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TECHNICAL EXPLANATION OF PROJECT ARGON

Orbital and Camera Requirements and Data Reduction Procedures

INTRODUCTION

The ARGON system employs statistical data processing techniques to convert rapidly the relatively inaccurate photographic ground and stellar data recovered from artificial earth satellites into an accurate world wide survey and global location reference system compatible with modern weapon system requirements.

The ARGON approach is both conventional and unconventional as compared to normal photogrammetry. It makes use of the data of exterior camera orientation which are available from orbits and which so far have not been available from aircraft producing normal aerial photography. Photogrammetric systems from other than satellite vehicles have not had the opportunity of taking into consideration the data used in this system for facilitating and expediting the ground data handling required to obtain world wide geodetic data of adequate operational accuracy in an extremely short time. The technique utilizes direct analytic methods and modern statistical mathematics and promises coherent world wide results on a uniform and unique world wide datum. This approach also eliminates the difficulties arising from the progression of errors inherent in all strictly conventional photogrammetric approaches.

The technique proceeds from photographic records produced by a mapping type camera in orbiting satellites producing ground and correlated star records simultaneously thus permitting fully the exploitation of exterior orientation data with a high degree of accuracy. Earlier studies indicate that strip type cameras must be excluded from consideration. Recent studies established that no advantage is to be gained from the use of convergent type cameras as far as accuracy or expediency of data processing is concerned and in addition poses a substantial weight problem. The Monticello statistical approach to large area surveys shows that a world wide survey with sufficient accuracy can be obtained without need for identifiable ground control points of high positional accuracy. The orbital reference obtained from photographs over surveyed territories is only used for producing accurate locations through statistically monitoring a networks adjustment by its statistical average and not through individual observations. This fact eliminates the need of the system for reference to a ground tracking network except for securing reliable recovery of the space records. Ground tracking data, unless it can be shown to be accurate, will not be used in the ground data handling system. If it is accurate it can be easily included. Thus, the ground data handling system need not rely on orbital tracking data; however, where such accurate information is available, it may easily be included.

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SYSTEM OBJECTIVES

The objective of this system is to obtain a unified world wide reference datum and to measure geoidal deviations from this datum with an accuracy required to obtain an absolute accuracy of distances within 750' between any two points on the surface of the earth. The system shall further produce a location reference file of pictorial (small scale photographic) images which will permit the tie-in of any target found on the earth's surface by semi-automatic image correlation, thus determining the location of that target with respect to the established datum.

CAMERA SYSTEM

It has been established that the only record which could possibly produce the necessary geometric accuracy required for meeting the objective must come from a photographic frame type camera of highest possible geometric fidelity (best mapping camera available). The camera must not only produce pictures of the ground providing complete ground coverage of the earth's surface, but must also produce a star record simultaneously with each ground recording permitting the determination of the spatial orientation of the optical axis and thus (in connection with time and location) permit the geometric rectification of each ground photograph into vertical perspective with a high degree of accuracy. It is contemplated that the orientation of the camera at the instant of exposure will be determinable to within 30 seconds of arc reducing deteriorating perspective distortions to acceptable tolerances. A record of the instant of exposure to determine the absolute time will also be required for a tie-in of space and earthbound coordinate systems. The best geometric and operational compromise results in a camera which records on 5 inch film, using a 3 inch focal length lens producing a 4½ x 4½ inch picture of the terrain, and simultaneously another lens of 3 inch focal length producing a 1½ x 2½ inch picture of a correlated view of the star field. The film carrying the photographic records in a latent form will be physically recovered.

Further details concerning camera characteristics are stated in Inclosure 1.

VEHICLE AND OPERATIONAL DATA

The camera is to be carried by a vehicle on a nearly circular and polar orbit at an orbital height which is determined by the requirement for coverage (approximately 200 nautical miles). Optimum coverage results from polar orbits if half of the provided satellites are launched in such a manner that the lighted portion of the earth is under the perigee while the other half are launched so that the lighted portion of the earth is under the apogee of the orbit. A local launch time of approximately 9 a.m. and 9 p.m. respectively for perigee and apogee recording gives minimum cloud cover under all prevailing weather conditions.

