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THE USE OF DMSP DIGITAL DATA FOR AURORAL MEASUREMENTS. (U)

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Gilbert Davidson

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PREPARED FOR

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
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FOREWORD

The effort discussed in this report concerns measurements of auroral intensities and spatial variations using satellite, aircraft, and ground-based sensors. Primary emphasis has been on calibration of night time sensors on two DMSP satellites, and on development of computer techniques for handling the DMSP digital tape data.

The author wishes to thank R. Nadile (AFGL/OPR), technical monitor, for his encouragement and support. We also wish to thank J. Bass (Logicon) and H. Fish (RDP) for their efforts in development of the computer programs, and R. Sears, (Lockheed Missiles and Space Corp.) for providing ground station data.

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1. INTRODUCTION

The Defense Meteorological Satellite Program (DMSP) has been providing unclassified meteorological imagery to the scientific community since early 1973. The forerunner to DMSP was the classified Defense System Applications Program (DSAP) which provided so-called DAPP (Data Acquisition and Processing Program) data.

Our effort has concentrated upon development of a data analysis system which will allow optimal use of DMSP auroral and airglow imagery for a variety of applications. The current version of DMSP, known as Block 5D, became operational in late 1975 with the launch of the F1 satellite. Since that time, three additional satellites were launched successfully and one unsuccessfully, with approximately three more planned before a possible integration into the shuttle program.

Our program has included calibration of the night time visible sensors on the F1 and F2 satellites in the Block 5D series. By correlating auroral intensities measured by ground and airborne photometers with the DMSP observation simultaneous in space and time, the night sensors on these two satellites have been calibrated in terms of effective auroral intensity. The approach to this calibration is unique, to our knowledge, since earlier approaches have used DMSP auroral data taken from photographic transparencies. The current approach uses the digital telemetry information from which the transparencies are produced. This digital data has been supplied by AFGWC.

Access to digital data on magnetic tape has allowed straightforward development of computer approaches to data handling. The effort has been to develop a flexible system which allows manipulation of the data dependent upon the specific application and presentation in a variety of formats.

The program has also included correlation of auroral observations from the calibrated DMSP F2 satellite with data taken by an uncalibrated satellite.

2. CHARACTERISTICS OF THE DMSP BLOCK 5D SERIES

The primary sensor on the DMSP satellite provides visual and infrared imagery of the earth on a continual basis, with the primary mission to provide meteorological data. In addition to the primary sensor there are a variety of smaller sensor packages. These generally have included the SSJ electron spectrometer and the SSIE plasma monitor.

To date, our program has used only data from the primary visible sensor on the DMSP. Table 2-1 lists some of the characteristics of the night time visible sensor. The orbital characteristics of the satellite are also given.

In order to perform its primary mission of providing timely and accurate meteorological data for the U.S. military on a global basis, the DMSP has been placed in a polar orbit at an inclination of 98.7° with respect to the equator. The design orbital altitude is 450 nautical miles (833 km), yielding an orbit period of 101 minutes.

The total data system for the primary sensor on the Block 5D DMSP is called the OLS (Operational Linear System). The OLS contains a number of changes from the 5 B/C series which yield improved system performance in terms of spatial resolution and accuracy.

The requirement for global meteorological data requires that the OLS optical system performs a scan which will yield continuous data when outputs from successive orbits are placed side-by-side. To do this, the optics scan a full angle of 112.5° in a direction perpendicular to the subsatellite track. This scan corresponds to a geocentric scan angle of 27.5° , yielding a scan on the earth's surface of 1655 nautical miles (3065 km). The 101 minute orbital period corresponds to an earth rotation of 25.4° under the satellite during each orbit. Thus, successive orbits yield scans which overlap slightly the scans of the previous orbit.

The orbital parameters of the satellite were configured to place it in a sun synchronous orbit, so that local time at the satellite is essentially constant for a given subsatellite latitude on each pass.

Table 2-1. Characteristics of DMSP Block 5D
Night Sensor

DMSP BLOCK 5D (NIGHT)

ORBIT CHARACTERISTICS:

- 450 NMI (833 km)
- 101 Minutes/Revolution
- 98.7° Inclination
- 81.3° North & South Max Lat. Subpoint

SCAN CHARACTERISTICS:

- 112.5° Full Angle
(27.5° Geocentric)
(1655 NMI)
- 1.5 NMI (2.8 km) Ground Resolution (nom.)
(Derived from 11.88 scan /sec rate
and 5 Scan Average with 8 KHz on-
board filter)
(Compensated FOV to yield nearly
constant footprint)
- 1464 Resolution elements/scan

ELECTRICAL CHARACTERISTICS:

- Lin and Log Sensitivities
- Dynamic Range = 100 on Log
= 64 on Lin
- Ground Programmable Gain (Saturation Value)
In finer than 1db steps from 1 - 63.875 db
(DB = 20 Log V (Out)/V (In))
- S/N Better than 6 at 8E-09 watts per cm sq per ster.

In the 5D series, F1 had equatorial crossings at approximately noon-midnight, providing excellent night-side auroral views. F2, F3, and F4 were morning-evening satellites with equatorial crossings in the 8 - 10 AM-PM time region.

A major change in the night time sensor for 5D compared to 5B/C was the shift to a photomultiplier as the detector from the silicon detector previously used. Silicon remains as the daytime sensor. Figure 2-1 shows the relative sensitivity curves for the photomultipliers used in F2 and F4. The response of the PMT's in F1 and F3 were quite similar to F2. The shift to red enhancement occurred in F4.

In addition to the day/night visual channel, the DMSP records simultaneous data in the infrared. In the F1 to F4 flights this channel was sensitive to thermal radiation in the 8 - 13 micron infrared band. The detector is HgCdTe cooled to approximately 108 K. To date, we have made only slight use of the infrared data. There is, as yet, no evidence of auroral effects being observable in this channel.

The design of the OLS improved considerably the uniformity of the system geometric resolution over the 5B/C series. The system is now required to have a resolution of 0.3 nautical miles for daytime viewing and 1.5 nmi for night imagery. The actual night resolution varies from approximately 1.2 nmi (2.2 km) at nadir to somewhat more than 1.5 nmi (2.8 km) at the ends of the scan.

The OLS uses an optical scanning technique combined with shaped detector surfaces to achieve its uniform spatial resolution, compared to the 5B/C series. The OLS rotates and switches the detector field of view to maintain image uniformity. This is combined with electrical gain switching along the scan to yield the desired scene sensitivity.

