the good faith and mutual interest of all parties concerned. This sort of cooperation is enormously

important for the future. With scientific objectives becoming ever more ambitious, the requirements for tracking data become more demanding. It is apparent that several groups pooling resources can achieve much more than can individuals alone. The future programs of all groups will be materially advanced by such cooperation, and it can even be argued that some programs are not feasible without it.

SAO agreed to participate with laser units that were in the process of construction. The fielding of these units and their subsequent operation taxed the resourcefulness of the whole organization. Indeed, it had to be considered an experiment to see whether such a program of fabrication, field installation, and immediate data acquisition in amounts and with a necessary precision could even be accomplished. The statistics attest to the increased volume of data as the program progressed.

ISAGEX was used as a period for improvement of the accuracy and reliability of the laser network under routine field operation. We faced the difficulties of repairing malfunctions and detecting operating problems while the observing program was continuing. This was a completely different situation from operating one or two systems, under essentially laboratory conditions, with all SAO technical personnel available at a domestic site. We had a mixed record as a result. Some problems slipped through the system until the validation process. Needless to say, the system has since been modified. In addition, studies were begun to improve the system's accuracy. Photographing the oscilloscope waveform for centroid detection was attempted on a routine basis. Analysis of these data is in progress, and preliminary results are reported here. This experiment will lead to improved signal detection and analysis in future operation.

ISAGEX was intended to provide a framework for individual agencies developing laser tracking to take data in an organized program. They could have routine predictions and an immediate evaluation of their data. This situation is very helpful for new systems. In the final accounting, only a few such new systems participated. However, they did have the benefits described, although on the whole, the data taken were too few to be geodetically significant. These systems have been in operation, and we hope they will be able to participate in a more substantial way during future programs such as EPSOC, currently being conducted by SAO.

The ISAGEX program has ushered in a new era of cooperative tracking programs. We have every indication that the laser data taken are of 1-m accuracy with 60-cm noise. We have good confirmation of the 10-m accuracy of our current geodetic tools, as well as the very real opportunity to obtain 1-m geodesy using these and other data.

Everyone at SAO and many individuals at CNES, NASA, and other organizations contributed in a substantial way. It is impossible to acknowledge them all. The contributors of this report join me in expressing our gratitude to these people. The program has achieved what it has only through such cooperation.

#### REFERENCE

GAPOSCHKIN, E. M., KOZAI, Y., VEIS, G., and WEIFFENBACH, G.

1971. Geodetic studies at the Smithsonian Astrophysical Observatory. Presented at the XVth IUGG General Assembly, Moscow, August.

#### SAO NETWORK DESCRIPTION

#### J. M. Thorp and M. A. Bush

Fifteen years ago, SAO conceived the idea of a worldwide network of photographic observing stations to track the artificial satellites proposed for the International Geophysical Year (IGY). Since the United States planned to launch its IGY satellites from Cape Kennedy into orbits with low inclinations, the original locations of the astrophysical observing stations were selected to obtain the best practical coverage of such orbits. Later, the low-latitude network configuration was modified to recognize the existence and importance of high-inclination satellites, which allow analysis of atmospheric and geodetic conditions at high latitude.

The ISAGEX network configuration is depicted in Figure 1, showing the locations of 11 astrophysical observing stations and the station in Dakar, Senegal, which was operated in cooperation with CNES. Each site is equipped with a Baker-Nunn tracking camera and a highly precise timing system. In addition, five stations have been augmented with laser ranging systems. Table 1 lists the COSPAR number and the location of the sites used in the ISAGEX program.

Figure 2 shows the Baker-Nunn camera at San Fernando, Spain, and Figure 3, the new SAO laser ranging system at Natal, Brazil.

The Baker-Nunn camera is a modified Super-Schmidt f/1, of 500-mm focal length (20 inches) and 500-mm aperture. A pyrex spherical mirror 760 mm (30 inches) in diameter and three corrector elements, two positive and one negative, constitute the optics, designed by J. G. Baker. The focal surface is approximately spherical, and the film is stretched under tension on a specially designed pyrex spherical surface. The field is 30° along the tracking axis and 5° along the perpendicular one. When the satellite position is fairly well known, the field along the tracking axis can be reduced to 15°, resulting in a considerable savings in film usage.



Figure 1. Configuration of the Baker-Nunn ISAGEX network.

X SAO AND COOPERATING AGENCY LASER INSTALLATIONS

FRENCH LASER

COOPERATING AGENCIES



Figure 2. The Baker-Nunn camera at San Fernando, Spain.



Figure 3. The new SAO laser ranging system at Natal, Brazil.

Station		
Location	COSPAR number	Equipment
San Fernando, Spain	9004	Baker-Nunn
Naini Tal, India	9006	Baker-Nunn
Maui, Hawaii	9012	Baker-Nunn
Mt. Hopkins, Arizona	9021	Baker-Nunn
Mt. Hopkins, Arizona	7921	Laser
Olifantsfontein, South Africa	9022	Baker-Nunn
Olifantsfontein, South Africa	7902	Laser
Island Lagoon, Australia	9023	Baker-Nunn
Dodaira, Japan	9025	Baker-Nunn
Arequipa, Peru	9027	Baker-Nunn
Arequipa, Peru	7907	Laser
Debre Zeit, Ethiopia	9028	Baker-Nunn
Dionysos, Greece	9030	Baker-Nunn
Dionysos, Greece	79 <b>30</b>	Laser
Natal, Brazil	9039	Baker-Nunn
Natal, Brazil	7929	Laser
Dakar, Senegal	9020	Baker-Nunn
Dakar, Senegal	7820	Laser

Table 1. Sites used in the ISAGEX program.

The standard film is Kodak Royal-X pan-recording 2475 (extended red) emulsion on a 4-mm estar base. The scale on the film is 2.46  $\mu$  arcsec<sup>-1</sup>, and 80% of the light is placed on a 20- $\mu$ -diameter disk. The camera can photograph stars of 14th mag with a 20-sec exposure. A barrell-type shutter, rotating in front of the focal surface

at a precise angular velocity, chops the trails of the stars (or of the satellites, if the camera is stationary) and provides the breaks that are used as references for the reduction of the film. The shutter (or chopper) rotates five times, making five breaks per exposure. When the shutter is in the middle of the central break, an electrical contact strobes a flashing tube that records the time from a slave clock in the camera. Time is thus recorded on the same film on which the satellite and stars appear. With the use of a phase shifter, the shutter can be synchronized to time signals so as to produce the middle of the central break at a predetermined time. This method can be used to perform simultaneous observations from several stations whose shutters are in full synchronization.

The Baker-Nunn can be operated in two basic modes, stationary and tracking. In the first, more simple mode, the camera is held stationary while the images of the satellite trail along the film. In the tracking mode, the body of the camera is driven at the same rate as the apparent angular velocity of the satellite, holding the image of the satellite to a point of light on the film.

The precision timing system is composed of an EECo clock that utilizes a 5-MHz Sulzer crystal oscillator as its frequency standard, a high-frequency receiver to monitor the WWV signal, and a VLF receiver. The VLF receiver monitors the very accurate frequency tones transmitted by various VLF stations around the world. The frequency of the crystal oscillator is continuously compared with these frequency tones, and the difference is displayed on both a chart recorder and an accumulated time-deviation counter. The oscillator can therefore be adjusted periodically by means of a tuning capacitor. As a further aid to more accurate timekeeping, a portable clock is carried from station to station to measure the relative settings of the clocks. Timing to within 100  $\mu$ sec is routinely achieved at all camera stations. At the laser sites, timing is maintained to within 50  $\mu$ sec, an accuracy necessary for laser ranging.

Since 1966, SAO has been improving the accuracy of its tracking technique by installing laser tracking systems at several of its camera locations. The Baker-Nunn provides very accurate directional data, and the laser provides the added dimension of range or the accurate determination of a satellite's height above the earth. The

increased accuracy of the Smithsonian tracking program as a result of the addition of lasers has innumerable research benefits.

SAO currently operates five laser tracking systems collocated with Baker-Nunn cameras at tracking stations in Mt. Hopkins, Arizona; Natal, Brazil; Arequipa, Peru; Olifantsfontein, South Africa; and Athens, Greece. With the exception of the last, which was assembled and operated in cooperation with the NTU of Athens, all systems were designed and built to SAO specifications and represent near state-of-the-art ruby-laser technology.

The following characteristics apply to the four systems operated by SAO: The type is ruby Q-switched; the peak power is 400 Mw; the pulse width is 18 nsec; the energy output is 7 J; the maximum pulse repetition rate is 4 pulses  $\min^{-1}$ ; the beam divergence can be varied from 0.5 to 6 mrad (or from 2 to 20 arcmin); the pointing is automatic-static, which permits day and night ranging and does not require that the satellite be sunlit; and the range resolution of the counter is 1 nsec. The laser transmitter utilizes two ruby rods, one for the oscillator and one from the amplifier stage. The rods are stimulated by the discharge of xenon high-voltage lamps. At lasing, some of the output energy is sampled by a photodetector that triggers the range measuring counter. The pulse, after traveling in space from the transmitter to the satellite, is reflected back from the retroreflectors mounted on the spacecraft and is focused by a 20-inch Cassegrain telescope onto a photomultiplier tube. The signal generated by the photomultiplier stops the counter, which then displays the elapsed time.

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One of the problems encountered in laser ranging is the variation in signal strength of the pulse reflected from the satellite. This variation is due in part to the fact that the signal varies inversely as the fourth power of the satellite range and in part to an observed "scintillation," or random effect. The variations in signal strength affect the range measurements. As we said, satellite range is obtained from a time-interval counter that is started by the transmitted pulse and stopped by the receiving pulse. The resolution of the counter is 1 nsec, but the duration of the pulse is 18 nsec. Hence, the counter reading changes significantly if it stops at different points on the pulse's leading edge. The counter stops when it reaches a threshold

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that has been set near the half-amplitude point of a weak return pulse. Since the system is calibrated for such a pulse and setting, errors are introduced when the return pulse varies from its average value. These errors, however, can be corrected if a photograph of each return pulse displayed on an oscilloscope is obtained. An automatic recording system capable of doing this for every pulse has been devised and is currently being field-tested. This correction can reduce the error in range measurements to 1 ft or less.

## DESCRIPTION OF THE SAO LASER SYSTEM CURRENTLY DEPLOYED IN BRAZIL, PERU, AND SOUTH AFRICA

#### P. W. Sozanski

The main components of SAO's laser system are the laser transmitter, the staticpointing pedestal, the telescope photoreceiver, the data system, and the epoch timing system (see Figure 1).



Figure 1. Laser ranging system.

To describe the operation of the laser system in simple terms, the laser transmitter head and the telescope photoreceiver are pointed by the static-pointing pedestal (see Figure 2) to the altitude and azimuth coordinates in accordance with predictions generated in Cambridge. The laser is then pulsed, under electronic or manual control, at the appropriate epoch, and a very short pulse of monochromatic light in a narrow beam is projected from the laser transmitter head toward the satellite. The transmitted pulse is detected at the transmitter by a photodiode whose output is an electrical pulse that starts the range interval counter and reads out the station clock to mark epoch. The light is reflected back from the satellite by its cube-corner reflectors and is detected photoelectrically by the telescope photoreceiver whose output is an electrical pulse that stops the range interval counter. The range from the laser system to the satellite is then calculated from the elapsed time, with due corrections for atmospheric and other effects.

Procurement started in early 1969, and the systems were fielded in late 1970.

A detailed description of the SAO laser system components follows:

#### 1. LASER TRANSMITTER

The laser transmitter was purchased in March 1969 from:

Spacerays, Inc. Northwest Industrial Park Burlington, Massachusetts 01803 (617)272-6220

The system is a flash-pumped, Q-switched ruby system with an oscillator and one amplifier stage. The output is a 4- to 5-J pulse 18 nsec wide. The beam is collimated with a Galilean telescope with an aperture of 12.7-cm diameter, the beam divergence is variable from 0.3 to 6.0 mrad (measured at full width, half-power points), the repetition rate is 4 ppm, and the wavelength of the output is 694 nm.

The laser transmitter system consists of three major units: the laser transmitter head, the power supply and control electronic units, and the cooling unit.



Figure 2. Laser transmitter head (right) and telescope photoreceiver (left) mounted on static-pointing pedestal.

#### 2. PEDESTAL

The pedestal was purchased in May 1969 from:

Tinsley Laboratories, Inc. 2448 Sixth Street Berkeley, California 94710 (415)843-6836

This pedestal is a static-pointing, open-loop unit of an altitude-over-azimuth biaxial configuration. Its overall accuracy is within 0.008 (great circle error of 0.5 arcmin or less).

The pedestal is a static-pointing unit, i.e., it moves to a given pointing direction, waits for the satellite to pass through that direction, and then moves on to the next such static point.

The unit is of the open-loop type, i.e., it does not operate as a servomechanism and does not require a feedback error signal. It relies instead on starting at a known pointing direction of two orthogonal axes and on simple addition and subtraction of known increments of motion about those axes to arrive at a new predetermined pointing direction. The known increments of motion are provided by reliable, precision, incremental-stepping motors fed by precomputed number-of-steps input data. The initial starting position is established by optical goniometers, and the continuous addition and subtraction is maintained by solid-state arithmetic units, counting registers, comparison logic circuitry, and visual displays.

The pedestal is positioned by manual decade-switch selection or by using a prepunched paper-tape input.

#### 3. TELESCOPE PHOTORECEIVER

The telescope photoreceiver was purchased in May 1969 from several vendors (see below). It contains three subsystems (see Figure 3). The first, the main subsystem, contains two components, a 53-cm-diameter f/4 paraboloidal primary and a 14.6-cm-diameter flat secondary. The primary has at least a 50-cm-diameter clear aperture and when combined with the secondary produces a field greater than 20 arcmin in diameter, an overall accuracy of better than 1/4 wave; after aluminizing and SiO overcoating, the primary has a minimum combined reflectance greater than 60% between 400 and 700 nm.





The second subsystem, the photomultiplier tube (PMT) optical subsystem, transfers the beam reflected by the main optical system through its components and onto the face of the PMT. The beam passes through a holder for a stack of gelatin filters, then through a field lens that directs the beam through the field stop wheel containing six apertures. These apertures are sized to produce fields of 2, 4, 8, 12, 16, and 20 arcmin in diameter. The diverging beam passes next through a collimating lens and then through a tiltable interference filter, a final imaging lens, and onto the face of the PMT. This system is designed to produce a 3.8-cm-diameter spot on the face of the PMT independent of field stop settings.

The third subsystem, the auxiliary viewing subsystem, consists of 1/4-wave flat flip mirror that, when inserted into the beam, directs the beam through the exit lenses onto a front surface diagonal mirror that reflects the beam through an illuminated reticle and out to the eyepiece for visual viewing.

A detailed breakdown of the photoreceiver is as follows:

<u>Telescope</u>. A 50-cm telescope is used to detect the laser return and was bought from:

Tinsley Laboratories, Inc. 2448 Sixth Street Berkeley, California 94710 (415)843-6836

<u>Photomultiplier Tube</u>. A RCA Model 7265, selected for a quantum efficiency of 4.5% or greater at 694 nm and a gain of  $2 \times 10^7$  or greater at 2400 v, is used to trigger the counter. It was purchased from:

Radio Corporation of America Industrial Tube Division New Holland Pike Lancaster, Pennsylvania 17604 (717)397-7661 <u>Photomultiplier Tube Housing</u>. A Products for Research Model PR 2100 (modified) housing, used to hold the PMT, was purchased from:

Products for Research 78 Holten Street Danvers, Massachusetts 01923 (617)774-3250

Interference Filters. A 20 Å interference filter and a 7 Å interference filter were purchased from:

Thin Films Products Division Infra-Red Industries 80 4th Avenue Waltham, Massachusetts 02154 (617)894-8410

#### 4. DATA SYSTEM

The data system was purchased during the interval from March 1969 through September 1970 from several vendors (see below). The system (Figure 4) consists of the measurement instrumentation as well as the digital-control and data-handling systems for the laser transmitter. The four functional subsystems are described below.

<u>Counter</u>. An Eldorado ElectroData Model 796 (modified) counter with a 1-nsec resolution is used to obtain the satellite range times. This unit was purchased from:

Eldorado ElectroData Corporation 601 Chalomar Road Concord, California 94520 (415)686-4200

Oscilloscope. A Tektronix Type R454 oscilloscope with modification 163D and a Tektronix Model C-40 oscilloscope camera are used to provide a means for visual monitoring and photographic recording of the laser transmitter output and the laser return pulses. The oscilloscope and camera were purchased from:

Tektronix, Inc. P. O. Box 500 Beaverton, Oregon 97005 (503)644-0161



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<u>Control System</u>. In addition to providing the basic time-interval measurement for satellite ranging, the laser data system must also record the observation epoch time (system clock); program the operating sequence of the laser transmitter unit, the pedestal, and the data system itself (tape reader, tape control, and laser control); condition the stop channel and the return pulse (range-gate generator and amplifier detector/monitor); and print out the digital data (intercoupler, digital printer, and tape perforator). All the control-system components with the exception of the digital printer and tape perforator were built by SAO. The digital printer and tape perforator (Model ASR-32, modified by SAO) were purchased from:

> The Teletype Corporation 5555 Touhy Avenue Skokie, Illinois 60076 (312)982-2000

<u>Racks</u>, <u>Power</u>, and <u>Cabling</u>. A Western Devices rack and blower unit, used to hold most of the data system, was purchased from:

Zero Manufacturing Company 1121 Chestnut Street Burbank, California 91503 (213)849-5521

A Bud Radio Company Model 2707 Series 60 rack is used to hold the tape-reader system and was purchased from:

Gerber Electronics 852 Providence Highway Dedham, Massachusetts 02026 (617)329-2400

A General Radio Model 1581-ALR2 voltage regulator is used to supply regulated AC power to the data system. It was purchased from:

General Radio Company 300 Baker Avenue West Concord, Massachusetts 01781 (617)369-4400 A Northeast Scientific regulated high-voltage power supply Model RQE-3001-21230 provides high voltage to the photomultiplier tube. It was purchased from:

Northeast Scientific Corporation 30 Wetherbee Street Acton, Massachusetts 01720 (617)263-7706

#### 5. EPOCH TIMING SYSTEM

The epoch timing systems, a Model ZA 34675 single-channel unit and a Model ZA 34685 dual-channel unit, were purchased in March 1965 from:

Electronic Engineering Company of California 1601 East Chestnut Avenue Santa Ana, California 92700 (714) 547-5651

The EECo timing system (see Figure 5) is used to provide epoch. It has a display resolution of 10  $\mu$ sec and an electrical resolution of 1  $\mu$ sec. The single-channel unit consists of a crystal oscillator, accumulator, oscilloscope, VLF receiver, chart recorder, WWV receiver, and a battery backup system. The dual-channel unit consists of the above plus an additional crystal oscillator, accumulator, and VLF receiver.



Figure 5. Epoch timing system (EECo). Solid lines show single-channel unit, while the dual-channel unit is represented by the solid lines and the dotted lines.

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#### CALIBRATION

#### C. R. H. Tsiang

The ranging accuracy of the laser system is calibrated through a procedure of ranging on a fixed land-based target at a surveyed distance, generally on the order of 0.25 to 1 mi. A calculation can be made to obtain the expected range time based on the surveyed distance and the atmospheric refractivity. Once an average range time is obtained from a series of target measurements, it is possible to compute a calibration number  $\tau_c$ , which can be reported along with the satellite range times. This number covers delays in the range counter, cabling, telescope, output detector, photomultiplier tube, and signal amplifier. It does not provide a means for obtaining a calibration factor for atmospheric delays, but otherwise accounts for all components in the range measuring path to and from the satellite.

The following formula can be used in computing the atmospheric refractivity N:

N = 80.29 
$$\frac{P}{T}$$
 - 11.9  $\frac{e}{T}$  ,

where P is the measured barometric pressure (in millibars), e the partial pressure of water vapor, and T the temperature (K). The calculation for two-way range time has been based on

$$\tau_{\rm s} = \frac{R_{\rm s}}{0.15} (1 + N \times 10^{-6} + 6.917 \times 10^{-4}) ,$$

where  $\tau_{s}$  is the calculated range time (nsec) for a surveyed distance of  $R_{s}$  (m). After noting that local temperature and pressure variations at any one location never change N by more than  $\pm 10\%$  and that the range equation gives subnanosecond variations in  $\tau_{s}$  for such changes, we decided that fixed values of N could be determined for each station. Rather than each station calculating its mean barometric pressure, we prepared a chart, which gives a direct conversion from the station altitude above the geoid in kilometers to values of N (see Figure 1).

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Figure 1. Atmospheric refractivity as a function of station height for an ambient temperature of 15°C at 6943 Å.

The system-calibration number reported in word eight of the 33333 observation message is obtained by subtracting the observed range time  $\tau_{\rm m}$  from  $\tau_{\rm s}$ , the range time calculated from the surveyed laser-to-target range:

 $\tau_{\rm s} - \tau_{\rm m} = \tau_{\rm c}$  .

The resulting system-calibration number  $\tau_c$  is reported as a signed quantity, which is added to all range measurements in the 33333 message. Generally,  $\tau_c$  is negative in the SAO laser systems.

In theory, the calibration of the instrument should change only if its components are changed, moved, or affected by environmental fluctuations or aging. By using the whole system to range on a fixed land-based target, we hoped that all such factors could be covered by the single system-calibration number. Attempts were made to simulate real operational conditions by regulating the pulse-repetition rate, photomultipliertube voltage, counter thresholds, amplifier gain, return signal level, output power level,

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etc. Several unavoidable differences existed between the ranging measurements on the satellites and those on the target - viz., corner cubes vs. nonspecular reflecting surface of the target; small solid angle subtended by the satellite vs. full-beam reflection by the target (8-ft  $\times$  8-ft wooden surface painted flat white); point-source satellite image vs. off-axis, near-field reflection by the target; short air-path length to ground-based target vs. full atmosphere to satellite, etc. None of these differences is trivial, but for operation of the laser at the original design levels (0.5-m resolution and 1-m accuracy), the calibration procedure and results appear to be satisfactory.

For the three stations with the new lasers, the variations in the reported calibration number over the course of most of ISAGEX did not exceed 15 nsec. All the new stations did experience some problems with calibration ranging when first set up, but they were confined to the first week of operations and apparently were cleared up by the beginning of the second ISAGEX period. For the most part, the variations in the reported calibrations were due to the following:

A. Replacement or relocation of components in the laser head, photoreceiver, or data system.

B. Readjustment of signal operating levels in the target-ranging procedure.

C. Readjusted survey figures for the laser-to-target distance.

Attempts at standardizing and improving the reliability of the calibration tests were made throughout ISAGEX as more experience and knowledge of the instrumentation was gained. During investigations into the error-reducing capabilities of photographically determined range-time corrections, certain observations led to the establishment of procedures that would minimize the effects of variations in signal level during target observations. These effects – the most detrimental ones for satellite ranging – were reduced to a level so that the most significant systematic error component of the calibration lay in the accuracy of the ground-survey information. Therefore, where survey information was questionable, additional measurements were made in an attempt to allow no more than a 4-cm error.

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Unfortunately, this has led to the establishment of more than one survey target distance at two of the South American stations. Table 1 shows the results obtained by local surveyors using conventional techniques. Note that certain sites have been measured to greater resolution than others. Only where special comments are included should this be considered significant. Ultimately, corrections will be applied to all ISAGEX calibration data when the stations are resurveyed with a laser geodimeter.

Apart from the systematic error contributed by the differences in survey results, the net range-time uncertainty introduced by the calibration should generally be better than  $\pm 2$  nsec. Photographic reduction of pulse images offers the possibility of decreasing the error to less than  $\pm 1$  nsec for many of the periods after May 1971. Reduction of these photographic data and distribution of the results will be made in 1972.

Station				
Location	COSPAR number	Date (1971)	Survey distance (m)	Refractivity constant N
Arequipa, Peru	7907	January 5	313.135	250
		October 1	312.844	250
Mt. Hopkins, Arizona	7921	January 5	776.329	172
Olifantsfontein, South Africa	7902	February 12	404.48	290
Natal, Brazil	7929	January 5	316.08	248
· · ·		April 28	316.08	340
		April 29	314.67	340
		September 23	315.62	340
Dionysos, Greece	7930	January 5	327.25	0
		April 9	$327.973^{*}$	0
		April 28	327.973	340

Table 1.	ISAGEX target range history:	Effective dates	of change	to new	values of
	survey distance and refractivi	ty constant N.			

Measurement made by laser geodimeter.

#### TIMING (EPOCH)

#### D. A. Arnold and J. M. Thorp

Epoch time is maintained at each station by use of the EECo precision time system (see Thorp and Bush, this volume) and by reference to UTC(USNO). A portable clock is used to set the station clock, which is then maintained by referencing the frequency of a 5-MHz Sulzer oscillator to a known frequency, broadcast by one of the various VLF stations. Each observing station maintains an estimate of its timing uncertainty in two ways: First, the accuracy of the original clock set from a portable clock is expressed as an uncertainty (usually  $\pm 5 \mu$ sec). Time is maintained at each station on one main channel, with one or more alternate channels keeping time independently for backup. If the main channel has to be reset to one of the backup channels, an additional uncertainty is added (usually  $\pm 5 \mu$ sec). The second uncertainty is the deviation of the oscillator caused by its drift in frequency. The oscillator drift is determined by comparing the phase of the VLF station with that of the oscillator at a particular time each day. Each station steers or guides its oscillator to keep its time-drift uncertainity as small as possible (usually  $\pm 50 \mu$ sec).

In addition to the above uncertainties, two sets of time corrections are added in order to have time equivalent to UTC(USNO). One set consists of corrections of hours, minutes, seconds, or parts of seconds when a failure has occurred in the main timekeeping channel. These corrections are confirmed by referring to the alternate timekeeping channel and the WWV time signals. If all channels fail, time reference is lost and a reset is necessary. The second set of corrections is added in Cambridge; this consists of the computed phase differences between the average VLF phase for a period (usually a month) and the phase of the VLF at the time the clock is set. These corrections, determined from data published in USNO time-service bulletins, are generally on the order of < 20  $\mu$ sec.

Two files of time corrections are maintained by the Data Services Division at SAO. The first gives the difference between A.S and UT1, and the second, the difference between A.S and the clocks at the observing stations. The time system A.S is related to UTC(USNO) by the expression

A. S - UTC(USNO) = 
$$6.140768 + 0.002592000(T - 39856.0)$$

for the period February 1, 1968, to January 1, 1972; T is the time in Modified Julian Days; 39856.0 is January 1.0, 1968; and the difference is given in seconds. The A.S - A.1 difference is about 0.8983 msec.

UT1 data are obtained from "Circular D," published monthly by the BIH. Values of UT1 - UTC(BIH) and AT - UTC(BIH) are listed at 5-day intervals. The difference A.S - AT is currently 35.3 msec. A.S - UT1 is calculated by the relation

$$A.S - UT1 = (A.S - AT) + [AT - UTC(BIH)] - [UT1 - UTC(BIH)]$$

A second-order polynomial is fitted to the A.S - UT1 values, and the coefficients are punched on cards. Usually, each polynomial covers a 50-day period. If the values change too rapidly, the interval can be reduced to 25 days.

The difference between the station clocks and UTC(USNO) is recorded by STADAD as described. The corrections are added to the A.S - UTC(USNO) difference to obtain the correction from the station clock to A.S time. Cards are punched giving these corrections as a series of straight-line segments specifying the values of the corrections at the beginning and end of each interval. A new card must be used whenever there is a gap, discontinuity, or change of slope in the time correction.

#### ATMOSPHERIC REDUCTION OF LASER DATA

#### C. G. Lehr

Laser ranges determined by using the value of the velocity of light in a vacuum must be corrected for the fact that the laser pulse travels at a lower velocity during its passage through the earth's atmosphere. The correction is currently made by means of the following formula (obtained in a personal communication from Gordon D. Thayer):

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$$r_{\rm m} = r_{\rm v} - \frac{2.238 + 0.0414 \, {\rm PT}^{-1} - 0.238 \, {\rm h}_{\rm s}}{\sin a + 10^{-3} \cot a}$$

where  $r_v$  is the uncorrected range (m),  $r_m$  is the corrected range (m), P is the atmospheric pressure (mb) at the laser station, T is the temperature (K) at the laser station,  $h_s$  is the laser's elevation above mean sea level (km), and a is the altitude angle of the satellite. The formula holds for a ruby laser, which operates at 694 nm. It should be used only when  $\theta_0 > 5^\circ$ , where  $\theta_0$  is the apparent altitude angle (i.e., the altitude angle uncorrected for atmospheric bending).

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#### PULSE ANALYSIS

#### C. R. H. Tsiang and C. G. Lehr

The effects of variations in pulse amplitude and shape must be carefully considered in attempting to reduce the noise and bias in laser range measurements. The simplest mode of operation in making time-interval measurements employs only a fixed-voltage threshold discriminator. Range times obtained this way are susceptible to errors caused by phenomena such as leading-edge walk and leading-edge pulse distortion. Attempts were made during operations to keep these effects to a minimum, and further work was done to record some of the laser passes on film. Errors on the order of  $\pm 5$  nsec can be expected when point-to-point amplitude changes affect the fixed threshold counter triggering circuit. Reduction of the photographic images of the outgoing- and return-pulse oscilloscope traces may produce range-correction figures to decrease the net range-counter errors to about  $\pm 1.7$  nsec. No work has yet been done to evaluate fully the accuracy of the photographic data collected during ISAGEX, and further study is necessary to substantiate empirically the estimated accuracy of  $\pm 1.7$  nsec. The process of photoreduction of the data and discussion of the system-accuracy potential is given in Lehr, Pearlman, and Scott (1970a). Early attempts at testing the effectiveness of this technique are presented in Lehr, Pearlman, and Scott (1970b).