In order to obtain total world coverage, a minimum of one each successful satellite is necessary for perigee and apogee recordings. The orbits must be laid out in such a manner that the 16th orbit is 1/5 of the distance between orbital crossings of the first orbit at their equatorial crossing. The resulting period of approximately 5403 seconds determines the orbital height to be near 180 nautical miles.

The duration of operation for each satellite will be 64 orbits or approximately four days. Repetitive coverage will be necessary in order to eliminate those areas covered by clouds on a single go-round. Using polar orbits, repetitive coverage will be available progressively towards polar latitudes. The total number of vehicles required to produce coverage of the earth's surface reasonably free of clouds will depend upon the latitude of interest and upon the reliability of the vehicle performance including the recovery cycle. Stabilization of the vehicle to the horizon will be required within a tolerance of ± 2 degrees RMS in pitch and roll about the vertical and in azimuth about the direction of orbital motion. In addition a residual angular velocity of 1 minute per second will be required.

Detailed orbital requirements are stated in Inclosure 2.

PROCESSING OF ORIGINAL PHOTOGRAPHIC RECORDS

Immediately upon recovery of the original film it shall be washed in distilled water to eliminate the influence of salt water which might have entered the film container while at sea. If the film is dry it will be left alone. The film shall then be shipped wet in a container filled with distilled water or dry to the ground data handling center. The original film will be processed with the utmost of care, keeping in mind the great value represented by each recovered film package. Greatest consideration will be given to those parameters which, in the processing procedure, might introduce systematic distortions of the image through stress, heat, and other mechanical influences. The original recordings will be then transferred immediately to a master copy from which duplicate negatives will be made as required. Greatest care again will be taken in the reproduction process so as to not lose detail contained in the original. The original film shall be archived and made available only for those processes which cannot be satisfied from duplicates. Strong discrimination will be executed in determining when the original film can be used.

GROUND DATA HANDLING SYSTEM

A world wide survey is obtained from the records produced by the mapping cameras in the orbiting satellites. The system which produces this survey is called the Ground Data Handling System. It uses the following input data: a) Satellite records consisting of ground and correlated star photographs, the record of absolute time, and auxiliary horizon recordings taken from the satellite's control system; and b) Pre-requisites consisting of maps of surveyed territories of the world at map scales of 1:250,000 and larger, and of star catalogues.

The Ground Data Handling System goes through the following procedural steps:

a. The pre-requisites are modified and annotated in such a manner as to permit automaticity of operation wherever applicable. This requires modification of the basic charts (pullups) and of the star catalogues (punch cards or tapes). The identification of individual points is not required other than for a very limited number of analytical checks for calibration and accuracy where highly accurate large scale map surveys (1:25,000 or 1:50,000) are available.

b. The location of the principal points of those photographs taken over surveyed territory are determined by placing them into available maps of these territories.

c. The orientation of the optical axis of each ground exposure is determined through an automatic measuring and computation process using the star record corresponding to that ground exposure.

d. The horizon plane at the principal point of each ground picture is determined in the space coordinate system by the location of that point transferred into the space location system by means of the time of exposure. The difference between the perpendicular to the horizon plane and the direction of the optical axis leads to tilt and swing for the corresponding ground photo. The process can be reiterated to get highest precision through a rapid convergent process.

e. By means of focal length and pictorial scale, an orbital point is determined at the end of the optical axis vector at each principal point which corresponds to the satellite position when the picture was taken. This position is expressed in coordinates of the space coordinate system. All photographs taken over surveyed territory produce such orbital observations. All orbital observations are registered according to survey datums which they refer.

