GOES VISSR

NOV 1978 Doc

DOCUMENTATION

MASTER

DO NOT SHIP THIS COPY!!! IF THIS IS THE LAST COPY, PLEASE ASK SECRETARY IN RM G-233 TO MAKE MORE COPIES.

VISSR DIGITAL ARCHIVE USERS' GUIDE

NATIONAL CLIMATIC CENTER

SATELLITE DATA SERVICES DIVISION

APPLICATIONS BRANCH

NOVEMBER 1978

INTRODUCTION

The Satellite Data Services Division (SDSD) of the National Climatic Center has, in conjunction with the National Environmental Satellite Service (NESS), established a digital tape archive of SMS/GOES VISSR data.

Four mile resolution visible and infrared sectors from satellites operating in both East and West positions are being archived. Since September 6, 1978 this archive includes three hourly data from both satellite positions. From August 1976 to that data coverage was limited to five IR sectors and one visible sector per day per satellite. Data from SMS-1, SMS-2, GOES-1, GOES-2, and GOES-3 is included in the archive.

In addition to the VISSR sector, SDSD maintains an archive of the cloud motion (wind) information derived operationally by NESS.

SDSD also maintains a comprehensive archive of SMS/GOES imagery (photographic negatives) including all sectors produced operationally by NESS (Infrared and Visible of various resolutions covering various areas). SDSD has archived over 500,000 negatives, dating back to May of 1974 (and a complete archive of Advanced Technology Satellite (ATS) imagery, dating back to February of 1966).

This Users' Guide is a brief summary of information available to support the use of the VISSR Digital Archive. The Guide is divided into a series of sections as follows:

A. Summary of VISSR System Characteristics

B. Obtaining Data from the SDSD Archive

C. VISSR Archive Data Characteristics

D. VISSR Tape Format

APPENDIX I. Earth-Location Equations

APPENDIX II. Temperature Calibration Table

APPENDIX III. Winds Archive

Note that the description of the digital tape archive contained in this Users' Guide updates that information provided in the SMS/GOES Users' Guide, published by NOAA/NESS and NASA (undated).

A. Summary of VISSR Sensor System Characteristics

VISSR is an acronym for Visible Infrared Spin Scan Radiometer, an instrument flown aboard the SMS/GOES series of geostationary satellites.

The VISSR scanning system consists of a mirror that is stepped to provide North to South viewing while the rotation of the satellite provides West-East scanning. The mirror is stepped following each West-East scan; 1821 scans constitute one full frame, providing "full disc" earth coverage. At the satellite rotation rate of 100 RPM, 18.21 minutes are required to complete one full frame.

The scanning mirror reflects the received radiation into a 16-inch diameter telescope. A fiber optics bundle is used to couple the telescope to eight Visible detectors (sensitive to the .54 to .70 micrometer band). The fiber optics are configured such that each of eight Visible channels has a .25 x .21 mr field of view, with the fields of view arranged in a linear array sweeping out the same scan line path. The field of view provides a nominal ground resolution of .9 km. The system, therefore, provides eight parallel West-East Visible data lines per West-East scan, covering the 8-km North-South band scanned by each step of the scanning mirror. In addition, germanium relay lenses are used to pass received radiation to two HgCd/Te IR detectors by way of an optical filter providing a 10.5 to 12.6 micrometer band pass. The resolution of the IR sensor is nominally 8 km, corresponding to one North-South step of the scanning mirror.

The output from the eight Visible detectors and one (or an average) of the two IR detectors is digitized on board the satellite and transmitted in real-time to earth. The quantitization of the IR data is 8 bits and of the Visible, 6 bits. The IR data are oversampled in the West-East direction, such that the sampling resolution is 4 km in the West-East direction, leading to the designation of "raw" IR data as "8 km x 4 km" resolution.

The real-time data are received at Wallops Island, Va. in bursts as the rotating mirror scans the earth. The data are formatted; calibration of the IR is performed; grid, orbit, attitude, and various other items of information are added; and the data are retransmitted at a lower rate back to the satellite for relay to various user stations. The data rate is selected such that the retransmission just occupies the interval between real-time data bursts; i.e., the retransmission is accomplished while the rotating mirror is viewing space between scans of the earth. These retransmitted data are known as "stretched" VISSR inasmuch as the time scale is stretched by virtue of the reduction in data rate.

The stretched VISSR data are received at the Data Utilization Station at Suitland, Md., and fed into the NESS VISSR Data Processing System. The NESS SMS/GOES Ground Processing System is described in detail in "Central Processing and Analysis of Geostationary Satellite Data", NOAA Technical Memorandum NESS 64 of March 1975.

The characteristics of the archived data are described in Section C of this Guide. Section D details the format in which GOES tapes obtained from SDSD will be written.

One product produced operationally from VISSR data is archived. These are manually and machine derived cloud motion (wind) vectors. This product is described in Appendix III.

B. Obtaining Data from the SDSD Archive

Data from the SDSD VISSR Archive are available in the form of selective or straight copies of tapes containing the visible and IR sectors, grid type printouts of the visible or IR data, and copies of tapes containing derived cloud motions/winds.

1. Selective Copies

Requesters may ask for only specific files, or "sectors" extracted from files, from a tape to be copied, and for portions of data from several VISSR Archive Tapes to be combined on a single tape. Arrangement for and price of this service may be obtained from SDSD. The user must provide the satellite ID and day (as for straight copying) and the time and data type (Visible or Infrared or both, if both are available at a given time). Additionally, if a copy of a portion of a sector is desired, the user must specify the latitude/longitude bounds of the sector to be copied.

2. Straight Copies

In the case of straight copies, the requester need only specify the satellite (by name or simply as East or West) and the date, and a copy will be made of all of the data archived for that date (see Section C). Each day's data for each satellite occupies three tapes (at 1600 bpi). The cost to the requester varies with the size of the total order as follows:

Number of Tapes	Cost to Requester
1 - 9	$60 per tape
10 - 49	$45 per tape
50 or more	$35 per tape

3. Grid Printouts

Requesters may ask for a portion of a file to be printout out on paper. Three types of printouts are available:

a. Psuedo-image, where different characters are used to represent different gray shades;

b. Data values where data values in the range of 0 - 255 are printed in an array format; and

c. Temperature values for IR data, in degrees Kelvin, printed in an array format (subject to the accuracy limitations noted in the paragraph on Calibration in Section C).

Requesters interested in obtaining data printouts should contact SDSD to make specific arrangements.

All requests for digital tapes (and/or hardcopy prints) etc. should be addressed to:

Satellite Data Services Division
Room 606, World Weather Building
Washington, D.C. 20233

Standing orders for certain specified scenes to be copied on a regular periodic basis will be accepted.

Orders for straight or selective tape copies which are not too extensive can generally be filled within ten days. If not otherwise specified by the user, tape copies will be written at 1600 bpi (9-track).

Services other than tape copying, such as data print-outs and the like, are special orders and the cost and servicing time will vary with the complexity of the request.

Documentation will be furnished to all requesters. Questions relating to the contents of the tape, calibration of the data, ordering and availability of the data, etc. should be referred to the personnel of the SDSD at (301) 763-8111.

C. VISSR Archive Data Characteristics

The archived VISSR data cover a rectangular sub-area of a complete frame, called the Archive Sector, illustrated in Figure 1 below:

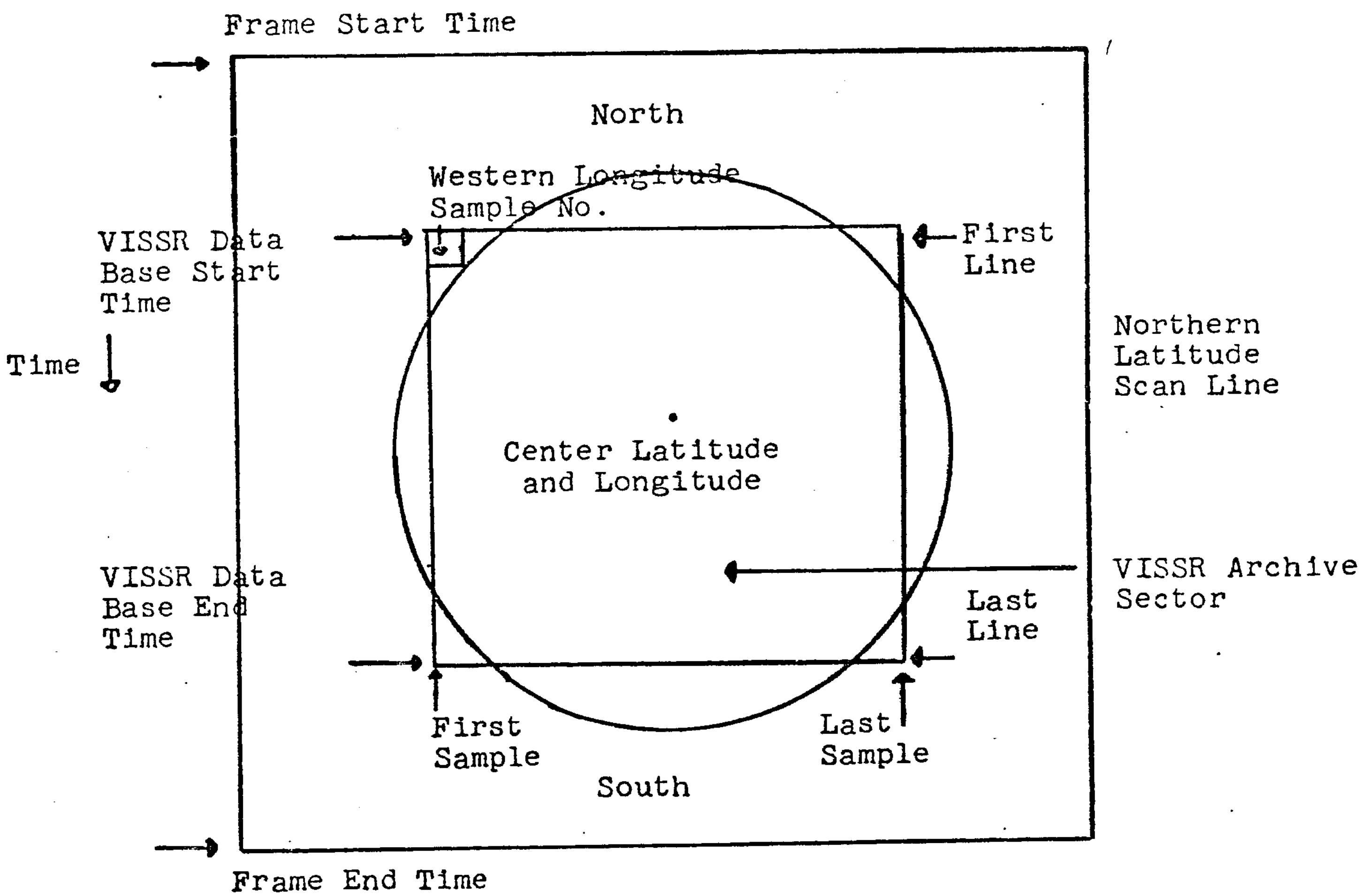


Figure 1. Archive Sector

The Archive Sector is made up of a series of horizontal scans, each consisting of a string of samples. The samples are referred to as bytes in the tape format documentation.