Table 1 lists the satellite passes covered by photography. Most returns were obtained on Polaroid film, rather than on 35-mm film, because of the former's quick developing process. This rapid feedback was advantageous to the laser operator for adjusting the amplification level in the return-signal circuitry. Saturation of the amplifier, the limited resolution range of the oscilloscope at a fixed gain, and the minimum voltage imposed by the counter threshold were the constraints that had to be satisfied. Returns were photographed successfully at all three new laser stations in spite of early problems, such as signal adjustment and operation of the laser with new procedures and with an already heavily burdened crew of observers.

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The listing of satellite passes gives some information of the quality and quantity of the data, even though little has been done so far to reduce the images for range correction factors. The column marked "Total reported observation points" refers to the number of range measurements reported by the station for each pass, and the next column gives the number of attempted photographic images. The actual number of traces of return or noise pulses is given in the column labeled "Images." Of these frames, only a few are of sufficient quality that they could be measured reliably. Those of reduction quality should produce measurements of at least ±3-nsec consistency, and probably no worse than 1.5 nsec rms. Those images that do not qualify to be counted in the "Reduction quality" column are usually very irregularly shaped, low-level returns or extremely strong returns that go off the oscilloscope screen or are distorted by the saturation of the amplifier. In some cases, there are images of noise pulses that have falsely stopped the range counter. Even in these rejected images, there is useful information about the behavior of the return-signal circuitry under extreme amplitude conditions. Aside from the measurement of the images for range correction figures, the most important additional data come from the cataloging of return-pulse amplitudes and shapes photographed under routine laser tracking procedures. These data can be applied to studies on the scintillation of returns and to the calculation or prediction of return amplitudes. The amount of photographic data amassed during the last part of ISAGEX is insufficient in itself to have much value. Some reduction work is planned, however, so that the results can be used to evaluate the effectiveness of the photographic technique and to improve the operational procedures of the data-recording system.

#### REFERENCES

LEHR, C. G., PEARLMAN, M. R., and SCOTT, J. L.

- 1970a. A photographic technique for improved laser-ranging accuracy. In Laser and Radar Investigations, ed. by Computer Sciences Corp., NASA, Washington, vol. III, pp. 51-56.
- 1970b. Range corrections from oscilloscopic displays of laser returns. Smithsonian Astrophys. Obs. Laser Rep. No. 4, 27 pp.

			Total	N	umber of fr	ames
Date	Time (UT)	Satellite	observation points	Total	Images	Reduction quality
		B	razil			
June 17	$22^{h}53^{m}$	7010901	7	4	4	0
June 18	08 23	6800201	9	2	2	0
June 19	06 06	7010901	3	2	2	0
August 5	22 34	6508901	39	45	17	0
August 11	20 53	6508901	31	24	12	0
August 11	21 22	6508901	11	15	7	0
August 13	23 14	7010901	1	3	1	1
August 14	08 03	6508901	20	15	10	4
August 14	22 20	6508901	13	. 3	3	3
August 22	02 14	6503201	5	3	1	0
August 22	06 32	6508901	19	9	6	0
August 23	21 33	6800201	10	15	3	0
August 24	03 28	6503201	1	2	1	0
August 31	03 53	6503201	7	6	4	1
September 1	05 56	7010901	9	4	3	1
September 23	22 27	6508901	25	22	11	3
September 27	23 31	6800201	18	18	15	8
October 1	22 58	6800201	20	21	15	3
October 1	22 59	6508901	20	9	2	1
October 3	22 24	65 <b>0320</b> 1	15	9	7	0
October 4	21 11	<b>650890</b> 1	15	3	3	0
October 16	06 58	6508901	14	3	3	3
October 24	05 22	6508901	15	7	6	2

Table 1. Satellite returns.

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			Total	N	lumber of fr	ames
Date	Time (UT)	Satellite	observation points	Total	Images	Reduction quality
		]	Peru			
May 19	17 <sup>h</sup> 59 <sup>m</sup>	6508901	41	26	25	9
May 19	22 09	6800201	33	26	26	8
May 20	1 <b>7</b> 55	6508901	16	28	<b>2</b> 8	6
May 22	02 53	6508901	8	2	2	0
May 28	03 23	6508901	17	1	1	1
June 3	01 36	6508901	31	20	20	0
June 8	13 01	6508901	60	35	27	5
June 8	23 01	6800201	17	16	14	0
June 8	23 58	6508901	34	28	21	1
June 9	00 13	6701101	16	5	5	0
June 9	13 04	6508901	49	14	14	7
June 10	00 01	6508901	43	29	20	7
June 10	11 20	6800201	21	14	12	0
June 10	<b>13</b> 10	6508901	45	13	9	2
June 11	00 06	6508901	31	15	13	0
June 11	13 16	6508901	55	48	37	22
June 11	22 08	6800201	4	3	2	0
June 12	13 20	6508901	51	39	33	20
June 13	13 24	6508901	29	17	12	0
June 13	22 16	6508901	22	15	15	0
June 13	$22 \ 47$	6800201	32	20	19	0
June 15	22 22	6508901	26	12	9	0
July 6	17 35	6508901	20	18	16	7
August 17	21 21	6508901	14	6	9	0

Table 1 (Cont.)

<u> </u>			Total	Ň	umber of fr	ames
Date	Time (UT)	Satellite	observation points	Total	Images	Reduction quality
<u></u>		Sout	h Africa			
August 19	00 <sup>h</sup> 08 <sup>m</sup>	6508901	45	60	33	· 5
August 20	00 11	6508901	28	44	27	4
August 23	00 24	6508901	42	54	22	10
August 24	00 26	6508901	31	56	12	1
August 24	07 16	6800201	5	31	8	1
August 24	17 52	6800201	12	25	3	0
August 25	06 07	6800201	. 9	36	16	0
August 26	00 37	6508901	28	49	20	7
August 26	22 36	6508901	12	41	8	0
August 26	22 39	6508901	14	4	3	0
August 27	17 19	6508901	15	24	14	2
August 27	22 40	6508901	29	49	16	0
August 28	00 47	6508901	10	32	20	0
August 29	22 48	6508901	40	57	15	0
August 30	18 15	6800201	14	23	14	0
August 30	22 53	6508901	37	55	36	0
August 31	06 10	6800201	3	32	17	0
August 31	22 56	6508901	41	56	35	0
September 1	17 06	6800201	10	16	7	. 0
September 4	21 90	6508901	35	47	24	0

Table 1 (Cont.)

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#### STATISTICS: RETURNS AND FAILURES

#### B. R. Miller

The following statistics represent the SAO and Air Force Baker-Nunn optical and the SAO laser returns during the months of intensive tracking on the individual satellites.

The first 2 months' predictions were generated with a paucity of observations, which may account for the sparse number of returns. During the rest of ISAGEX, as more observations became available for use in predicting orbits, the number of returns increased also.

The numbers here reflect the data collected during ISAGEX after gross errors were removed in the orbit computations for predictions.

The data were processed for validation purposes before being used in analysis. Therefore, there is a discrepancy in these figures and the final data used in the analysis.

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Station					
Location	COSPAR number	January	March	April	Total
	Optical I	Returns			
San Fernando, Spain	9004		10	5	15
Naini Tal, India	9006		6	6	12
Maui, Hawaii	9012		5	7	12
Mt. Hopkins, Arizona	9021	6	3	13	22
Olifantsfontein, South Africa	9022	5			5
Island Lagoon, Australia	9023	13	8	5	26
Dodaira, Japan	9025	8	1	9	18
Arequipa, Peru	9027			1	1
Debre Zeit, Ethiopia	9028			2	2
Dionysos, Greece	9030		7	13	20
Natal, Brazil	9039	1		5	6
Rosamund, California	9113	5	1		6
Cold Lake, Canada	9114	2	16		18
Johnston Island	9117	1			1
Mt. John, New Zealand	<b>91</b> 19	9	21	1	31
San Vito, Italy	9120		2	<u>13</u>	<u>    15</u>
Total		50	80	80	210
	Laser Re	eturns <sup>*</sup>			
Arequipa, Peru	7907			6 (18)	6 (18)
Mt. Hopkins, Arizona	7921		1 (3)	6 (21)	7 (24)
Natal, Brazil	7929	1 (1)		3 (8)	4 (9)
Dionysos, Greece	7930		<u>3 (5)</u>		3 (5)
Total		1 (1)	4 (8)	15 (47)	20 (56)

BE-B (6406401)

\* The first number is the number of passes of the satellite; the number in parentheses is the total number of points in those passes.

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Station					
Location	COSPAR number	Februar	y March	August	Total
	Optical	Returns		· · · · · · · · · · · · · · · · · · ·	
San Fernando, Spain	9004	6	1	30	37
Naini Tal, India	9006	14	3		17
Maui, Hawaii	9012	12	2	42	56
Mt. Hopkins, Arizona	9021	8	5		13
Olifantsfontein, South Africa	9022	20	3	21	44
Island Lagoon, Australia	9023	47	6	11	64
Dodaira, Japan	9025		8	7	15
Arequipa, Peru	9027	2		8	10
Debre Zeit, Ethiopia	9028	3		1	4
Dionysos, Greece	9030	2	2	44	48
Natal, Brazil	9039	5		5	10
Rosamund, California	9113	2	3		5
Cold Lake, Canada	9114	5	3	20	28
Johnston Island	9117	10		3	13
Mt. John, New Zealand	9119	34	4	26	64
San Vito, Italy	9120		_	<u>68</u>	68
Total		170	.40	286	496
	Laser R	eturns			
Olifantsfontein, South Africa	7902	4 (6)	1 (2)		5 (8)
Arequipa, Peru	7907	2 (9)	11 (30)	25 (181)	38 (220)
Mt. Hopkins, Arizona	7921	2 (4)	2 (4)	2 (3)	6 (11)
Natal, Brazil	7929	7 (20)	2 (6)	13 (46)	22 (72)
Dionysos, Greece	7930	<u></u>	1 (3)	10 (37)	<u>11 (40)</u>
Total		15 (39)	17 (45)	50 (267)	82 (351)

BE-C (6503201)

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Geos 1 (6508901)

Station										
Location	COSPAR	January	February	March	April	May	June	July	August	Total
				<b>Optical Retu</b>	rns					
San Fernando, Spain	9004	9	45	48	5	12	33	49	ę	201
Naini Tal, India	9006	13	23	16	13	4		5		74
Maui, Hawaii	9012			6	12	17	21	27	22	108
Mt. Hopkins, Arizona	9021	19	26	28	11	9	32	15	1	138
Olifantsfontein, South Africa	9022	1	9	17	40	က	6	°	80	87
Island Lagoon, Australia	9023	80	10	15	22	9	11	14	45	131
Dodaira, Japan	9025	27	21	18	ŝ	1	39	1		110
Arequipa, Peru	9027	4		25	36	I	6	13	75	163
Debre Zeit, Ethiopia	9028	80	15	11	12		15	6	7	72
Dionysos, Greece	9030	10	19	24	7	24	14	36	R	137
Natal, Brazil	9039	4	7	œ	13		18	ę	24	77
Rosamund, California	9113	12	17	15		6				53
Cold Lake, Canada	9114	ი	27	14			17	5.		66
Johnston Island	9117	en	9				41	10	4	63
Mt. John, New Zealand	9119	39	23		30	108	28	167	162	557 '
San Vito, Italy	9120	I	33	12	1	38		63		147
. Total		158	276	260	205	229	287	420	349	2184
				Laser Retur	us					
Olifantsfontein, South Africa	7902		7 (33)	13 (220)	26 (349)	32 (390)	36 (658)	49 (1362)	46 (1152)	209 (4164)
Arequipa, Peru	7907	5 (10)	2 (12)	13 (113)	23 (187)	41 (461)	58 (1442)	12 (404)	38 (742)	192 (3371)
Mt. Hopkins, Arizona	7921	2 (3)	4 (9)	7 (63)	13 (74)	16 (53)	2 (11)			44 (213)
Natal, Brazil	7929	5 (13)	16 (68)	1 (7)	19 (79)	22 (110)	22 (108)	12 (74)	19 (231)	116 (690)
Dionysos, Greece	7930		4 (8)	3 (8)	4 (8)	6 (26)	14 (66)	4 (17)		35 (133)
Total		12 (26)	33 (130)	37 (411)	85 (697)	117 (1040)	132 (2285)	77 (1857)	, 103 (2125)	596 (8571)

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Station					
Location	COSPAR number	March	April	June	Total
	Optical	Returns			
San Fernando, Spain	9004	6	17	51	74
Naini Tal, India	9006	6	14		20
Maui, Hawaii	9012	15	18	47	80
Mt. Hopkins, Arizona	9021	8	27	35	70
Olifantsfontein, South Africa	9022	11	7	5	23
Island Lagoon, Australia	9023	20	10	5	35
Dodaira, Japan	9025		16	1	17
Arequipa, Peru	9027		3	6	9
Debre Zeit, Ethiopia	9028	3	4	2	9
Dionysos, Greece	9030	2	19	33	54
Natal, Brazil	9039	1	2	4	7
Rosamund, California	9113		10	14	24
Cold Lake, Canada	9114				
Johnston Island	9117			12	12
Mt. John, New Zealand	9119	1	7		8
San Vito, Italy	9120		32	11	43
Total		73	189	226	488
	Laser 1	Returns			
Arequipa, Peru	7907			11 (134)	11 (134)
Mt. Hopkins, Arizona	7921	1 (6)		6 (19)	7 (25)
Natal, Brazil	7929			2 (11)	2 (11)
Dionysos, Greece	7930			36 (187)	<u>36 (187)</u>
Total		1 (6)		55 (351)	56 (357)

D1C (6701101)

Station								
Location	COSPAR number	January	February	March	April	May	July	Total
			Optical R	eturns				
San Fernando, Spain	9004	7	5	6	က	28	76	128
Naini Tal, India	9006	15	80	19	c,	7		52
Maui, Hawaii	9012		80	25	4	50	55	142
Mt. Hopkins, Arizona	9021	12	8	13	ວ	12	18	68
Olifantsfontein, South Africa	9022	œ	11		14	2	ວ	40
Island Lagoon, Australia	9023	24	18	6	14	7	5	77
Dodaira, Japan	9025	4	П	9	4	2	5	22
Arequipa, Peru	9027	1			4	4	5	14
Debre Zeit, Ethiopia	9028	2	5		2	3	9	18
Dionysos, Greece	9030	1	2	7	5	21	46	82
Natal, Brazil	9039		12	1			4	17
Rosamund, California	9113	10	1	4	7	13		30
Cold Lake, Canada	9114	2					5	7
Johnston Island	9117						ß	2
Mt. John, New Zealand	9119	27	22		29	12	10	100
San Vito, Italy	9120		10	9	15	9	94	131
Total		113	111	66	104	167	339	933
			Laser I	<b>eturns</b>				
Arequipa, Peru	7907	4 (5)			2 (15)	23 (272)		29 (292)
Mt. Hopkins, Arizona	7921	1 (2)	2 (3)	4 (17)		56 (439)		63 (461)
Natal, Brazil	7929				2 (8)	5 (26)	3 (19)	10 (53)
Dionysos, Greece	7930	ļ			1 (2)	21 (57)	14 (75)	36 (134)
Total		5 (7)	2 (3)	4 (17)	5 (25)	105 (794)	17 (94)	138 (940)

D1D (6701401)

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Station								
Location	COSPAR number	March	April	May	June	July	August	Total
			Optical R	eturns				
San Fernando, Spain	9004	ę	10	5		11	32	58
Naini Tal, India	9006	1	18	l			5	22
Maui, Hawaii	9012		19	18	12	19	25	93
Mt. Hopkins, Arizona	9021	5	30	ß	1	3	1	45
Olifantsfontein, South Africa	9022	25	15	5	I	3	80	57
Island Lagoon, Australia	9023	23	23	6	7	12	17	91
Dodaira, Japan	9025	ç	16	1			e S	23
Arequipa, Peru	9027	24	21	14	3	18	60	140
Debre Zeit, Ethiopia	9028	က	16	ល	I	10	23	58
Dionysos, Greece	9030	4	22	9		4	37	73
Natal, Brazil	9039	4	8	l	3	9	35	57
Rosamund, California	9113	က	10	4	4			21
Cold Lake, Canada	9114	10	10			3	26	49
Johnston Island	9117		5		1	∞	8	19
Mt. John, New Zealand	9119	19	40	43	40	58	74	274
San Vito, Italy	9120	Ţ	15		1	1	22	39
Total		128	275	114	73	156	373	1119
			Laser Re	eturns				
Olifantsfontein, South Africa	7902	7 (51)	18 (108)	20 (181)	29 (328)	20 (257)	23 (239)	117 (1164)
Arequipa, Peru	7907	2 (8)	16 (106)	23 (243)	31 (594)	13 (233)	15 (173)	100 (1357)
Mt. Hopkins, Arizona	7921	3 (17)	10 (44)	15 (95)	1 (6)		1 (1)	30 (163)
Natal, Brazil	7929		9 (49)	10 (66)	12 (51)	6 (77)	14 (102)	54 (345)
Dionysos, Greece	7930	2 (3)	2 (2)	2 (2)		3 (7)	9 (40)	18 (54)
Total		14 (79)	55 (309)	70 (587)	73 (979)	45 (574)	62 (555)	319 (3083)

Geos 2 (6800201)

Peole (7010901)

Station										
Location	COSPAR number	January	February	March	April	May	June	July	August	Total
				Optical	Returns					
laui, Hawaii	9012		æ	80	°	7	2	6	6	46
difantsfontein, South Africa	9022			1	5		61			വ
requipa, Peru	9027			4	10	10	11	8	18	61
ebre Zeit, Ethiopia	9028	10	8	9	10	14	5	9	7	63
atal, Brazil	9039	11		4	7	12	6	9	16	65
ohnston Island	9117	-1	<u>14</u>	2	-	<b>-</b>	7		I	28
Total		22	30	25	33	44	28	36	50	268
				Laser	Returns					
requipa, Peru	7907			6 (30)	5 (14)	2 (22)	27 (208)		2 (14)	42 (288)
atal, Brazil	7929	<u>1 (1)</u>				8 (21)	37 (192)	2 (20)	15 (58)	63 (292)
Total		1 (1)		6 (30)	5 (14)	10 (43)	64 (400)	2 (20)	17 (72)	105 (580)

#### EVALUATION OF LASER OPERATIONS

#### J. Thorp

We selected a 3-month period during ISAGEX for collecting laser data in order to evaluate the potential of the SAO laser system. We chose June, July, and August for its good weather and the South Africa station since it was ranging to only the Geos 1 and Geos 2 satellites. The evaluation, therefore, did not have to consider the questionable orbits or the bad aspect angles of the magnetically stabilized satellites.

Statistics were generated by using laser passage information compiled at each station. We considered both individual points (Figure 1) and total arcs (Figure 2). Two to 65 points were predicted per arc during this period, with an average of 35 points per arc. Arcs started and ended at 20° above the horizon.

For simplicity in preparing the graphs, each attempted point was considered an attempted arc and each successful point was considered a successful arc. This, however, did create some apparent discrepancies between the two graphs. The category "not attempted (N.A.) other," which includes pass conflicts, observer errors, and attempts not made owing to safety, shows a decided decrease when points are compared to arcs. The main reason for this is that points at the beginning and end of many passes were not attempted because of the hazards of operating below 30°.

Another discrepancy is apparent when successful points are compared to successful arcs. However, as the following statistics show, 44 to 64% of the arcs have less than 16 successful points:

<u> </u>		Perc	entage o	f arcs		
		Num	ber of p	oints	Total	Total
	1-3	4-6	7-15	16 or more	(points/arcs)	(points/arcs)
June	16%	20%	28%	36%	4834/141	1013/67
July	8%	10%	16%	66%	4001/114	1588/69
August	5%	11%	34%	50%	5572/152	1391/69





### Figure 1. Percentage of total predicted points from South Africa.



The percentage of successful points per pass seems to be related to weather (July had the best weather). During August, a period was reported as not attempted owing to a malfunction, but, in fact, the maintenance was scheduled for and performed during cloudy weather. From the statistics, we can expect that, in general, with the laser system operating properly, about 30% of the predicted points will be successful. When dealing with arcs, we see a higher percentage of overall success, in that about half the predicted arcs are successful. If we discount weather completely, the success ratio is higher, around 70%. The cases studied are ideal, and we feel that this is the best the system can do under present circumstances. When bad weather occurs and when satellites with less stable orbits are added, the success ratio drops substantially.

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#### PREDICTION PROBLEMS

#### J. Latimer

Generating accurate predictions is crucial to the successful use of static-pointing laser systems. The prediction-observation-orbit-determination cycle is a selfsustaining process when it works properly. In general, the process functioned reasonably well during ISAGEX, except for the Peole satellite, which, with a perigee of 500 km, is subject to a great deal of atmospheric drag.

Section 1 discusses the prediction accuracies obtained, and Section 2 presents a technique for improving poor predictions. Section 3 deals with the drag problem, especially as it relates to Peole.

#### 1. PREDICTION ACCURACIES

In Table 1 we have estimated the accuracy of predictions for the ISAGEX satellites during the saturation observing periods. The best way to express accuracies seems to be in topocentric arcminutes, since this bears most directly on the static-pointing laser system. In general, because of the beamwidth, prediction accuracies to 10 arcmin are desirable; a smaller accuracy presents problems for acquisition (although the problem is not completely insurmountable, as discussed in Section 2).

Predictions degrade exponentially in time. We give accuracies for the first and last day of each week's predictions. Interpolation will provide estimates for the other days. The figure for the first day is actually the rms of the orbit determination. Since we never found any discontinuity between the rms orbit fit and the residuals of the first day's observations using the extrapolated orbit, this seems an appropriate measure of the starting value.

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ISAGEX period	Week	Peole	Geos 1	Geos 2	DID	BE-B	BE-C	DIC
Ι	Jan. 6–13	No predictions	127			1. <del>3-4</del> 2		
	Jan. 13-20	Non-SAO orbit (25-min time difference)	1.854			2.3-20		
•	Jan. 20–27	4X	1.3-3.5			11. 5 <b>X</b>		
п	Feb. 10-18	4.5-1155	1-2				I3. 5	
	Feb. 18-24	4-215	1.8-2.5				1-3.8	
	Feb. 24-Mar. 3	490	0.8-2				1-7	
	Mar. 3-10	4.8-350	0.8-4.8				X-I	
Ħ	Mar. 24–31	4-63	0.8-13	I-10		10.8-37		
	Mar. 31-Apr. 7	5-167	0.8-2.5	0.8-6.8		0.8-2.8		
	Apr. 7-14	7.3–253	0.5-2.8	0.5-7.5		0.8-X		
IV	Apr. 28–May 5	0.8-850, 115	0.7-1.3	0.8-1.5	0.8-10			
	May 5–12	5-232, 29	0.7-9	0.8-1.5	0.5-9			
	May 12–19	4-54, 87	0.7-6	0.5-0.8	0.4 - 21			
Λ	June 59	1.5-220, 54	0.4 - 12	0.4-12				1-31
	June 9-16	2.4-53, 38	0.45	0.5-2				1-22
	June 16-23	3. 5-38, 22	0.4-7	0.3-11				0.778
	June 23-30	0.3-69,55	0.3-6	0.3-2				0.5-X
IV	July 14-21	2-490, 81	0.5-1.3	0.5-2.5	0.8-2			
	July 21-28	4.8-X, 59	0.5-4	0.5-13	0.7-14			
IIA	Aug. 11–18	4.8-X, 116	0.5-5	0.5-4.5			1-2.5	
	Aug. 18–25	1.3-53,87	0.5-3.4	0.5-1.4			6-1	
	Aug. 25-Sept. 1	1. 5-132, 86	0.5 - 2	0.5-2			0.8 - 1.3	
	-							

Table 1. Drediction accuracies (arcmin) from the first to the last day of each week.

The final day's accuracy is determined by a direct comparison of pointing angles from the expiring and the fresh predictions. This overlap day was generated to ensure operation even in the case of communications delays. Occasionally, there was no overlap day, and a comparison could not be made. This is indicated by an "X" in Table 1. Clearly, in any week, the final day's figure is uncertain by the amount of error in the next first day's prediction, which is almost always relatively small. The error is predominantly in the along-track direction; the across-track component is relatively insignificant.

Notice in the table the large errors in the Peole predictions. In an attempt to improve the accuracy, we generated Peole predictions twice a week beginning with period IV. From period IV on, we give two overlap-day comparisons in addition to the first orbit fit. Although there was noticeable improvement, Peole predictions remained troublesome (owing to atmospheric drag, see Section 3).

Finally, since we intended for these values to represent worst case situations, we chose to compare pointing angles at the culmination of each pass. Culmination, or the point of closest approach, is more sensitive to orbital errors than are lower elevation points.

#### 2. FIELD UPDATING OF PREDICTIONS

One of the useful properties of laser ranging systems is their ability to operate at low elevation angles. This permits errors in the predicted satellite mean anomaly to be quickly detected and corrected. Generally, the error in satellite mean anomaly is the only significant one in satellite ephemerides, so that when this error has been determined by field personnel, they can update predictions from the Computations Center in Cambridge by applying a simple correction to the firing time of their look angles.

Figure 1 demonstrates how the error in mean anomaly is determined. The satellite is predicted to be at position 1, azimuth, altitude, and range from the station, at epoch 1, and at position 2 at epoch 2. Suppose that at epoch 1 the observed and the predicted range differ by  $\Delta r$ . (It is feasible to obtain returns in this case, provided the major component of the satellite's motion is toward the observer; this is true very

early in the pass for passes with high culmination.) We can assume that the predicted time interval between epochs 1 and 2 is correct, although the epochs themselves are in error by  $\Delta t$ ; and similarly s, the range interval between positions 1 and 2, is correct, although the range to position 1 is wrong. Then,  $\Delta t = (d/s) \Delta r$ , approximately.



Figure 1. Satellite-station geometry at a low elevation angle.

Actually, for convenience,  $\Delta r$  and s are expressed in terms of propagation times rather than of distances. The time interval between successive predicted points, d, is almost always 15 sec; s varies, but it is typically around 0.5 msec for low elevation angles. In order to determine  $\Delta t$  quickly, station personnel use graphs of the linear relationships between  $\Delta t$  and  $\Delta r$  for the various values of s frequently encountered. The value  $\Delta r$  can be resolved to 1 nsec, so that, for example, when s = 0.5 msec and d = 15 sec,

 $\Delta t = \frac{30 \text{ msec mean-anomaly correction}}{1 \text{ nsec observed range error}}$ 

Figure 2 is the station graph for determining the error in mean anomaly. Given  $\Delta r$  and s,  $\Delta t$  can be quickly found.



Figure 2. Typical station graph for determination of mean-anomaly error: s = prop-agation-time differences between successive predicted points;  $\Delta r = (observed - predicted)$  range propagation time;  $\Delta t = mean-anomaly$  correction; d = 15 sec.

#### 3. ATMOSPHERIC-DRAG EFFECTS

The Peole satellite (7010901) has an apogee of 730 km and a perigee of 500 km. Predictions of it are difficult because not only is it subject to considerable atmospheric drag but also the drag is highly variable. Figure 3 shows the effects of drag varying by about an order of magnitude.





For predictions to be useful for laser ranging, we estimate that the acceleration in mean anomaly (the empirically determined term that represents the effect of drag) ought to be correct within 5 or 10 parts per million. As can be readily seen from Figure 3, the term frequently changes by several times this amount in just a few days. The problem amounts to predicting the future state of the atmosphere, for which there is no satisfactory procedure.

An additional problem is that of obtaining an adequate orbital determination in the first place. Orbit determination was frequently weak because of insufficient observations.

We attempted to correlate the orbital acceleration of Peole with two parameters that are readily obtainable. The first is  $\psi$ , the geocentric angle between the satellite perigee and the center of the atmospheric "hot spot," i.e., the subsolar "bulge" in the atmosphere. We set the hot-spot center at the subsolar point delayed by 30° in longitude. The angle  $\psi$  is plotted in Figure 3, along with preliminary values of our second parameter, the 10.7-cm solar flux, which gives a rough indication of the solar influence on atmospheric activity.

It seems apparent that the shapes of both the  $\psi$  and the flux curves are reflected in the acceleration of Peole, although not in any quantitatively consistent manner.

We conclude that the only feasible way to solve the prediction problem caused by Peole's high drag is to increase the frequency of the prediction-observation-orbitdetermination cycle. Yet, a cycle faster than the present twice-weekly one is impractical. Possibly, an orbit-computation capability on location at the laser sites would permit a rapid and accurate enough iteration of the cycle for the drag problem to be overcome.

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#### SIGNAL STRENGTH AND OBSERVABILITY

#### J. Latimer

One problem that the laser-ranging technique continually presents is that of observability; that is, how can the observer know if a particular satellite and laser geometrical configuration is such that he is likely to receive a sufficiently strong return signal?

Although this question applies to all satellites, an especially striking situation is that of the four magnetically stabilized satellites (BE-B, BE-C, DlC, and DlD) when they are observed from stations in the southern hemisphere. It can be very difficult to observe them successfully because the retroreflector arrays, on the northseeking ends of these satellites, tend to face away from southern stations.

To see the effect of this problem, we selected at random 26 passes (342 observations) of BE-C observed from station 7907 (Arequipa, Peru), at latitude -17°. The observations were made between August 31 and November 5, 1971, and all give acceptably small orbit-fit residuals. Figure 1 is a plot of the passes, in the station's altitude-azimuth coordinate system. Indeed, when the satellite is in the northern half of the sky, it cannot be observed from this station. (Attempts were made to observe all passes.)