f. Each set of observations referring to the same datum is used to compute the orbit from that individual datum. Since all computed orbits are actually the same orbit, the apparent discrepancies between resulting computations must be considered as being caused by datum discrepancies. The average of all datum computed orbits representing the same satellite weighted by the number of observations and the reliability of the individual datum will result in an optimum orbit which statistically best fits all observations pertaining to that orbit. The procedure of producing the best orbit is a reiterative computational process in which the parameters of size and shape of the earth will be modified in such a manner as to produce an absolute minimum of the discrepancies between all observations and the resultant single orbit. This orbit extending over useful (recording) life period of the satellite (4 days) establishes a tape measure with a defined space station assigned to each instant of time.

g. Space stations are thus defined over unsurveyed territory for the instant of time at which photographs have been taken over that territory. Also determined through the simultaneous star photograph is the direction at which the optical axis pointed at the instant of exposure with respect to the horizon plane at the mathematical reference surface obtained from the satellite location and the recorded time of exposure.

h. The tilt of the photographs can thus be determined using the known tilt and the distance from orbit to the mathematical reference surface. By tilt, height, and focal length, each picture can be rectified to correspond in scale and perspective to that reference surface.

i. A defined position on the reference surface can be assigned to the principal point of each picture taken over unsurveyed territory. These positions will later serve as networks points establishing the survey of the unsurveyed territory. The positional accuracy obtained for the assumed position is estimated to be in the order of 750 feet.

j. The density of coverage due to operation in polar orbits increases with latitude; consequently, the density of ground points over unsurveyed territory will be irregularly distributed. In order to obtain a reasonable regular network of principal points, all principal points determined will be plotted on a suitable projection. A selection is then made among those principal points which are best located for forming a regular network.

k. The selected records will also be partially covered by clouds. Repetitive cover of cloud areas will be used to eliminate the cloud cover in those pictures which are selected for the network. This elimination of cloud cover will be achieved through a process of projection matching.

l. The principal points of the original selected pictures serve then as assumed positions for a Monticello type network. Measurements between these points are obtained from the recordings through correlating the same area of the ground shown in adjacent recordings. This procedure of ground correlation permits the use of rapid electronic matching procedures providing great speed and automaticity of measurement. This technique establishes a measurement between reference points which are automatically marked in advance (fiducial mark centers), hence eliminating the time consuming interpretive process of point identification, thus providing the basis for automaticity of measurement.

m. From the individual measurements established between fiducial mark centers of the records, a network of measurements is formed which relatively places the fiducial mark centers with respect to each other on a common datum and scale. The accurate placement of the network on the surface of the earth in the desired datum results from the assumed positions of the network points which are obtained from orbits in conjunction with recorded tilt data. The assumed positions and the measurements are the basis for the determination of the orientation and the scale of the network through least square adjustment procedures. The internal least square adjustment of the network of measurements is obtained from an electrical network designed upon the analogy between Gauss' Statistical Procedures of Adjustment of Measurements by the Least Sum of Squares and Kirchoff's Laws of Electrical Networks. All computational processes for determining the scale, orientation, and internal adjustment of the network are comprised in one single reiterative, convergent computational program involving digital and analog computers. The time required for this computational process is a few hours.

n. The end products of the computational process are exact positions of the fiducial mark centers which serve as reference points and pictorial background as represented in the individual original records oriented with respect to North and properly scaled and annotated. The reference point coordinates and scale as well as orientation of the pictorial background are to be stored on magnetic tape in a form usable for further automatic computation. The pictorial background annotated with scale and orientation is kept in an automatic storing and retrieving system for further reference.

ANALYTICAL VERIFICATION

Analytical checks will be run independently of the ground data handling procedure in order to secure proper systems operation and to prove the consistency of data in those areas where highly accurate surveys are available. These analytical checks will require the use of large scale maps (1:62,500 or larger). A specific objective of the analytical checks will be to prove the consistency of the interior camera orientation during orbital performance.