Overall sensitivity of the night time channel is controllable from the ground over a range of 63-7/8 db in 1/8 db steps. In addition, one may select either a logarithmic or linear response in the amplifier. (For our purposes, 20 db = factor of 10 in input signal level.)

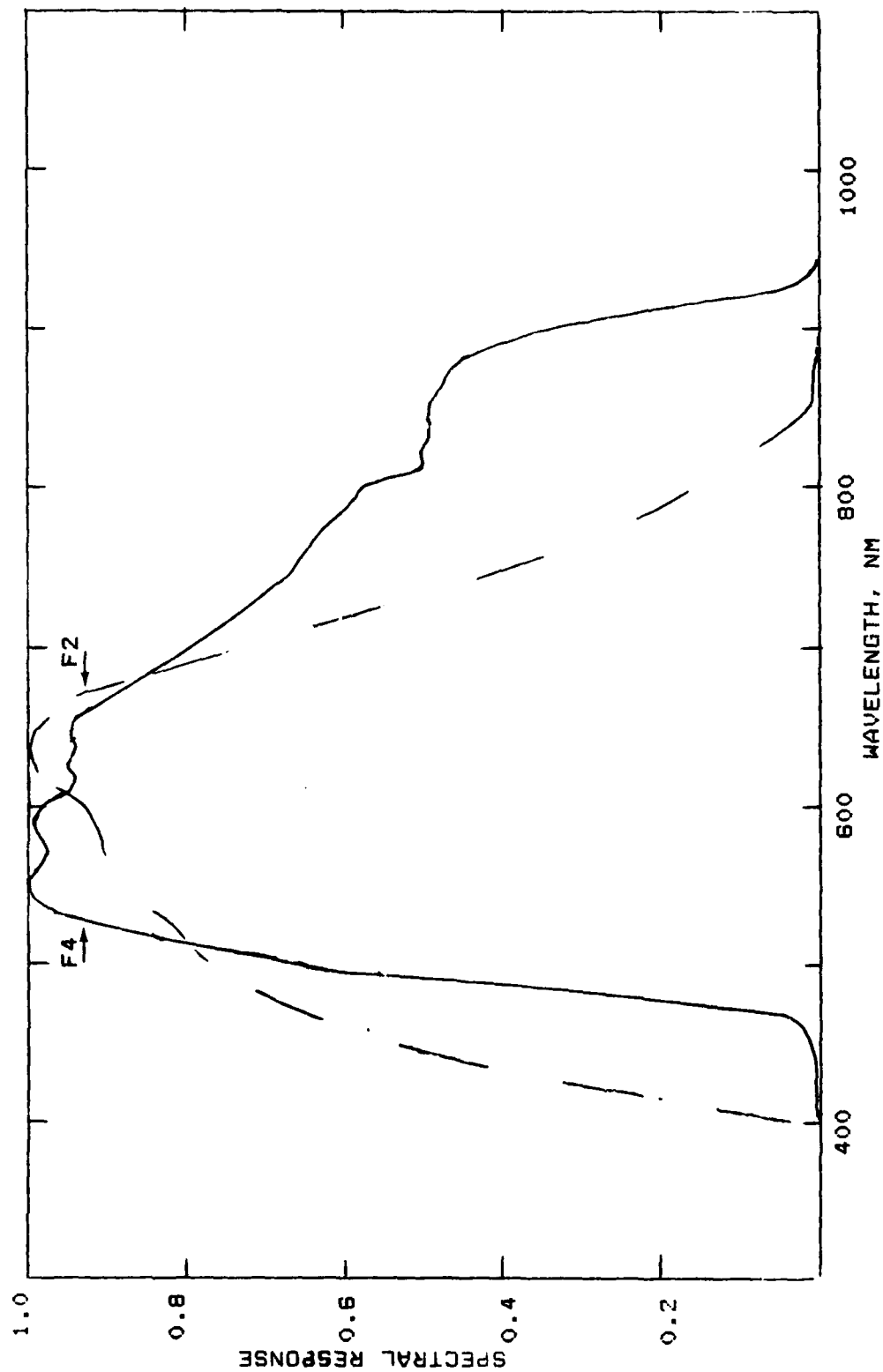


Figure 2-1. Relative Response of DMSP PhotoMultipliers.

Data is processed and digitized on board the satellite. The basic scan rate of the sensor system was configured to give continuous earth coverage when combining the subsatellite track velocity with the field-of-view of the sensor system. Since the subsatellite track velocity for the orbital parameters given earlier is 3.55 nmi per second, the required scan rate corresponding to the daytime 0.3 nmi resolution is 11.88 scans per second for continuous coverage. The onboard processing averages over five successive scans to yield the so-called "smoothed" daytime resolution of 1.5 nmi and the fixed night time 1.5 nmi resolution.

The smoothed data is filtered and digitized to yield 1464 pixels of data for each effective scan (average of five). The data is digitized with 5 bit resolution yielding a scene instantaneous dynamic range of 64 using the linear amplifier and a dynamic range of 100 using the log amplifier. The gain of the overall system can be changed over the 64 db range mentioned earlier to yield a total dynamic range of over 10^5 .

3. EXPERIMENTAL PROGRAM

The calibration effort has involved a number of simultaneous or near simultaneous spatial-temporal correlations between various DMSP Block 5D satellites and aircraft and ground stations viewing auroral situations. This included the use of satellite ephemeris predictions generated by AFGL/SUA and projected flight plans of the AFGL/OP NKC-135 (SN 53120) Flying Laboratory. An example of printed ephemeris data is shown in Fig 3-1. In those missions that involved ground measurements, plans were coordinated with the Lockheed group (R. Sears).

DMSP data has been supplied by AFGWC in two different forms during the period of this program. Early in the program, digital data for the specified satellite, revolution and time period was supplied as an octal dump on paper of pixel information by scan line. Figure 3-2 is an example of few scan lines of information. Each line contains 1464 pairs of octal numbers which represent 8^2 levels of signal information for each pixel. In addition, there is time code, gain, and other house-keeping information in each scan line. The data format will be discussed in more detail in Section 4.

Later in the program (after February 1979), the data requested from AFGWC was supplied on digital magnetic tape in a format compatible with the AFGL CDC computer.

