The Relation Between Solar Cell Flight Performance Data and Materials and Manufacturing Data

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Abstract

An initial determination of seven groups of flights has been made that may be suitable for the purposes of this study. Each of these groups consists of flights that have been in orbit and transmitting for at least three months, are unclassified, and have similar space environments.

Computer searches have been performed to obtain documents on silicon solar cells and on the flights in the seven groups mentioned above. As a result, a number of documents have been obtained.

Appropriate channels have been ascertained and individuals contacted to obtain data on radiation and thermal environments. These channels have been tested by requesting information on a restricted number of flights in order to determine the effectiveness and rapidity by which information can be obtained.

A general coding procedure has been devised to conveniently summarize and display the availability of the information needed in this study.

A number of pertinent documents have been obtained, and more are being received continually.

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I. Introduction

The purpose of this program is to examine the flight performance data for solar cell power systems in satellites, and to try to relate the differences in performance to the materials and manufacturing factors in the solar cell system.

The general method of approach consists of selecting a group of flights whose space environments are all similar, for which sufficient flight performance data exists, and for which information on the materials and manufacturing factors is available. For the selected group of flights, an attempt will be made to relate the differences in performance to specific materials or manufacturing parameters that may be expected to affect performance.

The work is divided into four general phases defined by the following outline:

Phase I:

A. Classify all flights from 1957 through 1967 according to their space environment, so that groups of flights with similar environment can be identified.

B. Ascertain availability of performance data and materials and manufacturing parameters.

C. Generate a coding procedure to facilitate the recording and use of information gathered relative to performance and materials and manufacturing factors.

Phase II: Select a group of flights based on the work in Phase I.

Phase III: Acquire and systematize the actual data needed for the flights selected in Phase II.

Phase IV: Perform analysis to relate materials and manufacturing factors to flight performance of the selected flights.

The work in Phase I was estimated to require six months. Although the work covered in this report covers the first three months of the contract period, Phase I is considerably more than half completed, since actual work was begun before the beginning date of the contract.

A space environment classification scheme was devised which permitted the 611 flights examined to be separated into groups of similar environments and preliminary decisions to be made on the suitability of these groups for the purposes of this study.

Major progress has been made in gathering information to ascertain the availability of data.

A coding procedure for the recording and use of the data has been devised.

II. The Flight Selection Problem

After examination of the Space Projects Log from 1957 to 1968, which included approximately 611 earth satellite flights, it was evident that some of the flights were not useful for the purpose of correlating solar power system performance with materials and manufacturing data. Accordingly, the flights were divided into three classes, which were defined by the following criteria:

Class # 1:

a) In orbit and transmitting data for three months or more
b) Project director NASA or DOD
c) Unclassified.

Class # 2:

a) In orbit and transmitting for three months or more
b) Project director DOD
c) Classified.

Class # 3:

a) Failed to orbit
b) In orbit and transmitting less than three months.

It is clear that Class # 1 is the most promising for our study, and that Class # 3 is unsuitable. Class # 2 may be suitable; however, clearance procedures and the time required to obtain data for classified flights make it desirable to avoid these flights if possible. Fortunately, Class # 1 includes over 200 flights, and an appropriate number of these will probably be suitable for the detailed materials and performance study. It was therefore decided to concentrate on Class # 1 for the time being. These are listed in Table I. In the event that the number of flights surviving the subsequent selection procedures is too small, use of flights in Class # 2 will be reconsidered.

The radiation, thermal and micrometeorite environments of an earth satellite are determined by five orbital parameters (perigee P, apogee A, inclination θ, period T, and calendar year). Ideally, the selected set subjected to detailed study should include only flights for which these parameters are identical. Since this is not possible, it is necessary to choose groups for which the orbital parameters are as close together as possible and lead to similar environments. Since the perigee and apogee determine the radiation environment to a great extent, these parameters were used as an initial basis.

A plot of perigee vs. apogee for the Class # 1 flights (Figure 1) shows a number of clusters along the 45° line, and suggests that a rational starting point for selecting flights with similar environments can be chosen by defining four sets of orbits. In Figure 1, these are labeled I (inside orbit), B (first belt orbit), S (synchronous orbit) and O (outside orbit). I orbits are defined as having perigee and apogee just inside the first radiation belt. The cutoff point was chosen as 700 miles because above this altitude, both electron and proton fluxes increase very rapidly with altitude from negligible to quite significant values. At present, this cutoff point is arbitrary. When a final flight selection is made, the boundaries defining each set of orbits will be reconsidered.

The B orbits are defined by the cluster in Figure 1 at about 2000 miles. This region is close to the maximum of the first radiation belt and contains a flux of about 10^{10} protons/cm^2 day and 10^{12}-10^{13} electrons/cm^2 day.

The S orbits are those for synchronous geostationary flights, while the O orbits are beyond the radiation belts.

Tables I through V list the Class # 1 flights in the four orbital classes defined above, along with the four orbital parameters for each flight.

For each orbital class, it is necessary to examine the period and inclination in order to search for flights with similar total orbital designation (perigee, apogee, period and angle of inclination). This was done by plotting angle of inclination vs. period in Figures 2 - 6.

A consideration of the flights in each of the orbital classes, based on the classification scheme given above, revealed the following characteristics for each orbital class:

A. <u>I Orbits</u>

(1) There are many flights in the inside orbits (sixty-five). This is a decided advantage for our study.

(2) Twenty-four of the flights are NASA directed.

(3) Particle radiation damage is minimal since the flights are below the maxima in the first radiation belt.

(4) Because of the low orbit, the thermal cycle is one of appreciable changes in temperature over times measured in minutes. This may have significant effects on solar cell performances.

(5) Because of (4), the angle of inclination θ and the period T are important parameters. Any materials study based on I orbits should only include flights whose T and θ are similar.

(6) There are two groups of flights with all orbital parameters similar: the group at $\theta \approx 32^{\circ}$ and the group at $\theta \approx 70^{\circ}$. The first group contains twelve (12) flights, eight (8) of which are NASA flights; the second group contains fifteen (15), none of which are NASA flights. These groups will be labeled I(32) and I(70) respectively.

(7) There is a group of seven (7) flights at $\theta \approx 80^{\circ}$ with T varying from 91 to 105 minutes, and a group of thirteen (13) flights with θ varying from about 48° to 60°. These groups will be labeled I(80) and I(55) respectively.

B. <u>B Orbits</u>

(1) These are all in a heavy radiation environment.

(2) The group contains twelve (12) flights, none of which are NASA directed. Nine (9) are USAF and three (3) are USN flights.

(3) Eleven (11) of the twelve (12) flights have similar θ and T, with $\theta \approx 90^{\circ}$.

(4) These polar orbits pass in and out of the maxima of the first radiation belt, and therefore, the radiation environment, as well as the thermal environment, varies during each revolution of the satellite.

C. <u>S Orbits</u>

(1) This group contains twenty-seven (27) vehicles, three (3) of which are NASA flights. Sixteen (16) of the flights are at $\theta \approx 0^{\circ}$ and six (6) are at $\theta \approx 7^{\circ}$.

(2) Philco-Ford is performing a solar cell degradation study of fifteen (15) members of this group. This would be a definite advantage for our study.

(3) For at least six (6) of these flights, the thermal environment has been estimated analytically by Hughes Aircraft Company. This also is a definite advantage for our study.

(4) Hughes has examined the expected solar cell degradation to be expected from the synchronous radiation environment.

(5) For at least six (6) of these flights, the only telemetered data concerning solar cells is the bus voltage. More extensive data would be desirable.

D. <u>O Orbits</u>

(1) These all have a flat thermal cycle.

(2) There are eight (8) satellites in this group, all of which are nuclear detection test satellites directed by USAF.

(3) There is no subgroup with similar θ; the θ values range from 32 to 41°. However, at these altitudes, such a variation in θ is probably not important.

From the above classification scheme, we are led to define the following groups of flights as having similar orbital parameters: I(32), I(55), I(70), I(80), B(90), S(0) and O(36).

We have provisionally separated the I flights into four subgroups, each with a different θ. However, further analysis is required to determine if this separation is to be retained. In particular, detailed analysis of the radiation and thermal environment is needed to decide whether or not the I(80) flights must indeed be separated from the I(70) flights, or whether they can be lumped together. Also, more work must be done to determine the environmental variation (particularly with respect to temperature) among the I(55) flights.

The flights in the S orbits have been labeled S(0) to indicate that most of them have an angle of inclination of 0°. We expect that those with $\theta \approx 7^{\circ}$ have environments similar to those at 0° and will be included in the S(0) group.

Although the Θ values for the O flights vary from 32° to 41°, we expect that this does not produce significant variations among their environments, since these satellites are very far from earth, and all O flights will probably be considered as one environmental group.

At this point, it is not possible to make an unequivocal choice as to which of the above groups or combinations of groups is best suited for our study. However, some statements as to relative desirability can be made.

The O group, for example, contains only eight members. This sample is already a small one, and any further reduction that may arise from the unsuitability of telemetered data or unavailability of materials data may seriously impair the value of any final conclusions.

The B group has a somewhat larger membership. Eleven of these flights ($\Theta \approx 90^{\circ}$) have similar orbital environments. These flights are of interest since they are in a relatively heavy radiation environment. However, the variable thermal cycle is not negligible even at these altitudes, and some difficulty may be experienced in sorting out the effects of radiation and of thermal variations. This, coupled with the fact that eleven is not a very large number makes this group somewhat less than an optimum choice.