The normal geographic coverage of the Archive Sector will be about 88° latitude by 99° longitude for data prior to November 14, 1977 and 105° latitude by 99° longitude thereafter. This coverage will be reduced when a satellite is operated in limited scan mode, as in the case of storm days when data are collected only as far south as 5° S. Even on normal operating days, some variation in coverage will occur. The Directory File (see section D) will indicate any data missing due to equipment failure or whatever.

The time for which data are available are shown below. Note that these times apply on normal operating days only, and even then may vary by up to an hour.

A. Since September 6, 1978:

West Satellite	East Satellite
0245Z IR ONLY	0000Z IR AND VIS
0545Z IR ONLY	0300Z IR ONLY
0845Z IR ONLY	0600Z IR ONLY
1015Z IR ONLY	0900Z IR ONLY
1045Z IR ONLY	0930Z IR ONLY
1145Z IR ONLY	1000Z IR ONLY
1445Z IR ONLY	1200Z IR ONLY
1515Z IR ONLY	1500Z IR AND VIS
1545Z IR ONLY	1600Z IR AND VIS
1745Z IR AND VIS	1800Z IR AND VIS
2045Z IR AND VIS	2100Z IR AND VIS
2145Z IR AND VIS	2130Z IR ONLY
2345Z IR AND VIS	2200Z IR ONLY

B. From August, 1976 to September 5, 1978:

West Satellite	East Satellite
1015Z IR ONLY	0930Z IR ONLY
1045Z IR ONLY	1000Z IR ONLY
1515Z IR ONLY	1600Z IR AND VIS
1545Z IR ONLY	2130Z IR ONLY
2145Z IR AND VIS	2200Z IR ONLY

The times shown in B above were selected to coincide with the two NESS "picture pair" operational cloud motion vector derivation runs, and to provide a daily sample of coincident visible and IR data. (The NESS cloud motion product is also archived, see Appendix III). To this base was added, as of September 6, 1978, three hourly coverage timed to coincide as nearly as possible with standard sysnoptic data times.

The Archive Sector is centered on the satellite subpoint in the East-West direction and usually will start at 50°N. The process by which this area is extracted involves the use of orbit and attitude information and the operational earth location software, the accuracy of which is about 10 km.

The IR data are archived at a resolution of 8 km in both directions (every other sample along each scan is dropped). The IR samples are 8 bit binary values (called "counts"), packed one per 8-bit byte. The Visible data are sampled and averaged from its original resolution of 1 km in both directions down to 8 km. The Visible samples are 6-bit counts packed right-justified into 8-bit bytes.

The IR data may be calibrated in terms of temperature. This is accomplished by a two-step process. The first step is a conversion from "raw" counts to "calibrated" counts done at Wallops Island prior to retransmission of the stretched-form data. This conversion is done according to a "lookup" table to compensate for an annual fluctuation in the sensor response. The second step is performed by the user, and is the conversion of calibrated counts (the IR data on the VISSR Archive Tapes are calibrated counts) to temperatures through use of the "lookup" table included as Appendix II to this Guide. The accuracy of these temperatures is limited to 2°K to 4°K, generally nearer 2°K in the winter and nearer 4°K in the summer. During the eclipse periods, three weeks on either side of the equinoxes, an additional 4°K error occurs due to thermal fluctuations on board the satellite as it moves through the earth's shadow. Note that the errors mentioned do not include the effects of atmospheric attenuation, etc., but are only errors arising within the radiometer system itself, which was not designed for quantative applications.

Earth-location of the data (Visible and Infrared) is possible using the benchmark data provided with each archived sector. The benchmark data consist of line and sample number coordinates of data samples falling on 2½° increments of latitude and longitude. The interpolation required is described in Section D of the description of the Benchmark Table. Users may also compute their own earth-location from the satellite orbit and attitude information included in the data (from November 1, 1976 on) as described in Section D.

D. VISSR Tape Format

This section describes the format in which VISSR data will be provided to the user.

1. Tape Layout

Tapes provided users will be 9-track, phase encoded, 1600 bpi unless otherwise requested. Each tape will contain a series of one or more picture files, each being a straight or selective copy of a specified archive sector.

The tapes in the SDSD Archive contain six full sectors preceded by a Directory File. A user requesting a straight complete copy of an archived tape will receive the Directory File as the first file on the tape.

The general layout of each tape is as follows:

Directory File (On Complete Copies Only)
End-of-File
Picture File #1
End-of-File
*
*
*
Picture File #n
End-of-File

Each Picture File consists of nominally 1373 records: a 320-byte Header Record, four 6720-byte records containing a 26,880-byte Benchmark Table, and 1368 Data Records, each containing the data from one scan or line of the SM/GOES picture. The maximum number of Data Records is 1368, the full archive image contains a maximum of 1368 lines. A selective copy sector limited in north-south extent would contain fewer lines. The length of a Data Record corresponding to a complete line is 1628 bytes. The length of Data Records of a sector limited in east-west extent will be less than 1628 bytes. The Header Record of each Picture File will include the number of Data Records in the Picture File and the length of each. The length of the Data Record is constant within the Picture File.

In the event of a missing picture, the End-of-File for that picture will be present, but no Data Records for the missing picture will be present.

2. Directory Record Format (Present only on Straight Copies)

The Directory Record is the single record in the Directory File. It contains a two-byte integer Fortran array dimensioned (6,6), where:

I is the Picture File Number (1-6).

where: (I,1) = Year of Picture on File #I.
(I,2) = Julian Day Number of Picture on File #I.
(I,3) = Hour of Picture on File #I.
(I,4) = Minutes of Picture on File #I.
(I,5) = Seconds of Picture on File #I.
(I,6) = Milliseconds of Picture on File #I.

If (I,1) through (I,6) equals zero, then there are no Data Records present in Picture File #I, but its End-of-File will be there to permit the positioning of the tape to a desired Picture File by counting the File Marks.

3. Header Record Format

Elements of the Header Record are either 2-byte (16-bit) of 4-byte (32-bit) integers. Except for the number of Data Records in the Picture File (bytes 313 to 316) and the number of bytes in each Data Record (bytes 317 to 320), the 4-byte integers are values multiplied by 100, and are intended to be used as floating point numbers (i.e., converted to floating point and divided by 100).

The Header Record bytes are to be interpreted as follows:

Byte #	Internal Format	Description	
1, 2	2-byte Integer	Year	Picture Start time or time of first VISSR Scan Line of that picture.
3, 4	"	Julian Day No.	
5, 6	"	Hour	
7, 8	"	Minutes	
9, 10	"	Seconds	
11, 12	"	Milliseconds	
13, 14	"	Year	VISSR Data Base Picture start time or time of VISSR scan that is the northern limit of the VISSR Data Base Picture.
15, 16	"	Julian Day No.	
17, 18	"	Hour	
19, 20	"	Minutes	
21, 22	"	Seconds	
23, 24	"	Milliseconds	
25, 26	"	Year	VISSR Data Base End time or time of the VISSR scan that is the Southern Limit of the VISSR Data Base Picture.
27, 28	"	Julian Day No.	
29, 30	"	Hour	
31, 32	"	Minutes	
33, 34	"	Seconds	
35, 36	"	Milliseconds	

Byte #	Internal Format	Description	
37, 38	2-byte Integer	VISSR Data Base Starting Scan Line	Parameters that determine where the VISSR Data Base extraction process begins; i.e., that I,J of the upper left corner.
39, 40	"	VISSR Data Base Starting Sample	
41, 42	"	VISSR Data Base Ending Scan Line #	
43	4-byte Integer	Center Latitude	Parameters that define the VISSR Data Base Sector.
47	"	Center Longitude	
51	"	Northern Latitude Limit	
55	"	Western Longitude Limit	
59	"	Unused	
63	"	Unused	
67	"	Unused	
71	"	Unused	
75	"	Average Bit Error Rate	Bit error rate is an indication of how noisy the data are.
79	"	Minimum Bit Error Rate	
83	"	Maximum Bit Error Rate	
87, 88	2-byte Integer	# of Single Line Dropouts	
89, 90	"	# of Multi-Line Dropouts	
91,130	"	List of up to 20 Single Line Dropouts	
131,190	"	Table of up to Ten Group Dropouts as follows: Word 1 - Last Good Scan Line Word 2 - First Good Scan Line Word 3 - # of Scans Dropped Out	
191,192	"	Center Latitude Scan	
193,194	"	Center Longitude Sample	
195,294	"	VISSR Ingest Computer Documentation	
295,296	"	Spares	
297,300	"	ASCII Code for Data Type (IRbb or VISb)	
301,312	"	Spares	
313,316	4-byte Integer	Number of Data Records in the Picture File (or scans in the Sector). Zero indicates a full copy of the Archive Data. Note that this is a true 32-bit integer, not a scaled floating point number.	
317,320	"	Number of bytes in each Data Record (scan); this is also a true 32-bit integer	

NOTE: Missing data for two-byte Integer Variables will be indicated by -1. Missing data for four-byte Integer Variables will be indicated by 99999.