Table 3-1 is a tabulation of digital data supplied by AFGWC through February 1980. The table identifies the data, satellite, revolution number, and universal time for which data exists. It also lists whether the data exists on binary magnetic tape or as paper print-out. The revolution number is considered redundant information. The date, time and satellite identification are the primary data identifiers.

3.1. Calibration of F1

During the period January 1979 through early February 1979 the Lockheed optical research site at Chatanika, Alaska was in operation.

PREPARED BY/FOR THE ANALYSIS AND SIMULATION BRANCH (SUB), AIR FORCE GEOPHYSICS LABORATORY, FT. MONTE 831-5161

STATION NO.	NO.	UNIVERSAL TIME	ELEV	AZIM	RANGE	ALT	RT	DEC	DECL	SUBSATELLITE	SUM	SAT
		DAY	DEC	DEC	DEC	DEC	DEC	DEC	DEC	DEC	DEC	DEC
1	1/26/73	20 4 50	15.38	69.82	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
2	1/26/73	20 4 59	15.39	69.83	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
3	1/26/73	20 5 08	15.40	69.84	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
4	1/26/73	20 5 17	15.41	69.85	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
5	1/26/73	20 5 26	15.42	69.86	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
6	1/26/73	20 5 35	15.43	69.87	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
7	1/26/73	20 5 44	15.44	69.88	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
8	1/26/73	20 5 53	15.45	69.89	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
9	1/26/73	20 6 02	15.46	69.90	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
10	1/26/73	20 6 11	15.47	69.91	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
11	1/26/73	20 6 20	15.48	69.92	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
12	1/26/73	20 6 29	15.49	69.93	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
13	1/26/73	20 6 38	15.50	69.94	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
14	1/26/73	20 6 47	15.51	69.95	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
15	1/26/73	20 6 56	15.52	69.96	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
16	1/26/73	20 7 05	15.53	69.97	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
17	1/26/73	20 7 14	15.54	69.98	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
18	1/26/73	20 7 23	15.55	69.99	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
19	1/26/73	20 7 32	15.56	70.00	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
20	1/26/73	20 7 41	15.57	70.01	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
21	1/26/73	20 7 50	15.58	70.02	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
22	1/26/73	20 7 59	15.59	70.03	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
23	1/26/73	20 8 08	15.60	70.04	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
24	1/26/73	20 8 17	15.61	70.05	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
25	1/26/73	20 8 26	15.62	70.06	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
26	1/26/73	20 8 35	15.63	70.07	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
27	1/26/73	20 8 44	15.64	70.08	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
28	1/26/73	20 8 53	15.65	70.09	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
29	1/26/73	20 9 02	15.66	70.10	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
30	1/26/73	20 9 11	15.67	70.11	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
31	1/26/73	20 9 20	15.68	70.12	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
32	1/26/73	20 9 29	15.69	70.13	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
33	1/26/73	20 9 38	15.70	70.14	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
34	1/26/73	20 9 47	15.71	70.15	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
35	1/26/73	20 9 56	15.72	70.16	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
36	1/26/73	20 10 05	15.73	70.17	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
37	1/26/73	20 10 14	15.74	70.18	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
38	1/26/73	20 10 23	15.75	70.19	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
39	1/26/73	20 10 32	15.76	70.20	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
40	1/26/73	20 10 41	15.77	70.21	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
41	1/26/73	20 10 50	15.78	70.22	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
42	1/26/73	20 10 59	15.79	70.23	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
43	1/26/73	20 11 08	15.80	70.24	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
44	1/26/73	20 11 17	15.81	70.25	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
45	1/26/73	20 11 26	15.82	70.26	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
46	1/26/73	20 11 35	15.83	70.27	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
47	1/26/73	20 11 44	15.84	70.28	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
48	1/26/73	20 11 53	15.85	70.29	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
49	1/26/73	20 12 02	15.86	70.30	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
50	1/26/73	20 12 11	15.87	70.31	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
51	1/26/73	20 12 20	15.88	70.32	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
52	1/26/73	20 12 29	15.89	70.33	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
53	1/26/73	20 12 38	15.90	70.34	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
54	1/26/73	20 12 47	15.91	70.35	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
55	1/26/73	20 12 56	15.92	70.36	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
56	1/26/73	20 13 05	15.93	70.37	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
57	1/26/73	20 13 14	15.94	70.38	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
58	1/26/73	20 13 23	15.95	70.39	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
59	1/26/73	20 13 32	15.96	70.40	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
60	1/26/73	20 13 41	15.97	70.41	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
61	1/26/73	20 13 50	15.98	70.42	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
62	1/26/73	20 13 59	15.99	70.43	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
63	1/26/73	20 14 08	16.00	70.44	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
64	1/26/73	20 14 17	16.01	70.45	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
65	1/26/73	20 14 26	16.02	70.46	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
66	1/26/73	20 14 35	16.03	70.47	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
67	1/26/73	20 14 44	16.04	70.48	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
68	1/26/73	20 14 53	16.05	70.49	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
69	1/26/73	20 15 02	16.06	70.50	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
70	1/26/73	20 15 11	16.07	70.51	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
71	1/26/73	20 15 20	16.08	70.52	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
72	1/26/73	20 15 29	16.09	70.53	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
73	1/26/73	20 15 38	16.10	70.54	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
74	1/26/73	20 15 47	16.11	70.55	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
75	1/26/73	20 15 56	16.12	70.56	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
76	1/26/73	20 16 05	16.13	70.57	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
77	1/26/73	20 16 14	16.14	70.58	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
78	1/26/73	20 16 23	16.15	70.59	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
79	1/26/73	20 16 32	16.16	70.60	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
80	1/26/73	20 16 41	16.17	70.61	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
81	1/26/73	20 16 50	16.18	70.62	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
82	1/26/73	20 16 59	16.19	70.63	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
83	1/26/73	20 17 08	16.20	70.64	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
84	1/26/73	20 17 17	16.21	70.65	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
85	1/26/73	20 17 26	16.22	70.66	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
86	1/26/73	20 17 35	16.23	70.67	213.1	171.74	147.43	22.32	65.16	105.98	24.32	64.18
87	1/26/73											

[illegible]

Figure 3-2. Dump of DMSP Digital Data(Octal)