The S group is an attractive one for several reasons. The orbits are very similar, and there are twenty-seven vehicles in S orbits. Also, these flights are the subject of studies by other organizations. These studies will be useful to us and may be thought of as at least partially complementary to ours. However, the thermal cycle is flat, and the radiation flux is not extremely high; thus, materials effects from these sources should be smaller than in lower orbits.

The I group is the largest of all. It contains four subgroups ($\Theta \approx 32^{\circ}$, $\Theta \approx 55^{\circ}$, $\Theta \approx 70^{\circ}$ and $\Theta \approx 80^{\circ}$) with 12, 13, 19 and 7 members respectively, it has a significantly varying thermal cycle, and radiation effects are considerably less than in the B orbits.

While we propose no selection among these groups at the present time, the above considerations may be used to determine the order in which we examine the detailed data for these groups. Accordingly, such examinations will begin with the four subgroups of the I flights, and S flights, and then proceed to the B and O flights.

In Tables II - IV, the flights of interest for this examination are listed along with orbital data. They include the four subgroups of I orbits with angles of inclination at $\theta \approx 32^{\circ}$, $\theta \approx 55^{\circ}$, $\theta \approx 70^{\circ}$ and $\theta \approx 80^{\circ}$; the eleven B flights at $\theta \approx 90^{\circ}$, all S flights with $\theta \approx 0^{\circ} - 8^{\circ}$, and O flights ($\theta \approx 32^{\circ} - 41^{\circ}$). These are designated I(32), I(55), I(70), I(80), B(90), S(0) and O(36) respectively.

From the method of selection, it is clear that the choice of the seven sets of flights just mentioned is an optimum one for collecting flights with similar environments, and any other choice would group the flights into environments that were less uniform for each group. However, it must be stressed that for each of the groups defined above, the environment of the solar cell assemblies still vary from one flight to another. This variation depends on time of orbit because of the temporal variations of the radiation environment, the variation of the physical configuration of the solar cell assemblies, and the variations arising from different parking (transfer) orbits. The extent and effects of this variation requires further analysis.

III. Information and Data Gathering

An important task in Phase I of this study is to ascertain the availability of information dealing with environment, procurement specifications, flight performance, testing and materials and manufacturing data. The availability of this information will, of course, strongly influence the choice of the groups to be studied in detail.

The steps by which we are pursuing the information gathering is the following:

A. Search for NASA documents dealing with silicon solar cells using the computer facility at the NASA Scientific and Technical Information Facility.

B. Search for unclassified DOD documents dealing with silicon solar cells using the computer facility at the Defense Documentation Center.

C. Examine lists obtained from the computer searches for documents dealing with flights in the I, B, S and O groups.

D. Obtain the documents listed from C above.

E. Obtain thermal and radiation environmental data as described below.

1. Computer Search of Literature

Two computer search facilities were used to obtain a broad coverage of unclassified reports relating to silicon solar cells in spacecraft.

a) NASA Scientific & Technical Information Division
P. O. Box 33
College Park, Maryland 20740
(Mr. Philip Eckert)

b) Defense Documentation Center
Cameron Station
Alexandria, Virginia 22314
(Mr. Thomas Lin)

Using both NASA and DOD facilities, it was hoped that all significant published documents could be obtained in this way. After considerable discussions with the individuals mentioned above the following computer searches were performed:

a) A broad coverage search using "Silicon Solar Cell" as an identifier in both facilities.

b) A specific search at both facilities in which information was sought on final flight reports, vendor reports on manufacture and testing of solar cell panels and spacecraft power supply, and flight performance.

In the specific computer search, the names of the NASA and DOD flights in the I, B, S and O flights were submitted and appropriate identifiers were used with the flight name to perform the search.

After careful review of the abstracts of all documents cited, the papers having relevance to this study were ordered through NASA and DDC Clearinghouses.

Table VI shows the number of documents cited, ordered and received as a result of these searches up to December 2, 1968.

2. DOD Flight Documentation

A list of all DOD sponsored flights from the I, B, S and O groups was prepared and sent to Lt. Steve Lacey, SAMSO, Los Angeles, California. We had arranged for Lt. Lacey to provide us with the names of individuals in the DOD or in industry who had responsibility for, or who possessed information relating to, silicon solar cells and solar panels used on these flights. A reply has not yet been obtained. When these names are known, the availability of the desired data will be ascertained.

3. NASA Flight Documentation

A list of NASA sponsored flights form I, B, S, and O orbits was sent to Mr. Robert Ziemer, Deputy Assistant Director of Projects. Mr. Ziemer agreed to supply us with the names of NASA people and vendors who were associated with the solar cell and solar panel development and procurement for these flights. In particular, we asked for the names of people who could supply us with the following kinds of information:

a) Detailed manufacturing and materials information

b) test and evaluation data

c) environmental data

d) flight performance data.

When this list is obtained, the vendors and NASA personnel will be contacted to determine the availability of the information mentioned above.

4. Radiation Environment Data

For the past eight years, the Laboratory for Theoretical Studies at Goddard Space Flight Center has calculated radiation environments for various flights. The results are available and can be obtained by making a request through appropriate NASA channels. If a flight for which a request is made has not been the subject of a previous radiation environment analysis, it can be performed with the following information:

a) Circular Orbits - altitude, inclination, epoch, vehicle and flight name.

b) Elliptical Orbits - perigee, apogee, period, inclination, epoch, vehicle and flight name.

The accuracy of such calculations is within a factor of 2 or 3.*

Sample data of radiation environments for a sampling of flights from each of the four flight subgroups were requested through our technical monitor for the following reasons:

a) The form of the data can be ascertained at an early stage.

b) The error limits can be determined.

c) The time involved in obtaining the data will be useful in planning Phase III of our study.

d) Verify nature of input data required to obtain these radiation studies.

*E. Stassinopoulos - private communication.

The following flights and information were supplied to Mr. E. G. Stassinopoulos:

FLIGHTS

I Orbits

Name	Intn'l. Desig.	Agency	Launch Date
1. TIROS 8	1963 54 A	NASA	12/21/63
Perigee	430 miles		
Apogee	473 miles		
Period	99.3 minutes		
Inclination	58.5 degrees		
2. NONE	1962 Σ1	USAF	5/15/62
Perigee	180 miles		
Apogee	401 miles		
Period	94.0 minutes		
Inclination	82.5 degrees		

S Orbits

Name	Intn'l. Desig.	Agency	Launch Date
1. ATS 1*	1966-110A	NASA	12/6/66
Perigee	22,277 miles		
Apogee	22,920 miles		
Period	660 minutes		
Inclination	0.2 degrees		

*What information is available for the parking orbit of this mission?

Name	Intn'l. Desig.	Agency	Launch Date
2. IDCSP 16*	1967 66B	USAF	7/1/67
Perigee	20,509 miles		
Apogee	20,846 miles		
Period	1309.8 minutes		
Inclination	7.2 degrees		

* What information is available for the parking orbit of this mission?

O Orbits

1. There is no NASA flight in this subgroup

FLIGHTS (continued)

O Orbits (continued)

	Name	Intn'l. Desig.	Agency	Launch Date
2.	VELA 3*	1964 40 A	USAF	7/17/64

Perigee	63,369 miles
Apogee	65,024 miles
Period	100.3 hours
Inclination	39.5 degrees

* What information is available for the parking orbit of this mission?

B Orbits

1. There is no NASA flight in this subgroup.

2.	LES 1	1965 8C	USAF	2/11/65

Perigee	1726 miles
Apogee	1744 miles
Period	147.7 minutes
Inclination	32.2 degrees

The results have not yet been received.

When a final selection of a flight group is made in Phase II of this study, it may be desirable to use the same radiation model to calculate the environments so as to avoid apparent differences in radiation environments due to the use of different models. When a single model is used, the conclusions relating to effects of the environment will be as valid as the radiation environment model but will not include errors generated by the use of different model environments.

5. Thermal Environmental Data

The detailed thermal environment for NASA flights and for some DOD flights can be obtained from the Thermal Physics Branch by contacting:

Mr. Milton Schach, Branch Chief
Thermal Physics Branch
Goddard Space Flight Center
Greenbelt, Maryland 20771

The members of this group have computed solar panel temperatures for many flights. Also, data is available of actual panel temperatures during the mission although this information is rarely published. We do not anticipate serious difficulty in obtaining these data for this group of flights selected in Phase II.

A selected group of six flights were sent to the Thermal Physics Branch to determine the nature and availability of these data for reasons similar to those under radiation environmental data. This list was as follows:

	Name	International Designation	Agency	Launch Date
1.	TIROS 8	1963 54A	NASA	12/21/67
2.	NONE	1962 1	USAF	5/15/62
3.	ATS 1	1966 110A	NASA	12/6/66
4.	IDCSP	1967 66B	USAF	7/1/67
5.	VELA 3	1964 40A	USAF	7/17/64
6.	LES 1	1965 8C	USAF	2/11/65

To date, the replies to this request were:

1. TIROS 8 - Contact Mr. Ralph Scott, RCA-AED (This was done but to date there has been no reply.)

2. ATS 1 - Cell temperature $15^{\circ}C \pm 5^{\circ}C$ except when satellite is in earth's shadow. Then the temperature drops to $-80^{\circ}C$ in a period of 70 minutes. (Note: If this is typical of the response, it may not be sufficient.)

3. VELA 3 - Contact Mr. James Moses, TRW Systems. (This was done and temperature as a function of "sun look angle" was obtained with an accuracy of $\pm 4^{\circ}C$. Although this is not sufficient, complete documentation is available upon furnishing a need-to-know.)