ERROR PROGRESSION ANALYSIS

An error progression analysis of the system under consideration showed that an accuracy of 266 feet was attainable. The 750 foot accuracy stated to be obtainable through Project ARGON is, therefore, conservative.

WEATHER CONSIDERATIONS

Weather conditions to be encountered over the area of interest have been studied and are presented in Inclosure 3. The most favorable month for securing photography has been determined to be the month of July.

GENERAL SPECIFICATIONS FOR TERRAIN-STELLAR CAMERA

A. INTRODUCTION

Many things must be considered in the selection of a camera to do a specific job. This is particularly true when the camera is to operate in an environment such as that imposed by an artificial earth satellite and requirements imposed by an unconventional data processing system. Some of the parameters to be considered are:

a. Camera cone angle.

b. Lens focal length.

c. Lens aperture and resolution.

d. Camera geometric characteristics.

e. Camera size and weight.

f. Availability.

g. Compatibility with ground processing system.

h. Method of holding film flat in focal plane.

i. Image motion compensation.

~~j. Reseau.~~

k. Cone pressurization.

l. Type of film.

m. Etc.

After a careful consideration of these and other parameters, it was possible to list the requirements for an optimum camera system to provide the photographic coverage and auxiliary data needed to accomplish a world-wide survey from satellite photography. Components of this camera system either are presently available or are under contract. They represent the state of the art.

The camera described in this report is really two calibrated cones locked rigidly together to insure a fixed relationship between their optical axes. The camera will contain two lenses; one lens will point vertically downward to photograph the earth and the other will be oriented

90° to it and will photograph the star field. The camera will be mounted rigidly to the vehicle and will depend on the satellite's stabilizing system to keep it properly oriented. A single roll of film will be used for recording the vertical photograph of the earth, the star field, absolute time in binary code and other auxiliary data. The film will be transported to a cassette immediately after exposure. The cassette is a part of the recovery package.

B. CAMERA SPECIFICATIONS

Focal Length

Terrain Cone 3"
Stellar Cone 3"

Format Size

Terrain Cone 4½" x 4½"
Stellar Cone 1½" x 2½"

Distortion (Radial & Tangential) - 0-6 microns

Cone Angle

Terrain Cone (across flats) 74°
Stellar Cone (across flats) 28° x 45°

Shutter - Inter-lens, high efficiency shutter for both lenses, synchronized to less than .0002 sec.

Shutter speeds - The following readily selectable shutter speeds shall be provided for the terrain cone: 1/100, 1/200, 1/400, 1/800 seconds. For the stellar cone the speeds shall vary between 2 seconds and 1/50 second.

Platen Flatness - ± .0001 in.

Lens

For Terrain Cone Baker 3" f/2.5 (T/4)
For Stellar Cone 3" f/1.5

Resolution - The lens-film combination of the terrain cone will have a resolution of 60 lines/mm AWAR using a standard high contrast resolution target in laboratory tests.

Resolution of stellar lens system under same conditions shall be 40 lines/mm.

Fiducial Markers - Naturally and artificially illuminated markers for terrain cone and two independent sets of artificially illuminated markers for stellar cone shall be provided.

Image Motion Compensation - Not required.

~~Reseau - For terrain record, a reseau of 0.002 in. diameter solid circles will be printed on each exposure. The circles will be randomly spaced to give an average density of one circle every 2 cm. The random spacing is for the purpose of avoiding any chance lock-on by the area match machine.~~

Cone Pressurization - The inner cones will be pressurized to approximately 1.5 lbs. per square inch. This will provide a means of film flattening and will reduce the tendency for the film emulsion to lose its moisture.

Perpendicularity of Fiducial Axes - The lines joining opposite fiducial markers shall intersect at an angle of $90^{\circ} \pm 10$ seconds.

Relationship of Optical Axes of Terrain and Stellar Cones - The axis of the terrain cone and the axis of the stellar cone shall intersect at an angle of $90^{\circ} \pm 1$ minute.