If we assume that the satellite is always oriented along the lines of the earth's magnetic field, we can calculate the aspect angle at the satellite between the symmetry axis (North) and the line of sight to the station. We used the spherical-harmonic representation (up to degree and order  $4^*$ ) of Cain, Hendricks, Langel, and Hudson (1967) as the geomagnetic model and derived aspect angles (see Appendix A) for each

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Although Cain's field is represented to degree and order 10, we found that the truncated field yielded aspect angles differing only by about 1°. This is sufficient, considering that the satellite is likely to oscillate about the field direction with an amplitude of a degree or more.

of the 342 observations. Figure 2 is a plot of the reflective area versus the angle of incidence for the BE-C satellite. Cases 1 and 2 are measured from different radial angles. We used mean values, since there is no way to determine the radial angle, and the difference is slight. The histogram in Figure 3 shows the observed frequency of occurrence of each aspect angle. The significance of the aspect angle is its relation to the effective area of the satellite retroreflector array.



Figure 1. 26 passes of BE-C in the altitude-azimuth coordinate system of the Peru station.

We could avoid generating laser predictions for magnetically stabilized satellites that are impossible to observe by calculating the aspect angle, choosing a suitable limit for the angle, and suppressing all predicted points exceeding that limit. Although the histogram of Figure 3 serves to confirm Figure 2 (there were no returns from aspect angles greater than 110°, the Figure 3 cutoff), the slow fall-off of returns for large aspect angles suggests that we ought to consider the range equation if we wish to determine whether particular satellite-station geometries are likely to be observable.



Figure 2. Reflective area vs. angle of incidence of BE-C (from Minott, 1963).



Figure 3. Histogram of the aspect angles of satellite BE-C.

We estimated average signal strengths for all the data by using the range equation of Appendix B and the retroreflector area function of Figure 2. The results are displayed in Figure 4. The large population at low signal strengths is disturbing, but we must consider the following factors:

A. <u>Error in the assumed beam divergence</u>. Owing to the method of recording the transmitted beam divergence, some estimates are surely too high; therefore, some signals are greater than indicated.

B. <u>Scintillation</u>. We estimated only the average signal – the actual signal may vary by more than an order of magnitude (Jaffe, 1971), and some of the low average signals probably yielded high actual signals.

C. <u>Weak-signal conditions</u>. There are many more opportunities to attempt observation under weak-signal conditions than under strong-signal conditions. Thus, although the probability of success diminishes, the number of opportunities greatly increases, yielding a significant number of weak-signal returns.



Figure 4. Histogram of relative signal strengths for Peru BE-C data.

Point C is easily verified. We constructed a uniform distribution of 706 satellite positions at a height of 1150 km (typical for BE-C) over Peru such that all points were above the elevation angle limit of 10°. By using a typical beam divergence (3.5 mrad) and the same values for the magnetic field that we used in Figure 3, we computed the expected average signal strengths. From the histogram in Figure 5, it is clear that the population of weak-signal situations is large.

In conclusion, we can see that satellite configurations yielding aspect angles greater than 110° can be suppressed without loss of possible observations. We will attempt to measure signal strengths directly in order to have a better idea of both the minimum useful signal and the statistical behavior of scintillation. In addition, we intend to extend this analysis to the gravitationally stabilized satellites Geos 1, Geos 2, and Peole. For these, the principal problem is that of obtaining returns at low station-elevation angles.



Figure 5. Histogram of estimated signal strengths for a uniform distribution of positions of BE-C from Peru.

#### REFERENCES

CAIN, J. C., HENDRICKS, S. J., LANGEL, R. A., and HUDSON, W. V. 1967. A proposed model for the International Geomagnetic Reference Field – 1965. NASA-TM-X-55845, 47 pp.

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 1971. Signal strength fluctuations in a laser ranging system due to optical interference between the many reflectors on a satellite. JPL Technical Memorandum 391-218 to P. M. Muller, July 28.

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1963. Monthly research and advanced technology development activity report for April 1963. Optical Systems Branch, NASA/GSFC, Memorandum to H. J. Goett, April 23.

#### APPENDIX A

#### COMPUTATION OF ASPECT ANGLE a

Station position:  $\vec{S}$ Observation vector (line-of-sight direction and range):  $\vec{O}$ Satellite position:  $\vec{P}$ Magnetic field at  $\vec{P}$ :  $\vec{F}$ 

Clearly,

$$\vec{s} + \vec{O} = \vec{P}$$

and

$$\cos a = -\frac{\vec{0} \cdot \vec{F}}{|\vec{0}||\vec{F}|}$$

where  $\vec{F} = \vec{F} (\vec{P})$ ; i.e.,

$$\overline{\mathbf{F}} = -\nabla \mathbf{V} \quad ,$$

where

$$V = a \sum_{n=1}^{n} \left(\frac{a}{r}\right)^{n+1} \sum_{m=0}^{n} \left(g_n^m \cos m\phi + h_n^m \sin m\phi\right) P_n^m (\theta) ;$$

r,  $\theta$ , and  $\phi$  are polar coordinates for  $\vec{P}$ , a is the earth's mean radius,  $P_n^m$  are Schmidt normalized spherical functions, and  $g_n^m$  and  $h_n^m$  are the coefficients of the magnetic-field representation.

#### APPENDIX B

#### RANGE EQUATION

We use the range equation from Lehr (1966):

$$S = \frac{E}{2.86 \times 10^{-19}} \left(\frac{1}{R^4}\right) \left(\frac{A_s}{\Omega_t}\right) \left(\frac{A_r}{\Omega_s}\right) T^2 \text{ photons}$$

where E is the output laser energy ( $\approx 7.2 \text{ J}$ ), R is the range to the satellite in megameters, T is the atmospheric transmission for Peru ( $\approx e^{-0.071/\sin \alpha}$ , where  $\alpha$  is the elevation angle), A<sub>s</sub> is the effective area of the satellite reflective surface,  $\Omega_s$  is the solid angle of the reflected laser beam (=  $2.83 \times 10^{-9} \text{ sr}$ ), A<sub>r</sub> is the effective area of the receiver aperture (=  $0.21 \text{ m}^2$ ), and  $\Omega_t$  is the solid angle of the transmitted laser beam. The numerical factor converts joules to photons at a wavelength of 6943 Å.

In addition, we use N = S/58 to represent the photodetector conversion efficiency, where N is the number of photoelectrons generated.

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#### LEHR, C. G.

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#### DATA FORMATS

B. R. Miller

#### 1. INTRODUCTION

The observational data formats described are the ones used by SAO in various computer programs.

The optical observation format is the same as that used in the past. It has been reproduced here to facilitate use by ISAGEX members.

The laser format has been revised to provide room for time designation to the nearest nanosecond and range to 0.01 m. Temperature is now given in degrees Celsius, pressure in millibars, and humidity in percent.

#### 2. SAO OPTICAL OBSERVATION CARD FORMAT AND EXPLANATION

Field	Column	<u>1</u>	Description
1	<u>1-7</u>	Satellite identificati	on
	1-2	year of launch from	1900
	3-5	number of launch in	that year
	6-7	particle number	
		Satellite 1959 al, fo	r example, would be designated 5900101.
2	8-12	<u>Observation number</u> – Each observation of a satellite in a given year is designated by a different number. The source of an observation is also indicated by the observation number.	
		1-9999 misc	ellaneous
		10000-19999 Bake	r-Nunn, field-reduced
		30000-39999 Moon	watch
		50000-59999 misc	ellaneous
		70000–79999 photo	reduced Baker-Nunn

Field	Column	Description
3	<u>13</u>	Blank
4	<u>14–17</u>	Station number – In the COSPAR numbering format, e.g., 9039 is Natal, Brazil.
5	$     \begin{array}{r}             \underline{18-23} \\             \underline{18-19} \\             \underline{20-21} \\             \underline{22-23}         \end{array} $	Date of observation year, from 1900 month day
6	24-33	<ul> <li><u>Time designation</u> - Different types of observations are made using different time systems. Different times used in reporting SAO observations are as follows:</li> <li>a. Field-reduced Baker-Nunn observations - generally WWV received before 1966, UTC(USNO) after.</li> <li>b. Photoreduced Baker-Nunn observations - A.S Note: A.S is a time scale with a fixed relation to NBS(A) before April 1968 and to A. 1 after then. Values of (A.S-WWV emitted) are available in tabular form.</li> </ul>
	24-25 26-27 28-29 30-33	hour minute second fraction of seconds, to 0.1 msec
7	$\frac{34-52}{34}$ $\frac{34}{35-36}$ $\frac{37-38}{39-40}$ $\frac{41-43}{44}$ $\frac{45-46}{47-48}$	The interpretation of the following field depends on the code in column 56. If column 56 is 0, then the observation is right ascension and declination $(a, \delta)$ . blank hours of a minutes of a seconds of a fractions of seconds to 0.001 sec sign of $\delta$ degrees of $\delta$ minutes of $\delta$
	49-50	seconds of o

ς.

Field	Column	Description	
	51 - 52	fractions of seconds to 0.01 sec	
		If column 56 is 1, the observation is altitude and azimuth corrected for atmospheric refraction. Altitude and azimuth observations not corrected for atmospheric refraction have 3 in column 56.	
	34 - 36	degrees of azimuth; 999 indicates azimuth is in mils	
	37-38	minutes of azimuth	
	39-40	seconds of azimuth	
	41-43	fraction of seconds to 0.001 sec	
	37-41	mils to nearest tenth if azimuth is in mils; decimal point assumed before column 41	
	44	blank	
	45 - 46	degrees of altitude; 999 indicates altitude is in mils	
	47-48	minutes of altitude	
	49 - 50	seconds of altitude	
	51 - 52	fractions of seconds to 0.01 sec	
	45-51	mils to nearest tenth if altitude is in mils; decimal assumed before column 51	
		If column 56 is 4, the observation is direction cosines $(l, m)$ , corrected for refraction; a 5 in column 56 indicates the observation is in direction cosines uncorrected for refraction.	
	34	sign of $\ell$ (blank or minus)	
	35 - 42	$\ell$ to 8 decimal places (decimal point implied before column 35)	
	43	blank	
	44	sign of m (blank or minus)	
	45-52	m to 8 decimal places (decimal point implied before column 45) $n = \ell^2 + m^2$	
8	<u>53 – 58</u>	Index codes	

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53 - 58

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### time-precision index

Code	Standard error in timing $\sigma_t$
0	No estimate
1	$\sigma_t \leq 0.0003 \text{ sec}$
2	$0.0003 < \sigma_{t} \leq 0.002$
3	$0.002 < \sigma_t \le 0.005$

### Field Col

Column

### Description

Code	Standard	d error in timing $\sigma_t$
4	0.005	$<\sigma_t \leq 0.02$
5	0.02	$<\sigma_{t} \leq 0.05$
6	0.05	$<\sigma_{t} \leq 0.2$
7	0.2	$<\sigma_t \le 0.5$
8	0.5	$<\sigma_t \le 2.0$
9		$\sigma_t > 2.0$
		-

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#### position precision index

Code	Standard error in direction $\sigma_{\rm D}$
00	No estimate
01	$\sigma_{\mathbf{D}} \leq 1.5$
02	$1!5 < \sigma_{\rm D} \le 2!5$
03	$2!'5 < \sigma_{\rm D}^{-1} \le 3!'5$
04	$3!5 < \sigma_{\rm D} \leq 4!5$
05	$4!'5 < \sigma_{\rm D}^{-} \le 5!'5$
06	$5!'5 < \sigma_{\rm D} \leq 6!'5$
07	$6!'5 < \sigma_{\rm D}^{-1} \le 7!'5$
08	$7!5 < \sigma_{\rm D}^{-1} \leq 8!5$
09	$8!5 < \sigma_{D} \leq 9!5$
10	$9!'5 < \sigma_{D} \le 10!'5$
11	$10!'5 < \sigma_{D} \le 11!'5$
12	$11!.5 < \sigma_{D} \le 12!.5$
13	$12!'5 < \sigma_{\rm D} \le 13!'5$
14	$13!'5 < \sigma_{D} \le 14!'5$
15	$14!'5 < \sigma_{D} \le 15!'5$
16	$15!'5 < \sigma_{D} \le 16!'5$
17	$16!'5 < \sigma_{D} \le 17!'5$
18	$17!5 < \sigma_{D} \le 18!5$
19	$18!'5 < \sigma_{\mathbf{D}} \le 19!'5$
20	$19!'5 < \sigma_{D} \le 20!'5$
21	$20!'5 < \sigma_{D} \le 22''$
22	22'' < $\sigma_{\rm D} \le 23!'5$
23	$23!'5 < \sigma_{D} \le 26''$
24	26'' < $\sigma_{\rm D} \le 29''$
25	$29" < \sigma_{D} \leq 33"$

### Field Column

.

### Description

Code	Standard error in direction $\sigma_{\rm D}$
26	$33'' < \sigma_{\rm D} \le 38''$
27	$38'' < \sigma_{\rm D}^{-1} \le 45''$
28	$45'' < \sigma_{\rm D}^{-} \le 54''$
29	54'' < $\sigma_{\rm D}^{-} \leq 1!1$
30	$1! 1 < \sigma_{\rm D}^{-1! 3}$
31	$1!3 < \sigma_{\mathbf{D}} \leq 1!7$
32	$1!7 < \sigma_{D} \leq 2!1$
33	$2! 1 < \sigma_{D}^{-} \leq 2! 7$
34	$2!7 < \sigma_{\rm D}^{-1} \leq 3!5$
35	$3! 5 < \sigma_{D} \leq 4! 4$
36	$4!4 < \sigma_{D} \leq 5!8$
37	$5!8 < \sigma_{D} \leq 7!5$
38	$7!5 < \sigma_{D} \leq 9!7$
39	9!7 < $\sigma_{\rm D} \le 13'$
40	13' $< \sigma_{\mathbf{D}} \leq 17'$
41	$17' < \sigma_{D} \leq 22'$
42	22' $< \sigma_{\rm D} \leq 28'$
43	$28' < \sigma_{D} \leq 37'$
44	$37' < \sigma_{D} \leq 49'$
45	49' $< \sigma_{\mathbf{D}} \leq 1$ °1
46	$1^{\circ} 1 < \sigma_{\mathbf{D}} \leq 1^{\circ} 4$
47	$1.4 < \sigma_{\mathbf{D}} \leq 1.8$
48	$1.8 < \sigma_{\mathbf{D}} \leq 2.4$
49	$2^{\circ}4 < \sigma_{D}$
, <b>.</b>	

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### observation type index

Code	Explanation
0	right ascension, declination
1 .	altitude, azimuth (corrected for refraction)
2	not used
3	altitude, azimuth (uncorrected for refraction)
4	$\ell$ , m (direction cosines, corrected for refraction)
5	l, m (direction cosines, uncorrected for refrac- tion)

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Field	Column	Description			
	57	This index re the observation and declination	fers to the date of equator and equinox to which on is referred. (Meaningful for right ascension on only.)		
		Index	Date		
		0	Date of observation		
		1	1855.0		
		2	1875.0		
		3	1900.0		
		4	1950.0		
	58	instrument de	escription index		
		Code	Optical observations		
		0	naked eye and binoculars, visual		
		1	telescope, aperture less than 5 inches		
		2	apogee telescope, astronomical refractor or reflector, theodolite, visual		
		3	Baker-Nunn camera, photographic		
		4	small missile tele-camera, tracking cameras with focal length 20 inches or greater, photo- graphic		
		5	cinetheodolite, tracking cameras with focal length less than 20 inches, photographic		
		6	Harvard meteor camera (Super-Schmidt), photographic		
		7	stationary telescope or camera with focal length equal to or less than 10 inches, photo- graphic		
		8	direction observation associated with a laser instrument		
		9	other instruments		
<b>9</b>	59-64	Blank			
10	65-70	Conversion fr A.1 - UT1	om the UT1 to the A.1 time system, i.e.,		
	65	minus if A. 1 · necessary	- UT1 is negative, or tens digit if positive and		

Field	Column	Description
	66	units digit of A. 1 - UT1 in seconds
	67-70	decimal fraction A.1 - UT1
11	71 - 80	Identification information
	71-75	film number
	76	contains an S if observation is simultaneous
12	77-78	Passive or flash information
		<ul> <li>a. If the satellite is a flashing one, column 77 will contain an F and column 78 will contain the number of the flash as it actually occurred. (This does not apply to ANNA flashes.)</li> <li>b. If the satellite is passive, columns 77 and 78 will contain the frame number.</li> </ul>
13	<u>79</u>	Contains the letter associated with the film number if any; otherwise it will be blank.
14	<u>80</u>	Used for balloon satellites to indicate a precision reduction correction for satellite size has been added; otherwise blank.
11	71-80	Moonwatch – used for apparent magnitude information.

Precisely reduced Baker-Nunn observations are given in the coordinate system of the <u>SAO Star Catalog</u> (equator and equinox of 1950.0). The positions have been corrected for annual aberration, and the star positions, for proper motion to the year of observation. No corrections have been applied for diurnal aberration or parallactic refraction.

The time of the observation is given in A.S (Smithsonian Atomic Time), defined by the expression

A.S - UTC(USNO) =  $6.^{S}$ 140768 + 0.002592000 (T - 39856.0)

for the time period February 1, 1968, to the present; T is the Universal Time in Modified Julian Days (MJD), and 39856 is January 1, 1968:

MJD = Julian Day - 2400000.5.

## 3. SAO LASER OBSERVATION FORMATS AND EXPLANATION

Field	Column	Description					
1	1-7	Satellite identification					
	$\frac{1}{1-2}$	year of launch from 1900					
	3-5	number of launch in that year					
	6-7	particle number					
		Satellite 1964 64A, for example, would be designated 6406401					
2	8-12	Observation number					
		20000-29999 uncorrected observation					
		70000-79999 corrected observation					
		90000-999999 GOCC laser and direction observation					
3	<u>13</u>	Blank					
4	<u>14-17</u>	Station number – In the COSPAR numbering format, e.g., 7921 is SAO laser site at Mt. Hopkins, Arizona. Station designations in the 7000 series include laser sites.					
5	18-23	Date of observation					
	18-19	year from 1900					
	20-21	month					
	22-23	day					
6	24-35	<u>Time designation</u> – Different types of observations are made using different time systems. Time systems used are indi- cated by the code in column 57.					
	24 - 25	hour					
	26-27	minute					
	28-29	second					
	30-35	fraction of seconds to 1 µsec					
7	36-52	Interpretation of the following field depends on the codes in columns 56 and 57.					
	36	blank					

Field	Column		Description
	37-46	range in me range obser	ters (decimal implied before column 45 allows vations to be specified to 0.01 m)
	47-48	blank	
	49-52	value of refi 57	cactivity correction to $0.01 \text{ m} - \text{code } 1$ in column
8	53-58	Index codes	
	53	time precisi	on index
		Code	Standard error in timing $\sigma_{t}$
		0	$\sigma_t \leq 0.000005 \text{ sec}$
		1	$\sigma_{t} \leq 0.0003 \text{ sec}$
	54-55	standard dev meters	viation of the range $\sigma_r$ in meters and tenths of
	56	observation	type index
		Code	Explanation
		1	altitude, azimuth on laser instrument
		8	laser range
	57	code to indic	cate time system and corrections applied
		Code	Explanation
		0	UTC emitted at transmission of laser pulse – no corrections applied to range
		1	A.S time at reception of laser pulse – refrac- tivity correction given in columns 49–52 but not applied to range
		2	A.S time at reception of laser pulse – refrac- tivity correction applied to range
		3	UTC time at the satellite (GOCC observations – refractivity correction applied to range)
	58	Instrument o	description index
		Code	Explanation
		8	Laser observation
9	59-64	Range corre column 57	ction – pulse shape and size – codes 0 and 1 in
	59	sign	
	60	meters	

Field	Column	Description
	61	10 centimeters
	62	centimeters
	63-64	blank
11	65-77	Pressure, humidity, temperature – uncorrected observations
		only, code 0 in column 57
	65-66	blank
	67-70	barometric pressure in millibars
	71-72	humidity in percent
	73	sign of temperature
	74-76	temperature to tenths of degrees Celsius
	77	blank
	65-77	Conversion from the UT1 to the A.1 time system
		i.e., A.1-UT1 (actually A.S), code 2 in column 57
	65	minus if A.S-UT1 is negative, or tens digit if positive and necessary
	66	units digit of A. S – UT1 in seconds
	67 - 72	decimal fraction of A.S-UT1
;	74-77	blank
12	78 - 80	Identification information
	78	blank
	79	type of laser pass
		Code Explanation
		0 night pass, satellite illuminated
		1 night pass, satellite in shadow
		2 daylight pass
	80	blank

#### DATA VALIDATION

E. M. Gaposchkin and G. M. Mendes

Each observing station performs the following calibration exercises:

A. Determination of the fundamental system delays to be applied to measured time intervals.

B. Precision check of the fundamental time-interval measurement.

C. Determination of the reliability of an individual measurement.

D. Calculation of the reproducibility of an individual measurement.

Even with this elaborate procedure, further checking and information are necessary; two approaches are employed:

A. Pass analysis, which depends on trends, noise, and consistency of the data.

B. Comparison of observations with precision orbit computation.

This latter approach, the primary tool used, is the subject of this section.

Laser data have a precision of 1 m and an accuracy that is probably somewhat better. On the other hand, our current set of geodetic parameters is based primarily on 20- to 40-m camera data. From the determination of these geodetic results, Gaposchkin and Lambeck (1970, 1971) estimated the station coordinates to an accuracy of 5 to 10 m. The accuracy of our orbit computation is no better than 5 to 10 m for optimum satellites (Geos 1) and significantly worse for others (Peole). It is clear that we cannot obtain an unambiguous validation of 1-m laser data with a 10-m tool.

Orbits were computed with 4 days of data every 2 days, i.e., with 2 days of overlap. Four days was usually sufficient to compute a reliable orbit, yet short enough to minimize the effects of errors in the gravity field and station coordinates.

Owing to the paucity of laser data, we have also incorporated other tracking data, including minitrack and field-reduced Baker-Nunn. As the main computation center, SAO received laser data from CNES and GSFC to be used for predictions. We included these data in our reference orbits, although we recognized that such data did not have the benefit of refinement and validation by the originating agency. The supplementary laser data used were from stations 7050 (GSFC), 7060 (Guam), 7815 (moved to 7809, Haute Provence), and 7804 (San Fernando). The data from station 7820 (Dakar) were not included because of uncertainties in the coordinates and timing. It was not our purpose to validate the data from other agencies, but our success in validation indeed hinged on having these supplementary laser data.

Very bad data were easy to detect. The detection of poor data proved to be very difficult. Ultimately, three rules were applied:

A. The successive orbits had to be consistent. Nonuniform evolution of the mean orbital elements indicated poor data had been included in the orbit determination.

B. Orbital residuals had to be consistent (i.e., reproducible) in the two computed orbits. Using a conservative estimate of the orbital accuracy, observations that had residuals greater than 50 m (500 m for Peole) were rejected.

C. The run of residuals in a pass had to be smooth. A large variation in residuals ( $\geq 50$  m) from point to point (1 sec apart) must be an observational error as there is no unmodeled orbital perturbation of that magnitude. The run (trend or signature) of the residuals is a very powerful device and hinges on having more than 10 observations per pass. Many passes early in ISAGEX did not have sufficient data for this test to be applied, and these were consequently very difficult to validate.

The applications of these rules had varying degrees of success. The confidence we can put in the validated data varies considerably from satellite to satellite and from period to period. Some of the data in periods II and III are questionable. Such data are distributed so that only when they are combined with laser and precisionreduced camera data can a final evaluation be made.

A few data were analyzed on a pass-by-pass (short arc) basis. This involved use of the orbit-computation program as an interpolation device, determining the parameters I, e,  $M_0$ , and n. The other orbital elements were held fixed at the values computed from long-arc computation. This interpolation will reject the groww outliers and will provide a measure of the noise (i.e., the precision) of the data. We have found this noise to be 50 to 100 cm. Figure 1 gives the typical residuals from a short-arc orbital fit.



Figure 1. Residuals for short-arc fit of satellite 6508901 from station 7907.

It became apparent that the trend of residuals for 4-day arcs would provide the same information when plotted as the short-arc residuals do. Further, bad points not discarded by the short-arc procedure often resulted in poor short-arc fits. The longer arcs discarded these bad points. In addition, many passes had so few points (< 5) that short arcs were not possible. Finally, short-arc computation provided no estimate of the accuracy. We therefore abandoned this approach and proceeded to use 4-day arcs.

The SAO and the French laser data were input to our processing program in A.S time at reception of the laser pulse and without the refraction correction given. The refraction correction was computed following Tsiang and Lehr (this volume), and time was converted to A. S at the satellite for orbital computation. The GSFC laser data were input in UTC time at the satellite and with refraction applied to range; again, time was converted to A. S at the satellite. We also used as inputs the tesseral harmonics determined in Standard Earth (II) (Gaposchkin and Lambeck, 1970), the station coordinates listed in Table 1 below, and the polar-motion values published by BIH. In Table 1, the station coordinates are given in megameters and the weight in arcseconds for all but the laser stations, which are in meters. Photoreduced weights where applicable are in parentheses.

Figure 2 gives the residuals of the same pass as in Figure 1 as it appears in a 4-day arc. The interpolation curve has been drawn to illustrate the short-arc fit. This particular pass was chosen because it was representative of SAO's ISAGEX laser data. It has a noise level of 0.93-m rms and an accuracy of 2.2-m rms.

Figure 3 gives the history of the semimajor axis for Geos 1 (6508901). The scatter appears to be less than 1 m, which indicates that the data are good, well-distributed, and well-understood. Geos 1 is a well-behaved satellite with an inclination of 59°. It is visible to many stations, thus giving rise to a nicely distributed data set. Its eccentricity of 0.071 presents no problems in the determination of the argument of perigee, and if we look at M2 as an indication of the magnitude of the modeled drag, we see that it is about  $5 \times 10^{-7}$  rev day<sup>-2</sup>, or 0.65 arcsec day<sup>-2</sup>.

Figure 4 gives the semimajor axis for Peole (7010901), with a scatter of less than 10 m. With an inclination of 15°, an eccentricity of 0.016, and M2 of  $3 \times 10^{-5}$  rev day<sup>-2</sup> (0.65 arcmin day<sup>-2</sup>), orbit computation for Peole is very challenging. Its inclination made it visible to very few stations (7907, 7929, 7060, 4492, 4800), four of which are in South America, giving rise to a badly distributed view of the satellite's orbit. Satellites with small inclinations make computation of both the argument of node and the argument of perigee difficult. The modeling of the drag and the solving for  $\mathring{\omega}$  and  $\mathring{\Omega}$  became impossible. We assumed values for  $\mathring{\omega}$  and  $\mathring{\Omega}$ , held them fixed, and solved for the drag modeling. This worked satisfactorily, but not so well as we had expected for laser data.

Station					
Location	COSPAR Number	X	Y	Z	Weight (arcsec)
	Bak	er-Nunn Station	<u>s</u>		
San Fernando, Spain	9004	5.105588	-0.555228	3,769667	34 (4)
Naini Tal, India	9006	1.018203	5.471103	3.109623	34 (4)
Maui, Hawaii	9012	-5.466053	-2. 404282	2.242171	34 (4)
Dakar, Senegal	9020	5.886264	-1.845649	1.615282	34 (4)
Mt. Hopkins, Arizona	9021	-1.936782	-5.077704	3.331916	34 (4)
Olifantsfontein, South Africa	9022	5.056125	2.716511	-2.775784	34 (4)
Island Lagoon, Australia	9023	<b>-3</b> .977765	3.725101	-3.303034	34 (4)
Dodaira, Japan	9025	-3.910438	3.376362	3.729219	34 (4)
Arequipa, Peru	9027	1.943040	-5.804207	-1.796491	34 (4)
Debre Zeit, Ethiopia	9028	4.903750	3.965201	0.963872	34 (4)
Dionysos, Greece	9030	4.595200	2.039446	3.912606	34 (4)
Natal, Brazil	9039	5.186461	-3.653856	-0.654325	34 (4)
Rosamund, California (AF)	9113	-2.450011	<b>-4.62442</b> 1	3.635035	34 (4)
Cold Lake, Canada (AF)	9114	-1.264838	-3.466884	5.185467	34 (4)
Johnston Island (AF)	9117	-6.007402	-1.111859	1.825730	34 (4)
Mt. John, New Zealand (AF)	91 <b>19</b>	-4.533650	0.761590	-4.407772	34 (4)
San Vito, Italy (AF)	9120	4.613757	1.485659	4.132293	34 (4)
		Laser Stations			(m)
GSFC, Maryland	7050	1.130673	-4.831368	3.994112	2
Guam Island	7060	-5.068960	3.584106	1.458756	2
Salisbury, Australia	78 <b>03</b>	-3.939150	3. 467040	-3.613265	2
San Fernando, Spain	7804	5.105606	-0.555251	3.769633	2
Haute Provence, France	7809	4.578352	0.457957	4.403160	2
Haute Provence, France	7815	4.578371	0.457950	4.403134	2
Dakar, Senegal	7820	5.886271	-1.845666	1.615250	2
Olifantsfontein, South Africa	7902	5.056125	2.716511	-2.775784	2
Arequipa, Peru	7907	1.942775	-5.804081	-1.796933	2
Mt. Hopkins, Arizona	7921	-1.936781	-5.077701	3.331921	2
Natal, Brazil	7929	5.186461	-3.653856	-0.654325	2
Dionysos, Greece	7930	4.595207	2.039446	3.912595	2

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### Table 1. Station coordinates used in the validation.

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Figure 2. Residuals for 4-day fit for satellite 6508901 from station 7907.



Figure 3. Evolution of semimajor axis for satellite 6508901 during ISAGEX periods IV and V.





The scatter for the remaining satellites was about 3 m, except for BE-B (6406401), which had so few data that its scatter was about 7 m.