4. LES 1 - Contact Lincoln Laboratories. (This was done through a Mr. Donald C. Mac Lelland. We were informed that temperature data is available after we establish a need-to-know.)

5. No comment made concerning numbers 2 and 4 above.

Although the results of this preliminary attempt leave something to be desired, it is felt that where necessary, the need-to-know can be established and detailed temperature data can be obtained for the selected group of flights.

IV. Classification Codes

To facilitate the handling and application of the information obtained for use in this study, it was decided to use the device of coded forms. Two types of codes will be used: a general code to record qualitatively the general availability of data, and sub-codes referring to the availability of specific data.

The general code and its dictionary are shown as Form C-01 and Form C-02 respectively. The code contains five categories; environmental data, procurement specifications, performance data, tests for acceptance and materials and manufacturing data.

From an examination of available documents, a decision will be made on the availability of data for each of the entries for these five categories. If the decision is positive, the appropriate entry letter will be circled.

For a number of these entries, such as those under materials and manufacturing data, each entry represents a considerable number of separate items. Therefore, a subcode is being devised for each entry representing multiple data to record the availability of the specific data.

Once the code forms have been completed, they will provide a convenient tool to display and compare the extent of information available for the various flights.

Form C-01

DATA AVAILABILITY CODE - PHASE I

CARA Flight Number ________________

Flight Name & International Designation __________________

E	SC	SP	P	T	M
M	W	W	PC	M	C
T	F	F	PV	R	I
R	M	M	IV	T	M
O	T	T	SCC	E	F
	R	R	OCV		A
	P	P	FF		D
	O	O	MPP		
			TS		

DIRECTIONS:

1. See Master Chart (Form C-02) for Letter Identification
2. Circle Letter When Information is Available
3. Write "A" Under Letter When Either the Document Containing Information is in CARA Office or When Person Holding Information is Known.

MASTER CHART: Dictionary for Form C-01

E (Environmental)	SC (Procurement Specifications for Cells)	SP (Procurement Specifications for Panels)
M (Mechanical)	W (Weight)	W (Weight)
T (Thermal)	F (Fabrication)	F (Fabrication)
R (Radiation)	D (Mounting and Deployment)	D (Mounting and Deployment)
O (Orbit Description)	M (Mechanical)	M (Mechanical)
	T (Thermal)	T (Thermal)
	R (Radiation)	R (Radiation)
	P (Power)	P (Power)
	O (Operation Schematic Details)	O (Operation Schematic Details)

P (Performance)	T (Tests for Acceptance)	M (Materials and Manufacturing)
PC (Panel Control)	M (Mechanical)	C (Cell Construction Details)
PV (Panel Voltage)	R (Radiation)	MT (Cell Materials)
IV (Current vs. Voltage)	T (Thermal)	I (Interconnections)
SCC (Short Circuit Current)	E (Efficiency)	M (Cell Mounting)
OCV (Open Circuit Voltage)		F (Frame Construction and Materials)
FF (Fill Factor)		A (Attachment of Panel)
MPP (Maximum Power Point)		D (Deployment)
TS (Telemetry Specifications)		

V. Summary

An initial determination of seven groups of flights has been made that may be suitable for the purposes of this study. Each of these groups consists of flights that have been in orbit and transmitting for at least three months, are unclassified, and have similar space environments.

Computer searches have been performed to obtain documents on silicon solar cells and on the flights in the seven groups mentioned above. As a result, a number of documents have been obtained.

Appropriate channels have been ascertained and individuals contacted to obtain data on radiation and thermal environments. These channels have been tested by requesting information on a restricted number of flights in order to determine the effectiveness and rapidity by which information can be obtained.

A general coding procedure has been devised to conveniently summarize and display the availability of the information needed in this study.

A number of pertinent documents have been obtained, and more are being received continually. These are being examined and pertinent availability of data will be entered in the general code form.

Work for the immediate future will include a continuation of information gathering, completion of sub-coding procedures for the availability of specific information, examination of documents obtained, and entering the availability of data into the code forms for purposes of display and comparison. It is expected that Phase I of this study will be completed within the next quarter.

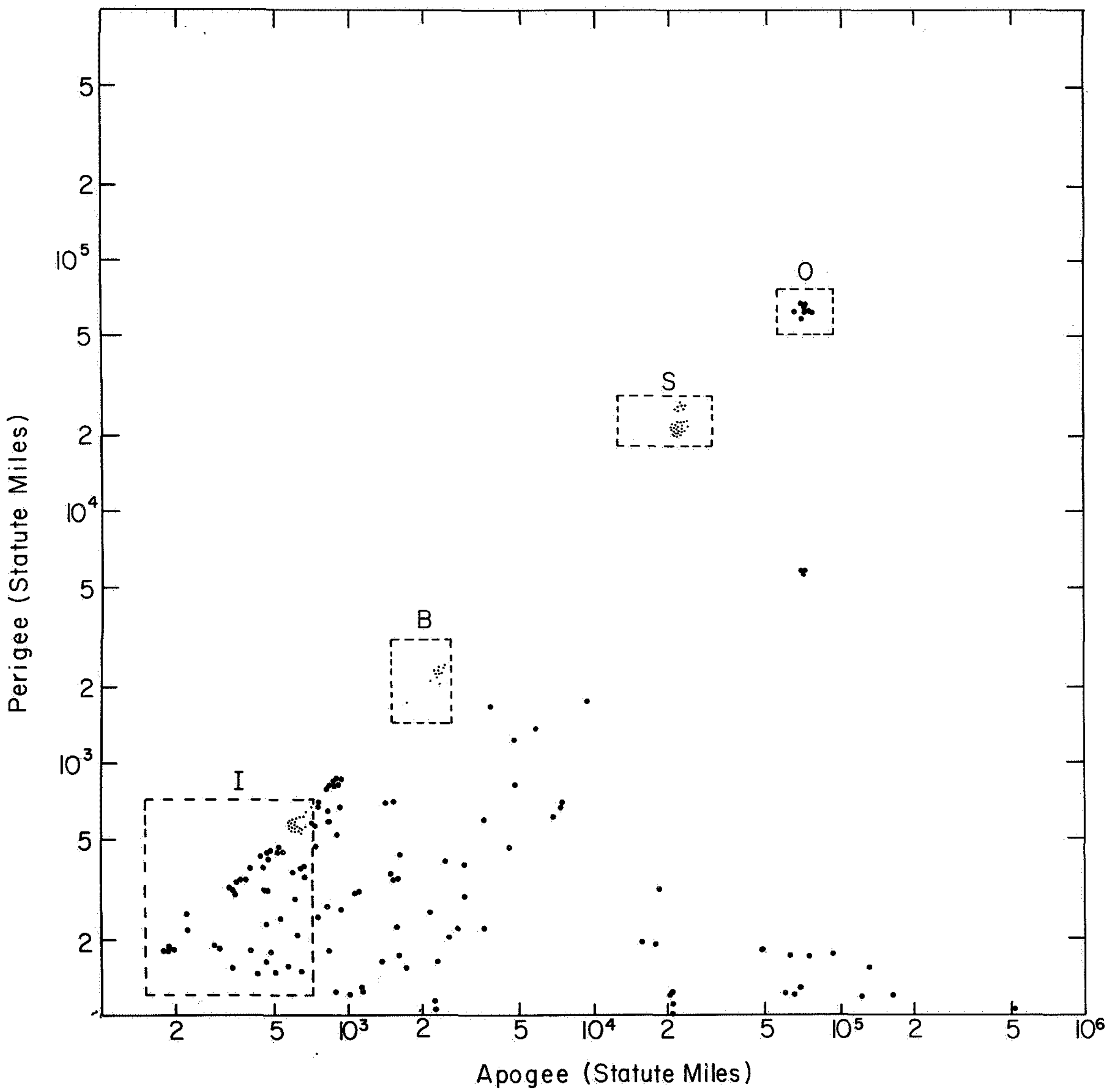

Fig. 1. Perigee vs. Apogee for Class # 1 Flights.