4. Benchmark Table

The Benchmark Table, written on tape as four 6720-byte records, consists of an array of 6720 4-byte Integers (a total of 26,880 bytes). The array is considered to be dimensioned as (42,40,4) where I and J are arbitrary indices for latitude and longitude, respectively:

(I,J,1) represents latitude of a point in degrees x 10.
(I,J,2) represents longitude of a point in degrees x 10.
(I,J,3) represents sample # for that point x 10.
(I,J,4) represents scan line # for that point x 10.

If (I,J,1) through (I,J,4) equals zero, there are no benchmarks for that point. This indicates that there are no data in the Picture File for the latitude and longitude indexed by the I,J (or that the latitude and longitude falls outside of the Picture File, which may be either a copy of the original archive image or a sector extracted from it).

To step through $2\frac{1}{2}°$ increments of longitude, step through the second subscript J. A value of 1 for J points to the Western-most longitude.

To step through $2\frac{1}{2}°$ increments of latitude, step through the first subscript I. A value of 1 for I points to the Northern-most latitude.

To use the Benchmark Record to locate data on the VISSR Archive Tape, apply the following formulas shown below. In the case of a sector extracted from a full image, the centering correction will have already been applied, and a value of zero should be used for CENTERING.

For Visible Data

$$VSCAN = 2 * BSCAN - SSCAN$$
$$VSAMPLE = \frac{1}{2} [BSAMPLE + CENTERING - SSAMPLE]$$

For Infrared Data

$$VSCAN = BSCAN - SSCAN$$
$$VSAMPLE = \frac{1}{2} [BSAMPLE + CENTERING - SSAMPLE]$$

where:
VSCAN = Scan line # on VISSR Archive Tape
BSCAN = Scan line # from Benchmark Record divided by 10.
SSCAN = VISSR data-base starting scan line # from the Header Record - 1.
VSAMPLE = Sample # on VISSR Archive Tape.
BSAMPLE = Sample # from Benchmark Record divided by 10.

CENTERING = 38th two-byte integer location of the VISSR Ingest Computer Documentation from the Header Record. Use zero if the formula is being applied to a sector.

SSAMPLE = VISSR data-base starting sample # from from the Header Record - 1.

To find point (VSCAN, VSAMPLE) on the VISSR Archive Tape, apply the following formulas:

NREC = VSCAN - 1
NBYTE = VSAMPLE + 129

where:

NREC = # of data records to skip on the VISSR Archive Tape before encountering the record containing the point (VSCAN, VSAMPLE).

NBYTE = Byte # within the record (NREC + 1) containing the point (VSCAN, VSAMPLE).

5. Data Record

Each Data Record contains the data from one scan, and consists of 129 bytes of documentation followed by up to 1499 bytes of data. Thus, the maximum length of a Data Record is 1628 bytes. A sector extracted from the original archive image, which is limited east and/or west, will be made up of shorter Data Records. The number and length of the Data Records in each Picture File appear in its Header Record.

The contents of the 129 documentation bytes are defined as follows:

Byte #	Description of Contents
1	Retrace - FE_{16} indicates scanner retrace.
2	Spacecraft name.
3	Unassigned.
4	Frame Code - FE_{16} indicates picture transmission.
5	Change Code - FE_{16} indicates first line picture if frame code is FE_{16} or last line plus one of picture if frame code is 1_{16}.
6	Step Code - FE_{16} indicates normal line transmission; 1_{16} indicates that this line is not to be used to expose film and facsimile recorder, line is not to be incremented (stopped).
7	Line delay - this number (1-8) denotes the delay to be introduced by the user, expressed in bit intervals.

Byte #	Description of Contents
8	IR selection - IR1 - 00000001 IR2 - 00000010 AUG - 00000100
9	Gray Scale Status - FE_{16} indicates gray scale information retransmission.
10	Direct Transmission Mode - FE_{16} indicates 28 Mb/Sec; 1_{16} indicates 14 Mb/Sec.
	Scan Count - BCD value split into 2 characters/word.
11	2 most significant BCD characters.
12	2 least significant BCD characters.
13	Scan Mode - A 00000001 B 00000010 C 00000100 D 00001000
	Beta Count — 24 bits.
14	8 most significant bits.
15	8 mid-bits.
16	8 least significant bits.
17	GRID/NO GRID - 1_1 indicates no grid information.
	Sync Error - 15 bits.
18	8 most significant bits.
19	7 least significant bits (least significant bit always 0).
	Bit Error Count - 13 bits.
20	8 most significant bits.
21	5 least significant bits (3 least significant bits always 0).
22	Setup Error - FE_{16} indicates setup error.
23	Computer Error Messages (S/DB) - 16 bits, any combination. Transfer Reject Errors - Time Input (Least Significant Bits) - Execute Output - NESS Output - Spacecraft Output High Rate I/O Errors - NESS Transfer - Output Transfer - Input Transfer (Most Significant Bits)
24	Interrupt Sequence Errors - NESS Output (Least Significant Bits) - 4x4 Output - Spacecraft Input - NESS Pre-Sync - 4x2 Output Miscellaneous Errors - Undefined - Magnetic Tape Output - Beta Output (Most Significant Bits)
25	Unassigned
26	Unassigned
	Date/Time - BCD

Byte #	Description of Contents
27	Year - 2 most significant digits.
28	Year - 2 least significant digits.
29	Day of Year - 2 most significant digits.
30	Day of Year - 2 least significant digits.
31	Hour.
32	Minute.
33	Seconds.
34	Millisecond x 10.
35	Black Enable - FE_{16} indicates annotation transmission.
36	Mode C - Calibrate - FE_{16} indicates that C-CAL is not used; otherwise: V1 00000001 V2 00000010 V3 00000100 V4 00001000 V5 00010000 V6 00100000 V7 01000000 V8 10000000
37	Bit/Frame Sync Lock - 00000001 Bit Lock 00000010 Frame Lock 00000100 Bit Frequency Lock
38	Limited Scan Mode Indicator - FE_{16} indicates limited scan mode.
39	Sample Control Mode (least significant bit) IR - 2PT IR - 1PT IR - EAT VISIBLE - 4PT VISIBLE - 1PT VISIBLE - EAT
40	Visible Channel Connection Code for each channel is as follows: 0 = Normal 1 = patched input reset V1 (LSB), V2, V3, V4, V5, V6, V7, V8 (MSB)
41	Scan Direction - FE_{16} indicates normal North-South direction.
42	Bi-Phase Modulation On/Off - FE_{16} indicates on.
43	Unassigned.
44	PLL Error Light - FE_{16} indicates error condition.
45	Test Data - Normal 00000000 Local 00000001 Remote 00000010 Comp. Gen.IR 00000100
46	Data Randomization - FE_{16} indicates on.
47	Sun Pulse Select - FE_{16} indicates digital; 1_{16} indicates analog.

Byte #	Description of Contents
48	NESS Mode Set - 4x4 IR 00000001
	MAX SV 00000001
	4x4 IR 00000010
49	Limited Scan Command Encoder Enable - FE_{16} indicates on.
50	Digital Sun Pulse - 8 bits.
51	Bit Error Light - FE_{16} indicates on.
52	Mean IR Difference - 8 bits.
53	RMS IR Difference - 8 bits.
54	Correction Table I.D. - 2 bytes.
55	Format Unknown.
	Position within Raster Line of left horizon point - 12 bits.
56	4 most significant bits (always 0).
57	8 least significant bits.
	Position within Raster Line of right horizon point - 12 bits.
58	4 most significant bits (always 0).
59	8 least significant bits.
60	Unassigned.
	Computer states messages (NESS ingest).
	Scan Line No. just processed - 11 bits.
61	3 most significant bits (5 most significant bits 0).
62	8 least significant bits.
63	Unassigned.
64	Missed Correlation Indicator - 1 = M.C.; 0 = M.C.
65	Number of bit slip interrupts detected during
66	Ingest of this scan line - 16 bits.
67	Unassigned.
68-79	Spares.
80	Telemetry Code Word.
81-98	Telemetry.
99-124	26 (8-bit) bytes of orbit and attitude [1].
	Group # equals 0 = No data.
	Group # equals N = Bytes 99=124 contain information in Group N as defined on following tables where N = 1 through 4.

NOTE: [1] = These locations were zero-filled prior to 1 November 1976 when the orbit and attitude data were inserted.

a. Orbit and Attitude (O/A) Documentation

From November 1, 1976, through October 31, 1977, the O/A documentation words were as described below. Starting with November 1, 1977, the O/A documentation words are as shown in the next section, New O/A Documentation.

Group # Equals 1

Byte #	Description of Contents	Units
99	Block Number	(1-10)
100	Group Number	(=1)
101-104	Date	(YYDDD$_{10}$)
105-108	Block Time (GMT)	msec *10
109-112	R.A. of Greenwich Meridian	deg *2^{21}
113-116	Geodetic Latitude of Subsatellite point	deg *2^{21}
117-120	Longitude of Subsatellite Point	deg *2^{21}
121-124	Height above Oblate Earth	KM *2^{13}

Group # Equals 2

Byte #	Description of Contents	Units
99	Block Number	(1-10)
100	Group Number	(=2)
		Km *2^{13}
101-104	X) Cartesian Components	
105-108	Y) In Celestial Coordinates	Km *2^{13}
109-112	Z)	
113-116	X) Satellite Velocity	
117-120	Y) In Celestial Coordinates	Km/Hr
121-124	Z	

Group # Equals 3 (For Odd Block #)

Byte #	Description of Contents	Units
99	Block Number	(1,3,5,7,9)
100	Group Number	(=3)
101-104	Spin Period	Microseconds
105-108	Spin Axis Right Ascension	deg *2^{21}
109-112	Spin Axis Declination	deg *2^{21}
113-116	A) Camera B) Misalignment C) Angles	deg *2^{21}

Group # Equals 3 (For Even Block #)

Byte #	Description of Contents	Units
99	Block Number	(2,4,6,8,10)
100	Group Number	(=3)
101-104	Spin Period	Microseconds
105-108	Spin Axis Right Ascension	deg *2^{21}
109-112	Spin Axis Declination	deg *2^{21}
113-116	North-South Stepping Angle (IR)	deg *2^{21}
117-120	East-West Sampling Angle (IR)	deg *2^{21}
121-124	Attitude I.D. where: 0 = Some Other method; 1 = Sun/Earth Sensors; 2 = Landmark (2-mile imagery) 3 = PICATT (Earth Edge Data); 4 = Reserved for Later Methods.	