Relative Swing Between Focal Planes - The relative swing between the two focal planes shall not exceed 1 minute.

Inherent Vibration and Dynamic Unbalance - The inherent vibration and dynamic unbalance of the operating camera shall be reduced (i.e., vibration and dynamic disturbance due to operation of motors, solenoids, relays, gear trains, shutters, etc.) to such a level that the degradation of image quality at the slowest shutter speed is not detectable by laboratory photographic tests using a standard resolution test target.

Weight Shift Compensation - The camera shall be designed such as to reduce to a usable limit any dynamic unbalancing effects of the camera mechanism which would coerce the camera mounting means.

Calibration - The camera calibration report will contain the following information:

a. Equivalent focal length.

b. Calibrated focal length.

c. Separate radial distortion values across diagonals and across flats at approximate 5° intervals.

d. Tangential distortion.

e. Point of Symmetry location.

f. Principal Point of Autocollimation coordinates.

g. Distance between fiducial markers.

h. Calibration of Reseau, or

i. Calibration of CFL markers.

j. Perpendicularity of fiducial axes.

k. The angle between the axis of the terrain camera and the axis of the stellar camera shall be measured to an accuracy of 3 seconds. The relative swing of the focal planes shall be measured to an accuracy of 3 seconds.

Estimated Weight and Size - The camera and 4000 feet of thin-based film will weigh no more than 150 pounds. Its size will not exceed 32" x 27" x 12".

Film

Type - Eastman SO 1188 Emulsion
Width - 5"
Base - Thin Base (0.0035 in.)
Length - 4000'
Weight - 75 lbs.
Spool Diameter - 15"

OPTIMUM ORBITAL DATA

Optimum Orbital Data is based, to a large extent, on those parameters which will produce a specified side lap and end lap in the areas in which control is to be established.

1. End Lap. Only end lap is necessary in areas containing existing control inasmuch as orbital data for each pass is restricted to the photography of the related pass. Thus photography from one pass cannot be employed to determine orbital data on a previous or subsequent pass by virtue of side lap.

The end lap for any given altitude and cone angle may be defined by the exposure interval inasmuch as altitude, neglecting air drag, establishes the period and the orbital velocity per second. Let us assume that 60% end lap for a cone angle of $2\gamma = 70^\circ$ along the direction of motion is required. End lap may then be computed as follows:

$$\Delta S = \sqrt{\frac{G.M}{\rho_0}} = \text{linear units of travel per second}$$

$$n = \frac{\Delta S}{\rho_0} = \sqrt{\frac{G.M}{\rho_0^3}} = \text{radian velocity per second}$$

where

$G.M$ = product of earth's mass and universal constant of gravity

$\rho_0 = \rho_E + H$

ρ_E = mean radius of the earth

H = altitude of camera station

Now 2θ is the number of radians covered by an exposure in the direction of motion and normal to the plane of motion.

$$\theta = I - \gamma$$

$$\gamma = 35^\circ$$

$$\sin I = \frac{\rho_0 \sin \gamma}{\rho_E}$$

60% end lap is 40% advance per exposure or .8θ. Therefore the exposure interval in sidereal seconds is expressed as $\frac{.8\theta}{n}$.

Thus, any specific end lap is achieved for any altitude and cone angle combination by simply defining the exposure interval. The equations for exposure interval are illustrated in Figure 1.