The number of validated SAO laser points broken down by station is given in Table 2. The ISAGEX periods covered by these data are listed in Table 3, where an X indicates a validated time period (Note: in-between time periods were also validated where possible).

Station							
Satellite	7902	7907	7921	7929	7930	Total	
6406401	-	12	13	5	-	30	
6503201	3	162	3	41	33	242	
6508901	3960	1408	16 <b>4</b>	528	106	6166	
6701101	-	-	9	3	88	100	
6701401	<b>-</b> .	235	412	43	109	799	
6800201	937	466	137	276	42	1858	
7010901	_	35	-	230	-	265	
Total	4900	2 <b>3</b> 18	738	1126	378	9460	

Table 2. Number of validated SAO laser points.

Table 3. Validated ISAGEX periods.

Satellite	II Feb. 15-Mar. 8 MJD 40997-41019		III Mar. 15–Apr. 15 41035–41057		IV Apr. 29-May 20 41070-41092		V June 5-26 41107-41129		VI July 14-31 41146-41164		VII Aug. 11-31 41174-41195
6406401			x								
6503201	, x										x
6508901	x	x	x	х	x	х	x	x	x	x	x
6701101							x				
6701401					x				x		-
6800201			x	х	x	х	х	х	х	x	x
7010901	x		x		x		x				х

As a result of our validation process, we can conclude the following:

A. The use of error signatures can be successfully employed to validate data. By error signatures, we mean:

1) Large scatter in the data.

2) Inconsistent mean orbital elements.

3) Lack of systematic trends in the residuals.

To observe these signatures, we require more than 10 observations per pass.

B. The overall accuracy of the data is at least 1 m, and the noise level, 60 cm.

C. The overall accuracy of our geodesy is 10 m for Geos-type satellites, as can be seen from the standard error of unit weight for orbital fits as reported by Gaposchkin and Mendes (this volume). This accuracy confirms the evaluation of Gaposchkin and Lambeck (1970, 1971). The weight for laser data was taken as 2 m.

D. With routine validation by use of Geos 1 data, a monitoring of a station's reliability to the 10- to 20-m level is possible.

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<sup>1970. 1969</sup> Smithsonian Standard Earth (II). Smithsonian Astrophys. Obs. Spec. Rep. No. 315, 93 pp.

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#### ORBITAL ELEMENTS FROM ISAGEX DATA

E. M. Gaposchkin and G. M. Mendes

The process of data validation hinges on a consistent evolution of orbital elements derived from the data. These elements are also useful for other analyses - e.g., of zonal harmonics and earth tides - and are given here. Only those ISAGEX data available at SAO for validation were used; the orbital elements will be revised when the complete set of data has been processed. However, these orbits are an improvement over previous ones, especially for Peole (7010901), the first geodetic satellite with such a low inclination. This catalog of satellite data is similar to those previously published by SAO (see, e.g., Miller, 1968). The orbital elements are mean elements in the sense that the effects of the short-period perturbations due to the earth's gravity field have been eliminated.

The SAO mean elements have been computed from observations covering several days and are given in the form of a table. The successive sets of elements are essentially independent of each other. Only entries that are considered satisfactory are given. A missing epoch is due to insufficient data.

The times of epoch in the mean elements are reckoned in Julian Days. For convenience, the number 2400000.5 has been subtracted to provide an abbreviated rotation, which we call "Modified Julian Days" or MJD.

The units of the orbital elements are degrees for angular quantities, megameters for metric quantities, and revolutions for the mean anomaly.

The tabulated values of SAO mean elements are as follows:

line 1 Satellite designation, epoch, first and last dates, standard error of unit weight, number of observations, and date the orbit was computed.

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line 2 Epoch.

line 3  $+\omega$ , argument of perigee and secular rate.

line 4  $\Omega$ , right ascension of the ascending node and secular rate.

line 5 I, inclination.

line 6 e, eccentricity.

line 7 M, mean anomaly; n, mean motion; and higher polynomial term(s) as appropriate.

These elements include the long-period perturbations evaluated with the zonal harmonics as tabulated in Gaposchkin and Lambeck (1970, 1971); the short-period perturbations due to the geopotential computed with the numerical values given in Gaposchkin and Lambeck (1970, 1971); and the lunar perturbations with period  $2\lambda_{((2))}$  computed as given by Gaposchkin (1966). The fundamental constants GM, ae, and the velocity of light are as follows:

 $GM = 3.986013 \times 10^{20} \text{ cm}^3 \text{ sec}^{-2}$ ae = 6.378155 × 10<sup>8</sup> cm , c = 2.997925 × 10<sup>10</sup> cm sec^{-1} .

The station coordinates used are given in Gaposchkin and Mendes (this volume).

The reference system adopted results in the inclination and the argument of perigee referred to the true equator of date. The right ascension of the ascending node is reckoned from the mean equinox of 1950.0 along the corresponding mean equator to the intersection with the moving true equator of date, and then along the true equator of date. To transform the right ascension of the node to the mean equinox of date, the following formula is used:

 $\Omega^{\circ} = \Omega^{\circ}(\text{SAO}) + 3.508 \times 10^{-5} \text{ (MJD - 33281)}$ 

The orbital theory used defines the mean elements. The orbit-computation program employed here is based on a set of formulas due to Aksnes (1970) for the short-period oblateness perturbations. The relationship between the mean elements from Von Zeipel's method as previously published and those by the Lie transform method is given by Aksnes (this volume).

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 1966. Orbit determination. In <u>Geodetic Parameters for a 1966 Smithsonian</u> <u>Institution Standard Earth</u>, ed. by C. A. Lundquist and G. Veis, Smithsonian Astrophys. Obs. Spec. Rep. No. 200, vol. 1, pp. 77-183.

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MILLER, B., prepared

1968. Satellite orbital data, No. E-8. Smithsonian Astrophys. Obs. Spec. Rep. No. 290, 27 pp.

ORBIT				
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.0250906913	0000121801			
.8202667524	13,3558666877 -4,5	781E-07		
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337.4581497518	.5794357587			
87.0023513990	-2.2414144378			
59.3579641471				
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78,0208966416	-2,2493428352			
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	-2.62401/02443
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.7114876121	11.96/9216499 -2.1862E-05 -5.4237E-06
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59.3719991431				
.0716512953	0000011978			
<b>.</b> 7499160 <u>410</u>	11.9679476819	-1-1135E-07	8.4336E-08	
41051,000	2.516	4165706		
5.419873-29.	782943 59,371	701-0717733	.7471385 11.9679	477 8 0733051
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59.3715222055	. 1000381330			
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6.723158 -34.	275782 59.371	156 .0718014	·6830510 11·9679	9494 8.0733843
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1965 89 A	41.055	41053.0 41057.	0 1.5462	128 02/03/72
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41055.000000	6.000000		·····	
7.0323120538	<b>.</b> 6513763594			
-38.9077941344	-2.2474430032		-	
59.3685839714	-,)^28630838			
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.6217230540	11.9679580643	=2.7396E=06	-8.3978E-07	
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8.026787 -38.	7/0104 59,368	154 .0718311	.0189645 11.9079	581 8,0733004
ORBIT	45057	11055 0 11059	0	17 55/07/73
1965 89 A				67 12703712
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50 3709814115	2.2440020504			
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5576521687	11.0679531328	5.1111F-06	1-8762F-06	
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9.318916 -43.	262620 59,370	479 .0718786	.5549045 11.9674	531 8.0733826
ORBIT				·
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- <b>PIÍI</b>	P111P11	P3111		
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.0716455243	.0000004630			
.4935176639	11-967964339	-1,3494F-n6	-8.1152E-07	
41059,00	n00 <b>1.4</b> 0	n4607545		
10.53614=-47.	757-21-59, 270	640 1719791	4907815 11.9679	264 - 8.0733//6

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1965 89 A	41061 41059.0 41063.0	1.5804 229 02/03/72
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41071.000000       3.500000       10.11         17.40244017       .55156155         -74.756900140       -2.2467096125         3.3704541314       .0005164499         .011500000       1.3466419742         1.189966463       11.9679554372       1.2628-06         1.189966463       11.9679554372       1.2628-06         1.4294.3       -74.72519       59.259487       .105335         1.4294.3       -74.72519       59.259487       .10729433       .106335         1.4294.3       -74.72519       59.259487       .107440       1.7421       416 12/16471         1965       59.369485566       .652633447       .2727433       .106335       .171648514         -9239628552       11.967953545       .27.1282505       .27.12805507       .1.28035507         .9359628552       11.9679532855       .27.1282507       .1.28035507       .12704/71         P111       P111       P111       P111       P111       P111       11.96795146         .9239628552       11.9679528565       .27.1282507       .1.28035507       .1.28035507         .94872803823       .19979528565       .27.1282567       .1.28035507       .1.2704/71         P111       P111       P111				1.0401	
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74.75680.8140       20.051764700125         59.3704561214       20.051764700         1.189066453       11.9677554377       1.262ñE-06       7.4587E-07         1.189066453       11.9677554377       1.262ñE-06       7.4587E-07         1.1927       1.346419742       .1063335       1.9659554       8.ñ733816         0Rait       41.072       00000       1.346711747       1.7021       116       127.427433         1965       69.4       41.072       011       93111       17021       116       127.427431         41072.000000       0.000000       10.131454       052833447       22228007       -7.28003E-07         0813       01455614       -000001535       -2.1282E-07       -7.28003E-07         08417       1.9679523685       -2.1282E-07       7.7892E-07         1965       89.4       41074       41075.0       3.2673       139 12/04/71         911       911       911       9111       9111       9111       112 12/04/71         912       913       92740089257.01       6.52231453       7792E-07       1.7892E-07         914       911       911       9111       9111       116       12/04/71         914       914	===17-4802449117===				
59:3704541214       0.005146499         07:176476315       0.000017717         1039654633       11.9679554372       1.262ñE-06         104:4290.03       -74.727919       59.269807       1.023338 17.9679554 8.ñ733816         08917       -1.3467419742       1.3467419742       1.592338 17.9679554 8.ñ733816         196:593       -1.4127       41072.01       1.074.9       1.7923       756 12764/71         P11       P11       P11       P3111       1.7923       756 12764/71         P11       P11       P3111       93111       1.7923       756 12764/71         P11       P11       P3111       P3111       1.7923       756 12764/71         P11       P11       P3111       P3111       1.7923       756 12764/71         P11       P11       P3111       P3111       1.7923       756 12764/71         P11       P11       P11       P3111       P3111       717 12038-07       71.26038-07         P11       P11       P11       P11       P11       P3111       71.22928-07       71.26038-07         P11       P11       P11       P11       P3111       71.22928-07       71.22928-07         P114       P11       P3111<	-74.75689.08140	-2.2467096125			
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	41071.0000	1.346	<u>19742</u>		
ORBIT. 1985 89 4 41472 41070.0 41074.0 1.7923 316 12/04/71 P111 P111 201 00000 10.1340131645 .6528033447 282.9901365364 -2.246887225 59.369485969 .0714496714000001535 	18-429403-74-7	127919 <b>59,3</b> 69	487	63335 11.95795	54 8.0733816
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39.3001117335         .0716551366       .0000028265         .9487249920       11.9679454462       -6.0260E-07       3.4567E-07         ORBIT       1965 89 A       41078       41076.0       41080.0       1.8894       232       12/04/71         P111       P111       P111       P3111       1.8894       232       12/04/71         P111       P111       P111       P3111       1.8894       232       12/04/71         P111       P111       P3111       P3111       1.8894       232       12/04/71         P111       P111       P3111       P3111       1.8894       232       12/04/71         P111       P111       P3111       P3111       1.5273       241       12/04/71         P111       P111       P111       P3111       P31711       1.5273       241       12/04/71         P111       P111       P111       P31711       1.5273       241       12/04/71         P111       P111       P31711       P31711       1.5273       241       12/04/71         P111       P111       P31711       P31711       1.5273       241       12/04/71         P111       P111       P31711	2/4,0089344125	-2,2455444494			
.0/10301900       .0001020200         .9487249920       11.9679454462       -6.0260E-07       3.4567E-07         ORBIT       1965 89 A       41078       41076.0       41080.0       1.8894       232 12/04/71         P111       P11       P01       P111       P3111       P3111       232 12/04/71         41078.000000       0.000000       0.000000       0.000000       22.0492804199       .6529562419         269.5153612269       -2.2467910904       .6529562419       .6529562419       .00000011703         269.5153612269       -2.2467910904       .0000011703       .00000011703       .0000011703         .8846244713       11.9679493851       -1.0785E=07       -1.22480E=07         96511       911       9211       P3111         1965       89 A       41078.0       41082.0       1.5273       241 12/04/71         9111       P111       P111       P3111       P31111       1.9273       241 12/04/71         9111       P111       P111       P3111       P31111       1.5273       241 12/04/71         9111       P111       P111       P3111       P31111       1.9273       241 12/04/71         9111       P111       P111       P3111 <td>39 3667 1633</td> <td></td> <td></td> <td></td> <td></td>	39 3667 1633				
0RBIT       11.901949492       0.020010       0.020010       0.020010         1965       89 A       41078       41076.0       41080.0       1.8894       232       12/04/71         P111       P111       P01       P111       P31111       20       232       12/04/71         41078.000000       0.000000       0.000000       0.000000       22.0492804199       .6529662419         269.5153612269       -2.2467910904       59.3700270576       .00000011703       .00000011703         .0716529050       .00000011703       .00000011703       .00000011703       .00000011703         .8846244713       11.9679493851       -1.0785E=07       -1.2480E=07         0RRIT       .911       P111       P31111         1965       89 A       41080       41082.0       1.5273       241       12/04/71         P111       P111       P111       P31111       P31111       1.5273       241       12/04/71         41080.000001       0.000000       2.000000       2.2469722895       59.3698420366       .22469722895       59.3698420366       .0000004951         59.3698420366       .0000004951       .0000004951       .0000004951       .0000004951       .00000004951	0/972/992	11-06797-54462	=6 0260F=07	2 4567F-07	
1965       89 A       41078       41076.0       41080.0       1.8894       232       12/04/71         111       P11       P11       P11       P11       P3111       111         41078.000000       0.000000       0.000000       0.000000       22.0492804199       6529662419         269.5153612269       -2.2467910904       59.3700270576       00000011703       0.0000011703         .0716529050       .0000011703       .00000011703       11.9679493851       -1.0785E=07       -1.2480F=07         0RR11       1965       89 A       41080       41078.0       41082+0       1.5273       241       12/04/71         1965       89 A       41080       6528969832       265:0214562996       -2.2469722895       59.3698420366       59.369884	0PpTT	11.000.0404408	0.02002 0.	3.43016-01	
P111       P111       P111       P31111         41078.000000       0.000000         22.0492804199       .6529662419         269.5153612269       -2.2467910904         59.3700270576       .00000011703         .0716529050       .0000011703         .8846244713       11.9679493851         .8846244713       11.9679493851         .8846244713       11.9679493851         .98711       .9111         .925       .99.3         .9241       .92.4471         .925       .99.3         .9241       .92.4471         .925       .99.3         .925       .99.3         .9241       .911         .911       .911         .9241       .92.4471         .925       .93.3         .925       .93.3         .925       .93.3         .920000       .900000         .923.3551298338       .6528969832         .923.3591298338       .6528969832         .923.3593.44562996       .9242469722895         .923.698426366       .9000004951         .921.6545634       .9000004951	1965 89 A	41078	41076.0 41080.0	1.8894	232 12/04/71
41078:000000       0:000000         22.0492804199       .6529662419         269:5153612269       -2:2467910904         59.3700270576       .00000011703         .8846244713       11:9679493851         .8846244713       11:9679493851         .8846244713       11:9679493851         .6529662419       .00000011703         .8846244713       11:9679493851         .967411       .00000011703         .9655       .9111         P111       P11         P111       P11         P111       P11         41080.000007       0.000000         23:3551298338       .6528969832         .265:0214562996       -2:2469722895         .9716545634       .0000004951	Phile	p <u>_1</u> p_ <u>1_</u>	<u>1</u> p <u>31111</u>	1.440.4	ي ماني ورو المركز العربية المركز ا مستقبل المركز
22.0492804199 .6529662419 269.5153612269 -2.2467910904 59.3700270576 .0716529050 .0000011703 .8846244713 11.9679493851 -1.0785E=07 -1.2480F=07 ORALI 1965-89 A 41080 41078.0 41082.0 1.5273 241 12/04/71 P11 P11 P11 P11 P11 P3111 41080.000000 0.00000 23.3551298338 .6528969802 265.0214562996 -2.2469722895 59.3698420366 .1716545634 .0000004951	41078-000000	0.00000			
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59.3700270576         .0716529050       .0000011703         .8846244713       11.9679493851       -1.0785E=07       -1.2480E=07         0RAIT       41080       41078.0       41082=0       1.5273       241       12/04/71         0RAIT       911       9111       93111       93111       241       12/04/71         911       9111       93111       93111       241       12/04/71         911       9111       93111       93111       241       12/04/71         911       9111       93111       93111       1.5273       241       12/04/71         911       9111       93111       93111       1.5273       241       12/04/71         911       9111       93111       93111       1.5273       241       12/04/71         9100000       0.000000       0.000000       0.000000       1.5273       241       12/04/71         23.3551298339       .6528969802       .0000000       .0000004951       .0000000       .0000004951         .0716545634       .0000004951       .0000004951       .00000004951       .00000004951       .00000004951	269.5153612269	-2.2467910904			
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	59.3700270576	-			
•8846244713       11•9679493851       ~1•9785E=07       ~1•2480E=07         0RAIT       41080       41078.0       41082.0       1.5273       241       12/04/71         1965       89 A       41080       41078.0       41082.0       1.5273       241       12/04/71         P111       P111       P111       P3111       P3111       41082.0       1.5273       241       12/04/71         41080.000007       0.000000       0.000000       23.3551298338       .6528969802       265.0214562996       ~2.2469722895         265.0214562996       ~2.2469722895       59.3698420366       ~0000004951       4000004951	•0716529 <u>050</u>	.0000011703			,
ORFII       1965       89 A       41080       41078.0       41082.0       1.5273       241       12/04/71         P111       P111       P111       P111       P3111       1.5273       241       12/04/71         41080.000007       0.000000       0.000000       23.3551298338       .6528969802       265.0214562996       -2.2469722895         59.3698420366       .0000004951       .0000004951       .0000004951       .0000004951	.8846244713	11.9679493851	-1.0785E=07	-1-2480E-07	
1965     89 A     41080     41078.0     41082.0     1.5273     241     12/04/71       p111     p111     p111     p3111     p3111     241     12/04/71       41080.000007     0.000000     0.000000     23.3551298338     .6528969802       265.0214562996     -2.2469722895       59.3698420366     -0000004951	ORALI				
p111     p111     p111     p31111       41080.000007     0.000000     23.3551298338     .6528969802       265.0214562996     -2.2469722895     59.3698420366       59.3698420366     .0000004951	1965 89 A	41080	41078.0 41082.0	1.5273	241 12/04/71
41080.000007 0.000000 23.3551298338 .65289698Å2 265.0214562996 -2.2469722895 59.3698420366	p111p111	- <u>p-1</u>	P3111	· · · · · · · · · · · · · · · · · · ·	
<pre>&lt;3.3551298339 .6527907002 265.0214562996 -2.2469722895 59.3698420366 .0716545634 .0000004951</pre>	41080.000000	<u>9.000000</u>			
59.3698420366 .0716545634 .0000004951	43-3551298338		·	•	
•1716545634 •0000004951	50 340843434	(4271203)			
THE REPORT OF THE TRANSPORT OF THE TRANSPORT	17.3070761100				
-8205223404 11+9579480598 -3+2003E=07 8+2048E=08	8205223404	11.9679480598	-3.2003E-07	8-2048E-08	