Byte #	Description of Contents		Units
99	Block Number		(1-10)
100	Group Number		(=4)
101-104	Beta)	From Tempo	
105-108	Beta-Dot)	Beta Generation	
109-112	To)	Program	
113-116	Right Ascension)	Satellite-Sun	
117-120	Declination)	Pointing Vector in Celestial System	deg $*2^{21}$
121-124	Block Time		msec *10
125-127	Spares		
128			
129			

b. New O/A Documentation

Starting with data for November 1, 1977, the O/A information is given in terms of Chebyshev Polynomials instead of Celestial Coordinates. A copy of a report titled Earth Location Equations describing the mathematics involved is attached as Appendix I.

The definition of the new O/A Documentation Bytes is described on the next two pages. The first is a definition of the meaning of each byte, and the second describes the order of the bytes within the Data Records.

ORBIT AND ATTITUDE DOCUMENTATION BYTES

NAME	UNIT	DESCRIPTION
DATE1	$YYDDD_{10}$ in binary	Date for TIME1: DATE1 $<$ 99366
TIME1	msec *10	Epoch (GMT): TIME1 $< 864 \times 10^6$
TIME2	msec *10	Not documented: TIME1 + 468×10^6
XN YN ZN	km $*2^{13}$	Satellite position at TIMEN in inertial coordinate system of date: N = 1 or 2
VXN VYN VZN	(km/hour) $*2^{13}$	Satellite velocity at TIMEN
SPER	usec	Satellite spin period with respect to earth at epoch
SPRAN	degrees $*2^{21}$	Spin axis right ascension at TIMEN
SPDCN	degrees $*2^{21}$	Spin axis declination at TIMEN
ZETA RHO ETA GAMMA	degrees $*2^{21}$	VISSR alignment coordinates: ZETA = line bias, RHO = element bias, ETA = skew bias and GAMMA = sun pulse to VISSR angle
ID	coded	Code to specify method used for O/A determination
SRAN	degrees $*2^{21}$	Sun right ascension at TIMEN
SDCN	degrees $*2^{21}$	Sun declination at TIMEN
GRAN	degrees $*2^{21}$	Greenwich right ascension at TIMEN
EST	msec *10	Eclipse start time on DATE1
EET	msec *10	Eclipse end time on DATE1
CBI	degrees $*273 *2^{11}$	Chebyshev Beta parameters: I = 0, ..., 9
	$(273 \times 2^{11} = \frac{6289920}{360} *2^5)$	
CXI CYI CZI	km $*2^{13}$	Chebyshev position parameters: I = 0, ...,10

ORBIT AND ATTITUDE (O/A) DOCUMENTATION

Data Record Documentation Byte Numbers	O/A Word (Byte) Number										
99	Block Number *	$01	$02	$03	$C4	$05	$06	$07	$08	$09	$0A
100	Minor Frame Index *	**	**	**	**	**	**	**	**	**	**
101 - 104	1	DATE1	SPER	EST	CB0	CX0	CY0	CZ0	--	--	--
105 - 108	2	TIME1	SPRA1	EET	CB1	CX1	CY1	CZ1	--	--	SPRA2
109 - 112	3	--	SPDC1	--	CB2	CX2	CY2	CZ2	--	--	SPDC2
113 - 116	4	--	ZETA	--	CB3	CX3	CY3	CZ3	--	--	--
117 - 120	5	--	RHO	--	CB4	CX4	CY4	CZ4	--	--	--
121 - 124	6	--	ETA	--	CB5	CX5	CY5	CZ5	--	--	--
101 - 104	7	X1	GAMMA	--	CB6	CX6	CY6	CZ6	--	X2	--
105 - 108	8	Y1	--	--	CB7	CX7	CY7	CZ7	--	Y2	--
109 - 112	9	Z1	ID	--	CB8	CX8	CY8	CZ8	--	Z2	--
113 - 116	10	VX1	SRA1	--	CB9	CX9	CY9	CZ9	--	VX2	SRA2
117 - 120	11	VY1	SDC1	--	--	CX10	CY10	CZ10	--	VY2	SDC2
121 - 124	12	VZ1	GRA1	--	--	--	--	--	--	VZ2	GRA2

* Block number = Minor Frame Index = $00 if O&A data not present;
$ implies hexadecimal notation.

** Minor Frame Index = $01 if O&A Word Number is less than 7; MFI = $02 otherwise.

EARTH LOCATION EQUATIONS

Revised
July 20, 1977

Contract NAS 5-23582

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
Greenbelt, Maryland 20771

Prepared by

WESTINGHOUSE ELECTRIC CORPORATION
Defense and Electronic Systems Center
Command and Control
P.O.Box 1693
Baltimore, Maryland 21203

EARTH LOCATION EQUATIONS

1.0 GENERAL

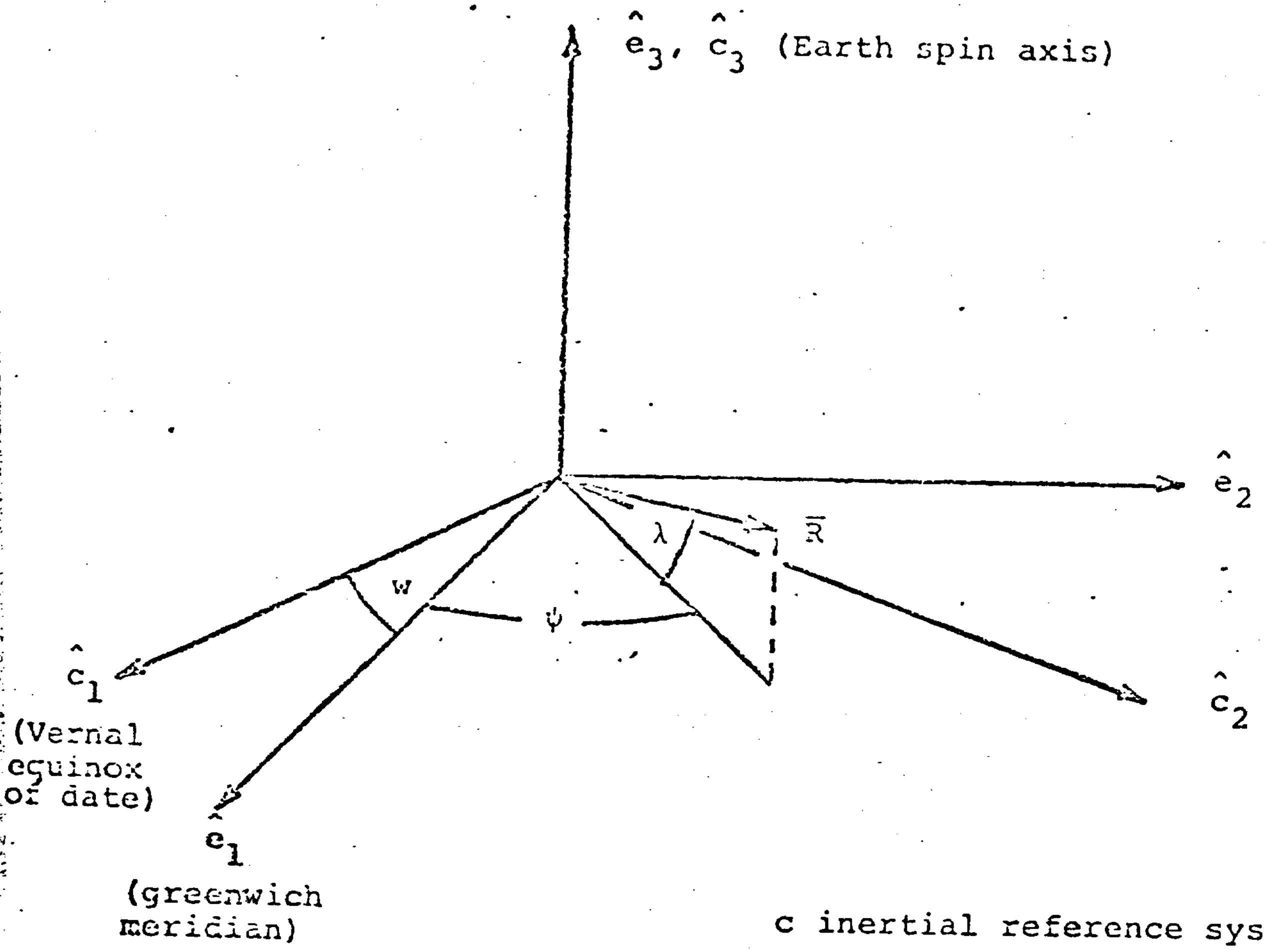
The objective of this program is to compute the line and element of the VISSR corresponding to a given point on the surface of the earth. The program can be divided into five parts:

1) Earth point-involves computation of a vector $\overline{R}$ from the earth center to a point specified by a latitude and longitude.
2) Satellite position-involves computing the satellite position vector $\overline{P}$ from the earth center.
3) View vector -- the earth point view vector $\overline{V}$, from the satellite position is computed in satellite coordinates.
4) Line;element -- The location of the VISSR line and element is computed from $\overline{V}$ and VISSR orientation parameters.
5) Time -- The predicted time at which the specified line and element is computed iteratively based upon frame start time.

This note is based upon the paper, "Image Navigation for Geosynchronous Meteorological Satellites" by C. T. Mottershead and D. R. Phillips.