Table 3-1. Digital Data Supplied by AFGWC

<u>Date</u>	<u>Satellite</u>	<u>Rev. #</u>	<u>Time (U.T.)</u>	<u>Type of Data</u>
9/2/78	F1	10221	11:05-11:10	Paper
10/25/78	F1	10972	10:30-10:56	Paper
10/31/78	F1	11057	10:24-10:53	Paper
11/1/78	F1	11071	10:06-10:22	Paper
11/2/78	F1	11085	9:45-10:09	Paper
1/29/79	F2	8547	7:20- 7:28	Paper
2/2/79	F2	8604	7:52- 7:57	Paper
2/3/79	F2	8618	7:35- 7:41	Paper
2/4/79	F2	8648	7:07- 7:12	Paper
2/5/79	F1	12432	10:11-10:20	Paper/Mag
2/6/79	F1	12446	9:54-10:00	Paper
4/18/79	F4	1466	1:54- 2:06	Mag
4/25/79	F1	13549	4:58- 5:02	Mag
4/27/79	F4	1594	2:30- 2:34	Mag
9/27/79	F2	11960	1:54- 1:58	Mag
9/27/79	F2	11961	3:35- 3:39	Mag
12/15/79	F2	13091	20:10-20:17	Mag
12/24/79	F2	13219	20:49-20:55	Mag
1/11/80	F2	13474	20:25-20:31	Mag
1/13/80	F2	13502	20:49-20:53	Mag
1/14/80	F2	13516	20:31-20:37	Mag
1/15/80	F2	13530	20:13-20:19	Mag
1/15/80	F2	13531	20:54-20:61	Mag
1/20/80	F2	13602	20:02-20:09	Mag
2/6/80	F2	13842	20:14-20:20	Mag
2/7/80	F2	13857	20:37-20:43	Mag
2/15/80	F2	13871	20:32-20:39	Mag

This site includes a three channel meridian scanning photometer as one of its primary instruments. The photometer channels are designed to measure 427.8, 557.7, and 630 nm radiation with a field-of-view of 3°. The instrument scans 80° each side of zenith at a rate of two degrees/second. Data is taken in 4° increments.

Figure 3-3 shows the approximate subsatellite track for Revolution 12432 (5 February, 1979) projected onto the Alaska map. Shown is the approximate ground track of the Lockheed photometer intersection at auroral altitudes. Figure 3-4 is a reproduction of the DMSP transparency generated from night time sensor data for the portion of Rev 12432 over Alaska. The location of Fairbanks is circled and the intersection of the three-color meridian scanning photometer with a surface at approximately 100 km is shown. The square envelopes Anchorage.

The DMSP F1 sensor during the portion of the orbit over Alaska was operating in linear mode with gain equal to 25 db. Table 3-2 tabulates a portion of the meridian scanning photometer data and the DMSP output when viewing the same region. It can be seen that time coincidence of the spatial scans occurred at approximately 72 km south of Chatanika during this scan (10 hr 58 min. UT). Averaging the two values nearest this coincidence yields an output of 58.13 for a 427.8 intensity of 1663 R. Since zero volts is an output of 63 and 5 volts is zero, this yields the following calibration (at 427.8; G = 25 Linear).

$$1 \text{ volt} = 4,300 \text{ R}$$

$$5 \text{ volts} = 21,500 \text{ R}$$

Standardizing to a gain of 63 db yields, for F1, (427.8; G = 63, linear)

$$1 \text{ volt} = 54.1 \text{ R}$$

$$5 \text{ volts} = 270 \text{ R}$$

3.2. Calibration of F2

A number of coordinated satellite and aircraft observations were made during the course of the program. For purposes of F2 calibration, the coordinated event of 27 September, 1979 is used. During this series of coordinated aircraft flights, the AFGL/OP NKC-135 (SN 53120)

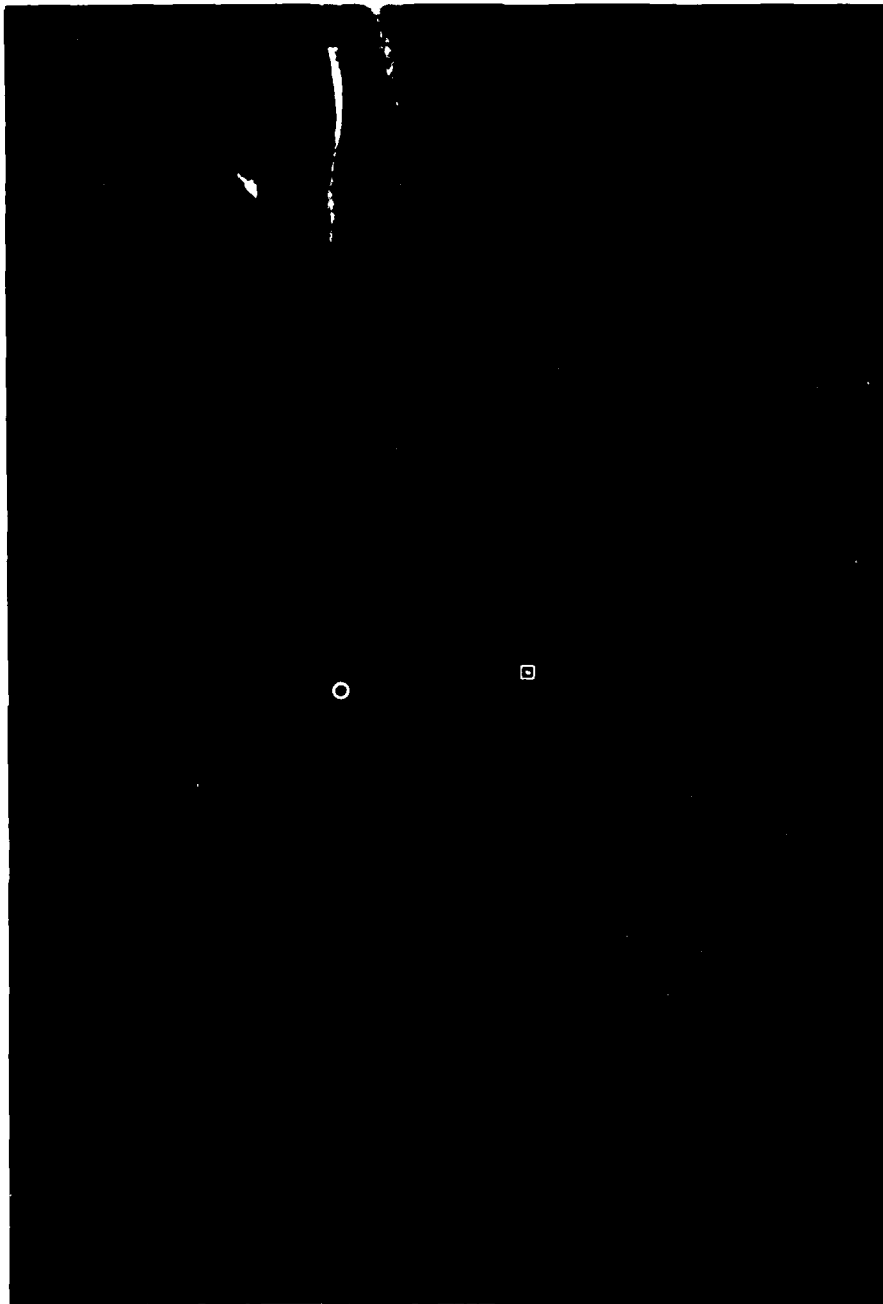


Figure 3-4. DMSP Photo Over Alaska (F1, 5 February 1979).