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ORBIT			
1965 89 A	41082 41080.0 41084.0	.6775	168 12/04/71
P111 P111	P01 P111 P31111		
41082,000000	0.00000		
24.659516954	•6514449913		
260.5281397457	-2.2464301936		
59.3696739148			
.0716551002	.0000009250		
• 7564205973	11•95/9503075 -4•1341E-07	9+54396-09	
URHII	41094		-1-12/04/71
-1362 87 A		1.0.4.0.	101-127 0- 1
41084.000000			
	•0510240171		
	-2.5402025418		
073657700			
• U/16577185	-0000000107 	2.60275-00	
0723190415		<u> </u>	
		2.7325	126 12/04/71
		K • 1 3 C J	120 12/04-12
41086.000000	0_00000		· •
27 2698496966			
251,5416652779	-2.2467241126		
59.3704780175			
.0716623352	.0000013975		
.6282068186	11.9679484826 -4.5207E-07	1.1681E-07	
ORBIT			
-1965 89 A	41088_41086.0_41090.0		212 12/04/71
P11 P11	p <sup>r</sup> 1 p11 p3111		
41088.000000	j.000000		
28.573691642	•6525234849		
247.0483161918	-2.2467327303		
59.3701739774			
.0716643320	.0000020351		
.564 <b>1998</b> 134	11.9679444686 -1.3559E-07	1.55565-07	
ORPIT			
1965 89 A	41090 41088.0 41092.0	3.3913	372 12/04/71
P111 P111	P11 P111 P31111		
41090.000000	0.00000		
29.8788634541	.652582421		
242.555129876	=2,246795#694		
59,3697851942			
.07166/1300	.0000013158		
.4999880537	11.96/9443466 =4.6324L=08	-3.8353E-08	
ORBIT			
	41096 41090 0 4109++0	2,76+1	279 2711771
41076-00000			
	+0011000711 -2.2466669466		
50 340433037C			
	-		
• 11/100001270	11-967946924	-6-9064F-00	
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OBPTT				
1965 89 4	41094 410	92.0 41096.0	<u> </u>	117 12/11/71
P111 P111	- Pâi	P3111		
41094.000000	5.000000			
32.4882574705	6532968541			
233,5686899714	-2,2465708331			
59-369454713				
.0716726653	.0000031099			
.3717639219	11.9679400753	-5.4928E-07	1.5125E-07	
ORBIT		_		
1965 89 A	41096 410	94.0 41098.0	<u>1.4032</u>	196-12/11/71
P111 -P111	p11p111	P31111		
41096.000000	n.9900990			
33,7939155159	•6510990114			
229.0757864449	-2.2465207879			
59.3689237377	_	· · · · · · · · · · · · · · · · · · ·		
.0716784382	.0000010531			
.3076442189	11.9679441562	3.45955-07		
ORA I T				
1965 89 A	41098 _ 410	96.0 41100.0	2.0047	218 12/11/1
P111 P111	P31 P111	P31111		
41098,000000	0.00000		•	
35.1978313954	.6522600093			
224.5824696711	-2.2466852857			
59.3688360163				
.0716795845	.000002841			
.2435286961	11.9679415872	2+3227E-08	1.9063E-09	
ORRIT				
			T <b>-T</b>	
1965 89 A	41100 410	98.0-41102.9	<u>1.5152</u>	<u>173 12/11/71</u>
1965 89 A P111 P111	41100 410 Pel PITI	98.0 41102.0 P31111	<u>1.5152</u>	<u>173 12/11/71</u>
1965 89 A P111 P111 41100.000000	4 <u>1100</u> 410 pši pjii n.0000ñ0	98.0 41102.0 031111	<u>1.5152</u>	<u>173 12/11/71</u>
1965 89 A P111 P111 41100.0000000 36.4032852544	41100 410 păi pjīi n.000000 .6536146337	98.0 41102.0 031111	<u>1.5152</u>	<u>173 12/11/71</u>
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557	41100 410 P31 P111 0.000000 .6536146337 -2.2467686225	98.0 <u>41102.9</u> 931111	<u>1.5152</u>	<u>173 12/11/71</u>
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838	41100 410 Pil Pill n.000000 .6536146337 ~2.2467686225	98.0 41102.9 P31111	<u>1.5152</u>	<u>173 12/11/71</u>
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838 .0716807809	41100 410 P01 P111 0.000000 .6536146337 -2.2467686225 .0000019611 11.9679383694	98.0 41102.9 931111	1.2945E=0.7	<u>173 12/11/71</u>
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838 0716807809 .1794098015	41100 410 Pāl Pļīj n.000000 .6536146337 ~2.2467686225 .0000019611 11.9679383698	98.0 41102.9 P31111 =3.7661E=07	1.2845E-07	<u>173 12/11/71</u>
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838 .0716807809 .1794098015 ORALT 1965 89 A	41100 410 Pil PITI 0.000000 .6536146337 -2.2467686225 .0000019611 11.9679383698 41102 411	98.0 41102.9 P31111 -3.7661E-07 00.0 41104.0	1.5152       1.2845E=07	<u>173 12/11/71</u> 200 12/11/71
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838 .0716807809 .1794098015 ORBIT 1965 89 A P111 P111	41100 410 Pāl P111 n.0000ñ0 .6536146337 -2.2467686225 .0000019611 11.967938369A 41102 411 P51 P111	98.0 41102.9 P31111 =3.7661E=07 00.0 41104.0 P31111	1.5152 ! -[.2845E=07 1.4889	<u>173 12/11/71</u> 200 12/11/71
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838 .0716807809 .1794098015 ORBIT 1965 89 A P111 P111 41102.000000	41100 410 Pāl P]11 0.000000 .6536146337 -2.2467686225 .0000019611 11.9679383698 41102 411 Pāl PĨ11 0.000000	98.0 41102.9 P31111 -3.7661E-07 00.0 41104.0 P31111	1.5152 1 -1.2845E=07 1.4889	<u>173 12/11/71</u> 200 12/11/71
1965 89 A P111 P111 41100.0000000 36.4632952544 220.0890595557 59.3686979838 .07168677809 .1794099015 ORALT 1965 89 A P111 P111 41102.000000 37.7088618846	41100 410 P61 P111 0.000000 .6536146337 -2.2467686225 .0000019611 11.9679383698 41102 411 P61 P111 ô.000000 .6534962328	98.0 41102.9 P3111 -3.7661E-07 00.0 41104.0 P3111	1.5152   -1.2845E-07 ].4889	<u>173 12/11/71</u> 200 12/11/71
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838 0716807809 1794098015 ORAIT 1965 89 A P111 P111 41102.000000 37.7088618846 215.5956562132	41100 410 Pil PIII 0.000000 .6536146337 -2.2467686225 .0000019611 11.9679383698 41102 411 pil Pili 0.00000 .6534962328 -2.2467840063	98.0 41102.9 P31111 -3.7661E-07 00.0 41104.0 P31111	1.5152   =1.2845E=07 1.4889	<u>173 12/11/71</u> 200 12/11/71
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838 .0716807809 .1794099015 ORALT 1965 89 A P111 P111 41102.000000 37.7088618846 215.5956562132 59.3682542945	41100 410 Pāl P111 n.0000ñ0 .6536146337 -2.2467686225 .0000019611 11.967938369A 41102 411 Pāl P111 ñ.0000ñ0 .6534962328 -2.2467840053	98.0 41102.9 P31111 =3.7661E=07 00.0 41104.0 P31111	1.5152   -[.2845E-07 1.4889	<u>173 12/11/71</u> 200 12/11/71
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838 .0716807809 .1794098015 ORALT 1965 89 A P111 P111 41102.000000 37.7088618846 215.5956562132 59.3682542945 .0716831044	41100 410 Pāl P]11 n.0000ñ0 .6536146337 -2.2467686225 .0000ñ19611 11.9679383698 41102 411 Pāl PĨ11 ñ.0000ñ0 .6534962328 -2.2467840053 .0000726975	98.0 41102.9 P31111 -3.7651E-07 00.0 41104.0 P31111	1.5152 1 -1.2845E-07 1.4889	<u>173 12/11/71</u> 200 12/11/71
1965 89 A P111 P111 41100.000000 36.4632852544 220.0890595557 59.3686979838 .07168677809 .1794098015 ORALT 1965 89 A P111 P111 41102.000000 37.7088618846 215.5956567132 59.3682542945 .0716831344 .1152877896	41100 410 P61 P111 n.000000 .6536146337 -2.2467686225 .0000019611 11.9679383698 41102 411 P51 P111 5.000000 .6534962328 -2.2467840063 .0000026975 11.9679366801	98.0 41102.9 P31111 =3.7661E-07 00.0 41104.0 P31111 -3.4426E-07	1 -1.2845E-07 1.4889 6.4888E-08	<u>173 12/11/71</u> 200 12/11/71
1965 89 A P111 P111 41 100.0000000 36.4632952544 220.0890595557 59.3686979838 .0716807809 .1794099015 ORAIT 1965 89 A P111 P111 41 102.000000 37.7088618946 215.5956562132 59.3682542945 .0716831044 .1152877896 ORAIT	41100 410 P61 P111 0.000000 .6536146337 -2.2467686225 .0000019611 11.9679383698 41102 411 P61 P111 0.000000 .6534962328 -2.2467840063 .0000026975 11.9679366801	98.0 41102.9 P3111 -3.7661E-07 00.0 41104.0 P3111 -3.4426E-07	1.5152 1.2845E=07 1.4889 6.4888E-08	<u>173 12/11/71</u> 200 12/11/71
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838 .0716807809 .1794099015 ORAIT 1965 89 A P111 P111 41102.000000 37.7088618846 215.5956562132 59.3682542945 .0716831344 .1152877896 ORAIT 1965 89 A	41100 410 Pil PIII n.0000ñ0 .6536146337 -2.2467686225 .0000019611 11.9679383698 41102 411 pil PIII i.000000 .6534962328 -2.2467840053 .0000026975 11.9679366851 41154 411	98.0 41102.9 P31111 =3.7661E=07 00.0 41104.0 P31111 -3.4426E-07 02.0 41105.0	1.5152 1.2845E=07 1.4889 6.4888E=08 1.6654	<u>173 12/11/71</u> 200 12/11/71 243 12/11/71
1965 89 A P111 P111 41100.000000 36.4032852544 220.0890595557 59.3686979838 .0716807809 .1794098015 ORHIT 1965 89 A P111 P111 41102.000000 37.7088618846 215.5956562132 59.3682542945 .0716831044 .1152877896 ORRIT 1965 89 A P111 P111	41100 410 Pil Pill n.0000ñ0 .6536146337 -2.2467686225 .0000ñ1961i 11.9679383698 41102 411 Pil Pill ñ.0000ñ0 .6534962328 -2.2467840053 .0000ñ26975 11.96793668ĵi 411 <u>04 411</u> Pill Pill	98.0 41102.9 P31111 -3.7651E-07 00.0 41104.0 P31111 -3.4426E-07 02.0 41105.0 P31111	1 -1.2845E-07 1.4889 6.4888E-08 7.6654	<u>173 12/11/71</u> 200 12/11/71 243 12/11/71
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1965 89 A P111 P111 41100.0000000 36.4632852544 220.0890595557 59.3686979838 .07168677809 .1794099015 ORALT 1965 89 A P111 P111 41102.000000 37.7088618846 215.5956562132 59.3682542945 .0716831044 .1152877896 ORALT 1965 89 A P111 P111 41104.000000 39.0141344410	41100 410 P61 P111 n.000000 .6536146337 -2.2467686225 .0000019611 11.9679383698 41102 411 p51 P111 5.000000 .6534962328 -2.2467840053 .0000026975 11.9679366801 .11.9679366801 .0000026975 11.9679366801 .0000026975 .1.9679366801 .0000026975 .1.9679366801 .0000026975 .1.9679366801 .0000026975 .1.9679366801 .0000026975 .1.9679366801 .00000026975 .1.9679366801 .00000026975 .1.9679366801 .00000026975 .00000026975 .0000000000 .6510500197	98.0 41102.9 P3111 -3.7661E-07 00.0 41104.0 P31111 -3.4426E-07 02.0 41106.0 P3111	1 -1.2845E=07 1.4889 6.4888E-08 1.6654	<u>173 12/11/71</u> 200 12/11/71 243 12/11/71
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.8908459222 11.9679392837 -5.9330E-07 7.1863E-08 ORBIT 1965 89 A 41111 41109.0 41113.0 2.9877 202 12/11/71 P111 P111 P111 P111 P3111 41111.000000 0.00945216 .009945216 .009945216 .0115956542 .0090945216 .0115956542 .0090945216 .0115956542 .0090945216 .0115956542 .009094527 .8267181762 11.9679399446 6.4951E-07 4.9738E-07 OPRIT 1965 89 4 41113 41111.0 41115.0 4.0083 150 12/11/71 P111 P111 P111 P3111 41113.00000 0.00000 44.8359114197 .5512976124 190.8848583342 -2.2459227966 59.36919652670005920801 .7626037203 11.9679447677 -5.0988E-07 -9.4970E-07 ORBIT 1965 89 A 41115 41113.0 41117.0 1.5773 109-12/11/71 P111 P111 P111 P3111 4115.00000 0.00000 44.635914456 .000000 44.115.00000 0.00000 44.115.00000 0.00000 44.115.00000 0.00000 44.115.00000 0.00000 44.115.00000 0.00000 44.115.00000 0.00000 44.115.00000 0.00000 44.115.00000 0.00000 45.598647799 .0534143524 186.3877988692 -2.2467646364 .0000302444 .0716984623734 11.9679360157 4.7661E-08 7.0393E-08	.0716902517	•000006251		• • •
0R81T       4111       41109.0       4113.0       2.9877       262 12/11/71         911       911       911       911       911       911       911       911         4111.000001       0.000000       4.00001       0.000000       4.00001       4.00000         43.584270512       .6507330261       .2.2458666066	.8908459222	11.9679392837 -5.933nE-07	7.1863E-09	
1965 89 A       41111       41109.0       41113.0       2.9877       202 12711771         P111       P111       P111       P111       P111       P31111         41111.000301       0.000300       43.5842705512       0.6507330261         195.3768863853       -2.2459666066       59.360075786       0.009415216         .0715956542       .0090431057	ORBIT	••••	- <sup>·</sup>	
P111       P111       P111       P31141         4111.000001       0.000000         43.584270512       0507330261         j95.3768863853       -2.2458666066         59.360075786       0009415216         .00145542       .000903057         .8267181762       11.9679399442         .8267181762       11.9679399442         .8267181762       11.9679399442         .9265897       .0009031057         .8267181762       11.9679399442         .9258914102       .5512975124         19658914102       .5512975124         190.8485838342       .2245456656         59.3691065267       .0005920801         .0117021850       .0000032261         .7626037203       11.9679447677       -5.5988E-07         .9365894	1965 89 A	41111 41109.0 41113.0	2.9877	202 12/11//1
4111:000001       0:000000         43:5842705512       :5507330261         j95:3768663953       :2:2458666066         59:3680075786       :000031057		P111 P111 P3111		
43.584276512       .8507330261         j95.3768663953       -2.2458666666         59.3768663953       -2.2458666666         9.716955542       .0000031057         .8267j81762       11.967939944a         6.4951E=07       4.9738E=07         OPRIT	41111.000009	0.00000		
195.376863953       -2.2458666066         59.3680075786       .0009415216         .0016956642       .000001057         .8267181762       11.9679399443       6.4951E=07       4.9738E=07         OPRIJ       PIII       PIII       PIII       PIII       PIII         1965       89.4       41113       41111.0       41115.0       4.0083       150       12711771         PIII       PIII       PIII       PIII       PIII       PIII       PIII       150       12711771         44.8859114197       .5512970124       .5512970124       .5512970124       .5512970124       .5512970124         190.8848588342       -2.2459227936       .900032251       .900032251       .900032251       .900032251       .900032251       .900032251       .900032251       .904970E=07       .94970E=07       .949	43.5842705512	•650/330261		· · · · · · · · · · · · · · · · · · ·
59.3680075786       .0009415216         .0716956642       .000031057         .8267181762       11.967939944â       6.4951E=07       4.9738E=07         OPRIT	195,3768863853	-2+2458666066		
.0715956542 .0000031057 .9267181762 11.9679399443 6.4951E=07 4.9738E=07 0R617 1965 89 4 41113 41111.0 41115.0 4.0083 150 12/11/71 P111 P111 P111 P3111 41113.0 41115.0 4.0083 150 12/11/71 4113.000000 0.0000000 44.8859114195 5.5512973124 190.8848588342 =2.2459227936 59.35919652670005920801 .0717021350 .0000032261 .7626037233 11.9679447677 -5.0988E=07 -9.4970E=07 0R617 1955 89 A 41115 41113.0 41117.0 1.5773 169-12/11/71 P111 P111 P111 P3111 4115.000005 0.000000 46.7986947999 .6534143624 186.3877988692 -2.2467646364 59.3667548131 .0000313563 .6984623734 11.9679360157 4.7661E=08 7.6393E=08	59.3680075786	.0009415216		
.8267181762       11.9679399444       6.4951E-07       4.9738E-07         OPRIT	.0715956542	.0000031057		
0R411       1965 89 A       41113 41111.0 41115.0 4.0083 150 12711771         P111       P111       P111       P3111         4113.00000       0.000000       0.000000         44.835914195       .5512970124         190.8848588342       -2.2469227906         59.3691965267      0005920801         .0717021850       .0000032261         .7626037203       11.9679447677       -5.0988E-07         .9511       .96589 A       41115 41113.0 41117.0 1.55773         .7626037203       11.9679447677       -5.0988E-07         .96589 A       41115 41113.0 41117.0 1.55773       169.12711771         P111       P111       P111       P3111         4115.000000       0.00000       41117.0 1.55773       169.12711771         P111       P111       P111       P3111       P3111         4115.000000       0.000000       46.1986947799       .6534143624       16534143624         186.3877988692       -2.2467646364       .0000913563       .0000913563       .6984623734       11.9679360157       4.7651E-08       7.6393E-08	.826/181762	11-96/939944 6 • 4951E=0/	4 9738 07	
1965       89 A       41113       41113.0       410083       150       1271771         P111       P111       P111       P3111       P3111       111 <t< td=""><td>ORALI</td><td></td><td></td><td></td></t<>	ORALI			
pitt       pitt       pitt       pitt       pitt         41ī13.000000       0.00000         44.835911419 <sup>2</sup> -6512970124         190.8848588342       -2.2459227906         59.3691965267       -0005920801         .0717021850       .0000032261         .7626037203       11.9679447677       -5.0988E-07         .955       89.4       41115       41113.0         1965       89.4       41115       41117.0       1.5773         0R91T       1965       9.40970E-07         1965       89.4       41115       41117.0       1.5773         1965       89.4       -111       P111       P111         111       9111       P111       P111       P111         4115.000000       0.000000       -2.2467646364       59.3667548131       0.0000302444         .0716984646       .0000313563       .6984623734       11.9679360157       4.7663E=08       7.6393E=08 <td>1963 89 A</td> <td></td> <td>4.0083</td> <td>150 127117/1</td>	1963 89 A		4.0083	150 127117/1
41113.000007 0.00000 44.885911419				
44.8859114197	41113.000009	0.00000		
190.83403347       2.22497,217.00         59.3691965267      0005920801         .0717021950       .0000932261         .7626037293       11.9679447677       -5.0988E-07       -9.4970E-07         ORBIT	44-635911419			
57.3571765267      0000032261         .0717021350       .0000032261         .7626037203       11.9679447677       -5.0988E-07       -9.4970E-07         ORBIT	F0-2401045247			
.0717021250 .7626037273 11.9679447677 -5.0988E-07 -9.49770E-07 ORBIT 1965 89 A 41115 41113.0 41117.0 1.5773 109-12/11/71 P111 P111 P111 P111 P31111 41115.000000 0.00000 46.1986949799 .6534143624 186.3877988692 -2.2467646364 59.3667548131 .0000013563 .0716984645 .0000013563 .6984623734 11.9679360157 4.7661E-08 7.0393E-08	57.3591705267	• 0000920801		
.7526(372)3       11.4677447677       5.0788L-07       -9.447702-07         ORBIT       1965       89 A       41115       41113.0       41117.0       1.5773       169-12/11/71         P111       P111       P111       P111       P3111       111       111         41115.000001       0.00000       0.00000       46.1986949799       .6534143624       186.3877988692       -2.2467646364         59.3667548131       .0000302444       .07169846465       .0000313563       .0000313563       .6984623734       11.9679360157       4.7661E-08       7.6393E-08	• 0/1/041850	•000002251 11 0679447677 === 0900E=07	-0 40705-07	
1965       89       41115       41113.0       41117.0       1.5773       1n9       12/11/71         P111       P111       P111       P111       P3111       P3111       P3111         41115.000000       0.00000       0.00000       0.00000       0.00000       0.00000         46.1986949799       .6534143624       .6534143624       .00000302444       .00000302444         .0716984645       .0000013563       .0000013563       .0000013563         .6984623734       11.9679360157       4.7661E-08       7.ñ393E-08	•/02003/203	TT+40/244/0//2+0288E_0/	-9.49/96-07	
1955 05 A       1115 41115.0 41115.0 41117.0 (				750 10/01/71
41115.000000       0.000000         46.1986949799       .6534143624         186.3877988692       -2.2467646364         59.3667548131       .0000302444         .0716984645       .0000013563         .6984623734       11.9679360157       4.7661E-08       7.0393E=08				
46.1986949799 .6534143624 186.3877988692 -2.2467646364 59.3667548131 .0000302444 .0716984645 .J000013563 .6984623734 11.9679360157 4.7661E-08 7.0393E-08		<u></u>		
186.3877988692       -2.2467646364         59.3667548131       .0300302444         .0716984646       .0000013563         .6984623734       11.9679360157       4.7661E=08       7.0393E=08	4-13.00.000			
100.3077302372       2.2407040304         59.3667548131       .0000302444         .0716984645       .0000313563         .6984623734       11.9679360157       4.7661E-08         7.ñ393E-08	TO: 1700747/77			
.0716984645 .J0000013563 .6984623734 11.9679360157 4.7661E-08 7.ñ393E-08	100,3011700072			
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	6094623734	11-9679360157 4 7641F-18	7 02925 00	
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1965 89 4	41117-41	115. 7 41119.0	3.6876	157 12/11/71
Plil pīīi	P111 P111	P3111		· .
41117.000000	5.000000	-		
47.5048353469	•652541778 <del>8</del>			
181.8943745239	-2,2457327786			
59.3665121171	-,0004502082			
.0717000142	.0000006053			
-6343356553	11.96/9364493	-6.2644E-07	3.9011E-07	
		1. t. 7		
D 1-1-1	-411741		3.6235	714 17710-1
	<u> </u>			
49 9098507314	-55265620/8			
177-4009105583	-2.2467790053			
59.3661471949	0000132545			
.0717012477		<u>.</u>		
.5702090532	11,7679365698	1,37656-08	1,7954E=07	
ORAIT				
1965 89 A	41121 41	119.0 41123.0	2.9878	266 12/16/71
P111 P111	P111 P111	P31111		•
41121.000000	0.00000		· .	
50-1158620319	.6535159213			
1/2.90/1902892				
39.3659725324				
5060820029	11.9679362915	2-9944F-07	-1-3911F-07	
ORBIT	11. 10. 1905 199			`
1965-89 A	41123 41	121-0-41125-0-	2.0173	247 12/16/71
P111 P111	▶111 ₽11	P3ī į l 1		
41123.000000	0.00000			
51.4238154578	•6544772316			
<u>1</u> 68.4133743931	-2,2468239918		2	
59.3661355540	•0007967926		I	
.0717065840	. 9000029015			
,4419519762	11,96/9320//2			
			2.2 <u>641E-07</u>	
ORATT	<u>/1105 - 11</u>	123 - 1127-1	2.2641E=07	
0R91T 1965-89 A		123.0 41127.0 p31111	-6945	266 12/17/71
0RB1T 1965 89 A P111 Pīji 41125 000000	4 <u>1125 41</u> P11) P111 0.000000	1 <del>23.ñ 41127.0</del> P31111	2.2 <u>641</u> E=07 .6945	266 12/17/71
0R917 1965-89-A P111 P111 41125.000000	41125 41 P111 P111 0.000000 -6529132386	1 <del>23.ñ 41127.0</del> P3īīl1	2.2 <u>641E=07</u> .6945	266 12/17/71
0R917 1965 89 A P111 Pīi1 41125.000000 52.7306498980 163.9198475398	41125 41 P111 P111 0.00000 .6529132386 -2.2469780646	12 <del>3.ñ 41127.0</del> P31111	2.2641E=07 .6945	266 12/17/71
08917 1965 89 A P111 Pīij 41125.000000 52.7306498980 163.9198475398 59.3667319858	41125 41 P11) P111 0.00000 -6529132386 -2.2469780646 0000213629	1 <del>23.ñ 41127.0</del> P31111	2.2 <u>641E=07</u> .6945	266 12/17/71
ORBIT 1965 89 A P111 PĪĪJ 41125.000000 52.7306498980 163.9198475398 59.3667319858 .0717097224	41125 41 P111 P111 0.00000 .6529132386 -2.2469780646 0000213629 .0000013247	123.ñ 41127.0 P31111	2.2641E=07 .6945	266 12/17/71
0R917 1965 89 A P111 P111 41125.000000 52.7306498980 163.9198475398 59.3667319858 .0717097224 .3778215474	41125 41 P111 P111 0.000000 .6529132386 -2.2469780646 -0000213629 .0000013247 11.9679362355	123.ñ 41127.0 P3II11 9.0392E-08	2.2641E=07 .6945 1.3741E-07	266 12/17/71
ORBIT 1965 89 A P111 PI11 41125.000000 52.7306498980 163.9198475398 59.3667319858 .0717097224 .3778215474 ORBIT	41125 41 P111 P111 0.00000 .6529132386 -2.2469780646 0000213629 .0000013247 11.9679362355	123.ñ 41127.0 P31111 9.0392E-08	2.2641E=07 .6945 1.3741E-07	266 12/17/71
ORBIT 1965 89 A P111 P111 41125.000000 52.7306498980 163.9198475398 59.3667319858 0717097224 .3778215474 ORBIT 1965 89 A	41125 41 P11) P111 0.00000 -6529132386 -2.2469780646 0000213629 .0000013247 11.9679362355 	123.ñ 41127.0 P31111 9.0392E-08 125.0 41129.0	2.2641E=07 .6945 1.3741E-07 1.3255	266 12/17/71 281 12/17/71
ORBIT 1965 89 A P111 P111 41125.000000 52.7306498980 163.9198475398 59.3667319858 .0717097224 .3778215474 ORBIT 1965 89 A P111 P111	41125 41 P111 P111 0.00000 .6529132386 -2.2469780646 0000213629 .0000013247 11.9679362355 41127 41 -P111 P111	123.0 41127.0 P31111 9.0392E-08 125.0 41129.0 P3111	2.2641E=07 .6945 1.3741E-07 1.3255	266 12/17/71 281 12/17/71
ORBIT 1965 89 A P111 P111 41125.000000 52.7306498980 163.9198475398 59.3667319858 .0717097224 .3778215474 ORBIT 1965 89 A P111 P111 41127.000000	41125 41 P111 P111 0.00000 .6529132386 -2.2469780646 0000213629 .0000013247 11.9679362355 41127 41 P111 P111 0.000000	123.0 41127.0 P31111 9.0392E-08 125.0 41129.0 P3111	2.2641E=07 .6945 1.3741E-07 1.3255	266 12/17/71 281 12/17/71
ORBIT 1965 89 A P111 P111 41125.000000 52.7306498980 163.9198475398 59.3667319858 0717097224 .3778215474 ORBIT 1965 89 A P111 P111 41127.000000 54.0365759785 550 425975745	41125 41 P111 P111 0.00000 .6529132386 -2.2469780646 0000213629 .0000013247 11.9679362355 41127 41 -P111 P111 0.00000 .6526431891 -2.2467554427	123.7 41127.0 P31111 9.0392E-08 125.0 41129.0 P3111	2.2641E=07 .6945 1.3741E-07 1.3255	266 12/17/71 281 12/17/71
ORBIT 1965 89 A P111 P111 41125.000000 52.7306498980 163.9198475398 59.3667319858 0717097224 .3778215474 ORBIT 1965 89 A P111 P111 41127.000000 54.0365759785 159.4259757686 50 2666912150	41125 41 P11) P111 0.00000 -6529132386 -2.2469780646 0000213629 .0000013247 11.9679362355 	123.0 41127.0 P31111 9.0392E-08 125.0 41129.0 P3111	2.2641E=07 .6945 1.3741E-07 1.3255	266 12/17/71 281 12/17/71
ORBIT 1965 89 A P111 P111 41125.000000 52.7306498980 163.9198475398 59.3667319858 .0717097224 .3778215474 ORBIT 1965 89 A P111 41127.000000 54.0365759785 159.4259757686 59.3666913108 .0717121301	41125 41 P111 P111 0.00000 .6529132386 -2.2469780646 0000213629 .0000013247 11.9679362355 41127 41 -P111 P111 0.000000 .6526401891 -2.2467550427 .0000521010 .0000010249	123.0 41127.0 P31111 9.0392E-08 125.0 41129.0 P3111	2.2641E=07 .6945 1.3741E-07 1.3255	266 12/17/71 281 12/17/71
ORBIT 1965 89 A P111 P111 41125.000000 52.7306498980 163.9198475398 59.3667319858 .0717097224 .3778215474 ORBIT 1965 89 A P111 41127.000000 54.0365759785 159.4259757686 59.3666913108 .0717121391 3136948281	41125 41 P111 P111 0.00000 .6529132386 -2.2469780646 0000213629 .0000013247 11.9679362355 41127 41 P111 0.000000 .6526401891 -2.2467550427 .0000521010 .0909010249 11.9679377468	123.7 41127.0 P31111 9.0392E-08 125.0 41129.0 P3111 P3111	2.2641E=07 .6945 1.3741E-07 1.3255 -8.9658Exce	266 12/17/71 281 12/17/71
ORBIT 1965 89 A P111 PII 41125.000000 52.7306498980 163.9198475398 59.3667319858 0717097224 .3778215474 ORBIT 1965 89 A P111 P111 41127.000000 54.0365759785 159.4259757686 59.366691318 .0717121391 .3136948981	41125 41 P111 P111 0.00000 .6529132386 -2.2469780646 -0000213629 .0000013247 11.9679362355 41127 41 P111 P111 0.000000 .6526451891 -2.2467555427 .0000521015 .0909010249 11.9679377458	123.0 41127.0 P31111 9.0392E-08 125.0 41129.0 P3111 -2.7955E-08	2.2641E=07 .6945 1.3741E-07 1-3255 -8.9658E-08	266 12/17/71 281 12/17/71
ORBIT 1965 89 A P111 PII1 41125.000000 52.7306498980 163.9198475398 59.3667319858 .0717097224 .3778215474 ORBIT 1965 89 A P111 P111 41127.000000 54.0365759785 159.4259757686 59.3666913108 .0717121391 .3136948381	41125 41 P11) P111 0.00000 0.6529132386 -2.2469780646 0000213629 0000013247 11.9679362355 41127 41 P111 P111 0.000000 0.6526401891 -2.2467550427 0.000521010 0.000521010 0.000010249 11.9679377458	123.0 41127.0 P31111 9.0392E-08 125.0 41129.0 P3111 P3111 -2.7955E→08	2.2641E=07 .6945 1.3741E-07 1.3255 -8.9658E=08	266 12/17/71 281 12/17/71

ORBIT				
1965 89 A	41129 4	1127.1 41131.0	1.0456	230 12/17/71
Plil Pīīī		P31111		
41129.000000	0.00000 °			
55.3442644787	,6537675374			
154.9328557852	-2,246725533			
59.3668851608	0000397414			
.0717138423	.0000004855			
.2495629177	11.9679352494	3.6513E-07	3.32358-08	
ORBIT	· · · · · · · · · · · · · · · · · · ·		· · · · · · · · · · · · · · · · · · ·	
1965 89 A	41131 4	1129.0 41133.0	1.0251	282 ]2/]///
41131.000000				
	2+240/370043			
07.3012322123	• 0 0 0 2 0 0 5 7 1 4		•	
1854332022	11 9579364401	=2 <u>6477</u> =07	-5 7245F_09	
OBBIT				
1965 89 A	41133 4	1131.0 41135.0	.6963	276 12/17/71
P111 P111	P111 P111	P3111		
41133.000000	ō.0000 <u>0</u> 0	·		· · ·
57.9554967035				
145.9461495527	-2.2468798074			
59,3683123624				
.0717200085	000000529			-
.1213113955	11.9679422901	4.0673E-07	7.9023E-08	
ORBIT				
1965 89 A	41135 4	1133.0 41137.9	.5596	309 12/17/71
PIII PILI		P3]]11		
41135.000000	1.000000			
59.2643673231	-554379842			
141.45230300/3	-2.24002020884			
07.0077207320	• 0000 339774			
• 116•251	11-067933363	2 95725-07	-5 1746F-00	
1965 89 A	41137 41	1135-0 41139-0	7398	280 12/17/71
	P111 0111	P31111		Հայկարեր՝ ԷլնայԲյան։ Բ՝ նահ։ ։
41137.000000	0.000000			
60.5729333499	.6541329976			
136.9587181135	-2.2468234369			
59.3680432144	.0000785514			
.0717287383	.0000020823			
.9930464621	11.9679353259	-5.5362E-08	-6.0557E-08	
ORBIT	-	-		
1965 89 A	41139 4	137.9 41141.9	1.0888	175 12/17/71
P11 P11	<u>21)1 011</u>	P3111		
41139.000000	<b>3.93000</b>			
61.8789242812	•6524536394		······································	
132.4659932253	-2.2466035295			
37.3685064215	100000000			
0711317157	-9000012328		2 012/5=07	
•7207611118	<u>, 1 • 70 + 7 J 7 7 1 J 0</u>			
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1965-89 A	41141 41139.0 41143.0	.8429	186 12/17/71
PIII PIII	P111 P111 P3111		1
41141,000000	0.000000		
63,1835766155	.6526n19629		
127.9726817.155			
59.3693413156	000 <u>39301</u>		
.0717329997	.0003001910		
.8648030555	11.9679398813 7.9964E=07	5+2324E-07	
-D111		[.43]	
66 6923300668	.6545133949		
123.4789138619	-2.2466703441		
59.3691297683	,0000518560		
.0717401517	.0000026463		
.8006771492	11,9679366524 =3,9150E=07	1.7784F=07	
ORBIT			
1965 89 A	41145 41143.0 41147.0	2.5000	404 12/17/71
P111 P111	P111 P111 P31111		
41145.000000	9 • 00 00 00		
65.8003951835	•6535609976		
118-9856468452	-2.7458455253		
59.3694009128	• 0 0 0 1 4 / 1 9 4 1		
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1945 99 A	41147 41145 0 41149 0		-263 2/17/71-
1965 89 A P111 P111		<u>1.9375</u>	263 12/17/71
P111 P111 41147.006000	4]147 4]145.0 41149*0 P111 P111 P3111 0.000000	<u>ī</u> ,9375	
1965 89 A P111 P111 41147.006000 67.1082721201	41147 41145.0 41149*0 P111 P111 P3111 0.00000 .6543551189	<u>1</u> .9375	
1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912	41147 41145.0 41149*0 P111 P111 P3111 0.000000 .6543551189 -2.2463930455	<u>1.9375</u>	- 263 12/17/71
1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733	41147 41145.0 41149.0 P111 P111 P31111 0.00000 .6543551189 -2.2463936455 .0002039856	<u>1.0375</u>	
1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733 .0717508738	91147 41145.0 41149*0 P111 P111 P31111 0.000000 -6543551189 -2.2463930455 .0002039850 -0000946416	<u>1.9375</u>	<u>, 553 12/17/71</u>
1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733 .0717568738 .6724296545	41147       41145.0       41149.0         P111       P111       P31111         0.00000       .6543551189         -2.2463930455       .0002039850         .0002039850       .0002039850         .11.9679367713       .5.2797£-07	<u>1</u> .9375 2.0303E-07	<u>563 12/17/71</u>
1965 89 A P111 P111 41147.006000 67.1082721251 114.4925316912 59.3697121733 .0717508738 .6724295545 ORFIT	41147       41145.0       41149.0         P111       P111       P31111         0.00000       .6543551189         -2.2463936455       .0002039856         .0002039856       .0002039856         11.9679367713       5.2797£-07	Ĩ.9375 2.0303E-07	553 12/17/71
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1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733 .0717568738 .6724296545 OR91T 1965 89 A P111 P111 I 1965 89 A	41147       41145.0       41149.0         P111       P111       P31111         0.00000       .6543551189         -2.2463930455       .0002039850         .0000046416       .0000046416         11.9679367713       5.2797E-07         41148       41146.0       41150.0         P111       P3111       P3111	Ĩ.9375 1 2.0303E-07 1.6572	263 12/17/71 326 12/10/71
1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733 0717568738 6724296545 OR511 1965 89 A P111 P111 41148.000000	41147       41145.0       41149.0         P111       P111       P31111         0.00000       .6543551189         -2.2463930455       .0002039850         .0000046416       .0000046416         11.9679367713       5.2797£-07         41148       41146.0       41150.0         P111       P3111       P31111         0.00000       .6534245377	<u>1</u> .9375 2.0303E-07 1.6072	263 12/17/71
1965 89 A P111 P111 41147.006000 67.1082721251 114.4925316912 59.3697121733 0717568798 .6724295545 0R91T 1965 89 A P111 P111 41148.000000 67.7598510484 112.2656287296	41147       41145.0       41149.0         P111       P111       P31111         0.00000       .6543551189         -2.2463930455       .0002039850         .0000046416       .000046416         11.9679367713       5.2797E-07         41148       4146.0       41150.0         P111       P3111       P31111         0.00000       .6534045377	<u>1.9375</u> 2.0303E-07 1.6072	- 563 12/17/71 - 326 12/10/71
1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733 .0717508788 .6724296545 0R91T 1965 89 A P111 P111 41148.000000 67.7598510484 112.2456.87296 59.3697315564	41147       41145.0       41149.0         P111       P111       P3111         0.00000       .6543551189         .2.2463936455       .002039856         .0000046416       .000046416         11.9679367713       .5.2797E-07         41148       41146.0       41150.0         P111       P3111       P31111         0.00000       .6534645377	Ĩ.9375 2.0303E-07 1.6572	263 12/17/71 326 12/10/71
1965 89 A P111 P111 41147.0060009 67.1082721201 114.4925316912 59.3697121733 .0717568738 .6724296545 OR511 1965 89 A P111 P111 41143.000000 67.7598510484 112.2456187296 59.3697315564 .0717510644	41147       41145.0       41149.0         P111       P111       P31111         0.00000       .6543551189         -2.2463930455       .0002039850         .0000046416       .000046416         11.9679367713       5.2797£-07         41148       41146.0       41150.0         P111       P3111       P31111         0.00000       .6534645377	<u>1.9375</u> 2.0303E-07 1.6072	563 12/17/71       326 12/10/71
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1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733 0717508788 .6724295545 0R91T 1965 89 A P111 P111 41148.000000 67.7598510484 112.2456187296 59.3697315564 .0717510644 .6403779587 0R91T	41147       41145.0       41149.0         P111       P111       P3111         0.00000       .6543551189         -2.246393850       .0002039850         0.000046416       .000046416         11.9679367713       5.2797E-07         41148       41146.0       41150.0         P111       P3111       P3111         0.00000       .6534645377       .6534645377         -2.2466140615       .0001489188       .0000025345         11.9679419386       4.1135E-07	<u>1</u> .9375 2.0303E-07 1.6072 3.0145E-08	- 553 12/17/71 326 12/10/71
1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733 .0717508738 .6724296545 ORGIT 1965 89 A P111 P111 41148.000000 67.7598510484 112.2456187296 59.3697315564 .0717510644 .6403779587 ORGIT 1965 89 A	41147       41145.0       41149.0         P111       P111       P3111         0.00000       .6543551189         -2.2463936455       .002039856         .0000046416       .000046416         11.9679367713       5.2797E-07         41148       41146.0       41150.0         P111       P3111       P3111         0.00000       .6534645377       .6534645377         -2.2466140615       .0001489188       .000025345         11.9679419386       4.1135E-07         41150       41148.0       41152.0	1.0375 2.0303E-07 1.6572 3.0145E-08 1.6417	- 353 12/17/71 326 12/10/71 
1965 89 A P111 P111 41147.006000 67.1082721251 114.4925316912 59.3697121733 .0717508738 .6724295545 ORGIT 1965 89 A P111 P111 41149.000000 67.7598510484 112.2456587296 59.3697315564 .0717510644 .6403779587 ORGIT 1965 89 A P111 P111	41147       41145.0       41149.0         P111       P111       P31111         0.00000       .6543551189         -2.2463930455       .0002039850         .0000046416       .0000046416         11.9679367713       5.2797£-07         41148       41146.0       41150.0         P111       P3111       P31111         0.00000       .6534045377       .0001489188         .0000025345       .0001489188       .0000025345         11.9679419386       4.1135E-07         41150       41148.0       41152.0         P111       P111       P31111	1.0375 2.0303E-07 1.6072 3.0145E-08 1.6417	363 12/17/71         326 12/10/71         326 12/10/71
1965 89 A P111 P111 41147.006000 67.1082721251 114.4925316912 59.3697121733 0717508798 .6724295545 0R91T 1965 89 A P111 P111 41148.000000 67.7598510484 112.2456787296 59.3697315564 .0717510644 .6403779587 0R91T 1965 89 A P111 P111 41159.000000	41147       41145.0       41149.0         P111       P111       P3111         0.00000       .6543551189         .6543551189       .2.2463936455         .0002039850       .0002039850         .0000046416	1.9375 2.0303E-07 1.6072 3.0145E-08 1.7417	363 12/17/71         326 12/10/71         327 12/10/71
1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733 0717508738 .6724296545 0R91T 1965 89 A P111 P111 41148.000000 67.7598510484 112.2456187296 59.3697315564 .0717510644 .6403779587 0R91T 1965 89 A P111 P111 41150.000000 69.0683209024	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	<u>1</u> .9375 2.0303E-07 1.6072 3.0145E-08 1.0417	- 563 12/17/71 326 12/10/71 
1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733 .0717508738 .6724296545 0R51T 1965 89 A P111 P111 41149.000000 67.7598510484 112.2456087296 59.3697315564 .0717510644 .6403779587 0R51T 1965 89 A P111 P111 41150.000000 69.0683209024 107.7521544933	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1.0375 2.0303E-07 1.6572 3.0145E-08 1.6417	363 12/17/71         326 12/10/71         327 12/10/71
1965 89 A P111 P111 41147.006000 67.1082721201 14.4925316912 59.3697121733 • 9717568738 • 6724296545 0R51T 1965 89 A P111 P111 41143.000000 67.7598510484 112.2456687296 59.3697315564 • 0717510644 • 6403779587 0R51T 1965 89 A P111 P111 41150.000000 69.0683209024 167.7521544933 59.3697290596	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1.9375 2.0303E-07 1.6072 3.0145E-08 1.0417	36       12/17/71         326       12/10/71         327       12/10/71
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1965 89 A P111 P111 41147.006000 67.1082721201 114.4925316912 59.3697121733 0717508788 .6724296545 0R91T 1965 89 A P111 P111 41148.000000 67.7598510484 112.2456.87296 59.3697315564 .0717510644 .6403779587 0R91T 1965 89 A P111 P111 41159.000000 69.0683209024 107.7521544933 59.3697290596 .0717573047 .5762588331	41147       41145.0       41149+0         P111       P111       P31111         0.00000       .6543551189         -2.2463930455       .0002039850         .0000046416       .0000046416         11.9679367713       5.27976-07         41148       41146.0       41150.0         P111       P3111       .00000         .6534045377	1.0375 2.0303E-07 1.6072 3.0145E-08 1.0417 2.6181E-08	- 563 12/17/71 326 12/10/71 - 12/10/71
1965 89 A P111 P111 41147.006000 67.1082721201 14.4925316912 59.3697121733 0717568738 .6724296545 0R51T 1965 89 A P111 P111 41143.000000 67.7598510484 112.2456187296 59.3697315564 .0717510644 .6403779587 0R51T 1965 89 A P111 P111 41159.000000 69.0683209024 107.7521544933 59.3697290596 .0717573047 .5762588331	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1.9375 2.0303E-07 1.6072 3.0145E-08 1.0417 2.6181E-08	563 12/17/71 326 12/10/71 337 12/10/71