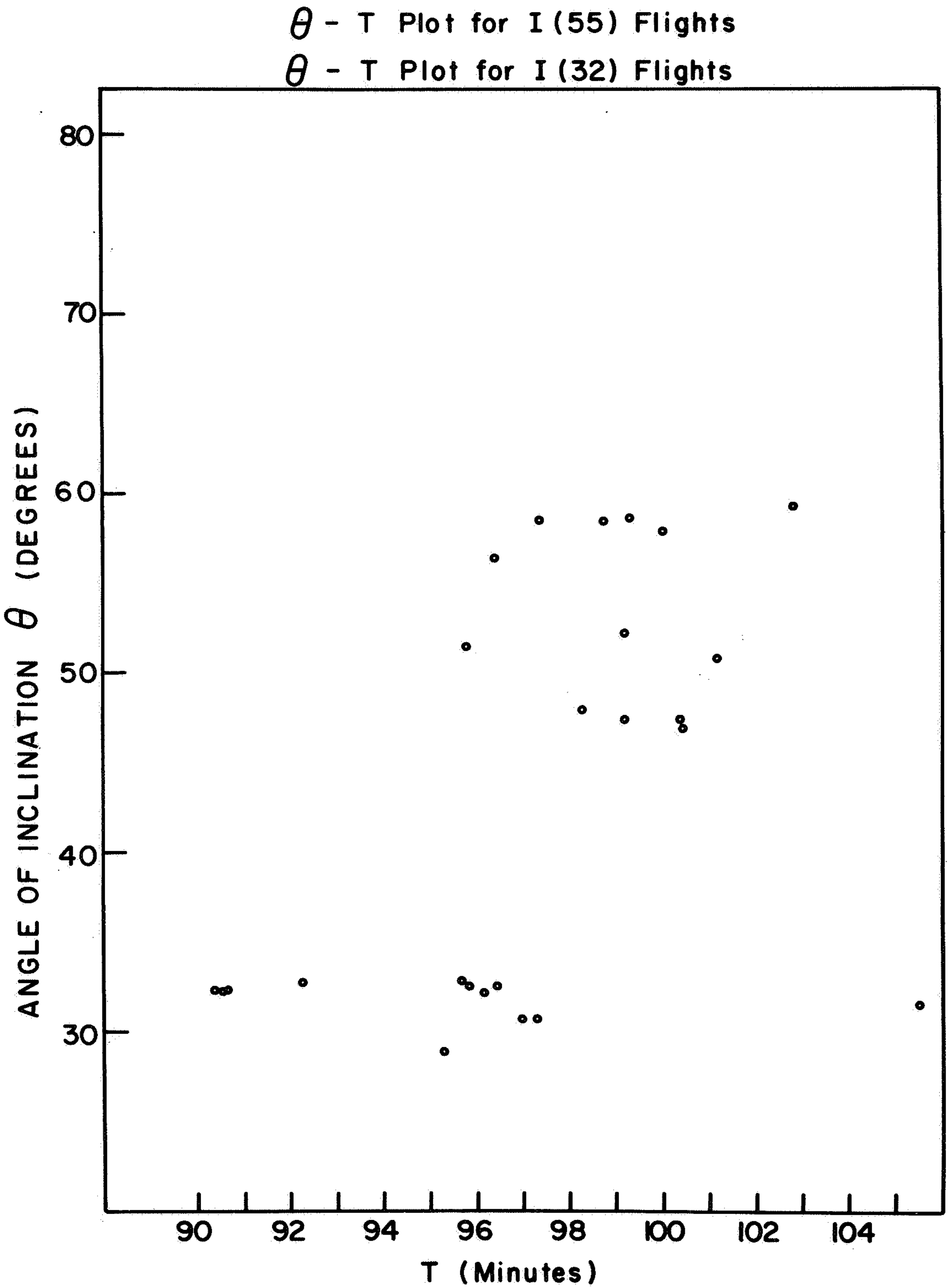

Fig. 2. Angle of Inclination vs. Period for I(55) and I(32) Flights.

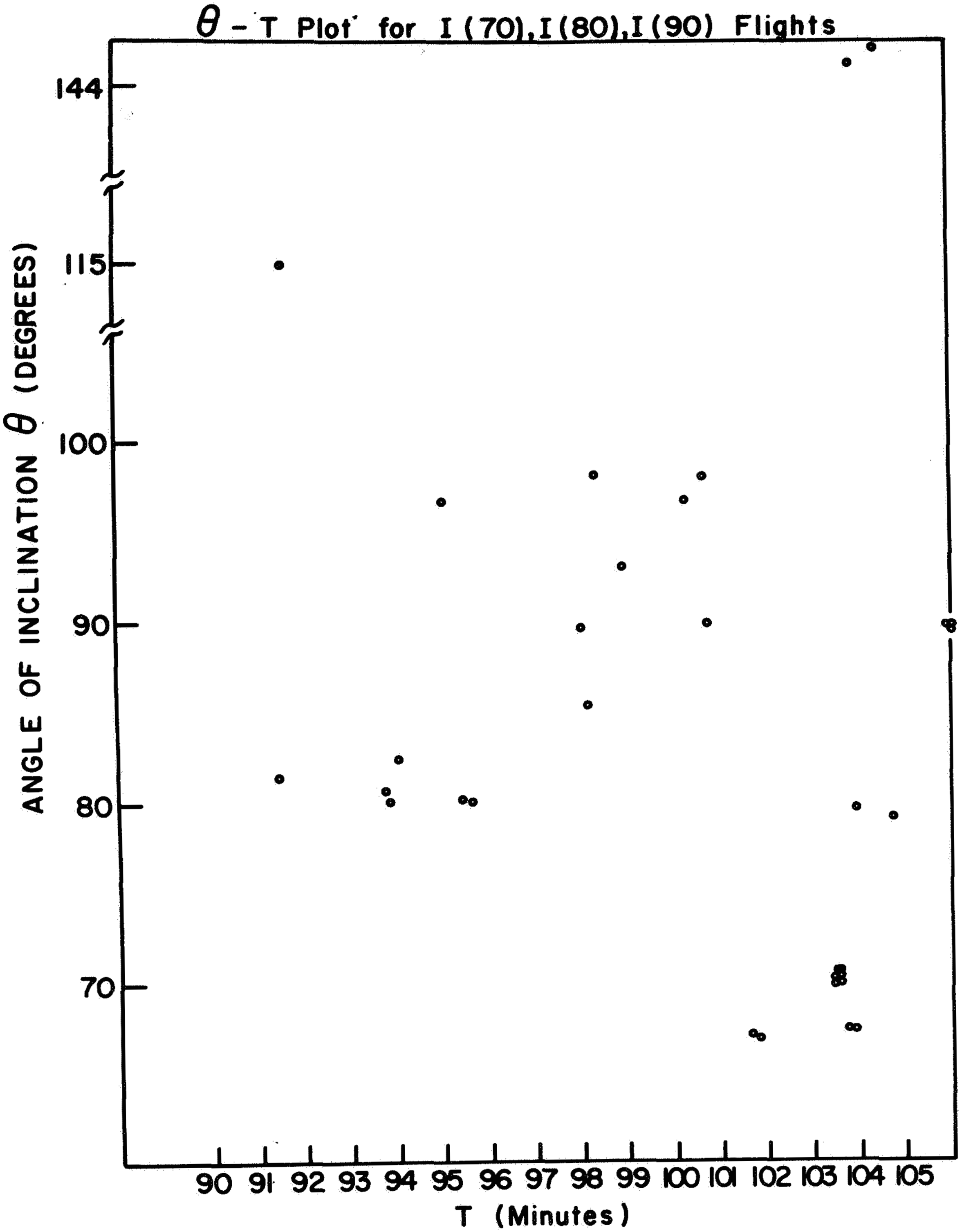

Fig. 3. Angle of Inclination vs. Period for I (70), I (80) and I (90) Flights.

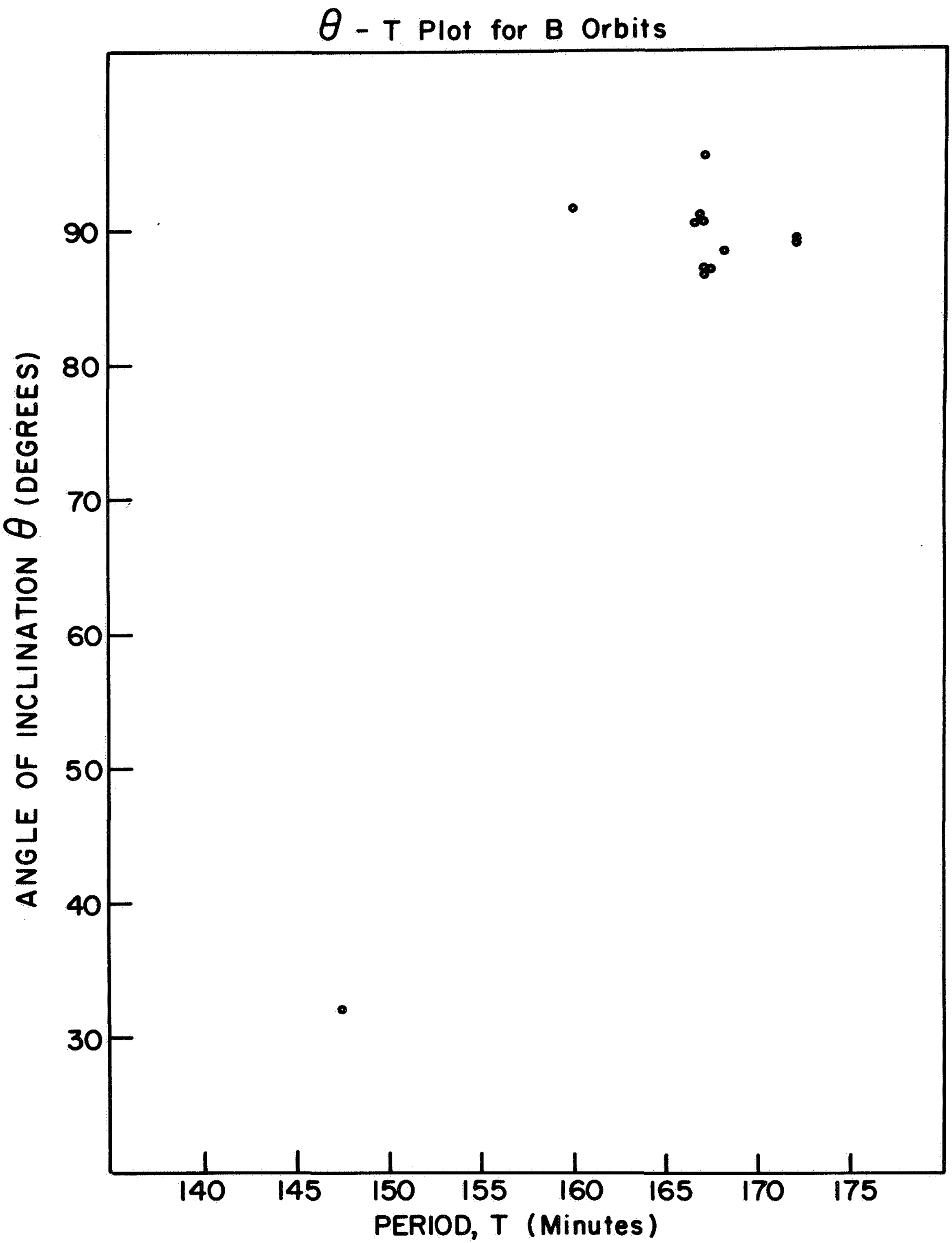

Fig. 4. Angle of Inclination vs. Period for B Flights.