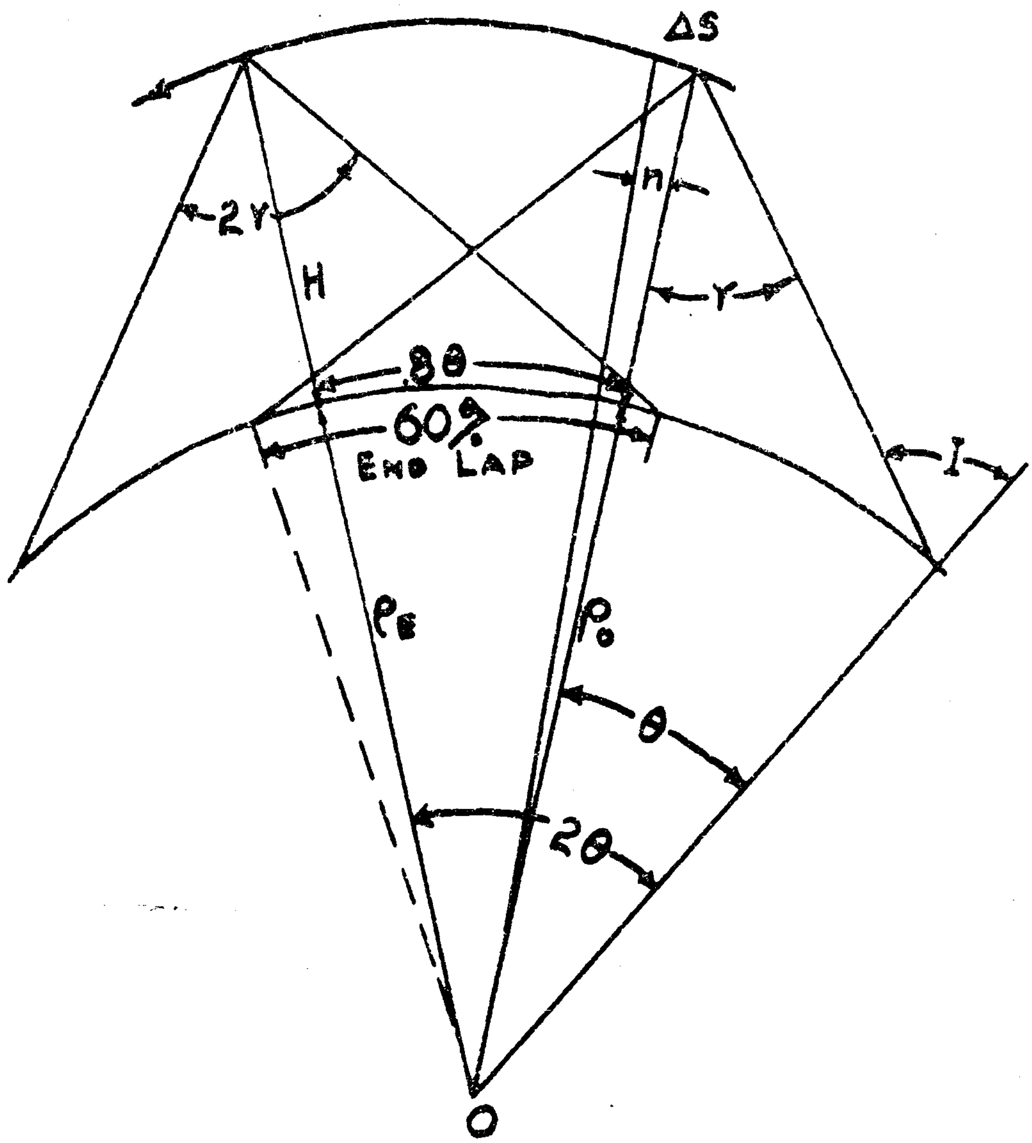

Figure 1. End lap as a function of cone angle, H, and orbital velocity

2. Side Lap. Lateral coverage or side lap is somewhat more involved since the camera is in orbit over a rotating object space. The factors affecting the photographic lateral coverage are:

a. Lateral cone angle and altitude.

b. Period of the satellite and rotational velocity of the earth.

c. Inclination of the satellite orbit to the earth's equator.

The inclination of the orbit is equal to the highest latitude covered by any pass. An inclination of zero degrees gives repeated coverage of the same equatorial belt. Since the most northern latitude of the areas of interest is greater than 75°, the resulting orbit will be near polar. The lateral gain between an orbit of 75° and a polar orbit is not significant. Therefore, the required period to provide a specific lateral coverage for a specific cone angle will be based on an orbit with an inclination of 90°.