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70,3777546489	,6533,69138			
103.2589076680	-2.2465899879			
59.3699466534	.0001869836			
.0717642944	.0000014419			
.5121375171	11.9679441828	-8,6169E-08	2.2560E-08	•
ORBIT			·	
1965 89 A	41154 41	152, 3 41156.0	1.4729	306 12/10/71
P111 P111		P3 <u>111</u>		
41154.000000	0.00000			
71.6940368334	.6528971412		`	
98.7659103009	-2.2464245343			
59.3703393843	.0002333871			
.0717671133	.0000017002			
.4489265161	11.9679456973	5.6032E-07	6.6601E-09	
ORBIT				
1965 89 A	41156 _ 41	154.0 41158.0	2.1665	<u>-599 15/11//1</u>
P111 P111	P111 P111	P31111		
41156.000000	0.00000			
77,9923445785	,6542728183			
94,2721419226	-2.2469 <u>3539</u> 02			
59,3698508275	00018/2203			
.071//17667	.0000022464			-
-38341374 <u>5</u> 5	11.9679446459	5,3899E=07	-4.5837£→08	
1960-89 A	41158_41	150.) 4115(	2.9369	214 2711711
41158,000000	0.00000			
	•0743001763 -7 24699797			
	-2.0240787101			
07.3070244490	-+0001441778			
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• 51 701124UZ	11.076.24.30281	4.1.1.0.5		
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41160 000000	5.00000			
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85,2850894517	=2.2464553540			
59.3702768002	, 1015723497			
.0717758987	1000017291			
2557022928	11.9679541040	1.06295-06	-6.0841E-07	
ORBIT				
-1965-89 A	41162 41	160.0 41164.9		-152-01/12/72-
P111 P111		P3111		
41162.000000	0.00000			
75.9723987425	.6574393102			
80.7885007980	-2.2456337223			
59+3669265137	• jó13908165 -			
.0717631575	-0000079177			
1916129659	11.7679338781	3.3441E-07	-5.6575E-08	
41152.000	.52639	48739		
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41164.000000	0.00000 -			
78-2269279977	.6555709826			
76.2972194297	-2,2469894626			
59-3695117219	)002021450			
0717856310	1000036465			
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1965-89-A	41166 41164.0	41168.0 1	1114 263 12/16/71	
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41166.000000	0.000000	•		
79,5330930617	-6568957114			
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	2,2408.001.34			
59.3692854982	• 0 10 1842295			
.071/840601	• 0 0 0 0 0 6 0 5 7 1			
.0633922563	11.9679385875 -8.53	54E-07 6	0239E-07	
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1965 89 A	41169 41166.0	41170-0 2	6150 346 12/16/71	
P11	p11p3	1111		
41168 000000	0.00000			_
	5570424210			
67.3097219338	-2.2407030135			
59.3694501227	0001 <u>6</u> 516 <u>78</u>			
•0717936569	•000002311		· · · · · · · · · · · · · · · · · · ·	
.9992775282	11.9679532054 2.48	43E=179	27265-08	
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1965 89 A	41170 41168.0	41172.0 1	.5592 344 12/16/71	_
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P111 41170.000000 82.1526860781 62.8155273819 59.3692094287 .0717947501 .9351802972 ORBIT 1965 89 A P111 P111 4172.000000 83.4623218785	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\frac{27E-07}{111}$	6053E-08 8129 209 12/16/71	
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P111 41170.000000 82.1526866781 62.8155273819 59.3692594237 .0717947501 .9351802972 OR91T 1965 89 A P111 P111 41172.000000 83.4623219781 58.3208698359 59.3692017530	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E-07 -4. 41174.0 1111	6053E-08 8129 209 12/16/71	
P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORBIT 1965 89 A P111 P111 41172.000000 83.4623218785 58.3208698359 59.3692017530 .0717966458	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E-07 -4. 41174.0 111	6053E-08 8129 209 12/16/71	
P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORBIT 1965 89 A P111 P111 41172.000000 83.4623218785 58.3208698359 59.3692017530 .0717966458 .871081161a	$\begin{array}{r rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	27E-07 -4. 41174.0 1111 63E-96 -4	6053E-08 8129 209 12/16/71	
P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORBIT 1965 89 A P111 P111 41172,000000 83.4623218785 58.3208698359 59.3692017530 .0717966458 .8710811613 ORBIT	$\begin{array}{r rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	27E=07 -4. 41174.0 1111 63E=96 -4.	6053E-08 8129 209 12/16/71	
P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORAIT 1965 89 A P111 P111 41172.000000 83.4623218783 58.3208698359 59.3692017530 .0717966458 .8710811613 ORAIT 1965 89 A	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E=07 -4. 41174.0 1111 63E=06 -6. 41175.0 I	6053E-08 8129 209 12/16/71 7173E-07 1912 156 12/16/71	
P111 41170.000000 82.1526860781 62.8155273819 59.3692594237 .0717947501 .9351802972 ORBIT 1965 89 A P111 41172.000000 83.4623219785 58.3208698359 59.3692017530 .0717966458 .8710811615 ORBIT 1965 89 A P111 P111 P111	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E=07 -4, 41174.0 1111 63E=06 -6, 41175.0 1, 1111	6053E-08 8129 209 12/16/71 7173E-07 1912 156 12/16/71	
P111 41170.000000 82.1526860781 62.8155273819 59.3692594237 .0717947501 .9351802972 ORBIT 1965 89 A P111 41172.000000 83.4623219785 58.3208698359 59.3692017530 .0717966458 .8710811615 ORBIT 1965 89 A P111 P111 P111 41174.000000	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E=07 -4, 41174.0 1111 63E=06 -6, 41175.0 1 1111	6053E-08 8129 209 12/16/71 7173E-07 1912 156 12/16/71	
P111 41170.000000 82.1526860781 62.8155273819 59.3692594237 .0717947501 .9351802972 ORBIT 1965 89 A P111 41172.000000 83.4623218785 58.3208698359 59.3692017530 .0717966458 .8710817613 ORBIT 1965 89 A P111 P111 4174.000000 84.7751162512	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E=07 -4, 41174.0 1111 63E=06 -5, 41175.9 1, 1111	5053E-08 8129 209 12/16/71 7173E-07 1912 156 12/16/71	
P111 41170.000000 82.1526860781 62.8155273819 59.3692594237 .0717947501 .9351802972 OR9IT 1965 89 A P111 41172.000000 83.4623218785 58.3208698359 59.3692017530 .0717966458 .8710811613 OR9IT 1965 89 A P111 P111 4174.000000 84.7751162512 .53.8275268353	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E=07 -4, 41174.0 1111 63E=?6 -4, 41175.0 I. 1111	5053E-08 8129 209 12/16/71 7173E-07 1912 156 12/16/71	
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P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORBIT 1965 89 A P111 P111 41172.000000 83.462321978 58.3208698359 59.3692017530 .0717966458 .8710811613 ORBIT 1965 89 A P111 P111 4174.000000 84.7751162512 53.8275263353 59.3680063925 .0717975400	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E-07 -4, 41174.0 1111 63E-96 -4, 41175.0 1 1111	.6053E-08 .8129 209 12/16/71 .7173E-07 .1912 156 12/16/71	
P111 41170.000000 82.1526860781 62.8155273819 59.3692594287 .0717947501 .9351802972 ORBIT 1965 89 A P111 P111 P111 41172.000000 83.462321878 58.3208698359 59.3692017530 .0717966458 .8710811618 ORBIT 1965 89 A P111 P111 P111 4174.000000 84.7751162512 53.8275268353 59.3680063925 .0717975509 84.6714200	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\frac{27E-07}{111} -4$ $\frac{41174\cdot0}{111}$ $63E-96 =6$ $\frac{41175\cdot9}{111}$ $65E-96 =2$	6053E-08 8129 209 12/16/71 7173E-07 1912 156 12/16/71	
P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORAIT 1965 89 A P111 41172.000000 83.4623218745 58.3208698359 59.3692017530 .0717966458 .8710811615 ORAIT 1965 89 A P111 P111 P111 P111 4174.000000 84.7751162512 53.8275268353 59.368063925 .0717975599 .8069714200	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E=07     -4       41174.0     -4       63E=06     -6       41175.9     -6       41175.9     -6       56E=06     >	6992E=07	
P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORBIT 1965 89 A P111 41172.000000 83.4623218785 58.3208698359 59.3692017530 .0717966458 .8710811613 ORBIT 1965 89 A P111 P111 P111 P111 4174.000000 84.7751162512 53.8275268353 59.3680063925 .0717975599 .8069714210	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E=07     -4       41174.0     -4       63E=06     -6       41175.0     -4       111     -4	6053E-08 8129 209 12/16/71 7173E-07 1012 156 12/16/71 6092E-07	
P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORBIT 1965 89 A P111 41172.000000 83.4623218785 58.3208698359 59.3692017530 .0717966458 .8710811613 ORBIT 1965 89 A P111 P111 P111 41174.000000 84.7751162512 53.8275268353 59.3680063925 .0717975509 .8069714200	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E=07     -4       27E=07     -4       41174+0	6053E-08 8129 209 12/16/71 7173E-07 1012 156 12/16/71 6092E-07	
P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORBIT 1965 89 A P111 41172.000000 83.4623218785 58.3208698359 59.3692017530 .0717966458 .8710811613 ORBIT 1965 89 A P111 P111 P111 41174.000000 84.7751162512 53.8275268353 59.3680063925 .0717975599 .8069714200	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27E=07     -4       27E=07     -4       41174+0	6053E-08 8129 209 12/16/71 7173E-07 1912 155 12/16/71 6992E-07	
P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORBIT 1965 89 A P111 41172.000000 83.4623218785 58.3208698359 59.3692017530 .0717966458 .8710811615 ORBIT 1965 89 A P111 P111 4174.000000 84.7751162512 53.8275268353 59.3680063925 .0717975509 .8069714200	$\begin{array}{c} p111 & p111 & p3\\ n.0000\bar{0}0\\ .6546334782\\ = 2.247292605\bar{1}\\ .0000213397\\ .000009672\\ 11.967950475\bar{1} & 3.54\\ & 4\bar{1}172 & 4\bar{1}170.0\\ p11\bar{1} & p\bar{1}\bar{1} & p3\\ \bar{0}.00000\\ .6548546454\\ - 2.247352394\bar{1}\\000\bar{1}1725\bar{0}\\ .000007382\\ 11.9679494997 & -1.666\\ & 4\bar{1}174 & 4\bar{1}172.3\\ p11\bar{1} & p\bar{1}\bar{1} & p3\\ \bar{0}.000\bar{0}\bar{0}\\ .6511262596\\ - 2.2478843892\\ .017589275\\ .0000132\bar{1}\bar{7}\\ 11.9679623898 & -1.666\\ \end{array}$	$\frac{27E = 07}{111} = -4$ $\frac{41174 \cdot 0}{111}$ $63E = 06 = -6$ $\frac{41175 \cdot 9}{111}$ $\frac{41175 \cdot 9}{111}$ $\frac{41175 \cdot 9}{111} = 2$	6053E-08 8129 209 12/16/71 7173E-07 1912 155 12/16/71 6992E-07	
P111 41170.000000 82.1526860781 62.8155273819 59.369294237 .0717947501 .9351802972 ORAIT 1965 89 A P111 41172.000000 83.4623218745 58.3208698359 59.3692017530 .0717966458 .8710811615 ORAIT 1965 89 A P111 P111 4174.000000 84.7751162512 53.8275268353 59.3680063925 .0717975599 .8069714200	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\frac{27E = 07}{111} = 4$ $\frac{41174 \cdot 0}{111}$ $63E = 06 = -6$ $\frac{41175 \cdot 9}{111}$ $63E = 06 = -2$	6053E-08 8129 209 12/16/71 7173E-07 1012 156 12/16/71 6992E-07	

ORBIT			
1965 89 A	41176 41174.0 41178.0	4.2435	351 12/10/71
P111 P111	P111 P111 P31111		
41176,000000	0.00000		
86.0793682969	+6534585898		
49.33325-2007	-2,2469122496		
59.3702872307	0001)47772		
.0717987292	.000005386		
.7428873565	11.9679525143 4.3335E-07	-1-9621E-08	
ORBIT		- 1204	
1965 89 A		3.4796	564 12/10/11
P11 P11			
41178.000900	n.000000		
87-3850339024	.554673/936		
44.8393743363	-2·24/0308/55		· ·
59.3701305327	•0001522238		·
.0719010771	.090004955		
	1.03055-0/	-1.48345-08-	
	41190 A1178 A (1103 A	3 3767	431 13/10/71
	1100 4110,0 4110,0 4110C+0	C+C40'	0/1 /6/10/ · ·
			· · ·
	6568831573		
40 3452219198	-2.2471416814		
59 370 3852350	.0002313166		
0718001763	=.0000006122		
-6146931557	11.9679499664 -1.0443E-07	-7.1395E-08	· ·
ORBIT			•
0R9IT 1965 89 A	41182 41180-0 41184-0		<u> </u>
0R9IT 1965 89 A Plil Pill	4 <u>1182 41180.0 41184.0</u> P111 p111 P3111	2+0390	<u> </u>
ORBIT 1965 89 A Plil Pill 41182.000000	41182 41180.0 41184.0 P111 P111 P3111 0.00000	2.0390	<u>446 12/10/71</u>
ORBIT 1965 89 A Pli1 Pi11 41182.000000 90.0030894671	41182 41180.0 41184.0 P111 P111 P3111 0.000000 -6537994533	<u>2.</u> 0390	<u>446 12/10/71</u>
0R9IT 1965 89 A Pli1 Pi11 41182,000000 90.0030894671 35.8511403792	41182 41180.0 41184.0 P111 P111 P3111 A.000000 -6537994533 -2.2470105685	2.0390	¥46 12/10/71
ORBIT 1965 89 A P111 P111 41182.000000 90.0030894671 35.8511403792 59.3708672561	4 <u>1182 4</u> 1180.0 41184.0 P111 P111 P3 <u>1</u> 11 0.000000 .6537994533 -2.2470105685 .0002200939	2.0390	<u>446 12/10/71</u>
0RBIT 1965 89 A Pl11 Pl11 41182.000000 90.0030894671 35.8511403792 59.3708672561 .0717987776	41182 41180.0 41184.0 P111 P111 P3111 0.000000 .6537994533 -2.2470105685 .0002200939 0000086429	2.0390	446 12/10/71
0R9IT 1965 89 A Pli1 Pli1 41182,000000 90.0030894671 35.8511403792 59.3708672561 .0717987706 .5505969917	41182 41180.0 41184.0 P111 P111 P3111 0.000000 .6537994533 -2.2470105685 .0002200939 0000066479 11.9679517504 -1.5334E-07	2+0390 5+1091E=08	<u>446 12/10/71</u>
ORBIT 1965 89 A Pli1 Pi11 41182,000000 90.0030894671 35.8511403792 59.3708672561 .0717987706 .5505969917 ORPIT	41182 41180.0 41184.0 P111 P111 P3111 a.000000 .6537994533 -2.2470105685 .0002200939 0000086429 11.9679517504 -1.5334E-07	2.0390 5.1091E=08	<u>446 12/10/71</u>
ORBIT 1965 89 A Ptil Pill 41182.000000 90.0030894671 35.8511403792 59.3708672561 .0717987766 .5505969917 ORBIT 1965 89 A	41182 41180.0 41184.0 P111 P11 P3111 0.000000 .6537994533 -2.2470105685 .0002200939 -0000086479 11.9679517504 -1.5334E-07 41184 4182.0 41186.0	2.0390 5.1091E=08 3.2032	446 12/10/71 433 12/10/71
ORBIT 1965 89 A P111 P111 41182.000909 90.0030894671 35.8511403792 59.3708672561 .0717987796 .5505969917 ORBIT 1965 89 A P111 F111	41182 41180.0 41184.0 P111 P11 P3111 0.000000 0537994533 -2.2470105685 0002200939 -0000086479 11.9679517504 -1.5334E-07 41184 4182.0 41186.0 P111 P111 P31111	2.0390 5.1091E=08 3.2032	446 12/10/71 433 12/10/71
ORBIT 1965 89 A Ptil Pill 41182,000000 90.0030894671 35.8511403792 59.3708672561 .0717987706 .5505969917 ORBIT 1965 89 A P111 FIII 41184.00000	41182 41180.0 41184.0 P111 P111 P3111 0.000000 0.6537994533 -2.2470105685 0002200939 -0000086479 11.9679517564 -1.5334E-07 41184 4182.0 41186.0 P111 P111 P31111 0.000000 (5777.000.5	2.0390 5.1091E-08 3.2032	446 12/10/71 433 12/10/71
ORBIT 1965 89 A Pli1 Pi11 41182,000000 90.0030894671 35.8511403792 59.3708672561 .0717987706 .5505969917 ORBIT 1965 89 A P111 FIII 41184.000000 91.3110874994	41182 41180.0 41184.0 P111 P11 P3111 a.000000 .6537994533 -2.2470105685 .0002200939 -0000086429 11.9679517564 -1.5334E=07 41184 4182.0 41186.0 P111 P111 P31111 0.000000 .6537109940	2.0390 5.1091E=08 3.2032	446 12/10/71 433 12/10/71
ORBIT 1965 89 A Ptil Pill 41182.000000 90.0030894671 35.8511403792 59.3708672561 .0717987706 .5505969917 ORBIT 1965 89 A P111 FII1 41184.000000 91.3110874994 31.3574488705	41182 41180.0 41184.0 P111 P11 P3[]11 n.000000 .6537994533 -2.2470105685 .0002200939 -0000086479 11.9679517504 -1.5334E-07 41184 41182.0 41186.0 P111 P111 P31111 0.000000 .6537109940 -2.2467744257	2.0390 5.1091E=08 3.2032	ăă6 12/Ĩ0/71 433 12/Ĩ0/71
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ORBIT 1965 89 A P111 P111 41182.000909 90.0030894671 35.8511403792 59.3708672561 .07179827766 .5505969917 ORBIT 1965 89 A P111 F111 41184.000000 91.3110874994 31.3574488765 59.3711394147 .0717970395 4864982552	41182 41180.0 41184.0 P111 P111 P3111 0.000000 0.6537994533 -2.2470105685 0002200939 -0000086429 11.9679517564 -1.5334E=07 41184 41182.0 41186.0 P111 P111 P31111 0.000000 0.6537109940 -2.2467744257 0000579032 0000003707 11.9679524692 -4 41525-08	2.0390 5.1091E-08 3.2032	446 12/10/71 433 12/10/71
ORBIT 1965 89 A Pli1 Pi11 41182,000000 90.0030894671 35.8511403792 59.3708672561 .0717987706 .5505969917 ORBIT 1965 89 A P111 FIII 41184.000000 91.3110874994 31.3574488705 59.3711394147 .0717970395 .4864989502	41182 41180.0 41184.0 P111 P111 P3111 a.000000 .6537994533 -2.2470105685 .0002200939 -0000086429 11.9679517504 -1.5334E-07 41184 4182.0 41186.0 P111 P111 P31111 0.00000 .6537109940 -2.2467744257 .0000579032 .000003707 11.9679524682 -6.4152E-08	2.0390 5.1091E=08 3.2032 -1.2695E-07	446 12/10/71 433 12/10/71
ORBIT 1965 89 A Ptil Pill 41182.000000 90.0030894671 35.8511403792 59.3708672561 .0717987706 .5505969917 ORPIT 1965 89 A P111 P111 41184.000000 91.3110874994 31.3574488705 59.3711394147 .0717970395 .4864989502 ORBIT	41182 41180.0 41184.0 P111 P11 P3111 a.000000 .6537994533 -2.2470105685 .0002200939 -0000086479 11.9679517564 -1.5334E-07 41184 4182.0 41186.0 P111 P111 P31111 0.000000 .6537109940 -2.2467744257 .0000579032 .000003707 11.9679524682 -6.4152E-08	2.0390 5.1091E=08 3.2032 -1.2695E-07	446 12/10/71 433 12/10/71
ORBIT 1965 89 A Ptil Pill 41182.000000 90.0030894671 35.8511403792 59.3708672561 .0717987766 .5505969917 ORBIT 1965 89 A P111 F111 41184.000000 91.3110874994 31.3574488766 59.3711394147 .0717970395 .4864989562 ORBIT 1965 89 A	41182 41180.0 41184.0 P111 P11 P3111 0.00000 0.6537994533 -2.2470105685 0.002200939 -0000066479 17.9679517564 -1.5334E-07 41184 4182.0 41186.0 P111 P111 P31111 0.00000 0.6537109946 -2.2467744257 000003707 11.9679524682 -6.4152E-08 41186 4184.1 4188.0	2.0390 5.1091E=08 3.2032 -1.2695E-07 1.5891	446 12/10/71 433 12/10/71 371 12/16/71
ORBIT 1965 89 A P111 P111 41182.000000 90.0030894671 35.8511403792 59.3708672561 .0717987796 .5505969917 ORBIT 1965 89 A P111 F111 41184.00000 91.3110874994 31.3574488765 59.3711394147 .0717970395 .4864989502 ORBIT 1965 89 A P111 P111	41182 41180.0 41184.0 P111 P11 P3111 0.00000 .6537994533 -2.2470105685 .0002200939 0000066479 1.9679517504 -1.5334E-07 41184 41182.0 41186.0 P111 P111 P31111 0.000000 .6537109940 -2.2467744257 .0000579032 .000003707 11.9679524682 -6.4152E-08 41186 41184.4 4188.0 P111 P111 P31111 P31111	2.0390 5.1091E=08 3.2032 -1.2695E-07 1.5891	ăă6 12/Ĩ0/71 433 12/10/71 37Ĩ ī2/Ĩ6/71
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ORBIT 1965 89 A Plii Plii 41182.000000 90.0030894671 35.8511403792 59.3708672561 .0717987706 .5505969917 ORBIT 1965 89 A Plii Plii 41184.000000 91.3110874994 31.3574488705 59.3711394147 .0717970395 .4864989502 ORBIT 1965 89 A Plii Plii 4186.000000 92.6183244882 26.8638742976	41182 41180.0 41184.0 P111 P111 P3111 a.000000 .6537994533 -2.2470105685 .0002200939 -0000086479 11.9679517504 -1.5334E=07 41184 41182.0 41186.0 P111 P111 P31111 0.000000 .6537109940 -2.2467744257 .000003707 11.9679524682 -6.4152E=08 41186 4184.4 4188.0 P111 P111 P31111 .000000 .653271347 -2.2469288542	2.0390 5.1091E=08 3.2032 -1.2695E-07 1.5891	<u> </u>
ORBIT 1965 89 A Ptil Pill 41182.000000 90.0030894671 35.8511403792 59.3708672561 .0717987706 .5505969917 ORBIT 1965 89 A P111 PII1 41184.000000 91.3110874994 31.3574488705 59.3711394147 .0717970395 .4864989502 ORBIT 1965 89 A P111 911 41186.000000 92.6183244882 26.8638742976 59.3713256834	41182 41180.0 41184.0 P111 P11 P3[]]1 n.000000 .6537994533 -2.2470105685 .0002200939 -0000086479 11.9679517504 -1.5334E-07 41184 41182.0 41186.0 P111 P111 P31111 0.000000 .6537109940 -2.2467744257 .000003707 11.9679524682 -6.4152E-08 41186 41184.* 41188.0 P11 P11 P31111 .000000 .653271347 -2.2469288542 .0002844896	2.0390 5.1091E=08 3.2032 -1.2695E-07 1.5891	<u> </u>
ORBIT 1965 89 A Ptil Pill 41182.000000 90.0030894671 35.8511403792 59.3708672561 .0717987766 .5505969917 ORBIT 1965 89 A P111 F111 41184.000000 91.3110874994 31.3574488766 59.3711394147 .0717970395 .4864989562 ORBIT 1965 89 A P111 P111 41186.000000 92.6183244882 26.8638742976 59.3713256934 0717971882	41182 41180.0 41184.0 P111 P111 P3111 0.00000 0.6537994533 -2.2470105685 0.002200939 0000086429 11.9679517564 -1.5334E-07 41184 41182.0 41186.0 P111 P111 P31111 0.000000 0.6537109946 -2.2467744257 000003707 11.9679524682 -6.4152E-08 41186 41184.4 4188.0 P111 P111 P31111 0.00000 0.653271347 -2.2469288542 0002844896 0000033438	2.0390 5.1091E=08 3.2032 -1.2695E-07 1.5891	446       12/10/71         433       12/10/71         371       12/10/71
ORBIT 1965 89 A Ptil PTI1 41182.000909 90.0030894671 35.8511403792 59.3708672561 .0717987796 .5505969917 ORBIT 1965 89 A P111 FTTT 41184.000009 91.3110874994 31.3574488765 59.3711394147 .0717970395 .4864989552 ORBIT 1965 89 A P111 FTT 1965 89 A P111 FTT 41186.000009 92.6183244882 26.8638742976 59.3713256934 .0717971982 .4224035908	41182 41180.0 41184.0 P111 P111 P31111 a.000000 .6537994533 -2.2470105685 .0002200939 -000006429 11.9679517504 -1.5334E=07 41184 41182.0 41186.0 P111 P111 P31111 0.000000 .6537109940 -2.2467744257 .0000579032 .000003707 11.9679524682 -6.4152E=08 41186 41184.5 41188.0 P111 P111 P31111 a.000000 .653271347 -2.2469288542 .0002844896 -000003438 11.9679532342 -2.6162E=07	2.0390 5.1091E=08 3.2032 -1.2695E-07 1.5891 -2.8709E=07	ăă6 12/Ĩ0/71 433 12/10/71 37Ĩ ī2/Ĩ6/71