2.0 EARTH POINT

The coordinate systems required are shown in Figure 1. We start with the geodetic latitude λ' and the longitude ψ. The earth is taken to be an oblate spheroid with equatorial radius a = 6378.144 km and polar radius b = 6356.759 km. Consider the intersection of the earth and a plane thru meridian ψ as shown in Figure 2. The geocentric latitude is computed from the geodetic latitude from equation (1). The earth radius is then computed from equation (2). The total length of the earth point vector $\overline{R}$ is then found from equation (3). Then $\overline{R}$ in the earth coordinate system is:



c inertial reference system

e earth reference system

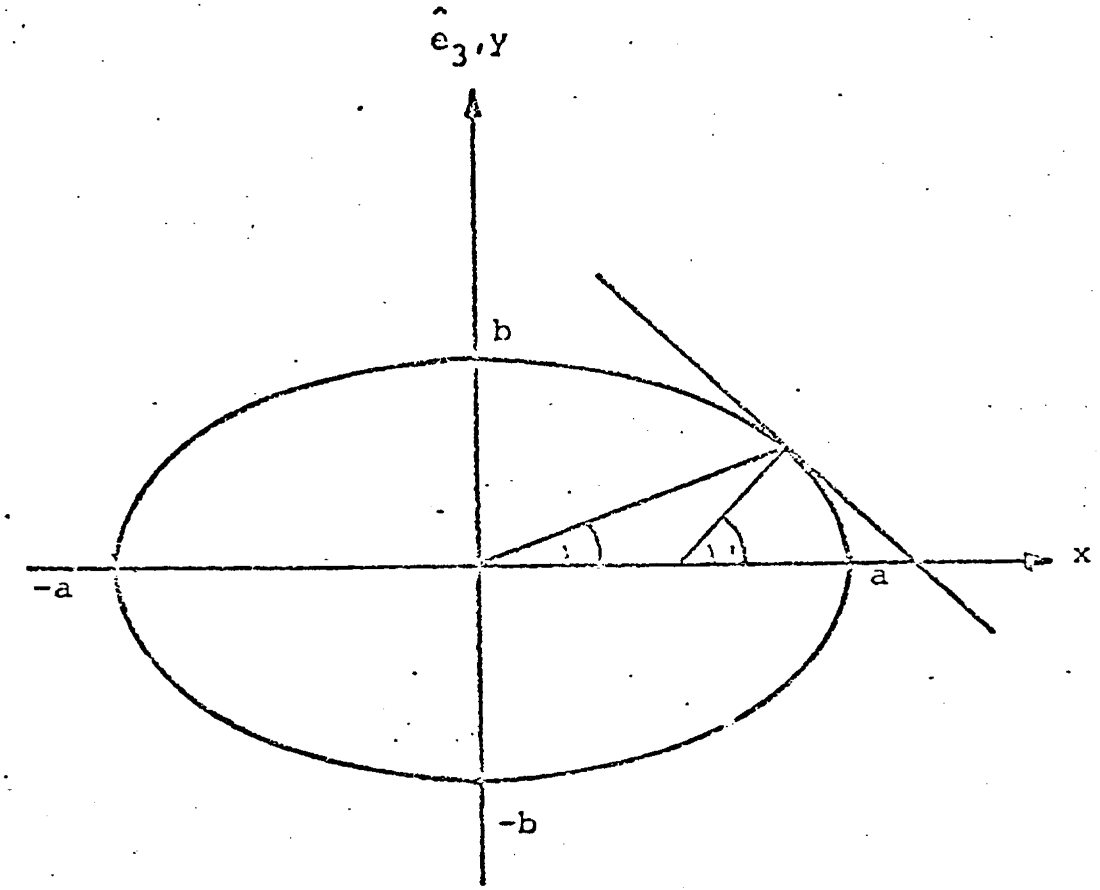
λ geocentric latitude

ψ east longitude

$\bar{R}$ vector from earth center to surface at λ, ψ

w earth spin angle ($w=90^{\circ}$ when $\hat{e}_1 = \hat{c}_2$)

Figure 1



λ geocentric latitude
λ' geodetic latitude
r earth radius

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

$$\tan \lambda = \frac{b^2}{a^2} \tan \lambda' \tag{1}$$

$$r = \frac{a}{[1 + \varepsilon \sin^2 \lambda]^{1/2}} \qquad \varepsilon = \frac{a^2 - b^2}{b^2} \tag{2}$$

$$|\bar{R}| = r \tag{3}$$

Figure 2. Latitude Relations

$$\bar{R}_E = r \begin{bmatrix} \cos\lambda \cos\psi \\ \cos\lambda \sin\psi \\ \sin\lambda \end{bmatrix}$$

Expressed in the inertial coordinate system we have

$$\bar{R}_C = r \begin{bmatrix} \cos\lambda \cos(\psi+w) \\ \cos\lambda \sin(\psi+w) \\ \sin\lambda \end{bmatrix}$$

where w is the earth rotation angle at time t at which the VISSR scans the desired earth point. Time will be normalized for a period starting at epoch, t_e (DATE1 + TIME1; see Appendix) and ending at epoch plus (D = 13 hours). Then normalized time u is:

$$u = \frac{2\,(t-t_e)}{D} - 1 \tag{4a}$$

(Note that all unnormalized times t, t_e and D must be in the same units.)

The angle w is then:

$$w = \frac{1}{2}\,(w_2 + w_1 + (w_2 - w_1)\;u) \tag{4b}$$

where w_1 = GRA1 and w_2 = GRA2; see Appendix.

3.0 SATELLITE POSITION

The satellite position, in the inertial coordinate system, will be computed from three Chebychev polynomials -- one per dimension. Each polynomial will have 11 parameters CXI, CYI or CZI; see Appendix.

Thus for any direction we have:

$$P = \sum_{i=0}^{10} C_i\, T_i\,(u) \tag{5a}$$

where C_i = CXI, CYI or CZI

$$T_o\,(u) = 1$$
$$T_1\,(u) = u$$
$$T_n\,(u) = 2u\,T_{n-1}\,(u) - T_{n-2}\,(u) \text{ for } n \geq 2$$

and the prime on the summation indicates that the term C_o should be multiplied by 1/2.

If we now define:

$$b_i(u) = 2u\, b_{i+1}(u) - b_{i+2}(u) + C_i \quad \text{for } i=0, \ldots, 10$$

$$b_{11}(u) = b_{12}(u) = 0$$

Then

$$P = \frac{1}{2}\left(b_o(u) - b_2(u)\right) \tag{5b}$$

4.0 VIEW VECTOR

The vector $\overline{V}$ from the satellite to the earth point, in inertial coordinates, is:

$$\overline{V}_c = \overline{R}_c - \overline{P}_c. \tag{6}$$

We wish to express vector $\overline{V}$ in a satellite coordinate system. One component $(\hat{S}_3)$ of the desired coordinate system is the satellite spin vector. The direction of this vector in inertial coordinates, see Figure 3, is given by:

$$\delta = \frac{1}{2}\left[\delta_2 + \delta_1 + (\delta_2 - \delta_1)\, u\right] \tag{7a}$$

$$\alpha = \frac{1}{2}\left[\alpha_2 + \alpha_1 + (\alpha_2 - \alpha_1)\, u\right] \tag{7b}$$

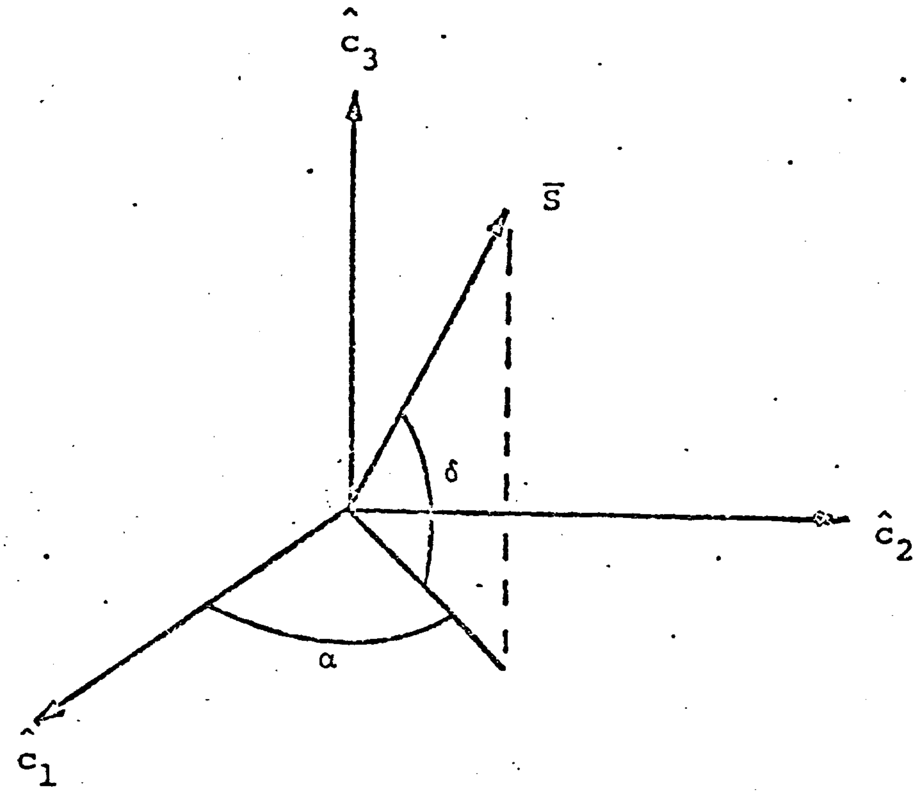
where δ_1 = SPDC1, δ_2 = SPDC2, α_1 = SPRA1 and α_2 = SPRA2; see Appendix.