Since the lateral and longitudinal cone angle is fixed at 70° and the earth's rotation rate is constant, a specified side lap is dependent only on altitude for a circular orbit inasmuch as altitude defines the period, $P = \frac{2\pi}{n}$

The westward advance of the ascending node in longitude may be obtained from

$$\Delta\lambda'' = \frac{P}{15}$$

and the number of passes per sidereal day may be obtained from

$$\frac{360 \times 60 \times 60}{\Delta\lambda''} = N + dP$$

where N is the number of completed passes and dP is the fractional part of a pass added to the whole number of passes to complete one sidereal day.

$$dP = \frac{d\lambda}{\Delta\lambda}$$

where $d\lambda$ is the shift in longitude of the ascending node at the end of one sidereal day and

$$\text{Sid. Days} = \frac{\Delta\lambda}{d\lambda}$$

which is the number of sidereal days required for complete coverage when $d\lambda$ divided the desired side lap is equal to unity. The side lap converges to 100% at the pole, regardless of the side lap at the equator.

Since the area requiring side lap is above 45° latitude and, since convergence of the side lap increases toward the poles, we take as our criteria 30% side lap at latitude 45°. This gives projected to the equator the desired longitude shift per day.

$$d\lambda = .7(2\theta)\sec 45^\circ = 2\theta$$

where $\frac{d\lambda}{2\theta}$ = unity defines the optimum altitude and period. Three sequential tables from which the optimum orbital data may be interpolated can then be computed with these simple formulae. The tables are restricted to those values surrounding the optimum values.

From these tables the following optimum data are established:

H = 180 nautical miles or 207 statute miles

P = 5463.497 seconds

Number of sidereal days	=	5.38
Exposure interval	=	25.844 seconds
Side lap at 45° ϕ	=	30 %
Side lap at Equator	=	0%
Lateral strip coverage	=	4°15'26.3"
Advance per exposure	=	1°42'10.52"
Photo Coverage	=	255 x 255 nautical miles

In addition, time will be recorded to within 0.001 second.

Table 1. <u>Determination of Radian Velocity and Period</u>

H (naut. miles)	H (feet)	$\rho_E = 20{,}902{,}944'$ $\rho_E + H = \rho_o$ (feet)	$\rho_o \cdot 10^6$ cm	$\rho_o^2 \cdot 10^{12}$ cm^2	$\rho_o^3 \cdot 10^{20}$ cm^3	n^2	Radian Vel. n (Radian/sec)	Period $P = \frac{2\pi}{n}$ $2\pi = 6.283184$ (seconds)
170	1,033,600	21,936,544	668.62586	447,060.54	2,989,162.4	.00000133358	.00115481	5,440.882
179.85	1,093,488	21,996,432	670.45125	449,504.98	3,013,711.1	.00000132272	.00115010	5,463.164
180	1,094,400	21,997,344	670.47905	449,542.16	3,014,086.0	.00000132256	.00115003	5,463.497
180.15	1,095,312	21,998,256	670.50684	449,579.42	3,014,460.8	.00000132239	.00114995	5,463.877
190	1,155,200	22,058,144	672.33223	452,030.63	3,039,147.6	.00000131165	.00114527	5,486.204
200	1,216,000	22,118,944	674.18541	454,525.97	3,064,347.8	.00000130086	.00114055	5,508.908