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1963 89 A	41188 41180.9 4	1.6454	
P111 P111	P111 P111 P311	11	
41188,000000	0.00000		
	,6538565998		
22.3700253458	-2,2469536342		
59.3729213968	.0004058878		
.0717954205	0000011700		
.3583056597	11.96/949647) -1.9109	E=0/ 6-1989E=08	
ORBIT			
1965 89 A	41190 41188 3 4	1192-0 2.7197	255 177 187 1
9111 - P111	0111 p111 p311		
41190.000003	0.00000		
95.232793.926	•6532854269		
17.8763672720	-2.2464857385		
59.3726182285	0000893820		
• 0717928747	-,0000010151		
.2942052946	11.9679499137-2.4174	E=07 1.9352E=08	
ORAIT			
1965 89 A	41192 41190.0 4	1194.0 1.7918	256 12/16/1
P111 P111	P111 P111 P311	. 1 1	
41192.000000	0.000000		
96.5389365n13	.6529594197		
13,3835433564	-2.2467624819		
59.3722183944	• 0 0 0 2 0 5 3 8 6 4		
.0717910332	-•000000397 <u>8</u>		
.2301054638	17.9679510670 -6.0498	E-08 -1.4903E-07	
ORBIT	· · · · · · · · · · · · · · · · · · ·	<b></b> -	
1965 89 A	41194 41192.0 4	1196.0 1.3598	200 12/16/71
P111 P111	P112 P11 P314		
41194.000000	0.00000		
97.8452294152	.6532221871		
8.889666916	-2.2472261475	2	
59.3729312424	• 0008847676	ſ	
.0717887777			
.1660054211	11.9679493345 -4.9995	E=07 -2.6585E=07	
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1967-11 A	41111 41109.0 41113.0	3.3796	51 12/30/71
P111 P111	Pôl Pîlî P3111		-
41111 000000	0.00000		
29-141-281-15=2	<u>50934712577</u>		
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.0512050626			
- 9179076443	13,8602244502 5,45418-00	-3,9829E-07	· · ·
ORBIT		· · ·	
196/11 A	41113 41111 1 41115 0	5-2336	90 12/30//1
P111 F11	P11 0111 P3111		
41113.000000	<b>9.9000</b> 00		
231.0998791744	5.9875854473		
221.8648803545	-4.7415544215		
39.9593428911			
0512063729			· · · ·
8026107773	13-8602401276 6-40195-06	1.4176F-07	
App 17			
196/ 11 A		2.0211	109 12/30/11
PIII PIII	PPL PIL P31144		
41115.000000	0.00000		
243-086988n137	5.98243168n4		
212.379785840;	-4.7441671898		
39.9582628423			
0512002071	-0000023592		
5230798244	13-8602809476 4-6073F=06	4.94395-07	·
ORPIT			
		2	25 12/30/11
41117.000000	0.00000		
255.0535338676	5.9840096233		
202.892/200475	-4.7429100453		
39.9583964001	., <b>u e</b>		
.0512029935	.0000003330		
.2436557935	13.86n29532n3 4.2929E-n6	-9.6002E-07	
ORBIT			
1967 11 A	41119 41117.0 41121.0	2.4694	262 02/07/72
P111 P111	p <sup>-1</sup> p111 p31111		
41119-000000	ō.0000ō0		
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193 4075623789	-4-7633 <u>000459</u>		
20-050349502			
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.0512033952	•000000220		
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.9642036773	13-8603175790 4-8333E-06	-8.3451E-07	
+ 41119.00	13-8603175790 4-8333E-06 000 2-4693908979	-8.3451E-07	··· · ····
.9642636773 ♥ 41119.00 <u>266.988775</u> 193.	13-8603175790 4-8333E-05 000 2.4693908979 407417 39.960144 0505690 -96	-8.3451E-07 43469 <u>13.8603</u>	75 7,3207118
.9642636773 * 41119.00 266.988775 193. ORBIT	13.8603175790 4.8333E-05 000 2.4693908979 407417 39.960144 0505690 96	-8.3451E-97 <del>43469 13.8683</del>	7, 3207118
.9642636773 * 41119.00 266.988775 193. 0RB11 1967 11 A	13.8603175790 4.8333E-05 000 2.46939ñ8979 407417 39.960144 0505690 96 41121 41119.0 41123.0	-8.3451E-07 43469 13.8603 2.6791	74 7,3207118 288 02/07/72
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+ 41119.00 266.988775 193. 0RBIT 1967 11 A P111 P111 41121.000000	13.8603175790 4.8333E-05 000 2.46939ñ8979 407417 39.960144 .0505690 .96 41121 41119.0 41123.0 Pôt Pill P31111 0.000000	-8.3451E-07 43469 13.8603 2.6791	76 7,3207118 288 02/07/72
* 41119.00 266.988775 193. 0RBII 1967 11 A P111 P111 41121.000000 278.9842804357	13.8603175790 4.8333E-05 000 2.46939ñ8979 407417 39.960144 .0505690 .96 41121 41119.0 41123.0 Pñt Pīlt P31111 6.000000 5.9838915964	-8.3451E-07 43469 13.8603 2.6791	75 7,3207118 288 02/07/72
* 4119.00 266.988775 193. 0RBIT 1967 11 A P111 P111 41121.000000 278.9842804357 183.9209141956	13.8603175790 4.8333E-05 000 2.46939ñ8979 407417 39.960144 .0506690 .96 41121 41119.0 41123.0 Pñt Pill P31111 0.000000 5.9838915964 -4.7432149815	-8.3451E-07 43469 13.86631 2.6791	75 7,3207118 269 02/07/72
* 4119.00 266.988775 193. 0RB11 1967 11 A P111 P111 41121.000000 278.9842804357 183.9209141956 39.9582167241	13.8603175790 4.8333E-05 000 2.46939ñ8979 407417 39.960144 .0506690 .96 41121 41119.0 41123.0 Pôt P111 P31111 0.000000 5.9838915964 -4.7432149815	-8.3451E-07 43469 13.8663 2.6791	75 7,3207118 288 02/07/72
* 4119.00 266.988775 193. 0R811 1967 11 A P111 P111 41121.000000 278.9842804357 183.9209141956 39.9582167241 0512020105	13.8603175790 4.8333E-05 000 2.46939ñ8979 497417 39.960144 0505690 .96 41121 41119.0 41123.0 Pôt Pīlt P31111 6.000000 5.9838915964 -4.7432149815	-8.3451E-07 43469 13.8663 2.6791	76 7,3207118 288 02/07/72
* 41119.00 266.988775 193. 0RBIT 1967 11 A P111 P111 41121.000000 278.9842804357 183.9209141956 39.9582167241 .0512030195	13.8603175790 4.8333E-05 000 2.46939ñ8979 407417 39.960144 .0505690 .96 41121 41119.0 41123.0 Pñt Pilt P31111 0.000000 5.9838915964 -4.7432149815 0000000742 0000000742	-8.3451E-07 43469 13.8663 2.6791	75 7,3207118 268 02/07/72
* 41119.00 266.988775 193. 0RB1T 1967 11 A P111 P111 41121.000000 278.9842804357 183.9209141956 39.9582167241 .0512020195 .6849119189	13.8603175790 4.8333E-05 000 2.46939ñ8979 407417 39.960144 .0505690 .96 41121 41119.0 41123.0 Pñt P11t P31111 0.000000 5.9838915964 -4.7432149815 0000000742 13.8693263311 4.0381E-06	-8.3451E-07 43469 13.8603 2.6791 6.7345E-07	75 7,3207118 288 02/07/72
* 4119.00 266.988775 193. 0R811 1967 11 A P111 P111 41121.000000 278.9842804357 183.9209141956 39.9582167241 .0512020195 .6849119189 * 41121.00	13.8603175790 4.8333E-05 000 2.46939ñ8979 407417 39.960144 .0505690 .96 41121 41119.0 41123.0 Pñt Pilt P31111 0.000000 5.9838915964 -4.7432149815 000000742 13.8693263311 4.0381E-06 000 2.679ñ791398	-8.3451E-07 43469 13.8603 2.6791 6.7345E-07	75 7,3207118 288 02/07/72
* 41119.00 266.988775 193. 0RB11 1967 11 A P111 P111 41121.000000 278.9842804357 183.9209141956 39.9582167241 .0512030195 .6849119189 * 41121.00 279.073796 183.	13.8603175790 4.8333E-05 000 2.46939ñ8979 407417 39.960144 .0505690 .96 41121 41119.0 41123.0 Pñt Pill P31111 0.000000 5.9838915964 -4.7432149815 000000742 13.8603263311 4.0381E-06 000 2.679ñ791398 921352 39.96nñ74 .0506740 .68	-8.3451E-07 43469 13.8603 2.6791 6.7345E-07 46618 13.96032	263 7,3207087
* 4119.00 266.988775 193. 0RBII 1967 11 A P111 P111 41121.000000 278.9842804357 183.9209141956 39.9582167241 .0512020195 .6849119189 * 41121.00 279.073796 183.	$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	-8.3451E-07 43469 13.8603 2.6791 6.7345E-07 46618 13.9603;	263 7.3207118 288 02/07/72
* 4119.00 266.988775 193. 0RBII 1967 11 A P111 P111 41121.000000 278.9842804357 183.9209141956 39.9582167241 .0512020195 .6849119189 * 41121.00 279.073796 183.	13.8603175790       4.8333E-05         000       2.46939ñ8979         407417       39.960144       0505690       .96         41121       41119.0       41123.0         Pñt       Pīli       P31111         0.00000       5.9838915964       .96         -4.7432149815      0000000742         13.8693263311       4.0381E-06         050       2.6790791398         921352       39.960074       .0506740       .68	-8.3451E-07 43469 13.8603 2.6791 6.7345E-07 46618 13.86032	263 7.3207118 289 02/07/72

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174.4347652172	-4.74279	101671		
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.4055737068	13+86033	383858 3•694nE=06	-7.3818E-07	
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41125.000000		0		
302 9307628383	5.00198	21959		
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	+ 1420	91213		
39,9531511280				
.0512022339	00000	97469		
1262545565	13.86033	697 <u>78 6.5994E-05</u>	7,1384E-07	
* 41125_0	0000	2.1789314531		
303 246690 144	950646	39.059752 0507450	1253749 13.8483378	7. 2007050
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196/11 A	- 4]	127 41125.9 41129	· 9 2 • 5 <del>3</del> 96 1	79-02/07//2
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	E 00533	Seane		• .
314.9010103468	2,20024			
155,4589862729	•4.74371	/5564		
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.0511998217	00000	162/6 87505 8-0150E=06	1.5964F=ñ6	
.0511998217 .8469983191		162/6 87505 8.0150E=06 2.5896001736	Ī.5864E-06	
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.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.8603 10000 5.467988	15276 87585 2.5896801786 39.960759 .0508089	Ī.5864E∼06 .845846õ l3.86ñ3788	7.3206903
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.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.86.23 10000 5.46.7988	152/6 87505 8.0150E-06 2.5896001736 39.960759 .0508089	1.5864E-06 .8458460 13.860378A	7.3206903
.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.86.237 10000 5.46.7988	152/6 87505 8.0150E-06 2.5896001736 39.960759 .0508089	1.5864E-06 .8458460 13.8603788	7.3206903
.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.86237 10000 5.467988	152/6 87505 8.0150E-06 2.5896001736 39.960759 .0508089	Ī.5864E-0̂6 .845846õ l3.86ñ3788	7.3206903
.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.86.23 0000 .46.7988	152/6 87505 8.0150E-06 2.5896001736 39.960759 .0508089	1.5864E-06 .8458460 13.8603788	7.3206903
.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.86.23 0000 5.46.7988	152/6 87505 8.0150E-06 2.5896001736 39.960759 .0508089	Ĩ.5864E-Ô6 .845846õ l3.86ñ3788	7.3206903
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.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.86.237 0000 5.46.7988	152/6 87505 8.0150E=06 2.5896001736 39.960759 .0508089	Ĩ.5864E-Ô6 .845846Õ l3.86∩3788	7.3206903
.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.86.23 0000 .46.7988	15276 87505 8.0150E-06 2.5896001736 39.960759 .0508089	Ĩ.5864E-Ô6 .845846Õ l3.86∩3788	7.3206903
.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.86.23 0000 .46.7988	152/6 87505 8.0150E-06 2.5896001736 39.960759 .0508089	Ĩ.5864E-Ô6 .845846Õ l3.86∩3788	7.3206903
.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.86.23 0000 .46.7988	152/6 87505 8.0150E-06 2.5896001736 39.960759 .0508089	<b>1.5864E-0̂6</b> .8458460̂ 13.86∩̂3788	7.3206903
.0511998217 .8469983191 * 41127.0 315.313500 155	0000 13.86.23 0000 .46.7988	15276 87505 8.0150E-06 2.5896001736 39.960759 .0508089	<b>1.5864E-0̂6</b> .8458460̂ 13.86∩̂3788	7.3206903
.0511998217 .8469983191 * 41127.0 315.313500 155	0000 3.86.23 0000 .46.7988	152/6 87505 8.0150E-06 2.5896001776 39.960759 .0508089	Ĩ.5864E-Ô6 .845846õ l3.86ñ3788 !	7.3206903
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168.2220309987-	-4.2226936477			
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.0840063953	0000017948			
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159.7766831 <u>9</u> 38	-4.2226137172			
39.4323254836		·		
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39.4321122199				
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117.54955559994	-4.2226265066			
39.4320777365				·
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109-1042451757	-4.2224448856			
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39.4311001482	-4+22(1371135	-		
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71-076043-241-	9971	32708969	91705 12-9306	52-7-7073317-
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41039.000000	0.00000			
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115.5034641684 .0319698798 .0231064983 41041,0000 64.765472 247,2 ORAIT 68 002-01 P111 P111 41043,000000 60.8214587189 250.1019213372 105.8128717012 .0319558971 .6844686197 41043,0000	0000349589 0000001878 12.3326697521 5. 10 1.2975326434 97745 105.808871 .0 41043 41041.0 P111 P111 0.000000 -1.5321711422 1.4614846411 .0019313604 0004076201 12.8306892842 3. 0 2.2157926317	9624E=07 327534 • 02 <u>41045</u> •0 231111 231111	Ĩ•6325E÷Ŏ7 12094 12•83ñ6A 2•2158 9•8511E=07	9á 7.7073059 <u>147 01/13/</u> 72
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255.7047331554	1.4:14459745			
105.8105538974	. 001-168119			
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47.8596429412	-1.6209658863			
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105.8122220130	.0010485445			
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195.8149402520	• 300/44304	9		
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41071.00 16.948616 289 ORBIT 1968 02 A P111 P111 41072.0000001 13.8250735975 290.7280908759 105.8155077341 .0319901514 2264723868 ORBIT 1968 02 A P111 P111 41074.000000 10.5855345732 293.5310797656 195.8157544648 .0319870481 .4348428748 OR9IT 1968 02 A P111 P111 41076.000000 7.3449949349 296.3326777784 105.8154842189 .1319887192	$   \begin{array}{r}     12.533543134 \\     2000 & 1.7 \\     2.323773 & 105.8 \\     41072 \\     p51 & p \\     0.00000 \\     -1.519284753 \\     1.401056379 \\    900001617 \\     12.830656474 \\     41074 \\     P51 & p \\     0.000000 \\     -1.620110174 \\     1.401653224 \\    000002797 \\     12.830557904 \\     \hline     41076 \\     p51 & p \\     0.00002797 \\     12.830557904 \\     \hline     41076 \\     p51 & p \\     0.00002797 \\     12.830557904 \\     \hline     41076 \\     p51 & p \\     0.900000 \\     -1.618472195 \\     1.400366046 \\     .000053223 \\   \end{array} $	9 -2.1864E - 07 992080272 17058 .0322174 41070.0 41074 111 P3111 2 7 5 2 2.3396E - 07 41072.0 41076 111 P31111 5 6 3 0 1.2768E - 07 41074.0 41978 111 P31111 9 7 3	3.5256F-07 .9386940 12.830 0 2.6648 -1.7306E-07 0 1.4781 3.3782E-07 0 1.4371	6431 7.7073165 221 12/11/71 148 12/11/71
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299.1344969840	1.4010847351			
145.8161955331				
.1319930790	.0000021890			
.7574652497	12,8306561187	-3.113[E-07	-2-1909E-07	· · ·
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301.9369725115	1.4011893770			
105.8160392826		· · · · · · · · ·	•	
• 0319928481	0000094794			
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105.8178461453			4 -	· · ·
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7414900515	12.8346654727	5.6716E-96	2.2177E-06	
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1968 62 A	41186	41084.0 41088.0	1.1253	106 12/11/71
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41086,000000	0.00000		. ,	
=8.944367793i	-1.6125128490			
310.3435514435	1.4010979459			
105.8170127497				
.0319979320	0000051096			
.4027687798	12.9306400196	-2.3215E-06	4-3363E-07	
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313.1455922367	· 1.4010142024		•	
105.816/060701				
.0319950943	000004382			
.0640123782	12.8306556139	4.4012E-08	4-45595-08	
.0640123782 -	12.8306556139	4.4012E-08	4.4559E-08	
.0640123782	12.8306556139	4.4012E-08	4,4554 <u>5</u> -08	

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41090.000000	ō•00000		
-15.3133466587	-1.6175595365		
315.9478289151	1.4711659765		
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.0319958860	.0000014746		
.7253163776	12.8306534135 -1.4203E-07	-6.3356E-08	
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1968 n 2 A	41094 41092.0 41096.0	2,4487	58 12/16/71
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-21.7682518174	-1.6353149289		
341.5530547954	1.4005905155		· · · ·
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1968 ñ2 A         P111         41098.000000         -28.2471500180         327.1558633700         105.8167910325         .0319915315         .3705151548         ORFIT         68.02 A         P111         P111         .030000	41098 41096.0 41100.0 PI PIII P31111 3.000000 -1.6123090115 1.4006324515 0000036248 12.8306344298 -2.9539E=06 41109 41107.0 41111.0 P1 PI11 P31111 0.000000 -2.1297616666	1.6406 -1.68165-07 30.4275	125 12/17/71 64 12/10/71
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1968       n2       A         P111       P111         41098.000000         -28.2471500180         327.1558033700         105.8167910325         .0319915315         .3705151548         ORFIT         68.02         P111         P111         P111         911         911         911         911         911         911         911         911         911         913         914.0001977436         342.5859920640         105.7416243322         .0319925419         .5076033627	41098 41096.0 41100.0 P1 P111 P31111 3.000000 -1.6123090115 1.4006324515 0000036248 12.8306344298 -2.9539E-06 41109 41107.0 41111.0 P1 P111 P31111 0.000000 -2.1297616666 1.3998613846 .0001950227 12.8319921287 1.3543E-07	1.6406 -1.68165-07 30.4275 -5.69635-06	125 12/17/71 64 12/10/71
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68 62 A P111 P111 41119,000000 297.7114812318 356.5792988548 105.8170959259 .0319801035 .8144122964 ORFIT 68 62 A P111 P111 41121.000909 294.4676109251 359.3913583671 105.8173346757 .0319787613 .4757421622	4119 41 P-71 P111 0.000000 -1.6216985693 1.4010533924 .0000001552 12.8306637203 41121 41 P-71 P111 0.000000 -1.6203743430 1.4009648645 0000023853 12.8306608775	117.0 41121.0 P31111 1.0872E=07 119.0 41123.0 P31111 -1.5492E=07	4.0519 5.1313E-08 3.7784 -4.4726E-08	
68 62 A PI11 P111 41119,000000 297.7114812318 356.5792988548 105.8170909259 .0319801030 .8144122964 ORBIT 68 62 A P111 P111 41121.000909 294.4676109251 359.3913583671 105.8173346756 .0319787513 .4757421622 ORBIT	4119 41 P-71 P111 0.000000 -1.6216985693 1.4010533924 0000001552 12.8306637208 41121 41 P-71 P111 0.000000 -1.6203743435 1.4009548645 0000023853 12.8306608775	117.0 41121.0 P3111 1.0872E-07 119.0 41123.0 P3111 -1.5492E-07	4.0519 5.1313E-08 3.7784 -4.4726E-08	776 12/10/71 141 12/10/71
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68 02 A P111 P111 41119.000000 297.7114812318 356.5792988548 105.8170909259 .0319801030 .8144122964 ORFIT 68 02 A P111 P111 4121.000000 294.4676100251 359.3813583671 105.8173346751 .0319787613 .4757421622 ORFIT 68 02 A P111 P111	4119 41 P-71 P111 0.000000 -1.6216985693 1.4010533924 .000001552 12.8306637208 41121 41 P-71 P111 7.0000023853 12.8306608775 0000023853 12.8306608775 41123 41 P-1 P111 0000023853 12.8306608775	117.0 41121.0 P31111 1.0872E=07 119.0 41123.0 P31111 -1.5492E=07 121.0 41125.0 P3111	4.0519 5.1313E-08 3.7784 -4.4726E-08 1.5319	
68 02 A P111 P111 41119.000000 297.7114812318 356.5792988548 105.8170909259 .0319801030 .8144122964 ORFIT 68 02 A P111 P111 41721.000909 294.4676109251 359.3913583671 105.8173346750 .0319787613 .4757421622 ORAIT 68 02 A P111 P111 41123.000000	4119 41 P-71 P111 0.000000 -1.6216985693 1.4010533924 .0000001552 12.8306637208 41121 41 P-71 P111 7.00000023853 12.8306608775 -41123 41 P-71 P111 2.000000	117.0 41121.0 P31111 1.0872E-07 119.0 41123.0 P31111 -1.5492E-07 121.0 41125.0 P31111	4.0519 5.1313E-08 3.7784 -4.4726E-08 1.5319	<ul> <li>&gt;76 12/10/71</li> <li>141 12/10/71</li> <li>132 12/10/71</li> </ul>
68 02 A P111 P111 41119.000000 297.7114812318 356.5792988548 105.8170909259 0319801030 .8144122964 ORFIT 68 02 A P111 P111 4121.000909 294.4676109251 359.3913583671 105.8173346751 .0319787613 .4757421622 ORAIT 68 02 A P111 P111 41123.000600 291.2253927974	41119 41 P-71 P111 0.000000 -1.6216985693 1.4010533924 .0000061552 12.8306637208 41121 41 P-01 P111 0.000000 -1.6203743430 1.4009648645 0000023853 12.8306608775 41123 41 P01 P111 0.00000 -1.6233076822 1.6233076822	117.0 41121.0 P31111 1.0872E-07 119.0 41123.0 P31111 -1.5492E-07 121.0 41125.0 P31111	4.0519 5.1313E-08 3.7784 -4.4726E-08 1.5319	<ul> <li>&gt;76 12/10/71</li> <li>141 12/10/71</li> <li>132 12/10/71</li> </ul>
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68 02 A P111 P111 41119,000000 297.7114812318 356.5792988548 105.8170909259 .0319801030 .8144122964 ORFIT 68 02 A P111 P111 4121.000900 294.4676109251 359.3913583671 105.8173346750 .0319787613 .4757421622 ORAIT 68 02 A P111 P111 41123.000600 291.2253927974 2.1836573916 105.8171233723	4119 41 P-71 P111 0.000000 -1.6216985693 1.4010533924 0000001552 12.8306637208 41121 41 P-71 P111 0.000000 -1.6203743430 1.4009648645 00000023853 12.8306608775 41123 41 P-71 P111 7.00000 -1.6233776822 1.401124853	117.0 41121.0 P31111 1.0872E-07 119.0 41123.0 P31111 -1.5492E-07 121.0 41125.0 P31111	4.0519 5.1313E-08 3.7784 -4.4726E-08 1.5319	776 12/10/71 141 12/10/71 132 12/10/71
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10.5908368436	1.4009210004		
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250.6758137652	-[-6247/6369]		
37.2099031685	1.401414/00/		. •
105.8156102960	•0008249557		
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41150.000000	0.00000		
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41152.000000	0•00 <u>0</u> 0		
244.1911591274	-1.6284051224		
42,8143108132	1,4013640157		
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240,9527601914	-1.5799613353		
45.6179551377	1.3979560605		
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234-4855746435	-1.6131910581		
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.2102263727	12.8306346172 7.40985-0	6 5.6897E-06	
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231.2250055446	-1.6086743907	i	
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105-8142698518	30098/2071		
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227.9844958583	==1.6075865045		
56.8247287895	1.4007035780		
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.0319910729	•000004607n		
.5329193615	12.8306240386 -1.2694E-0	6 8.9561E-07	
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1968 52 A	4 <u>1</u> 164 4 <u>1</u> 162 <u>, 3</u> 4 <u>1</u> 16	5.0 I.7609	131 12/10/71
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41164.0000nn	0.00000		
224.7679634899	-1.6118718592		
59.6271437481	1.4014248403	•	
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P111 P111	P111 P111 P31111		
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.0319877816			
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218-2647903200	-1.627719814		
65-2312001450	1,3994246317		
105.8137704249	.0003445700		
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1968 02 A	41170 41168.0 41172.0	1.0953	72 12/17/71
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68.0310333803	1.4000336342		
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1968 ñ2 A P111 P111 41172,000000 211,7971729899 70,9241296020	41172 41170.0 41174.0 P111 P111 P3111 0.000000 -1.6132572855 1.6005182817	•9700	173 12/17/71
1968 02 A P111 P111 41172.000000 211.7971720899 70.8341296928 105 8147676210	41172 41170.0 41174.0 P111 P111 P3111 0.000000 -1.6132572835 1.4005183817 - 0005294646	•9700	173 12/17/71
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1968 ō2 A P111 P111 41172.000000 211.7971729899 70.8341296928 105.8147676219 .0319923172 8396522694	41172 41170.0 41174.0 P111 P111 P3111 0.000000 -1.6132572855 1.4005183817 0005294646 .0000035353 12.8306364135 -6.22555-07	•9700 1 5281F=06	- <b>īī3 12/ī7/71</b>
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1968 62 A P111 P111 41184.000000 192.369163922 87.6437461823 105.8108983558 .0319962666 .8072847933 ORBIT 1968 62 A P117 P111 41188.000000 185.8703918437 93.2467765959 105.810720093 .0319969740 .1299456235 ORBIT 1968 62 A P111 P111 41190.000000 182.633696346 96.0479681931 105.8099964629 .031990979	41184 P111 P11 0.000000 -1.6062366303 1.4008227242 0000885715 0000019513 12.8306169714 41188 P111 P11 0.000000 -1.6147352719 1.4003027959 0000662665 0000016763 12.8306419495 41195 -41195 -2.020000 -1.6198838032 1.4005618227 9004471673 .0000006525	<pre>+j182;9 41186+0 P31j11 4.8816E=09 4.8816E=09 1186.0 41190.0 P31j11 5.0357E=08 si188.0 41192*0 P31j11</pre>	2.6971 1.5317E=06 3.1229 -1.8295E=06 1.7991 .7991	229 12/16/71 762 12/16/71 763 12/16/71
1968 02 A P111 P111 41184.000000 192.369163922 87.6437461823 105.8108983558 .0319962666 .8072847933 ORBIT 1968 02 A P117 P111 41188.000000 185.8703918437 93.2467775959 105.810720093 .0319969740 .1299456235 ORBIT 1968 02 A P111 P111 41190.000000 192.6330696346 96.0479681931 105.8099964629 .031990979 .031990979 .031990979 .031990979 .031990979 .031990979 .031990979	41184 P111 P11 0.000000 -1.6062366303 1.4008227242 0000885715 0000019513 12.8306169714 41188 P111 P11 0.000000 -1.6147352719 1.4003027959 000062665 0000016763 12.8306419495 41195 41195 000000 -1.5198838032 1.4005618227 0004471673 .000006525 12.9306528341	+ <u>j</u> 182,9 41186+0 P31j11 4.8816E-09 4.8816E-09 1186.0 41190.0 P31j11 5.0357E-08 -j188.0 41192*0 P31j11 -3.8208E-08	2.6971 1.5317E=06 3.1229 -1.8295E=06 1.7991 2.0140E=08	229-12/16/71 762 12/16/71 763 12/16/71
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Î66.029219       Î2.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         ORpIT       1970-109 A       41014       41012.0       41016.0       .6192       41       6192       41       6192       41       6192       41       6192       41       6192       41       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       6192       <
166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         ORBIT       1970-109 A       41014.00       41012.0       41016.0       .6192       4107/72         P110       P110       P010       P010       900000       41016.0       .6192       4107/72         41014.000000       .000000       .000000       .000000       .000000       .0000000
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166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         0RpIT       1970       109       A       41014       41012.0       41015.0       .6192       410727/72         P110       P110       P01       P111       P2111       P2111       1970.109.4       41014.000000       .000000         197.9042297792       13.06997800000       -6.9858900000       -6.9858900000       -6.9858900000         15.0017593658       -0000055207       -0000055207       -0000055207       -0000055207
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166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         0ReIT       1970-109 A       41014       41012.0       41015.0       .6192       4101/27/72         P110       P110       P01       P01       P111       P2111         41014.000000       .000000       .000000       .000000         192.9042297292       13.0699780000       .000000         192.9042297292       13.0699780000       .000000         192.9042297292       13.0699780000       .000000         192.9042297292       13.0699780000       .000000         192.9042297395       13.06997800000       .000000         .0164334004      0000355307       .0637E=05
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166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         ORBIT       1970       109       41014       41012.0       41015.0       .6192       4107/72         P110       P110       P01       P111       P2111       10       41014.000000       .000000         1970.9042297292       13.0699780000       .000000       .000000       .000000       .000000         192.9042297292       13.0699780000       .000000       .000000       .000000       .000000         192.9042297292       13.06997800000       .0000000       .0000000       .0000000       .0000000         192.9042297292       13.06997800000       .0000355307       .00164334004       .0000355307       .00164334004       .0000355307         .0164334004       .000003       .0191936779       .0163840       .9740347       14.8166391045       .0022183
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166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         0RgIT       1970.109 A       41014       41012.0       41015.0       .6192       4101/27/72         P110       P110       P01       P111       P2111       101/27/72         41014.000000       .000000       .000000       .000000       .000000         192.9042297292       13.06997800000       .000000       .000000         192.9042297292       13.06997800000       .000000       .0000000         192.9042297292       13.06997800000       .0000000       .0000000         192.9042297292       13.06997800000       .0000000       .0000000         15.0017593658       .016334004       .00000355307       .0163759350         .0164334004       .000000       .6191936779       .9740347       14.8166391       7.0022183         0RBIT       192.135180       -1.698220       15.0011933       .0163840       .9740347       14.8166391       7.0022183         0RBIT       1970       109 A       41014.0       41018.0       1.3377       36 01/27/72
166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         0Rait       1970.109 A       41014       41012.0       41015.0       .6192       410727/72         P110       P110       P01       P111       P2111       1014.000000       .000000         192.9042297292       13.0699780000       .000000       .000000       .000000       .000000         192.9042297292       13.0699780000       .01639780000       .0164334004       .0000355307       .0164334004       .0000355307         .0164334004      0000355307       .0163840       .9740347       14.8166391045       .0163840       .9740347       14.8166391       7.0022183         .0811       .92.135180       -1.698220       15.001933       .0163840       .9740347       14.8166391       7.0022183         0R811       .9010       .901       .9110       .9111       .92111       .9112       .9112         1970       109 A       41016       41014.0       41018.0       1.3377       36 01/27/72         P110       .9110       .9111       .92111       .92111       .92111       .9112
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166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         ORALT       1970-109 A       41014       41012.0       41015.0       .0192       410727/72         P110       P110       P110       P111       P2111       1014.000000       .000000         1970-109 A       .000000       .000000       .000000       .000000       .000000         1970-9042297392       13.06997800000       .000000       .000000       .000000       .000000         1970-9042297392       13.06997800000       .0000000       .0000000       .0000000       .0000000         1970-109 A       -00000355307       .0637E=05       .0163840       .9740347       14.8166391       .0022183         0RBIT       .9718056193       14.8166391045       3.0637E=05       .9740347       14.8166391       .0022183         0RBIT       .970-109 A       .41016       .9740347       14.8166391       .0022183         0RBIT       .9710       .9110       .9111       .9211       .9740347       14.8166391       .0027772         1970       109 A       .9110       .9111       .9211       .9211       .9000000       .9000000         218.9455178167
166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         ORBIT       1970       109 A       41014       41012.0       41015.0       .6192       41       01/27/72         P110       P110       P01       P111       P2111       11       11/27/72         41014.000000       .000000       .000000       .000000       .000000       .000000         192.9042297292       13.0699780000       .063750000       .063750000       .016434004       .0000355307         .0164334004      0000355307       .06375005       .0163840       .9740347       14.8166391       7.0022183         0RBIT       .92135180       -1.698220       15.001933       .0163840       .9740347       14.8166391       7.0022183         0RBIT       .970109       A       41016       41014.0       41018.0       1.3377       36       01/27/72         P10       P10       P10       P11       P211       .00000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .0000000       .0000000
166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         ORPIT       970109 A       41014       41012.0       41015.0       .6192       41072772         P110       P110       P01       P111       P2111       .000000       .000000         192.9042297292       13.0699780000       .000000       .000000       .000000       .000000         192.9042297292       13.0699780000       .000000       .000000       .000000       .000000         192.9042297292       13.06997800000       .0000355307       .016344169410       .0000355307       .0164334004       .0000355307         .0164334004       =.0000355307       .3.0637E=05       .16191360       .9740347       14.8166391       7.0022193         0RBIT       .9718856193       .14.8166391       .0163840       .9740347       14.8166391       7.0022193         0RBIT       .9710000       .6191933       .0163840       .9740347       14.8166391       7.0022193         0RBIT       .9710000       .6000000       .6191933       .0163840       .9740347       14.8166391       7.0022193         0RBIT       .9710       .911       .911       .9211       .013777       .3601/
166.029219       12.244823       15.002410       .0165589       .3498684       14.8164993       7.0022624         ORBIT       970-109 A       41014       41012.0       41015.0       .6192       410772         P110       P110       P01       P111       P2111       .000000       .000000         192.9042297292       13.0699780000       .000000       .000000       .000000       .000000         192.9042297292       13.0699780000       .000000       .000000       .000000       .000000         192.9042297292       13.0699780000       .000000       .000000       .0000000       .0007593658         .0164334004      0000355307       .0637E-05       .0637479       .0022103         .08817       .9718856193       .14.8166391045       .063840       .9740347       14.8166391       7.0022103         ORBIT       .9710       .910       .014       .0163840       .9740347       14.8166391       7.0022103         ORBIT       .910       .910       .911       .9111       .92111       .910227/72         P10       .910       .911       .9111       .92111       .91027/72       .91027/72         P10       .910       .911       .9111       .92
166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         0RPIT       1970109 A       41014.00000       .000000       .000000       .000000         1970109 A       41014.00000       .000000       .000000       .000000       .000000         1970109 A       41014.00000       .000000       .000000       .000000       .000000         192.9042297292       13.0697800000       .000000       .000000       .000000       .000000         192.9042297292       13.0697800000       .0000355307       .06378-05       .016334004       .0000355307         .0164334004       -0000355307       .06378-05       .01631840       .9740347       14.8166391       7.0022103         0RBIT       .0192       .0193       .0163840       .9740347       14.8166391       7.0022103         0RBIT       .0190       .000000       .000000       .000000       .000000       .000000         218.8455178157       .000000       .000000       .000000       .000000       .000000       .0000673615       .0000673615       .0000673615       .0000673615       .0000673615       .0000673615       .0000673615       .0000673615       .0000673615       .0000673615       .0000673615
166.029219       12.244823       15.002410       .0165589       .3498684       14.8164993       7.0022624         0RFIT       970109       A       41014       41012.0       41015.0       .6192       41       01/27/72         P110       P011       P111       P2111       41014.00000       .000000       192.9112       41014.00000       .000000         192.9342297292       13.06997800000       .0000355307       .0164334004      0000355307       .0164334004       .0000355307         .0164334004      0000355307       .0163840       .9740347       14.8166391       7.0022103         0R81T       .9710056193       14.48166391045       .3.0637E=05       .169334.016       .3377       36 01/27/72         910       P110       P111       P111       P2111       .0163840       .9740347       14.8156391       7.0022103         0R81T       .0109       A       41016       41014.0       41018.0       1.3377       36 01/27/72         910       P110       P111       P2111       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .000000       .0000000       .00527472       .000673615       .005
166.029219       12.244823       15.002410       .0165589       .3408684       14.8164993       7.0022624         0REIT       1970       104       41014       41012.0       41015.0       .0192       410172772         P110       P110       P011       P2111       P2111       1072772         41014.00000       .000000       .000000       .000000       .000000         192.9042297292       13.06997800000       .017593658       .01643340.00       .01635307       .0637E=05         .01643340.004       .6191936779       .0163840       .9740347       14.8166391       7.0022103         0881       1970.109 A       41016       41014.0       41018.0       1.3377       36 01/27/72         1970.109 A       41016       41014.0       41018.0       1.3377       36 01/27/72         1970.109 A       41016       41014.0       41018.0       1.3377       36 01/27/72         P110       P110       P111       P2111       12.0699780000       .13377       36 01/27/72         1970.109 A       41016       41014.0       41018.0       1.3377       36 01/27/72         P110       P110       P111       P2111       12.06997800000       .15.6549499273       -6.9858