Then

$$\overline{S} = \begin{bmatrix} \cos\delta \cos\alpha \\ \cos\delta \sin\alpha \\ \sin\delta \end{bmatrix} = \hat{S}_3 \tag{8}$$

The direction of the other two components of the satellite coordinate system are now defined. We define $\hat{S}_1$ as the unit vector in a plane orthogonal to $\hat{S}_3$ which is aligned with the negative projection of the $\overline{P}$ vector in this plane. Then, as shown in Figure 4:

$$\hat{S}_1 = \frac{-\overline{P} + (\overline{P}\cdot\overline{S})\,\overline{S}}{\sqrt{P^2 - (\overline{P}\cdot\overline{S})^2}} \quad \text{where } \overline{P}.\overline{S} = P_1S_1 + P_2S_2 + P_3S_3 \tag{9}$$



$\bar{S}$ vector representing spin axis

δ declination of $\bar{S}$ ($\delta=90^{\circ}$ and $\alpha=0^{\circ}$ when $\bar{S}=\hat{C}_3$)

α right ascension of $\bar{S}$ ($\alpha=90^{\circ}$ when projection is along $\hat{C}_2$)

Figure 3. Spin Vector

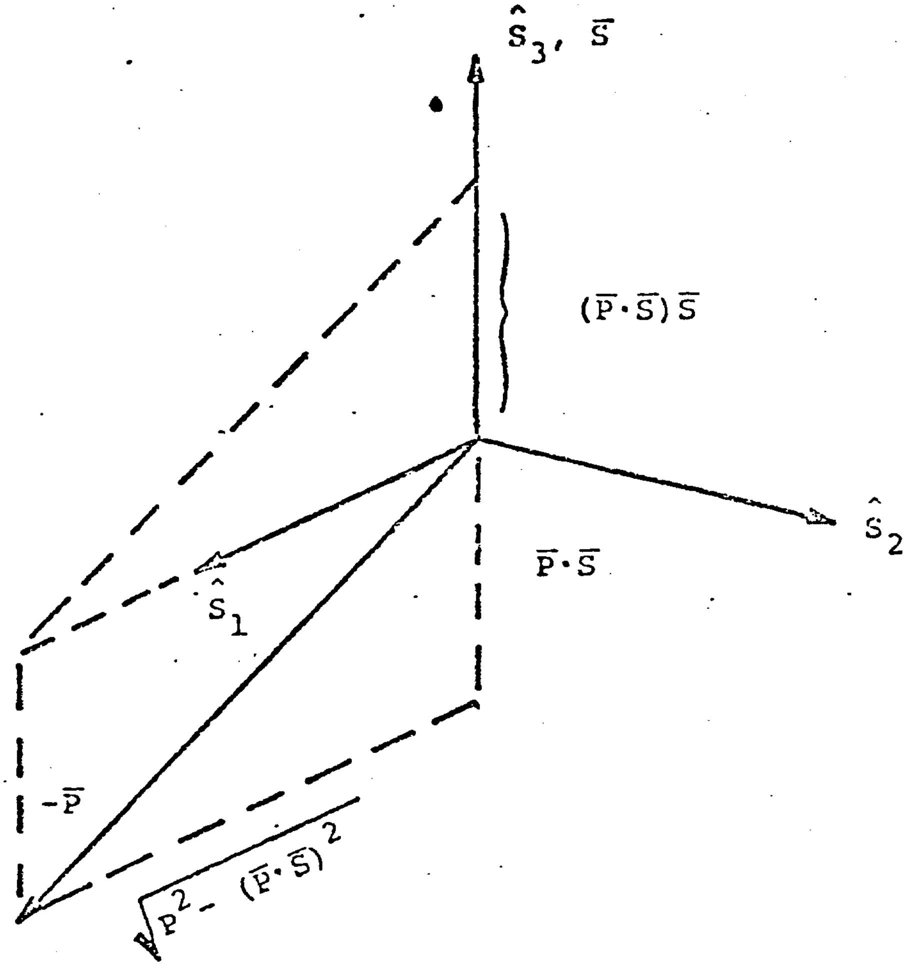


Figure 4. Satellite Coordinate System

The denominator is the length of the vector defined by the numerator. Then:

$$\hat{S}_2 = \hat{S}_3 \times \hat{S}_1 \text{ , where } A X B = \begin{bmatrix} a_2 b_3 - a_3 b_2 \\ a_3 b_1 - a_1 b_3 \\ a_1 b_2 - a_2 b_1 \end{bmatrix} \tag{10}$$

Thus we have obtained three unit orthogonal vectors $\hat{S}_1$, $\hat{S}_2$, $\hat{S}_3$ each of which is defined in the inertial system. To find the components of $\bar{V}$ in the $\hat{S}$ system we can form:

$$\bar{V}_s = \begin{bmatrix} \hat{S}_1{}^T \\ \hat{S}_2{}^T \\ \hat{S}_3{}^T \end{bmatrix} \bar{V}_c \tag{11}$$

where T denotes transpose.

5.0 LINE AND ELEMENT

To define a coordinate system fixed in the rotating spacecraft, we should define a reference line fixed in the spacecraft. We define that reference as the projection of the sun sensor FOV into the spin plane for the actual sun elevation. Thus, we note that this reference line is not actually fixed in the spacecraft since it will generally vary with the sun elevation and the spin vector orientation relative to the sun sensor. This reference has been selected since it corresponds to the actual sun pulse produced by the spacecraft. Figure 5 shows this reference denoted as $\hat{J}$ at an angle of $\gamma+\theta$ from $\hat{S}_1$. The unit vector $\hat{S}_1'$ represents the predicted location of the intersection of the VISSR FOV plane and the spin plane and is at an angle γ from $\hat{J}$. The azimuth angle θ is between the earth oriented unit vector $\hat{S}_1$ and the rotating spacecraft vector $\hat{S}_1'$. The angle γ is based upon the best available data from landmark or other measurements made prior to the actual VISSR data acquisition.

Then, using this angle γ (see section 7), we may note that each earth image as produced by the synchronizer-data buffer (S/DB) is not precisely centered in the east-west (spin plane) direction. Thus the data implies that the actual VISSR FOV plane has shifted by an angle we call element bias and designate as ρ. This angle includes all residual terms in the spin plane due to factors such as measurement errors or shifts in the VISSR or sun sensor mounting and relative delays of signals in the spacecraft and ground station not accounted for by the angle γ. Since such residual errors are not predictable the S/DB documented value for this term will normally be zero; see Appendix.

In general the VISSR FOV plane does not contain the spin vector $\hat{S}_3''$. We can define a unit vector $\hat{S}_3'''$ which is coincident with the projection of $\hat{S}_3''$ into the VISSR FOV plane; see Figure 6. The angle between $\hat{S}_3''$ and $\hat{S}_3'''$ is denoted by η and called the skew bias.