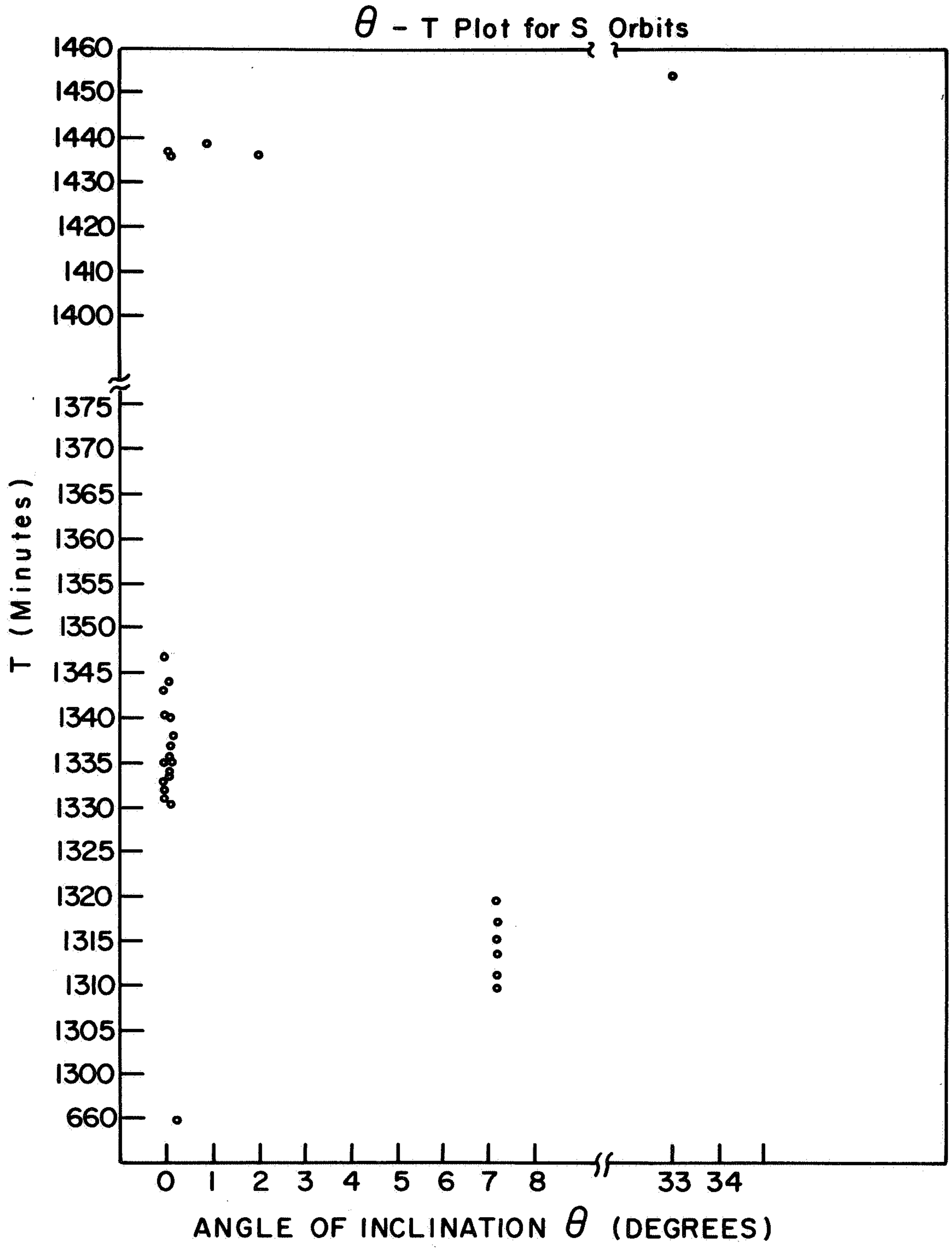

Fig. 5. Angle of Inclination vs. Period for S Flights.

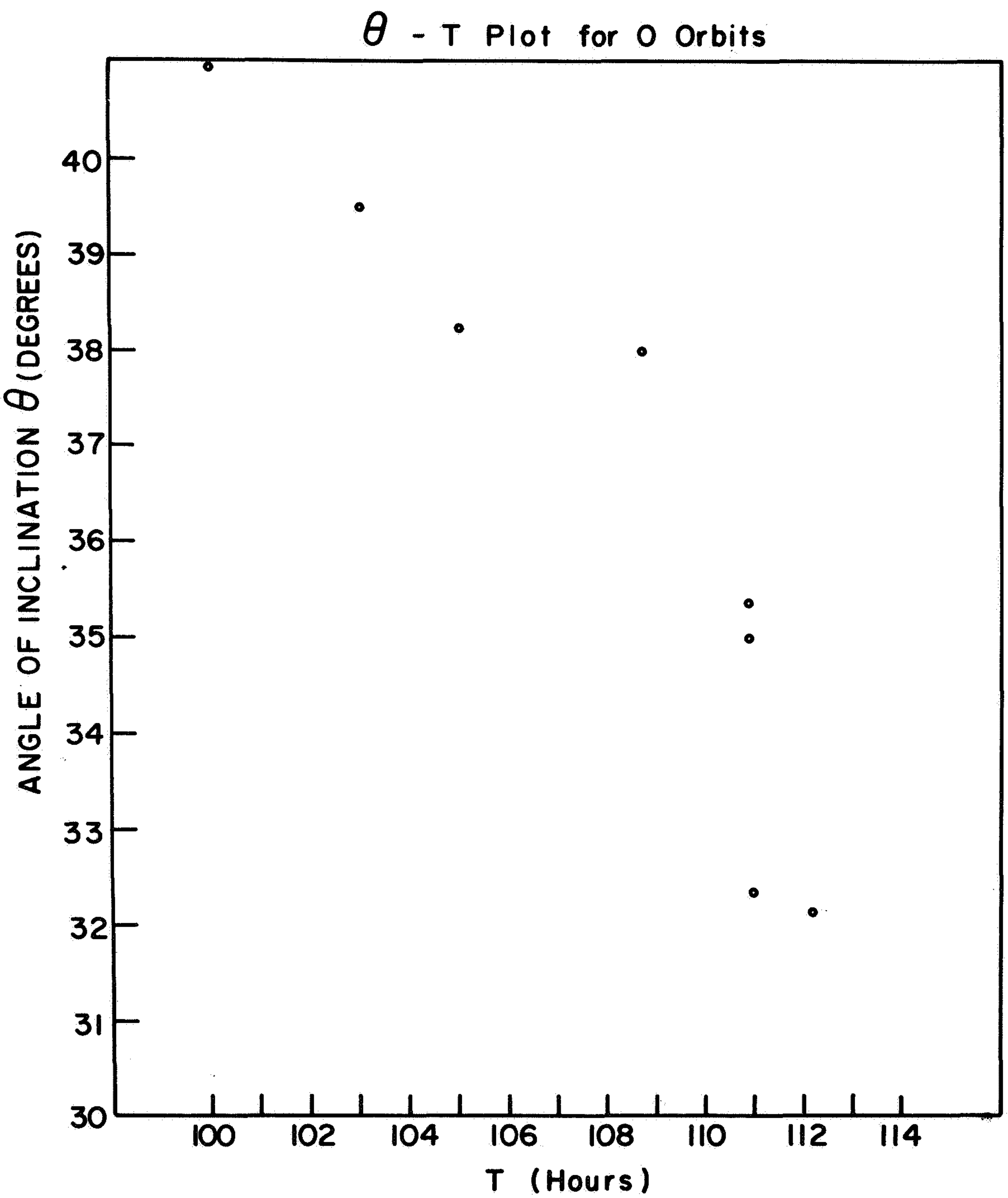

Fig. 6. Angle of Inclination vs. Period for O Flights.

TABLE I

LOG OF 1958-68 SPACE PROJECTS - CLASS # 1

NAME	INT'L. DESIG.	PROJ. DIR.	DATE	SITE	PERIGEE*	APOGEE
EXPLORER 1	1958 A1	USA	1/31/58	ETR	224	1584
VANGUARD 1	1958 B2	USN	3/17/58	ETR	405	2462
EXPLORER 4	1958 E1	ARPA	7/26/58	ETR	163	1372
PIONEER 4	1959 N1	NASA	3/3/59	ETR	.9871AU	1.142AU
EXPLORER 7	1959 I1	NASA	10/13/59	ETR	346	676
DISCOVERER 8	1959 Λ1	USAF	11/20/59	WTR	120	1032
TIROS 1	1960 B2	NASA	4/1/60	ETR	430	468
TRANSIT 1B	1960 Γ2	ARPA	4/13/60	ETR	232	463
TRANSIT 2A	1960 H1	USN	6/22/60	ETR	389	665
SOLRAD 1	1960 H2	USN	6/22/60	ETR	382	657
PIONEER 5	1960 A1	NASA	3/11/60	ETR	.8061AU	.995AU
TIROS 2	1960 II1	NASA	11/23/60	ETR	387	452
DISCOVERER 18	1960 Σ1	USAF	12/7/60	WTR	143	426
SAMOS 2	1961 A1	USAF	1/31/61	WTR	300	350
DISCOVERER 20	1961 E1	USAF	2/17/61	WTR	177	486
DISCOVERER 21	1961 Z1	USAF	2/18/61	WTR	149	659
DISCOVERER 23	1961 Λ1	USAF	4/8/61	WTR	126	882
EXPLORER 11	1961 N1	NASA	4/27/61	ETR	304	1113
TRANSIT 4A	1961 O1	USN	6/29/61	ETR	534	623
INJUN 1/ SOLRAD 3	1961 O2	USN	6/29/61	ETR	534	634
DISCOVERER 26	1961 II1	USAF	7/7/61	WTR	146	503

*Indicates miles except where noted.