Table 3-2. GROUND SITE/DMSP F1 COINCIDENCE
(5 February 1979)

Distance South (km)	Photometer Time (U.T.)	F1 Time (U.T.)	F1 Output (63 to 0 = 0 to 5 volts)	Ground Site I (4278) (R)
48	10:15:03	10:14:53	59.4	1115
58.2	10:15:01	10:14:55	58.9	1376
68.7	10:14:59	10:14:57	58.35	1569
79.8	10:14:57	10:14:59	57.9	1756
93.4	10:14:55	10:15:01	57.8	1937
109	10:14:43	10:15:04	57.6	2064
123	10:14:51	10:15:06	57.5	2417
140	10:14:49	10:15:09	56.8	2554

was operating from Pease AFB, New Hampshire, flying over Newfoundland and Quebec and returning to Pease. Two revolutions of F2 (Rev 11960 and Rev 11961) scanned regions of aurora which were viewed simultaneously by the AFGL twelve channel visible photometer (System E5 operated by PhotoMetrics). This photometer was near zenith (15° forward) pointing. Table 3-3 shows the aircraft coordinates (from the flight log) and the subsatellite location near the time of coincidence (1:56 U.T.). Fig 3-5 shows the approximate aircraft position on the Rev 11960 pictorial data.

Figure 3-6 shows the pixel values given from the computer reduction of the F2 Rev 11960 output supplied by AFGWC for the scan which included the photometer field-of-view (2° full angle). Averaging the six pixel values closest to the photometer field yields a pixel value of 26 (where zero to 63 is 5 volts to zero volts). During this portion of the orbit, F2 was operated at gain = 57 in Log mode.

The photometer output at the time of coincidence (1:55:17) yielded a value of 350 R at 427.8 nm.

The calculation of the F2 calibration is as follows. F2 during this time was in its logarithmic mode. The voltage telemetered is still 0 - 5 volts, yielding levels of 0 - 63 for pixel values. The equivalent linear voltage into the log amplifier is given by

$$V_{in} = 0.05 \log^{-1} \left[\frac{5(1 - V_{pix})}{2.5} \right]$$

For our case, $V_{pix} = 26$, yielding

$$V_{in} = 0.05 \log^{-1} 1.75 = 0.747 \text{ volts}$$

$$0.75 \text{ volts in} = 350 \text{ R (427.8)}$$

$$1 \text{ volt in} = 467 \text{ R}$$

$$5 \text{ volts in} = 2,333 \text{ R (G = 57)}$$

For G = 63 we have:

$$\text{Using dB} = 20 \log \frac{V_2}{V_1}$$

$$1 \text{ volt} = 234 \text{ R (427.8)} \quad 5 \text{ volts} = 1170 \text{ R (427.8)}.$$

Table 3-3. AIRCRAFT DMSP F2 COINCIDENCE
(27 September 1979)

<u>Time (U.T.)</u>	<u>A/C Lat</u>	<u>A/C Long</u>	<u>A/C Hdng</u>	<u>Comment</u>	<u>F2 Lat</u>	<u>F2 Long</u>	<u>Rev</u>
01:52	51°56'	66°01'	000	Left turn			
01:54	52°06'	66°06'	325	End turn	56°04'	57°18'	11960
01:56	52°	66°19'	325°		49°18'	60°51'	11960
02:03	53°03'	67°02'	327°				



Figure 3-5. DMSP Photograph (F2, 27 September 1979).