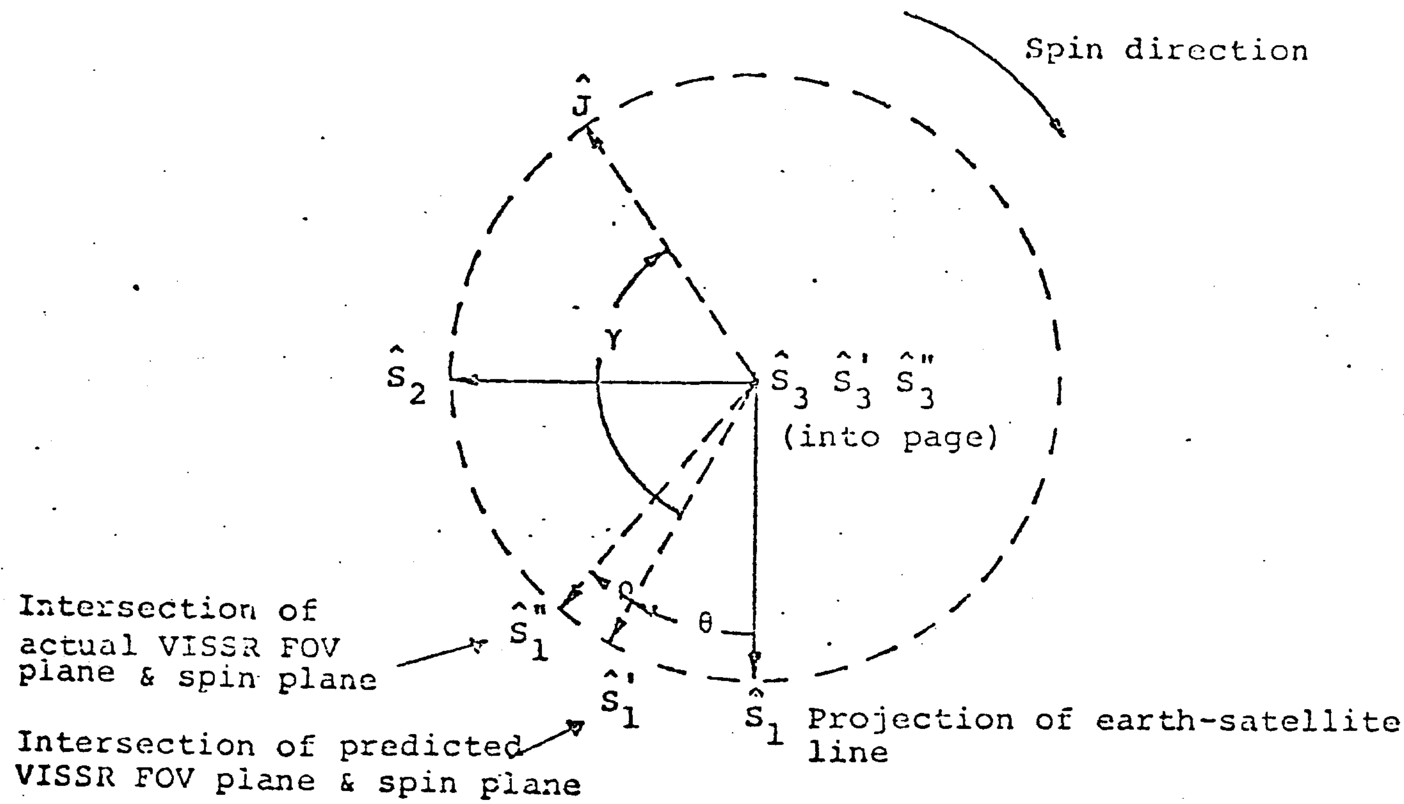
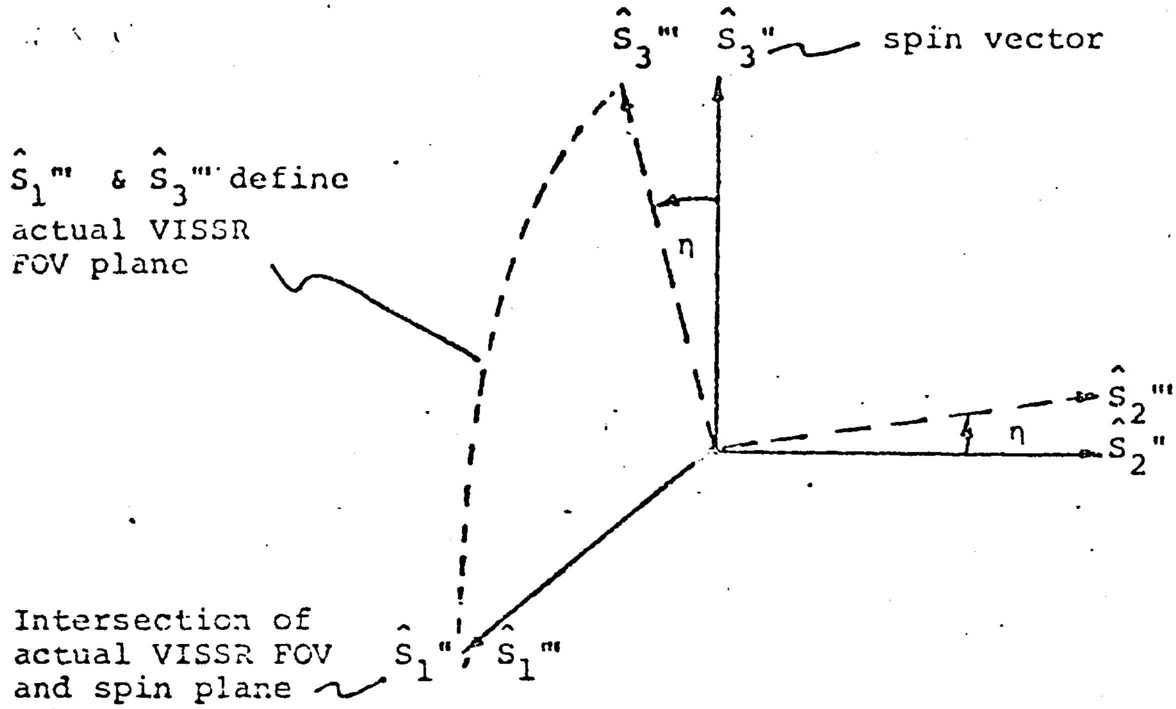
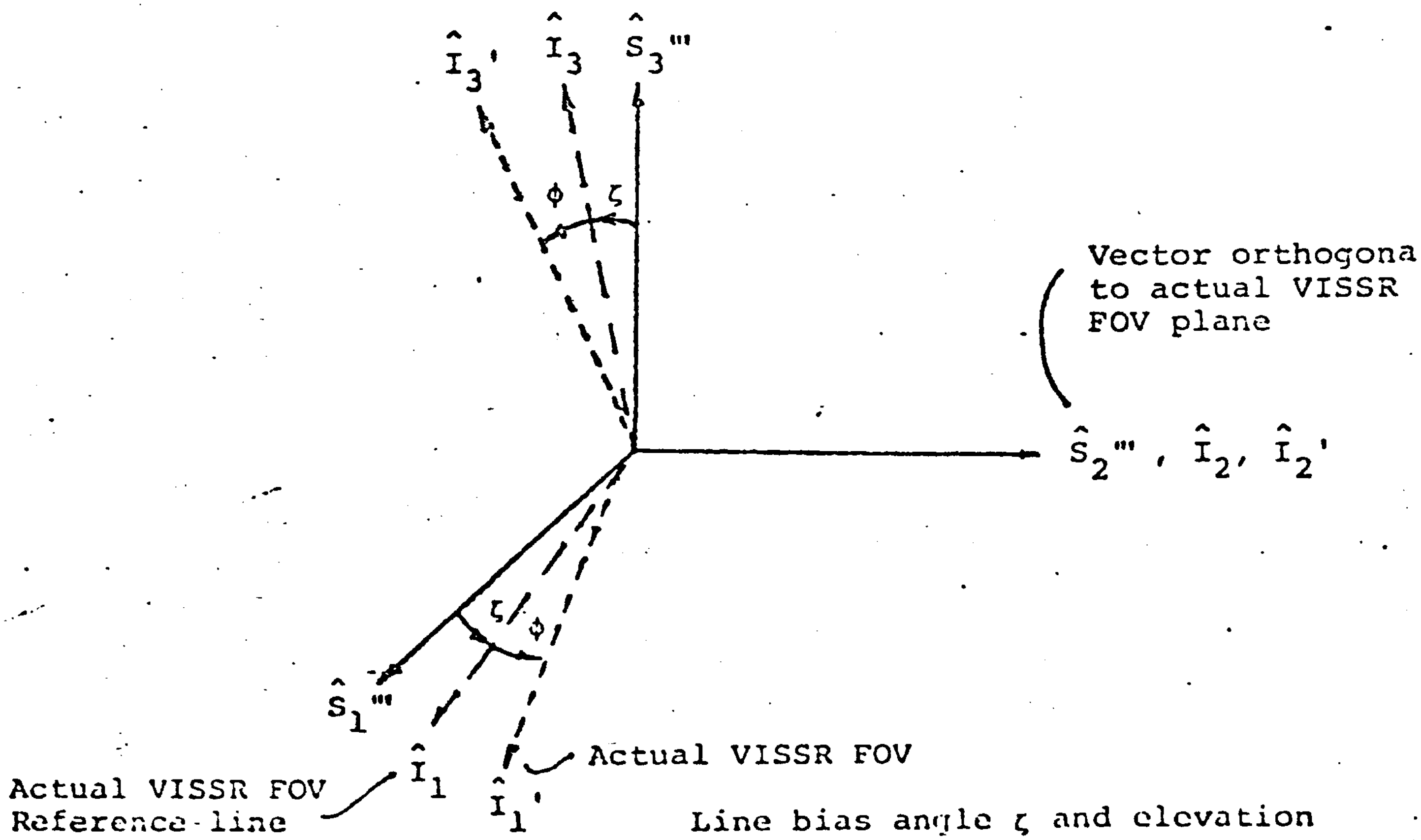


Figure 5. Spacecraft Reference Line



Skew bias angle η



Line bias angle ζ and elevation angle φ

As a result of VISSR mirror stepping, the actual VISSR FOV usually moves between the normal north limit (scan count = 1) and the normal south limit (scan count = 1821). (There is also an expanded scanning mode in which both limits can be exceeded.) The actual VISSR FOV reference line $\hat{I}_1$ is defined as corresponding to the actual FOV at a scan count of 911. The angle between the reference line $\hat{I}_1$ and intersection of the actual VISSR FOV and the spin plane $\hat{S}_1'''$ is called the line bias and denoted by ζ.

Finally the actual VISSR FOV line, represented by unit vector $\hat{I}_1'$, is at some elevation angle ϕ from $\hat{I}_1$. Note that this angle is positive if the earth point is north of the spin plane.

We may now proceed to express the view vector $\bar{V}_S$ in the VISSR coordinate system $\hat{I}'$. We obtain:

$$\bar{V}_S'' = \begin{bmatrix} \cos(\theta+\rho) & \sin(\theta+\rho) & 0 \\ -\sin(\theta+\rho) & \cos(\theta+\rho) & 0 \\ 0 & 0 & 1 \end{bmatrix} \bar{V}_S \qquad (12)$$

$$\bar{V}_S''' = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\eta & \sin\eta \\ 0 & -\sin\eta & \cos\eta \end{bmatrix} \bar{V}_S'' \qquad (13)$$

$$\bar{V}_I' = \begin{bmatrix} \cos(\zeta+\phi) & 0 & -\sin(\zeta+\phi) \\ 0 & 1 & 0 \\ \sin(\zeta+\phi) & 0 & \cos(\zeta+\phi) \end{bmatrix} \bar{V}_S''' \qquad (14)$$

The vector $\bar{V}$ in the image coordinate system is constrained to lie in the $\hat{I}_1\hat{I}_3$ plane. Therefore $V_{I_2} = 0 = V_{S_2}'''$

$$V_{S_2}''' = V_{S_2}'' \cos\eta + V_{S_3}'' \sin\eta = 0$$

$$V_{S_3}'' = V_{S_3}; \; V_{S_2}'' = -V_{S_3} \tan\eta \qquad (15a)$$

$$V_{S_2}'' = -V_{S_1} \sin(\theta+\rho) + V_{S_2} \cos(\theta+\rho)$$

Then:

$$V_{S_3} \tan\eta = V_{S_1} \sin(\theta+\rho) - V_{S_2} \cos(\theta+\rho) \quad (15b)$$

In equation (15) all the quantities except θ are known. We may solve this equation by first defining:

$$\sigma = \arctan\left(\frac{V_{S_2}}{V_{S_1}}\right) \quad (16)$$

Then:

$$V_{S_2} = \sqrt{V_{S_1}^{\,2} + V_{S_2}^{\,2}}\ \sin\sigma$$

$$V_{S_1} = \sqrt{V_{S_1}^{\,2} + V_{S_2}^{\,2}}\ \cos\sigma$$

and

$$\frac{V_{S_3} \tan\eta}{\sqrt{V_{S_1}^{\,2} + V_{S_2}^{\,2}}} = \cos\sigma \sin(\theta+\rho) - \sin\sigma \cos(\theta+\rho)$$

$$= \sin(\theta+\rho-\sigma) \triangleq \sin\xi \quad (17)$$

To avoid the need for an arcsin routine, we may write ξ as:

$$\xi = \arctan\left(\frac{V_{S_3} \tan\eta}{\sqrt{V_{S_1}^2 + V_{S_2}^2 - V_{S_3}^2 \tan^2\eta}}\right) \quad (18)$$

for the IR data (4x2 mile) is the ratio of the total data acquisition angle 2K ($K=9\ 3/16^{\circ}$) to the total number of samples S (S=3822):

$$\mu_E = \frac{2K}{S} \simeq 0.004807692^{\circ}$$

(The mode A visible data (½ x ½ mile) angular separation is $\frac{\mu_E}{4}$.) Since there are 3822 IR samples per line we shall let the center element CE number be 1911.5. Then

$$E = \frac{\theta}{\mu_E} + CE \qquad (20)$$

Similarly the angular separation of scan lines is given by the VISSR mirror shaft encoder characteristic

$$\mu_L = \frac{45^{\circ}}{2^{12}} \simeq 0.01098633^{\circ}$$

When the scan mirror is at its reference line the scan count output by the S/DB is L=911. In general we have:

$$L = 911 - \frac{\phi}{\mu_L} \qquad (21)$$

6.0 TIME

The computation of satellite view vector requires knowledge of time which is not available until after computation of the desired VISSR elevation. The equations presented in the previous sections which result in the elevation angle can be denoted by $\phi_{i+1} = f(t_i)$. The time t_i is ideally the time at which the radiometer will scan the specified earth point. In practice it is estimated from ϕ_i using an equation $t_i = g(\phi_i)$, more specifically:

$$t_i \doteq t_{i-1} - \frac{(\phi_i - \phi_{i-1})T}{\mu_L} \qquad (22)$$

where T is the satellite spin period SPER; see Appendix.