TABLE I (Cont'd.)

Log of 1958-68 Space Projects - Class # 1

Name	Int'l. Desig.	Proj. Dir.	Date	Site	Perigee	Apogee
TIROS 3	1961 P1	NASA	7/12/61	ETR	461	506
MIDAS 3	1961 Σ1	USAF	7/12/61	WTR	2130	2130
EXPLORER 12	1961 Υ1	NASA	8/15/61	ETR	182	48,000
DISCOVERER 30	1961 Ω1	USAF	9/12/61	WTR	154	345
MIDAS 4	1961 AΔ1	USAF	10/21/61	WTR	2058	2324
TRANSIT 4B	1961 AH 1	USN	11/15/61	ETR	582	700
TRAAC	1961 AH 2	USN	11/15/61	ETR	562	720
RANGER 3	1962 A1	NASA	1/26/62	ETR	.9839AU	1.163AU
TIROS 4	1962 B1	NASA	2/8/62	ETR	441	525
OSO 1	1962 Z1	NASA	3/7/62	ETR	344	370
NONE	1962 K1	USAF	4/9/62	WTR	1731	2116
ARIEL 1	1962 O1	NASA/UK	4/26/62	ETR	242	754
NONE	1962 Σ1	USAF	5/15/62	WTR	180	401
TIROS 5	1962 AA1	NASA	6/19/62	ETR	367	604
TELSTAR 1	1962 AE 1	AT&T	7/10/62	ETR	593	3503
MARINER 2	1962 AP 1	NASA	8/26/62	ETR	.7046AU	1.229AU
TIROS 6	1962 AΨ1	NASA	9/18/62	ETR	423	444
EXPLORER 14	1962 BΓ1	NASA	10/2/62	ETR	174	61,190
RANGER 5	1962 BH1	NASA	10/18/62	ETR	.9490AU	1.052AU
EXPLORER 15	1962 BΛ1	NASA	10/27/62	ETR	194	10,760
ANNA 1B	1962 BM1	USN	10/31/62	ETR	670	728
INJUN 3	1962 BT2	USAF/USN	12/12/62	WTR	153	1729
RELAY 1	1962 BΥ1	NASA	12/13/62	ETR	819	4612
EXPLORER 16	1962 BX1	NASA	12/16/62	WI	466	733
EXPLORER 17	1963 9A	NASA	4/2/63	ETR	158	568

TABLE I (Cont'd.)

Log of 1958-68 Space Projects - Class # 1

Name	Int'l. Desig.	Proj. Dir.	Date	Site	Perigee	Apogee
TELSTAR 2	1963 13A	AT&T	5/7/63	ETR	604	6713
NONE	1963 14A	USAF	5/9/63	WTR	2249	2290
ERS 5	1963 14B	USAF	5/9/63	WTR	2241	2297
ERS 6	1963 14C	USAF	5/9/63	WTR	2238	2282
NONE	1963 22A	USN	6/15/63	WTR	463	528
TIROS 7	1963 24A	NASA	6/19/63	ETR	385	401
HITCH-HIKER 1	1963 25B	USAF	6/26/63	WTR	201	2571
GEOPHYSICAL RESEARCH SATELLITE	1963 26A	USAF	6/28/63	WI	267	808
ERS 9	1963 30B	USAF	7/18/63	WTR	2276	2319
SYNCOM 2	1963 31A	NASA	7/26/63	ETR	22,062	22,750
NONE	1963 38C	USAF/USN	9/28/63	WTR	667	705
VELA 1	1963 39A	USAF	10/16/63	ETR	63,441	70,631
VELA 2	1963 39C	USAF	10/16/63	ETR	62,806	72,974
EXPLORER 18	1963 46A	NASA	11/26/63	ETR	119	122,522
ATLAS-CENTAUR 2	1963 47A	NASA	11/27/63	ETR	303	1093
EXPLORER 19	1963 53A	NASA	12/19/63	WTR	366	1487
TIROS 8	1963 54A	NASA	12/21/63	ETR	430	474
GGSE 1	1964 1B	USN/USA	1/11/64	WTR	560	585
SECOR 1	1964 1C	USN/USA	1/11/64	WTR	563	582
SOLRAD 7A	1964 1D	USN/USA	1/11/64	WTR	563	582
RELAY 2	1964 3A	NASA	1/21/64	ETR	1298	4606
ECHO 2	1964 4A	NASA	1/25/64	WTR	642	816
SATURN SA-5	1964 5A	NASA	1/19/64	ETR	164	471

TABLE I (Cont'd.)

Log of 1958-68 Space Projects - Class # 1

Name	Int'l. Desig.	Proj. Dir.	Date	Site	Perigee	Apogee
ARIEL 2	1964 15A	NASA/UK	3/27/64	WI	180	843
VELA 3	1964 40A	USAF	7/17/64	ETR	63,369	65,024
VELA 4	1964 40B	USAF	7/17/64	ETR	58,766	69,482
ERS 13	1964 40C	USAF	7/17/64	ETR	120	64,886
NONE	1964 45B	USAF	8/14/64	WTR	163	2332
SYNCOM 3	1964 47A	NASA	8/19/64	ETR	22,164	22,312
NONE	1964 48A	USAF	8/21/64	WTR	217	226
EXPLORER 20	1964 51A	NASA	8/25/64	WTR	541	634
OGO 1	1964 54A	NASA	9/4/64	ETR	175	92,827
EXPLORER 21	1964 60A	NASA	10/3/64	ETR	122	59,253
EXPLORER 22	1964 64A	NASA	10/9/64	WTR	549	669
MARINER 3	1964 73A	NASA	11/5/64	ETR	.6150AU	.8155AU
EXPLORER 23	1964 74A	NASA	11/6/64	WI	288	609
EXPLORER 24	1964 76A	NASA	11/21/64	WTR	344	1551
EXPLORER 25	1964 76B	NASA	11/21/64	WTR	345	1547
MARINER 4	1964 77A	NASA	11/28/64	ETR	1.1089AU	1.5730AU
NONE	1964 83C	USAF/USN	12/12/64	WTR	639	672
EXPLORER 26	1964 86A	NASA	12/21/64	ETR	190	16,280
TIROS 9	1965 4A	NASA	1/22/65	ETR	435	1602
OSO 2	1965 7A	NASA	2/3/65	ETR	343	393
LES 1	1965 8C	USAF	2/11/65	ETR	1726	1744
PEGASUS 1	1965 9A	NASA	2/16/65	ETR	308	462
GGSE 2	1965 16B	USAF/	3/9/65	WTR	562	583
GGSE 3	1965 16C	USN/ USA	3/9/65	WTR	562	583

TABLE I (Cont'd.)

Log of 1958-68 Space Projects - Class # 1

Name	Int'l. Desig.	Proj. Dir.	Date	Site	Perigee	Apogee
SOLRAD 7B	1965 16D	USAF/ USN/ USA	3/9/65	WTR	562	583
SECOR 3	1965 16E		3/9/65	WTR	562	583
OSCAR 3	1965 16F		3/9/65	WTR	565	585
SURCAL	1965 16G		3/9/65	WTR	564	585
SURCAL	1965 16H		3/9/65	WTR	563	586
SECOR 2	1965 17B	USN/USA	3/11/65	WTR	206	624
SNAPSHOT	1965 27A	USAF/USA	4/3/65	WTR	805	826
SECOR 4	1965 27B	USAF/USA	4/3/65	WTR	797	816
EARLY BIRD	1965 28A	CSC	4/6/65	ETR	21,748	22,733
EXPLORER 27	1965 32A	NASA	4/29/65	WI	584	819
LES 2	1965 34B	USAF	5/6/65	ETR	1757	9384
PEGASUS 2	1965 39A	NASA	5/25/65	ETR	314	466
EXPLORER 28	1965 42A	NASA	5/29/65	ETR	121	163,831
VELA 5	1965 58A	USAF	7/20/65	ETR	66,476	72,234
VELA 6	1965 58B	USAF	7/20/65	ETR	63,217	75,561
ERS 17	1965 58C	USAF	7/20/65	ETR	129	69,723
PEGASUS 3	1965 60A	NASA	7/30/65	ETR	323	336
SECOR 5	1965 63A	USA	8/10/65	WI	702	1503
ATLAS-CENTAUR 6	1965 64A	NASA	8/11/65	ETR	105	509,829
SURCAL	1965 65B	USN	8/13/65	WTR	680	738
SURCAL	1965 65C	USN	8/13/65	WTR	680	738
SURCAL	1965 65E	USN	8/13/65	WTR	680	738
NONE	1965 65F	USN	8/13/65	WTR	680	738
SURCAL	1965 65H	USN	8/13/65	WTR	680	738
SURCAL	1965 65L	USN	8/13/65	WTR	680	738

TABLE I (Cont'd.)