OMSPF2 AURORA STRUCTURE REV 11960 SEP 27, 1979

SCAN	TIME	LAT	LONG	ALT	OMGT	AZ	GAIN	MINMAX	7 48	0'S 681-157	OSY
0	V	LAT	LONG	0ST	0	V	0ST	0	V	0	0ST
169	24	52.17	63.13	281.37	240.4	219	31	52.30	64.22	280.51	316.3
170	21	52.17	63.19	281.36	241.9	220	28	52.30	64.29	280.67	317.8
171	21	52.17	63.17	281.34	243.4	221	28	52.30	64.27	280.67	319.4
172	33	52.17	63.19	281.32	244.9	222	27	52.30	64.29	280.69	320.9
173	12	52.18	63.21	281.31	246.4	223	30	52.31	64.31	280.64	322.5
174	22	52.18	63.24	281.29	247.9	224	27	52.31	64.34	280.62	324.1
175	30	52.18	63.26	281.27	249.4	225	30	52.31	64.36	280.60	325.6
176	33	52.19	63.30	281.24	252.4	227	26	52.32	64.40	280.37	328.7
177	33	52.19	63.30	281.22	253.9	228	27	52.32	64.42	280.35	330.3
178	16	52.19	63.34	281.20	255.4	229	24	52.32	64.45	280.33	331.9
179	30	52.20	63.36	281.19	256.9	230	30	52.32	64.47	280.31	333.4
180	29	52.20	63.39	281.17	258.4	231	24	52.33	64.49	280.29	335.0
181	29	52.20	63.41	281.15	259.9	232	20	52.33	64.52	280.28	336.6
182	29	52.20	63.43	281.14	261.4	233	23	52.33	64.54	280.26	338.1
183	31	52.20	63.45	281.12	262.9	234	31	52.33	64.56	280.24	339.7
184	26	52.21	63.47	281.10	264.4	235	24	52.34	64.58	280.22	341.3
185	34	52.21	63.49	281.08	265.9	236	21	52.34	64.61	280.20	342.9
186	34	52.21	63.51	281.07	267.4	237	26	52.34	64.63	280.19	344.4
187	32	52.21	63.52	281.07	268.9	238	27	52.34	64.65	280.17	346.0
188	40	52.22	63.54	281.05	270.4	239	29	52.35	64.68	280.15	347.6
189	34	52.22	63.56	281.03	271.9	240	24	52.35	64.70	280.13	349.2
190	27	52.22	63.58	281.02	273.4	241	26	52.35	64.72	280.11	350.8
191	38	52.22	63.60	281.00	274.9	242	25	52.35	64.74	280.09	352.4
192	31	52.23	63.62	280.98	276.4	243	23	52.36	64.77	280.08	354.0
193	26	52.23	63.64	280.96	277.9	244	28	52.36	64.79	280.06	355.5
194	39	52.23	63.67	280.95	279.4	245	28	52.36	64.81	280.04	357.1
195	30	52.23	63.69	280.93	280.9	246	25	52.36	64.83	280.02	358.7
196	31	52.24	63.71	280.91	282.4	247	26	52.37	64.85	280.00	360.3
197	30	52.24	63.73	280.89	283.9	248	27	52.37	64.88	279.98	361.9
198	31	52.24	63.76	280.88	285.4	249	27	52.37	64.90	279.96	363.5
199	31	52.24	63.78	280.86	286.9	250	22	52.37	64.91	279.97	365.1
200	30	52.25	63.80	280.84	288.4	251	25	52.38	64.93	279.95	366.7
201	31	52.25	63.82	280.82	289.9	252	25	52.38	64.95	279.93	368.3
202	32	52.25	63.84	280.81	291.4	253	27	52.38	64.97	279.91	369.9
203	36	52.25	63.87	280.79	292.9	254	19	52.38	65.00	279.89	371.5
204	35	52.26	63.89	280.77	294.4	255	19	52.38	65.02	279.87	373.1
205	35	52.26	63.91	280.75	295.9	256	19	52.39	65.05	279.86	374.7
206	30	52.26	63.93	280.74	297.4	257	19	52.39	65.07	279.84	376.3
207	25	52.27	63.95	280.72	298.9	258	19	52.39	65.09	279.82	377.9
208	32	52.27	63.98	280.70	299.4	259	25	52.39	65.12	279.80	379.5
209	36	52.27	64.00	280.68	300.9	260	24	52.40	65.14	279.78	381.1
210	26	52.27	64.02	280.67	302.4	261	26	52.40	65.16	279.76	382.7
211	26	52.28	64.04	280.65	303.9	261	29	52.40	65.19	279.74	384.3
212	32	52.28	64.07	280.63	305.4	262	32	52.40	65.21	279.73	385.9
213	34	52.28	64.09	280.61	306.9	263	33	52.41	65.23	279.71	387.5
214	30	52.28	64.11	280.60	308.4	264	25	52.41	65.26	279.69	389.1
215	28	52.29	64.13	280.58	309.9	265	23	52.41	65.28	279.67	390.7
216	27	52.29	64.16	280.56	311.4	266	27	52.41	65.31	279.65	392.3
217	27	52.29	64.18	280.54	312.9	267	16	52.42	65.33	279.63	393.9
218	30	52.29	64.20	280.53	314.4	268	21	52.42	65.35	279.61	395.5
219	30	52.29	64.22	280.51	315.9	269	21	52.42	65.37	279.59	397.1
220	30	52.29	64.24	280.49	317.4	270	21	52.42	65.39	279.57	398.7
221	30	52.29	64.26	280.47	318.9	271	21	52.42	65.41	279.55	400.3
222	30	52.29	64.28	280.45	320.4	272	21	52.42	65.43	279.53	401.9
223	30	52.29	64.30	280.43	321.9	273	21	52.42	65.45	279.51	403.5
224	30	52.29	64.32	280.41	323.4	274	21	52.42	65.47	279.49	405.1
225	30	52.29	64.34	280.39	324.9	275	21	52.42	65.49	279.47	406.7
226	30	52.29	64.36	280.37	326.4	276	21	52.42	65.51	279.45	408.3
227	30	52.29	64.38	280.35	327.9	277	21	52.42	65.53	279.43	409.9
228	30	52.29	64.40	280.33	329.4	278	21	52.42	65.55	279.41	411.5
229	30	52.29	64.42	280.31	330.9	279	21	52.42	65.57	279.39	413.1
230	30	52.29	64.44	280.29	332.4	280	21	52.42	65.59	279.37	414.7
231	30	52.29	64.46	280.27	333.9	281	21	52.42	65.61	279.35	416.3
232	30	52.29	64.48	280.25	335.4	282	21	52.42	65.63	279.33	417.9
233	30	52.29	64.50	280.23	336.9	283	21	52.42	65.65	279.31	419.5
234	30	52.29	64.52	280.21	338.4	284	21	52.42	65.67	279.29	421.1
235	30	52.29	64.54	280.19	339.9	285	21	52.42	65.69	279.27	422.7
236	30	52.29	64.56	280.17	341.4	286	21	52.42	65.71	279.25	424.3
237	30	52.29	64.58	280.15	342.9	287	21	52.42	65.73	279.23	425.9
238	30	52.29	64.60	280.13	344.4	288	21	52.42	65.75	279.21	427.5
239	30	52.29	64.62	280.11	345.9	289	21	52.42	65.77	279.19	429.1
240	30	52.29	64.64	280.09	347.4	290	21	52.42	65.79	279.17	430.7
241	30	52.29	64.66	280.07	348.9	291	21	52.42	65.81	279.15	432.3
242	30	52.29	64.68	280.05	350.4	292	21	52.42	65.83	279.13	433.9
243	30	52.29	64.70	280.03	351.9	293	21	52.42	65.85	279.11	435.5
244	30	52.29	64.72	280.01	353.4	294	21	52.42	65.87	279.09	437.1
245	30	52.29	64.74	279.99	354.9	295	21	52.42	65.89	279.07	438.7
246	30	52.29	64.76	279.97	356.4	296	21	52.42	65.91	279.05	440.3
247	30	52.29	64.78	279.95	357.9	297	21	52.42	65.93	279.03	441.9
248	30	52.29	64.80	279.93	359.4	298	21	52.42	65.95	279.01	443.5
249	30	52.29	64.82	279.91	360.9	299	21	52.42	65.97	278.99	445.1
250	30	52.29	64.84	279.89	362.4	300	21	52.42	65.99	278.97	446.7
251	30	52.29	64.86	279.87	363.9	301	21	52.42	66.01	278.95	448.3
252	30	52.29	64.88	279.85	365.4	302	21	52.42	66.03	278.93	449.9
253	30	52.29	64.90	279.83	366.9	303	21	52.42	66.05	278.91	451.5
254	30	52.29	64.92	279.81	368.4	304	21	52.42	66.07	278.89	453.1
255	30	52.29	64.94	279.79	369.9	305	21	52.42	66.09	278.87	454.7
256	30	52.29	64.96	279.77	371.4	306	21	52.42	66.11	278.85	456.3
257	30	52.29	64.98	279.75	372.9	307	21	52.42	66.13	278.83	457.9
258	30	52.29	65.00	279.73	374.4	308	21	52.42	66.15	278.81	459.5
259	30	52.29	65.02	279.71	375.9	309	21	52.42	66.17	278.79	461.1
260	30	52.29	65.04	279.69	377.4	310	21	52.42	66.19	278.77	462.7
261	30	52.29	65.06	279.67	378.9	311	21	52.42	66.21	278.75	464.3
262	30	52.29	65.08	279.65	380.4	312	21	52.42	66.23	278.73	465.9
263	30	52.29	65.10	279.63	381.9	313	21	52.42	66.25	278.71	467.5
264	30	52.29	65.12	279.61	383.4	314	21	52.42	66.27	278.69	469.1
265	30	52.29	65.14	279.59	384.9	315	21	52.42	66.29	278.67	470.7
266	30	52.29	65.16	279.57	386.4	316	21	52.42	66.31	278.65	472.3
267	30	52.29	65.18	279.55	387.9	317	21	52.42	66.33	278.63	473.9
268	30	52.29	65.20	279.53	389.4	318	21	52.42	66.35	278.61	475.5
269	30	52.29	65.22	279.51	390.9	319	21	52.42	66.37	278.59	477.1
270	30	52.29	65.24	279.49	392.4	320	21	52.42	66.39	278.57	478.7
271	30	52.29	65.26	279.47	393.9	321	21	52.42	66.41	278.55	480.3
272	30	52.29	65.28	279.45	395.4	322					