Table 2. <u>Longitude Shift Per Pass, Number Passes Per Day, Photo Coverage</u>

H (naut. miles)	$15P = \Delta\lambda$ (seconds)	Shift per Pass $\Delta\lambda$	$\frac{\rho_o + H}{\rho_o}$	sin I $= \sin\gamma \frac{\rho_o + H}{\rho_o}$	I	θ $I - \gamma$	Passes per Day $360°/\Delta\lambda$ = [illegible]	Photo Coverage 2θ
170	81,613.23	22°40'13"23	1.0494476	.60193842	37°00'31"87	2°00'31"87	15.879778	4°01'03"74
179.85	81,947.46	22°45'47"46	1.0523126	.60358171	37°07'36"67	2°07'36"67	15.815011	4°15'13"34
180	81,952.46	22°45'52"46	1.0523563	.60360678	37°07'43"15	2°07'43"15	15.814046	4°15'26"30
180.15	81,958.16	22°45'58"16	1.0523999	.60363179	37°07'49"62	2°07'49"62	15.812946	4°15'39"24
190	82,293.06	22°51'33"06	1.0552649	.60527508	37°14'55"10	2°14'55"10	15.748594	4°29'50"20
200	82,633.62	22°57'13"62	1.0581736	.60694345	37°22'07"76	2 22'07"76	15.683689	4°44'15"52

Table III. **Longitude Shift Per Sidereal Day, Side Lap, Exposure Interval, Number of Days to Complete Mission**

H (nautical miles)	2θ	.8θ = 2θx0.4	Shift Per Sidereal Day $d\lambda = dP \cdot \Delta\lambda$	1.98θ = 2θx.99	.θ (radians)	Side lap 30% $\frac{d\lambda}{2\theta}$	Exp. Int. = $\frac{.8\theta}{n}$ (sidereal seconds)	No. of days $\frac{\Delta\lambda}{d\lambda}$
170	14,463.74	5,785.50	9,811.71	14,319.10	.02804890	0.67837	24.289	8.32
179.85	15,313.34	6,125.34	15,159.38	15,160.21	.02971083	0.98995	25.833	5.40
180	15,326.30	6,130.52	15,239.38	15,173.07	.02972160	0.99433	25.844	5.38
180.15	15,339.24	6,135.70	15,330.60	15,185.85	.02974671	1.0x056	25.868	5.35
190	16,190.20	6,476.08	20,688.97	16,028.30	.03139692	1.27787	27.414	3.98
200	17,055.52	6,822.21	26,137.92	16,884.96	.03307501	1.53252	28.999	3.16

WEATHER CONDITIONS TOP SECRET

A study was made to determine the month best suited for obtaining ARGON photography. Six weather charts were produced. The charts were plotted using the mean number of days with a total sky cover of $\leq$ 5/10ths, between 1200-1400 hours local standard time, for the months of April through September. The charts represent the monthly statistical averages of many years' records. The Climatic Center, Headquarters, Air Weather Service, prepared the charts. They represent the monthly summarizations of the total Weather Service holdings. Although the charts are general planning guides, they are sufficiently accurate for the purpose of selecting the best average month for ARGON photography. These data are considered the best available for the area in question.

The six weather charts used for this study are attached to the original report only. Time did not permit the reproduction of additional copies. It is planned to prepare and disseminate copies of the charts at a later date.

The charts are color coded to reflect the weather conditions between the isolines when the cloud cover is 5/10ths or less.

1. Red indicates 20 days (60%) favorable photographic weather.
2. Green indicates 14 days (50%) favorable photographic weather.
3. Blue indicates 10 days (33%) of favorable photographic weather.

It has been determined that cloud cover, up to 7/10ths or 8/10ths of the sky over any area will generally leave sufficient ground detail uncovered.

A detailed analysis of the charts clearly indicates that the month of July is the best month for obtaining the maximum photographic coverage over the Soviet Union and surrounding areas. A statistical analysis of weather for this month indicates the most favorable random distribution of cloud cover. The weather records for other parts of the world for the month of July indicates a higher rate of cloud-free days.

The charts also indicate that if we desire to photograph only the northern area of the Soviet Union, it would be better to do so late in April or early in May. If photographic cover is desired for the southern area, it would be advisable to select the month of August or early September. It is obvious from the charts that the stable, warm air fronts move from north to south. The storm track also follows a similar path.