To start this iterative process we can estimate ϕ_1 using a spherical earth model, nominal synchronous orbit and nominal attitude. Then

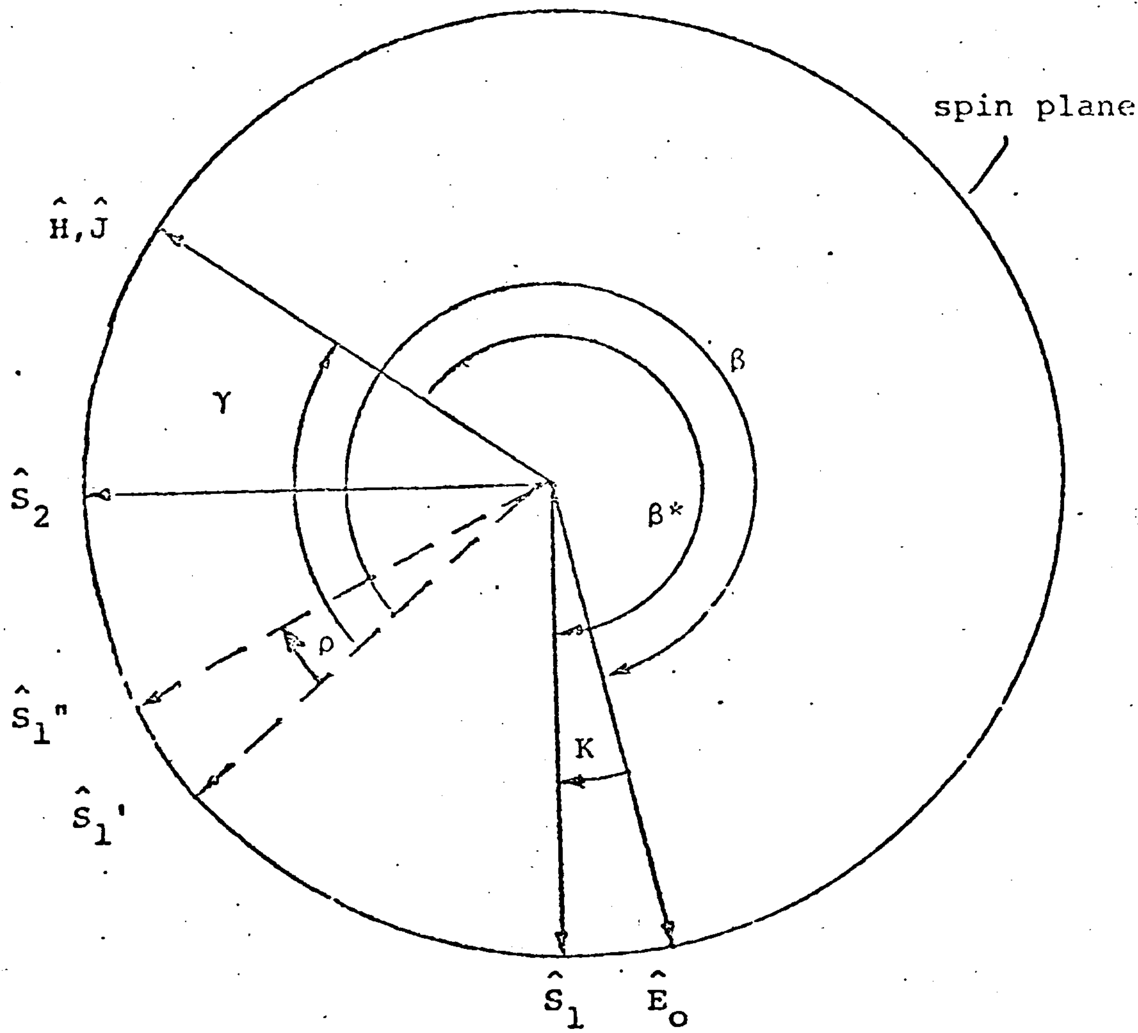
$$\phi_1 = \tan^{-1}\left\{\frac{\sin\lambda'}{m-\cos\lambda'}\right\} - \zeta \qquad (23)$$

where $m = 6.611$ is the distance from the satellite to earth center in units of earth radii.

If we let $t_o = t_F$ (the predicted frame start time) and let $\phi_o = 910\ \mu_L$ (the elevation angle at frame start) then:

$$t_1 = t_F - \left(\frac{\phi_1}{\mu_L} - 910\right) T \qquad (24)$$

The iteration process will continue until either $|\phi_i - \phi_{i-1}|$ is less than some constant ε_ϕ or the iteration parameter i exceeds some constant I_ϕ. $\varepsilon_\phi = 2\text{x}10^{-6}$ radians.



$\hat{J}$: sun sensor

$\hat{H}$: sun-satellite projection

$\hat{S}_1$: earth-satellite projection

$\hat{E}_o$: data acquisition start line

$\hat{S}_1'$: predicted VISSR FOV plane-spin plane intersection

$\hat{S}_1''$: actual VISSR FOV plane-spin plane intersection

solid lines ——— Fixed coordinates

dashed lines - - - Rotating coordinates

Figure 7. Beta Geometry

7.0 BETA ANGLE

Interpretation of the preceding equations requires an adequate understanding of the role played by the sun-earth angle beta. In this section this angle is defined and its relation to other angles is reviewed.

The line from the satellite to the sun can be projected into the spin plane and denoted by unit vector $\hat{H}$. Whenever the rotating sun sensor reference $\hat{J}$ becomes coincident with $\hat{H}$ a sun pulse is produced. Figure 7 is a view of the spin plane when $\hat{H}$ and $\hat{J}$ are aligned. The angle between $\hat{H}$ and $\hat{S}_1$ is denoted by β^*. We define a unit vector $\hat{E}_o$ at a fixed angle K from $\hat{S}_1 (K = 9\ 3/16^o)$. Data acquisition by the S/DB commences whenever the rotating vector $\hat{S}_1'$ becomes aligned with $\hat{E}_o$; data acquisition then continues for a total angle of 2K degrees.

The angle β is defined as the satellite rotation angle from the $\hat{H}$-$\hat{J}$ coincidence until the following $\hat{E}_o$-$\hat{S}_1'$ coincidence. Then

$$\beta = \beta^* + \gamma - K \qquad (25)$$

APPENDIX II. TEMPERATURE CALIBRATION TABLE

The final temperature calibration table reference on Page C-2 may be used to convert the 8-bit data-count values to temperature values.

The following FORTRAN logic may be used to compute the table which is a 256-word array of temperature values (°K x 10). The array is indexed by the value of the Infrared data sample.

```
      DIMENSION KELVIN (256)
      N= 3300
      DO1 I = 1,176
      KELVIN (I) = N
      N = N-5
  1   CONTINUE
      DO2 I = 177,256
      KELVIN (I) = N
      N = N-10
  2   CONTINUE
```

N is initialized at 3300, representing a temperature of 330.0°K which corresponds to the lowest count value (0).

An example of a FORTRAN statement using the table would be:

```
KTEM = KELVIN (IRVAL + 1)
```

where: KTEM: Temperature, °K x 10

KELVIN: Temperature Table

IRVAL: An IR Data Value (0-255)

A printout of the table follows with temperature values in °K, °C, and °F for each possible IR data-count value.

APPENDIX III. WINDS ARCHIVE

The Winds Archive consists of sets of cloud motion vectors derived operationally by NESS by manual and automated techniques. The techniques involved are described in NOAA Technical Memorandum NESS 64 Central Processing and Analysis of Geostationary Satellite Data (March 1975).

This data is archived from October, 1974 to the present. On 18 November, 1974, the cloud motion derivation operation was expanded from once to twice daily. The times each are nominally 0930Z/1000Z and 2130Z/2200Z from the East Satellite and 1015Z/1045Z and 1515Z/1545Z from the West Satellite.

The winds tapes are formatted as shown in the table below. Note that for each vector the pressure altitudes and temperature are also provided. About 750 vectors are derived daily per satellite.

Monthly Winds Archive Tape Format

One archive tape will contain one month's accumulation of both manual movie-loop and automated picture-pair derived wind vectors.

Files	1 per tape
Records	as many as required
Record length	6000 8 bit bytes (1500 32 bit words)
(Vectors/Record	N vectors, where N = 1,200; if N is less than 200, record will be zero filled)
Vector length	15 elements
Element length	2 bytes or 16 bits/element (binary)
Trailor record	200, zero element vectors
Recording mode	binary
Density	800 bpi/1600 bpi
Tracks	9 track

Vector Description by element

Element No.	Description
1	Year e.g. 4 = 1974
2	Month e.g. 11 = November
3	Day of month
4	Hour e.g. 14 = 1400 GMT
5	Pressure in tens of mb. e.g. 55 = 550 mb.
6	Temperature in °K (whole degrees)
7	Latitude x 10 e.g. -788 - 78.8°S
8	Longitude °W x 10 e.g. 1903 = 169.7°E
9	Direction in degrees
10	Speed in knots
11	Octant, standard global octant (N-0,1,2,3), (S-5,6,7,8)
12	Count*, 1-9999, unique for each vector on a given run
13	Source code 1 = Suitland, Md.
14	Height confidence factor, 0-9, low to high
15	Total confidence factor, 0-9, low to high

*Picture pair derived wind vectors will start with 501.