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ORBIT				
1970 109 A	41019 4101	6.0 41020.0	1.9996	30 01/27/72
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7-010.000000				
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15.0011581222				
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·2365245070	14-8168323508	3.2126E-05		
41018.000	00 1.9995933	3979		
245-652074-29	602071 15-001893	- ñ 162261	374297 14-8168	24-7-0021575
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	() A 2 A	8 1		95 01/27/72
P110 P110		PZIII		
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272.6066486971	13,0699780000	,		
-43.6072726300-	-6.9858900000			
15 0078452473				
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9600210776	1/ 9168059102	-2 25145-05		
.0070219778				•
41020-0000	00 2.0134058	51.33		al a staitore
272.642926 -43.0	607101 15.008649	.0161931 .8	689197 14.81689	158 7.00213/5
ORBIT				
1970 109 A	41039 4103	6.0 41040.0	.8583	28 01/27/72
P110 P110	pi1pi1i	P2111		
A1039 00000	-1.000000			
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190.8840/85948	=0+01010000			
14.9924524901				
.0165018339	0000773456			
4256-54425	14.8176712168	3.3799E-05		
41038.000	.8582907	454		· · · · · · · · · · · · · · · · · · ·
150-017648 190-0	880564 14.992556	.0166141 .5	762867 14-81760	12 7.0019152
OPDIT				
		9-0	70 <u>05</u>	
12/0-104 A	<u>+1140</u> 4103			
P110 P110	- <b>b</b> <u>v</u> <b>i</b> - <b>b</b> <u>i</u> <u>i</u> <u>i</u>	P6111		
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176.9637711690	13-231300000			
176.9004533522	-6.9791030000			
14.9965354818				
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176.176491 176.0	896531 14,99648/	• *163855 • 2	125555 14.81774	<u>91 7.0018086</u>
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1970 109 A	41042 4104	0.0 41044.0	2.8939	50 01/27/72
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A1042 000000				
505697500F	-12-231300000			
162.97/1833638	-0.4141030000			· · · · · · · · · · · · · · · · · · ·
14.9974537526				
.0163366134	0000854290	_		
.8454633090	14.8178828683	4.4414E-05		
41042.0000	2.8939663	027		
202 866874 162 0	272657 14 007768		474297 14 81799	20 7 0018265
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ORALT 31 01/27/72 1970-109 A 41744 41042.0 41046.0 1.0042 PI11 P2111 P110 P01 P110 41044.000000 .000000. 229.9226581588 149.0432009885 -5.9791830008 14.9958412161 -.0000780994 .0163243337 .4816972316 14.8180543923 3.250AE-05 41044.00000 1.0041568058 229.407910 149.040762 14.996450 0161499 4831353 14.8180544 7.0017725 OREIT 1970-109 A 41046 41044.0 41048.0 1.3560 77 01/27/72 Þŋl P110 P110. P111 41046.000000 +000000 256,7004040101 13.231300000 135,0745n54124 -6,979103000n 14 9947531524 .0000165588 .0163056117 .1171541725 14.8182676546 4.91345-05 1.3560215758 41046.00000 256.515836 135.073642 14.995530 .0160829 .1176698 14.8182677 7.0017053 ORRIT 41046.0 41050.0 1.3037 54 11/27/72 1970 109 A P01 P111 P2111 P110 P110 41048.000000 .000000 283.2032100914 13,231300000 121,1217506888 -5.9791030000 14.9926911854 .0162915214 -.0000119598 .7537623959 14.81847∴9852 4.8760F-05 1,3237049448 41048.00000 283.386594 121.122607 14,993468 .0160687 .7532501 14.8184710 7.0016412 ORBIT =1970=109 A \_\_\_\_\_41050 \_\_41048.0 \_\_41052.0 \_\_\_\_5989 12 01/27/72 P110 P110 P31 P111 P2111 41050.000000 .000000 13.231300000 309.7159209709 -6.9791030000 107.1522774642 15.0112820179 .0162767959 0000195378 .3907837941 14.818685651 6.44376-05 41050.00000 .5989923620 310.228916 197.154697 15.011893 .0151012 .3893507 14.8186857 7.0015736 ORPIT 44 01/27/72 41052 41050.0 41054.0 .6394 1970 109 A pl10= pl10 pl1 pl1 pl1 41052.000000 336.2479283687 13.231300000 93.1647466374 -5.9791030000 15.0142015670 .0000125002 .0162904078 .0283002030 14-8189431450 6-4<del>277E-05</del> 41052.00000 .5394289474 336.978902 93.168269 15.014517 .0161997 .0262579 14.8189431 7.0014925

ORALT		
1970 109 A		
P110 P110	P51 41054 41052.0 41056.0 1.0063 84 01/27/72	
41054,000000	-010000	
2.7256270133	17-231 200000	
79.2596721468	-5 9791737777	
15,0075616685	717 274 (5) 9 9 9 4	
0162825557	- 0000045520	
.6662522403		
41054.00	1.006313002	
3.518222 79	263581-15-077512	
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1970 109 A	41056 41054 41059 0	
P110 P110	Pal 2111 Parts 41038.0 1.6202 86 01/27/12	
41056.000000	•000000	
29.2176691756	13.2313000000	·
65.3046785464	-6,979103000n	
14.9995626573		
.0162772718	.000001979A	
.3048175320	14.8194815092 7.82925-05	
41056-00	00 1+2202134497	
29.905120 65	308151 14.999173 .CI63893 .3028962 14.8194815 7 0013230	
URALI		
1970 169 A	41078 41076.0 41080.0 1.2164 94 01/26/72	
F110 P110	P01 P11 P2111	
410/8.000000	0.00000	
340.5956965347	13.2313000000	·
2/1./690667966	-6+9779800000	
14.9976494841		
• 0162098124	• 0000593937	
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	1.2164003330	
0PDIT	12594 14.998149 .0160657 .3559574 14.8212304 7.0007722	
41089 000000	P01 P11 P211	
147,0521275960		
257-8154677389	75+251500000n 76-077900000n	
14.99712566449	A • • • • • • • • • • • • • • • • • • •	
.0002864568	14.8213324141 1.225/5-05	
41080.000	( 1-77)7095816	
347.827124 257.	19235 14.997298 0162446 - 0010200 1/ 02	
ORBIT	• 0918/90 14-8213324 7-0007401	_
1970 109 A	41082 41080.0 41084.0 2 1062	
110P110	P01P111P21112.1982 80 01/26/72	
41082.000000	······································	
13-5491920826	13.2313000000	
243-8539724895	-6.977980000	
14.9967707723		
·0163092858	•0000356795	
.6429352798	14-8214496016 5-4071F-05	
41082.0000	2.1962220098	
14.316223 243.8	78:6 14.996580 .0163641 .6407917 14-8214/96 7 0057020	
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41084 000000	ő.oonoőo	L # f 7 +		
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229.8909187079	-6-9779800000			
14,9975169521				
.0163153847	.0000082698			
.2857767936	14-8214937713	2.1241E-05		
41084-000	1.742023	7143		
40-640090-229	893997 14.997775		41004 14-8214	38 7,0006892
ORPIT				
1970 109 A	41086 410	84.0 41088.0	.8618	76 01/26/72
P110 P110		P2111		
41086.000000	8.00000			· · · · · ·
66.5858714771	13.2313000000	· · · · · · · · · · · · · · · · · · ·		• •
215-9119699331	-6.9779806000			
14-9969637973				
0163106085	0000118568			
9286924360	14.9215920256	2.13605-05		
41086.000	.801786	5649		
66.895706 215.	913583 14.996240	.0165182 .92	278263 14.82159	26 7.0006583
ORRIT				
1970-109 A	41088 4101	86.0 41090+0	1.0530	52 01/26/72
P110 P110	P01	P2111		
41088.000000	0.00000			
93,0307837754	13.2313000000		•	``
201.9794654965	-6.9779800000	;		·.
14,9941307780				
.0163473941	.0000550941			
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41089.000	1.0 <u>9</u> 1.052985	5560		
92.989729 201.	979250 14.993343	.0165727 .57	20714 14.82169	062 7.0006255
ORBIT				· · · · · · · · · · · · · · · · · · ·
1970-109-A	41090 4108	38.0-41092.0	1+5629	90-01/26/72
P110 P110	P01 P111	P2111		
41090.000000	C•000000			
<u>119-2477380010</u>	<u> 13-5313060000</u>			
187.9916531073	-6.9779800000			
14.9982512752		, f	,	
.0163426456	000012096			
,2162916908	14-8218355315	3.12915-05		
41090.000	1.561975	3801		
118.867211 187.	989669 14.997561	.0165402 .21	73554 14.82183	155 7.0005816
ORBIT	· ••• • ••• •			T. 77
1970 109 A	41109 4110	0/.0 <u>41111.0</u>	•7052	76 01/27//2
P10	P,1	PZII		
41109,000000	.00000			
11,1522322900	13.2313030000			
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14,9942681818				,
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.8361/24099	14.925019489	2-01956-05		
41109.000	00 7152227	/1[8		
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41111.000000 .00000	
37.6184686554 13.2313000000	
41.4035740097 -6.9791610000	
14-9917852116	
.0162511999 .0000211312	
.4814669023 14.8227127571 2.9754E=05	
41111.00000 .7817104074	
38.241582 41.406734 14.993301 0163905 4797253 14.8227128 7.0003054	
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197A 140 A (1113 A111 A A115 A 7037 78 A1/27/12	
•0162697125 •0000092814	
•1270817136 14•8228244981 2•7563E=05	
41113.00000 .79372/5/65	:
64.406364 21.437448 14.99/284 .0164732 .1261257 14.8228245 7.0002/02	
OREIT	
$1970 109 A = 41115 41113 \cdot 0 41117 \cdot 0 2 \cdot 1062 93 01/27772$	
<u>P110 P110 P01 P111 P2114</u>	
41115.000000 .000000	
90.4616968917 13.2313000000	
13.4749373388 -6.9791610000	
14.9996952416	
• 016262569n =• 0000004660n	
.7730285179 14.8229310793 2.5361E=05	_
41115.00000 2.1062156613	
90.455404 13.474905 14.998905 .0164883 .7730461 14.8229311 7.0002367	
ORAIT	
1970 109 A 41117 41115 0 41119 0 12 8867 140 1727/72	
P110 P110 P01 P111 P2111	
AL117 000000	
116,8956227249 13,2313000000	
- 4853875190 -6.9791610000	
14,9998017867	
4190745818 14 8230330602 2 6886F=05	
110,341313 -440/210 14,999(00 -0(04707 -4600030 14+023033) /*0002040	
1970 109 A 91119 41111.0 41121.00 1.4955 (18 01/2//2	
-14.4525639635 -5.9/91610000	
14.9988456954	
.0162548082	
.0652135344 [4.823133259] 2.4929E=05	
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142.743686 -14.455768 14.998372 .0163911 .0669788 14.8231333 7.0001730	

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-1970 109 A	41121 411	19.0 41123.0 1.4	929 97 01/27/72
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41121.000000	.000000-		
169-9495217685	3.23130000		
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0162353122	- 0000175922		
7115650044	14-8232340779	2.52475-05	
411200040	1.492336	5808	
160 68531 - 28		71-274-74	-14-922247-7-0001413-
=09617			
	41123 411		
		P2111	
41123,000000	•000000		
196.3032519744	13.5313000000		
-42,3761315558	-6-9791610009		
14.9986873173			
,0161947374	0000209343		
.3581449965	14.8233139472	1.84035-05	
41123.00	•489641	5741	د. ۲۰۰۰ محمد بر به ۲۰۰۰ و در سرد داد است.
<u> </u>	.379812 14.998904	.0161322 .3602924	14.8233139 7.0001161
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-1970 109 A	41175 411	73 . 41177.0 1.7	166 57 01/27/72
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41175.000000	-1.000000		
165,1661015790	13.231300000		
314 5214493940	-6.9843190000		· · ·
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300-5495962155	-6.9843190000		
14.9970465989			
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.8641365657	14.8250775960	1.9095E-05	
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190.905303 300	•54584! <u>14•997201</u>	.0161025 .8062310	14.8250775 6.9995610
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1970 109 A	41179 411	77.0 41181.0 2.2	346 62 01/27/72
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41179,000000	.999000		
218.262333774	13.231300000		
286,5775438954	-6.9843190000		
14,9955314669		· · ·	
0161679425			
S1-20407795	.0000007012	5-2514F-05	
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## A NOTE ON THE RELATIONSHIP AND AGREEMENT BETWEEN TWO SATELLITE THEORIES

### K. Aksnes

We shall refer to the two theories under consideration as theory A (Gaposchkin, Cherniack, Briggs, and Benima, 1971; Kozai, 1962) and theory B (Aksnes, 1970). The main purpose here is to introduce some simple theoretical relations by means of which, when the elements of one theory are given, we can predict those of the other.

Theory B differs from theory A in that the former makes use of 1) a reference orbit that is a rotating ellipse (intermediate orbit) instead of a fixed ellipse, 2) Hill variables instead of Delaunay variables, and 3) Hori's method in Lie series rather than Von Zeipel's method in Taylor series.

In both theories, the periodic perturbations are expressed as deviations from a <u>mean orbit</u> whose elements are semimajor axis a, eccentricity e, mean anomaly M, inclination i, argument of perigee  $\omega$ , and right ascension of the ascending node  $\Omega$ . To distinguish between the two sets of elements, we shall attach a subscript "0" to those of theory A. Although, strictly speaking, the formulas introduced below are valid only if the mean elements are constants or linear functions of time, they should also be sufficiently good approximations if the mean elements are allowed to contain long-period terms, as is the case with the SAO mean elements.

For convenience, M,  $\omega$ , and  $\Omega$  have been so defined that

$$\mathbf{M} = \mathbf{M}_0, \quad \boldsymbol{\omega} = \boldsymbol{\omega}_0, \quad \boldsymbol{\Omega} = \boldsymbol{\Omega}_0 \quad . \tag{1}$$

However, internally, theory B utilizes a set of elements g and h that differ from  $\omega$  and  $\Omega$  by the amount of rotation that the intermediate orbit is undergoing, viz.,

$$ω = g + g_{21}(g + M)$$
,  $Ω = h + g_{32}(ω + M)$ , (2)

where

$$g_{21} = -\frac{3}{4}\gamma (1 - 5c^2) - \frac{1}{64}\gamma^2 (41 + 30c^2 - 135c^4) + 0(\gamma^3) ,$$
  

$$g_{32} = -\frac{3}{16}c [8\gamma + \gamma^2(7 - 33c^2)] + 0(\gamma^3) .$$
(3)

Here and in the following, we have used the notation

c = cos i , n = 
$$\sqrt{\mu/a^3}$$
 ,  $\eta = \sqrt{1 - e^2}$  , G =  $\eta \sqrt{\mu a}$  ,  
 $\gamma = \frac{J_2}{a^2 \eta^4}$  ,  $\gamma_4 = \frac{J_4}{J_2^2}$  ,

where a is measured in earth radii. The mean rates of change of  $\rm M_0,\ \omega_0,\ and\ \Omega_0$  are given by

$$\begin{split} \dot{M}_{0} &= n_{0} - \frac{3}{4} n_{0} \gamma_{0} \eta_{0} \left\{ 1 - 3c_{0}^{2} - \frac{1}{32} \gamma_{0} \left[ 10(1 - 6c_{0}^{2} + 13c_{0}^{4}) - 5(5 - 18c_{0}^{2} + 5c_{0}^{4}) e_{0}^{2} + 16\eta_{0} (1 - 6c_{0}^{2} + 9c_{0}^{4}) - 15\gamma_{4} (3 - 30c_{0}^{2} + 35c_{0}^{4}) e_{0}^{2} \right] \right\} + 0(\gamma^{3}) , \end{split}$$

$$\begin{split} \dot{\omega}_{0} &= -\frac{3}{4} n_{0} \gamma_{0} \left\{ 1 - 5c_{0}^{2} + \frac{1}{32} \gamma_{0} \left[ 2(5 + 43c_{0}^{2})(1 - 5c_{0}^{2}) + (25 - 126c_{0}^{2} + 45c_{0}^{4}) e_{0}^{2} - 24\eta_{0} (1 - 8c_{0}^{2} + 15c_{0}^{4}) + 20\gamma_{4} (3 - 36c_{0}^{2} + 49c_{0}^{4}) + 45\gamma_{4} (1 - 14c_{0}^{2} + 21c_{0}^{4})e_{0}^{2} \right] \right\} + 0(\gamma^{3}) , \end{split}$$

$$\end{split}$$

and

$$\hat{\Omega}_{0} = -\frac{3}{2}n_{0}\gamma_{0}c_{0}\left\{1 - \frac{1}{16}\gamma_{0}\left[4 - 40c_{0}^{2} - (9 - 5c_{0}^{2})e_{0}^{2} + 12\eta_{0}(1 - 3c_{0}^{2}) - 5\gamma_{4}(3 - 7c_{0}^{2})(2 + 3e_{0}^{2})\right]\right\} + 0(\gamma^{3}) \quad .$$
(6)

These are invariant rates, and although expressed differently, they must be equal individually to  $\dot{M}$ ,  $\dot{\omega}$ , and  $\dot{\Omega}$ , which are given by

$$\dot{M} = n + \frac{3}{128} n\gamma^2 \eta \left[ 8(1 - 6c^2 + 5c^4) - 5(5 - 18c^2 + 5c^4) e^2 - 15\gamma_4(3 - 30c^2 + 35c^4) e^2 \right] + 0(\gamma^3) , \qquad (7)$$

$$\begin{split} & \omega = g + g_{21} (g + M) , \\ \dot{g} &= -\frac{1}{128} n\gamma^2 \left[ 44 - 300c^4 + (75 - 378c^2 + 135c^4) e^2 + 60\gamma_4 (3 - 36c^2 + 49c^4) \right] \\ &+ 135\gamma_4 (1 - 14c^2 + 21c^4) e^2 + 0(\gamma^3) , \end{split}$$
(8)

and

$$\dot{\Omega} = \dot{h} + g_{32}(\dot{\omega} + \dot{M}) , \qquad (9)$$
  
$$\dot{h} = \frac{3}{32} \operatorname{nc\gamma}^{2} [2 - 10c^{2} - (9 - 5c^{2})e^{2} - 5\gamma_{4}(3 - 7c^{2})(2 + 3e^{2})] + 0(\gamma^{3}) .$$

Aksnes (1970) has shown that the elements a, e, and i relate to  $a_0$ ,  $e_0$ , and  $i_0$  through the following equations:

$$\frac{1}{a} = \frac{1}{a_0} \left\{ 1 - \frac{1}{2} \eta_0 \gamma_0 (1 - 3c_0^2) + \frac{1}{32} \eta_0 \gamma_0^2 \left[ 1 + 6\eta_0 - (6 + 36\eta_0) c_0^2 + (45 + 54\eta_0) c_0^4 \right] \right\} + 0(\gamma^3) , \qquad (10)$$

$$G = G_0 \left[ 1 + \frac{1}{4} \gamma_0 \left( 1 - 3c_0^2 \right) \right] + 0(\gamma^2) , \qquad (11)$$

and

$$c = c_0 \left[ 1 + \frac{3}{4} \gamma_0 \left( 1 - c_0^2 \right) \right] + 0(\gamma^2) \quad .$$
 (12)

While the third-order parts of equations (3) to (9) are available in the cited literature, the terms beyond the second order in equation (10) and the first order in equations (11) and (12) are not known.

For conversion between the two sets of mean elements, equations (1) and (10) to (12) will suffice. In view of the importance of these equations, we have tested them on the orbits of three actual satellites (Table 1). The first two sets of elements have been derived by fitting theory A (line 1) and theory B (line 2) to a series of mostly very accurate laser observations in the manner described by Gaposchkin and Mendes ("Orbital Elements from ISAGEX Data," this volume). The third line shows the elements predicted for theory B by means of the above-mentioned equations and the elements on line 1. The agreement between the last two sets of elements is very good and well within standard errors. The two theories agree on the computed ranges to a few tenths of a meter.

Satellite	Theory	a	е	i	М	΄ ω	Ω
6701401, 261 observations	( A	1.1925238	0.0838280	39: 44949	33:64344	194: 54493	1 <b>34: 43624</b>
	В	1.1921616	0.0838340	39.43323	33.64344	194.54491	134. 43625
	( B (Pred.)	1.1921616	0.0838329	39.43321	33.64344	194.54493	134.43624
6508901, 241 observations	( A	1.2656913	0.0721680	59.38145	294.47892	24.26520	265.05593
	Зв	1.2657869	0.0721670	59.36859	294.47892	24.26519	<b>26</b> 5. <b>05594</b>
	(B (Pred.)	1.2657869	0.0721664	59.36859	294.47892	24.26520	265.05593
6800201, 138 observations	( A	1.2080431	0.0320070	105.80768	149. 20308	2.42648	301.93324
	ζв	1.2083920	0.0320040	105.81605	149.20308	2.42648	301.93324
	( B (Pred.)	1.2083920	0.0320045	105.81605	149.20308	2.42648	301.93324

Table 1. Comparison of mean elements for three satellites at epoch 41080.0.

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KOZAI, Y.

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### ABBREVIATIONS USED IN THIS REPORT

BIH	Bureau International de l'Heure			
CNES	Centre National d'Etudes Spatiales			
EPSOC	Earth Physics Satellite Observation Campaign			
GOCC	Geodetic Operations Control Center			
GSFC	Goddard Space Flight Center			
IGY	International Geophysical Year			
ISAGEX	International Satellite Geodesy Experiment			
NASA	National Aeronautics and Space Administration			
NTU	National Technical University, Athens, Greece			
PMT	Photomultiplier Tube			
SAO	Smithsonian Astrophysical Observatory			
USNO	United States Naval Observatory			

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