Log of 1958-68 Space Projects - Class # 1

Name	Int'l. Desig.	Proj. Dir.	Date	Site	Perigee	Apogee
OV1 2	1965 78A	USAF	10/5/65	WTR	256	2146
OGO 2	1965 81A	NASA	10/14/65	WTR	260	941
OV2 1/LCS2	1965 82A	USAF	10/15/65	ETR	439	492
EXPLORER 29	1965 89A	NASA	11/6/65	ETR	693	1414
EXPLORER 30	1965 93A	USN/NASA	11/18/65	WI	440	548
EXPLORER 31	1965 98B	NASA	11/28/65	WTR	314	1850
PIONEER 6	1965 105A	NASA	12/16/65	ETR	0.814AU	0.985AU
OV2 3	1965 108A	USAF	12/21/65	ETR	110	20,903
LES 4	1965 108B	USAF	12/21/65	ETR	124	20,890
OSCAR 4	1965 108C	USAF	12/21/65	ETR	101	20,847
LES 3	1965 108D	USAF	12/21/65	ETR	121	20,477
ESSA 1	1966 8A	ESSA	2/3/66	ETR	432	521
ESSA 2	1966 16A	ESSA	2/28/66	ETR	843	885
OV1 4	1966 25A	USAF	3/30/66	WTR	550	630
OV1 5	1966 25B	USAF	3/30/66	WTR	613	659
OV3 1	1966 34A	USAF	4/22/66	WTR	220	3568
NIMBUS 2	1966 40A	NASA	5/15/66	WTR	684	734
EXPLORER 32	1966 44A	NASA	5/25/66	ETR	173	1629
OGO 3	1966 49A	NASA	6/6/66	ETR	170	75,769
SECOR 6	1966 51B	USAF/USA	6/9/66	WTR	104	2266
ERS 16	1966 51C	USAF/USA	6/9/66	WTR	112	2251
OV3 4	1966 52A	USAF	6/10/66	WI	399	2939
GGTS 1	1966 53A	USAF	6/16/66	ETR	20,913	21,051
IDCSP 1	1966 53B	USAF	6/16/66	ETR	20,923	21,053

TABLE I (Cont'd.)

Log of 1958-68 Space Projects - Class # 1

Name	Int'l. Desig.	Proj. Dir.	Date	Site	Perigee	Apogee
IDCSP 2	1966 53C	USAF	6/16/66	ETR	20,927	21,066
IDCSP 3	1966 53D	USAF	6/16/66	ETR	20,936	21,088
IDCSP 4	1966 53E	USAF	6/16/66	ETR	20,935	21,194
IDCSP 5	1966 53F	USAF	6/16/66	ETR	20,949	21,258
IDCSP 6	1966 53G	USAF	6/16/66	ETR	20,936	21,139
IDCSP 7	1966 53H	USAF	6/16/66	ETR	20,948	21,350
PAGEOS	1966 56A	NASA	6/23/66	WTR	2607	2662
EXPLORER 33	1966 58A	NASA	7/1/66	ETR	9880	270,560
OV1 8	1966 63A	USAF	7/13/66	WTR	612	635
OV3 3	1966 70A	USAF	8/4/66	WTR	220	2780
PIONEER 7	1966 75A	NASA	8/17/66	ETR	1.010AU	1.125AU
SECOR 7	1966 77B	USAF/USA	8/19/66	WTR	2287	2299
ERS 15	1966 77C	USAF/USA	8/19/66	WTR	2280	2300
ESSA 3	1966 87A	ESSA	10/2/66	WTR	860	923
SECOR 8	1966 89B	USAF	10/5/66	WTR	2287	2304
INTELSAT 2A	1966 96A	CSC	10/26/66	ETR	2088	23,014
OV4 3	1966 99A	USAF	11/3/66	ETR	187	188
OV4 1R	1966 99B	USAF	11/3/66	ETR	181	181
OV4 1T	1966 99D	USAF	11/3/66	ETR	181	190
LUNAR ORBITER 2	1966 100A	NASA	11/6/66	ETR	129	1147
ATS 1	1966 110A	NASA	12/6/66	ETR	22,277	22,920
OV1 9	1966 111A	USAF	12/11/66	WTR	297	3004
OV1 10	1966 111B	USAF	12/11/66	WTR	403	479
PACIFIC 1	1967 1A	CSC	1/11/67	ETR	22,244	22,257

TABLE I (Cont'd.)

Log of 1958-68 Space Projects - Class # 1

Name	Int'l. Desig.	Proj. Dir.	Date	Site	Perigee	Apogee
IDCSP 8	1967 3A	USAF	1/18/67	ETR	20,835	21,038
IDCSP 9	1967 3B	USAF	1/18/67	ETR	20,854	21,031
IDCSP 10	1967 3C	USAF	1/18/67	ETR	20,867	21,036
IDCSP 11	1967 3D	USAF	1/18/67	ETR	20,875	21,063
IDCSP 12	1967 3E	USAF	1/18/67	ETR	20,901	21,089
IDCSP 13	1967 3F	USAF	1/18/67	ETR	20,923	21,128
IDCSP 14	1967 3G	USAF	1/18/67	ETR	20,932	21,192
IDCSP 15	1967 3H	USAF	1/18/67	ETR	20,935	21,275
ESSA 4	1967 6A	ESSA	1/26/67	WTR	822	894
LUNAR ORBITER 3	1967 8A	NASA	2/4/67	ETR	124	1150
OSO 3	1967 20A	NASA	3/8/67	ETR	336	354
ATLANTIC 2	1967 26A	CSC	3/22/67	ETR	22,246	22,254
ATS 2	1967 31A	NASA	4/5/67	ETR	115	6947
ESSA 5	1967 36A	ESSA	4/20/67	WTR	840	883
VELA 7	1967 40A	USAF	4/28/67	ETR	67,804	69,991
VELA 8	1967 40B	USAF	4/28/67	ETR	67,238	71,674
ERS 18	1967 40C	USAF	4/28/67	ETR	5357	69,316
OV5 3	1967 40D	USAF	4/28/67	ETR	5357	69,316
OV5 1	1967 40E	USAF	4/28/67	ETR	5357	69,316
LUNAR ORBITER 4	1967 41A	NASA	5/4/67	ETR	1681	3750
ARIEL 3*	1967 42A	UK	5/5/67	WTR	306	373
EXPLORER 34	1967 51A	NASA	5/24/67	WTR	154	131,187

*Exception made here because ARIEL 3 is a well documented flight.

TABLE I (Cont'd.)

Log of 1958-68 Space Projects - Class # 1

Name	Int'l. Desig.	Proj. Dir.	Date	Site	Perigee	Apogee
SURCAL	1967 53B	USAF/USN	5/31/67	WTR	570	582
GGSE 4	1967 53C	USAF/USN	5/31/67	WTR	569	577
GGSE 5	1967 53D	USAF/USN	5/31/67	WTR	570	575
SURCAL	1967 53F	USAF/USN	5/31/67	WTR	569	575
SURCAL	1967 53J	USAF/USN	5/31/67	WTR	569	577
MARINER 5	1967 60A	NASA	6/14/67	ETR		
SECOR 9	1967 65A	USA/USN	6/29/67	WTR	2362	2451
AURORA 1	1967 65B	USA/USN	6/29/67	WTR	2370	2458
IDCSP 16	1967 66B	USAF	7/1/67	ETR	20,509	20,846
IDCSP 17	1967 66C	USAF	7/1/67	ETR	20,542	20,857
IDCSP 18	1967 66D	USAF	7/1/67	ETR	20,582	20,866
DATS 1	1967 66E	USAF	7/1/67	ETR	20,620	20,875
DODGE	1967 66F	USAF	7/1/67	ETR	20,661	20,884
LES 5	1967 66G	USAF	7/1/67	ETR	20,692	20,894
EXPLORER 35	1967 70A	NASA	7/19/67	ETR	500	4600
OGO 4	1967 73A	NASA	7/28/67	WTR	256	564
LUNAR ORBITER 5	1967 75A	NASA	8/1/67	ETR	122	3738
PACIFIC 2	1967 94A	CSC	9/27/67	ETR	22,220	22,245
OSO 4	1967 100A	NASA	10/18/67	ETR	334	354
ATS 3	1967 111A	NASA	11/5/67	ETR	22,228	22,254
ESSA 6	1967 114A	ESSA	11/10/67	WTR	876	925
OV3 6	1967 120A	USAF	12/4/67	WTR	252	271
PIONEER 8	1967 123A	NASA	12/13/67	ETR	1.0AU	1.1AU
TTS 1	1967 123B	NASA	12/13/67	ETR	182	300
EXPLORER 36	1968 02A	NASA	1/11/68	WTR	635	926

TABLE II

"Inside Orbits" (I)

Total List for "Radiationless" Orbits (<700 miles)