3.3 Calibration Summary

As shown in Section 3.1 and 3.2, the calibration of F1, from a coincident measurement with the Chatanika Meridian Scanning Photometer and the calibration of F2 from a coincident measurement with the AFGL/OP NKC-135 are:

F1 (Linear Mode)

$$1 \text{ volt} = 54.1 \times \log^{-1} \left(\frac{63-G}{20} \right) R (427.8)$$

where

G = gain

$$\text{volts} = 5 \left(1 - \frac{V_{\text{pix}}}{63} \right)$$

V_{pix} = telemetered pixel value (0 to 63)

$$I (427.8) = 270 \left(1 - \frac{V_{\text{pix}}}{63} \right) \log^{-1} \left(\frac{63-G}{20} \right) R$$

F2 (Linear Mode)

$$I (427.8) = 1,170 \left(1 - \frac{V_{\text{pix}}}{63} \right) \log^{-1} \left(\frac{63-G}{20} \right) R$$

For the log mode we have

F1 (log)

$$I (427.8) = 2.7 \log^{-1} \left[2 \left(1 - \frac{V_{\text{pix}}}{63} \right) \right] \log^{-1} \left[\frac{63-G}{20} \right] R$$

F2 (log)

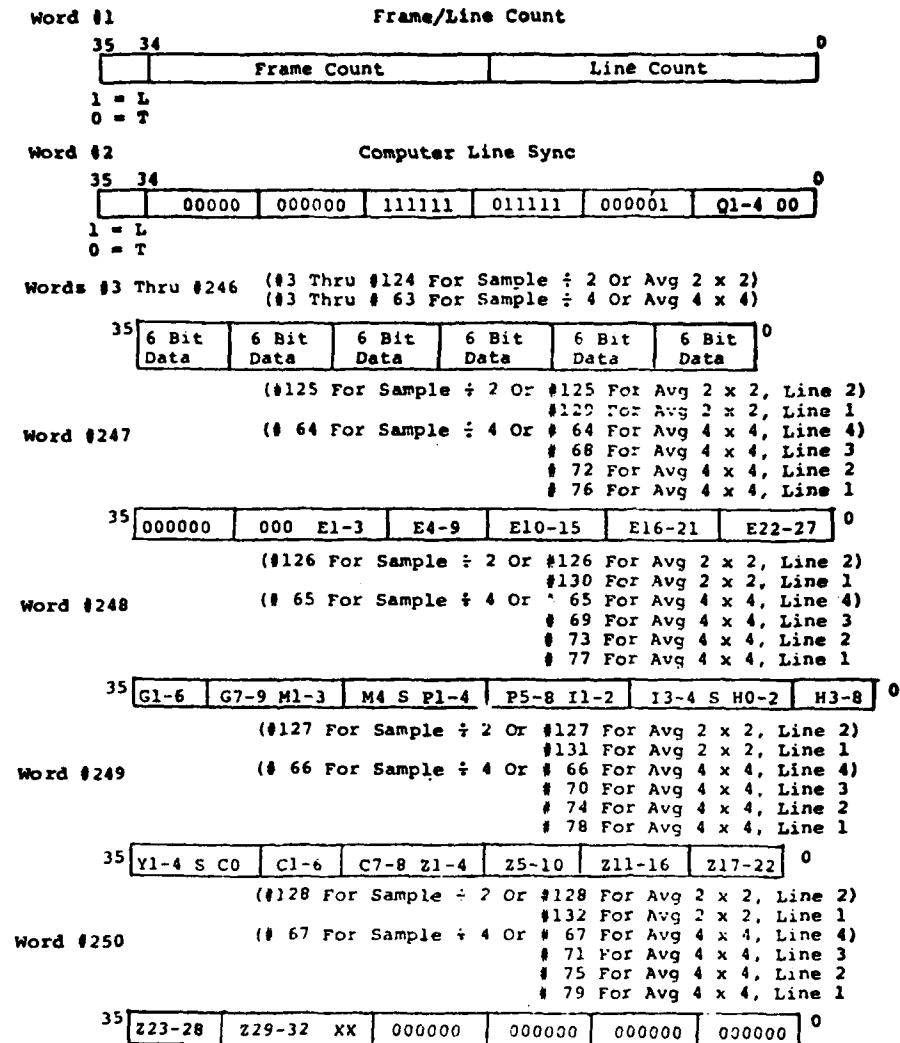
$$I (427.8) = 11.7 \log^{-1} \left[2 \left(1 - \frac{V_{\text{pix}}}{63} \right) \right] \log^{-1} \left[\frac{63-G}{20} \right] R$$