	Designation			P miles	A miles	T min.	θ^{o}
1.	1965 60A	Pegasus 3	NASA	323	336	95.3	28.9
2.	1965 9A	Pegasus 1	NASA	308	462	97.0	31.7
3.	1965 39A	Pegasus 2	NASA	314	466	97.3	31.7
4.	1961 AH1	Transit 4B	USN	582	700	105.6	32.4
5.	1962 Z1	OSO 1	NASA	344	370	96.2	32.8
6.	1966 99A	OV4 3	USAF	188	187	90.6	32.8
7.	1966 99B	OV4 1R	USAF	181	181	90.4	32.8
8.	1966 99D	OV4 1T	USAF	181	190	90.7	32.8
9.	1965 7A	OSO 2	NASA	343	393	96.5	32.9
10.	1967 20A	OSO 3	NASA	336	354	95.9	32.9
11.	1967 123B	TTS1	NASA	182	300	92.3	32.9
12.	1967 100A	OSO 4	NASA	334	354	95.7	32.9
13.	1961 P1	Tiros 3	NASA	461	506	100.4	47.8
14.	1962 B1	Tiros 4	NASA	441	525	100.4	48.3
15.	1960 B2	Tiros 1	NASA	430	468	99.2	48.3
16.	1960 II-1	Tiros 2	NASA	387	452	98.3	48.5
17.	1959 I-1	Explorer 7	NASA	346	676	101.2	50.3
18.	1960 Γ2	Transit 1B	ARPA	232	463	95.8	51.3
19.	1964 74A	Explorer 23	NASA	288	610	99.2	51.9
20.	1963 9A	Explorer 17	NASA	158	568	96.4	57.6
21.	1962 AA1	Tiros 5	NASA	367	604	100.5	58.1
22.	1962 AΨ1	Tiros 6	NASA	423	444	98.7	58.2
23.	1963 24A	Tiros 7	NASA	385	401	97.4	58.2
24.	1963 54A	Tiros 8	NASA	430	473	99.3	58.5
25.	1965 93A	Explorer 30	USN/NASA	440	548	102.8	59.7
26.	1960 H1	Transit 2A	USN	389	665	101.7	66.7
27.	1960 H2	Solrad 1	USN	382	657	101.6	66.8
28.	1961 01	Transit 4A	USN	534	623	103.7	67.0
29.	1961 02	Injun 1/ Solrad 3	USN	534	634	103.8	67.0
30.	1964 1D	Solrad 7A	USN/USA	563	578	103.5	69.9
31.	1964 1C	Secor 1	USN/USA	563	578	103.5	69.9
32.	1964 1B	GGSE 1	USN/USA	560	585	103.5	70
33.	1967 53B	Surcal	USAF/USN	570	582	103.5	70
34.	1967 53C	GGSE 4	USAF/USN	569	577	103.4	70
35.	1967 53D	GGSE 5	USAF/USN	570	575	103.4	70
36.	1967 53F	Surcal	USAF/USN	569	575	103.4	69.9
37.	1967 53J	Surcal	USAF/USN	569	577	103.4	70.0
38.	1965 16B	GGSE 2	USN/USA/USAF	562	583	103.5	70.1
39.	1965 16C	GGSE 3	USN/USA/USAF	562	583	103.5	70.1
40.	1965 16D	Solrad 7B	USN/USA/USAF	562	583	103.4	70.1

TABLE II (Cont'd.)

"Inside Orbits" (I)

Total List for "Radiationless" Orbits (<700 miles)

	Designation			P miles	A miles	T min.	θ^o
41.	1965 16E	Secor 3	USN/USA/USAF	562	583	103.5	70.1
42.	1965 16F	Oscar 3	USN/USA/USAF	565	585	103.5	70.1
43.	1965 16G	Surcal	USN/USA/USAF	564	585	103.5	70.1
44.	1965 16H	Surcal	USN/USA/USAF	563	586	103.5	70.1
45.	1965 64A	Explorer 22	NASA	549	669	104.7	79.7
46.	1964 51A	Explorer 20	NASA	540	634	103.9	79.9
47.	1960 Σ1	Discoverer 18	USAF	143	426	93.8	80.8
48.	1961 E1	Discoverer 20	USAF	177	486	95.4	80.4
49.	1961 Z1	Discoverer 21	USAF	149	659	93.8	80.4
50.	1961 AK1	Discoverer 36	USAF	148	280	91.5	81.2
51.	1962 Σ1	None	USAF	180	401	94.0	82.5
52.	1967 42A	Ariel 3*	UK	306	373	95.6	80.2
53.	1967 73A	OGO 4	NASA	256	564	98.1	86
54.	1964 83C	None	USAF/USN	639	672	106.3	90
55.	1964 83D	None	USAF/USN	639	672	106.3	90
56.	1963 38C	None	USN	667	705	107.4	89.9
57.	1965 17B	Secor 2	USA	206	624	98.0	89.9
58.	1963 22A	None	USAF/USN	463	528	100.7	90
59.	1966 111B	OV1-10	USAF	403	479	98.9	93.5
60.	1966 8A	ESSA 1	ESSA	432	521	100.2	97.9
61.	1961 A1	Samos 2	USAF	300	350	95	97.0
62.	1965 51A	Tiros 10	NASA	458	517	100.6	98.6
63.	1964 48A	None	USAF	217	226	91.6	115
64.	1966 25A	OV1 4	USAF	550	630	103.9	144.5
65.	1966 25B	OV1 5	USAF	613	659	104.4	144.7

* Note: Well documented flight although not a NASA or DOD.

TABLE III

"First Belt" Orbits (B) 1500 - 2500 Miles

	Designation				P miles	A miles	T min.	θ°
1.	1961	Σ1	Midas 3	USAF	2130	2130	160	91.1
2.	1961	AΔ1	Midas 4	USAF	2058	2324	166	95.9
3.	1963	14A	None	USAF	2249	2290	166.6	87.4
4.	1963	14B	ERS 5	USAF	2241	2297	166.5	87.4
5.	1963	14C	ERS 6	USAF	2238	2282	166.5	87.3
6.	1963	30B	ERS 9	USAF	2276	2319	167.9	88.4
7.	1965	8C	LES 1	USAF	1726	1744	147.7	32.2
8.	1966	77B	Secor 7	USAF/USA	2287	2299	167.6	90.1
9.	1966	77C	ERS 15	USAF/USA	2280	2300	167.5	90.1
10.	1966	89B	Secor 8	USAF	2287	2304	167.6	90.2
11.	1967	65A	Secor 9	USA/USN	2362	2451	172.1	89.8
12.	1967	65B	Aurora 1	USA/USN	2370	2458	172.1	89.8

TABLE IV

Geostationary Orbits (S)

	Designation			P miles	A miles	T min.	θ^o
1.	1963 31A	Syncom 2	NASA	22,062	22,750	1454	33.1
2.	1964 47A	Syncom 3	NASA	22,164	22,312	1436.2	0.1
3.	1965 28A	Early Bird	CSC	21,748	22,733	1436.4	0.1
4.	1966 53A	GGTS 1	USAF	20,913	21,051	1334.2	0.1
5.	1966 53B	IDCSP 1	USAF	20,923	21,053	1334.7	0.1
6.	1966 53C	IDCSP 2	USAF	20,927	21,066	1335.3	0.1
7.	1966 53D	IDCSP 3	USAF	20,936	21,088	1336.6	0.1
8.	1966 53E	IDCSP 4	USAF	20,935	21,194	1340.8	0.0
9.	1966 53F	IDCSP 5	USAF	20,949	21,258	1344.0	0.1
10.	1966 53G	IDCSP 6	USAF	20,936	21,139	1338.6	0.2
11.	1966 53H	IDCSP 7	USAF	20,948	21,350	1347.6	0.0
12.	1966 110A	ATS 1	NASA	22,277	22,920	660	0.2
13.	1967 3A	IDCSP 8	USAF	20,835	21,038	1330	0.1
14.	1967 3B	IDCSP 9	USAF	20,854	21,031	1331	0.0
15.	1967 3C	IDCSP 10	USAF	20,867	21,036	1332	0.0
16.	1967 3D	IDCSP 11	USAF	20,875	21,063	1333	0.0
17.	1967 3E	IDCSP 12	USAF	20,901	21,089	1335	0.0
18.	1967 3F	IDCSP 13	USAF	20,923	21,128	1337	0.1
19.	1967 3G	IDCSP 14	USAF	20,932	21,192	1340	0.1
20.	1967 3H	IDCSP 15	USAF	20,935	21,275	1343	0.0
21.	1967 26A	Atlantic 2	CSC	22,246	22,254	1436.1	2.0
22.	1967 66B	IDCSP 16	USAF	20,509	20,846	1309.8	7.2
23.	1967 66C	IDCSP 17	USAF	20,542	20,857	1311.6	7.2
24.	1967 66D	IDCSP 18	USAF	20,582	20,866	1313.5	7.2
25.	1967 66E	DATS 1	USAF	20,620	20,875	1315	7.2
26.	1967 66F	DODGE	USN	20,661	20,884	1317	7.2
27.	1967 66G	LES 5	USAF	20,692	20,894	1319	7.2
28.	1967 94A	Pacific 2	CSC	22,220	22,245	1439.5	0.9

TABLE V

Deep Orbits (O) 60,000 - 70,000 Miles

	Designation		P miles	A miles	T min.	θ°
1.	1963 39A Vela 1	USAF	63,441	70,031	105	38.3
2.	1963 39C Vela 2	USAF	62,806	72,974	108.7	38.0
3.	1964 40A Vela 3	USAF	63,369	65,024	100.3	39.5
4.	1964 40B Vela 4	USAF	58,766	69,482	100.1	40.9
5.	1965 58A Vela 5	USAF	66,476	72,234	110.9	35.2
6.	1966 58B Vela 6	USAF	63,217	75,561	110.9	35.0
7.	1967 40A Vela 7	USAF	67,804	69,991	111.0	32.2
8.	1967 40B Vela 8	USAF	67,238	71,674	112.2	32.1

TABLE VI

Citations Obtained From

From Computer Literature Searches

Search Control Number	Number of Documents Cited	Number of Documents Ordered	Number of Documents Received
NASA # 7140 (1)	930	219	35
DDC # 000803 (1)	94	40	32
NASA # 7400 (2)	41	26	1
DDC # 002510 (2)	67	19	0

(1) Broad Coverage Searches

(2) Specific Searches