4. TREATMENT OF DATA

As mentioned earlier, the DMSP data of interest has been most recently supplied on magnetic tape by AFGWC. Figure 3-2 showed a dump of the tape data. Figure 4-1 gives the format of the data as supplied. The data for each scan line is composed of 250 36 bit words. Each 36 bit word, as seen in Figure 3-2, is composed of 12 octal digits (0 - 7). From the format of Fig 4-1, it can be seen that the first two words contain Line Count and Sync information. The pixel data is contained in the following 244 words as pairs of octal digits yielding levels of 0 - 63 for each pixel. Word 247 contains the time code as a 27 bit (9 octal digits) number representing U.T. in seconds times 1024. Word 248 contains a 9 bit (3 octal) number for the gain setting, with G1 = MSB and G9 = LSB. G1 - G6 represent the whole number G = zero to G = 63 values. Word 248 also contains a 4 bit number (M1 - M4). M1 gives information as to whether the amplifier is operating in linear or log mode. A zero in this position is used for linear and a 1 for log. M2 - M4, if all 1's, tell us that the amplifier was in preset gain mode. Other options are various AGC modes. The remaining bits in words 248 - 250 give calibration information for the various detectors and also vehicle identification.

Figure 4-2 illustrates the operations which are performed on the data. The digital data, as received from AFGWC on magnetic tape, is operated on by program PIXEL. This program unpacks data from the time interval of interest and merges this data with satellite ephemeris data for the time of interest for the particular satellite. This merged data, which now contains coordinate and time information for every pixel, is reformatted and output is made to permanent file for later use. PIXEL 2 is used only to provide a viewable output of this merged, reformatted data.

ARCLDB is a program used to produce a data base along an arc at an arbitrary angle to the satellite trajectory. This is necessary in order to compare the DMSP measurement with those of another instrument on the ground, on an aircraft, or on another satellite viewing a region



X May Be Either 1 Or 0

FORMATTED 6-BIT SMOOTH DATA OUTPUT

Figure 4-1. Format of Block 5D Tape Data.

DATA FLOW BLOCK DIAGRAM

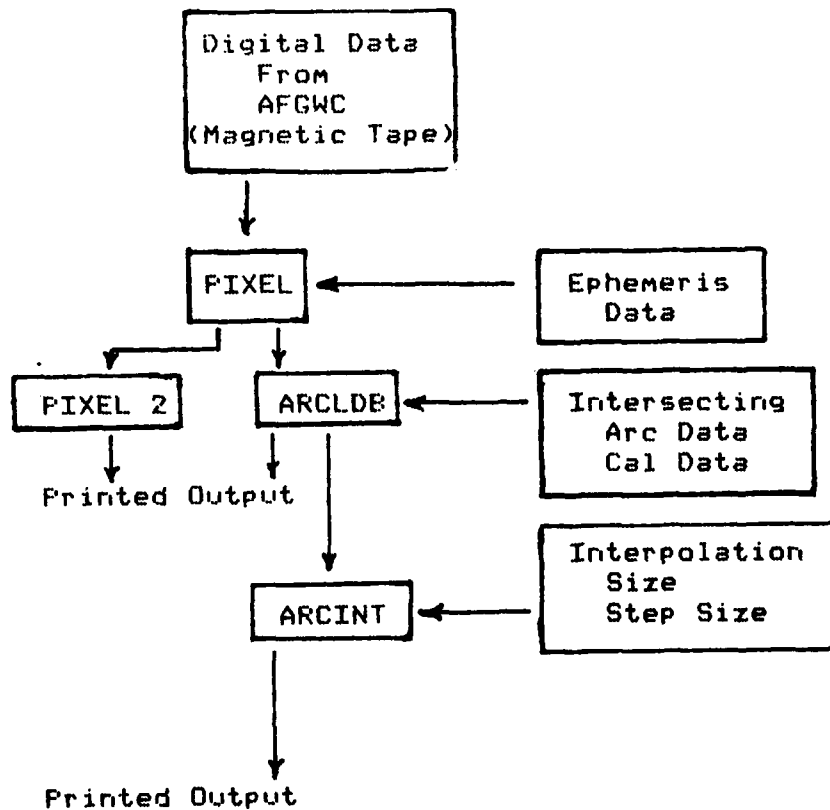


Figure 4-2.

viewed by DMSP. The absolute calibration of the sensor is inserted in ARCLDB so that results are in kR.

The program ARCINT uses the data base produced by ARCLDB to compute, by interpolation, the intensity as measured by DMSP along an arc centered at an arbitrary point and at an arbitrary angle.

4.1 Event of 11 January, 1980

As an example of the output of the various data processing programs we use data taken by satellite F2 on 11 January, 1980. Fig 4-3 is a reproduction of the transparency as supplied by AFGWC for the time period near 20 hrs 27 min UT. The satellite was moving downward during this period. The pairs of squares in the left margin occur every 120 seconds. The upper pair are at a time of 20:25.7 UT. The large city in the lower right corner is Moscow, with Leningrad visible as the next largest city to the northwest.

Fig. 4-4 shows the output of program PIXEL 2 for a 10 second time portion roughly midway between the upper two pairs of time squares. This is an example of short-form printout for the merged pixel-geographic information. A minimal amount of data is shown for each scan line. This includes the time of the scan, subsatellite coordinates, altitude of the satellite, the altitude assumed for the aurora (100 km), the octal digits which give the gain (in this case 310 octal or 011001000 binary, yielding $G = 25$) and state of the amplifier (74 octal or 111100 binary, yielding log preset gain). The final set of columns give the minimum and maximum decimal values for pixels on that scan line and the location pixel number of these values. Pixel number runs from -732 to 732. It should be remembered that minimum decimal value represents maximum signal. Negative pixel location numbers are on the right half of the picture. Figure 4-5 is the long-form output of PIXEL 2, showing coordinates and values for every pixel in a particular scan.

Figure 4-6 shows the output of program ARCLDB for points near a portion of the line drawn on the photo in Figure 4-3 representing the intersection of an arbitrary scan by another instrument with the

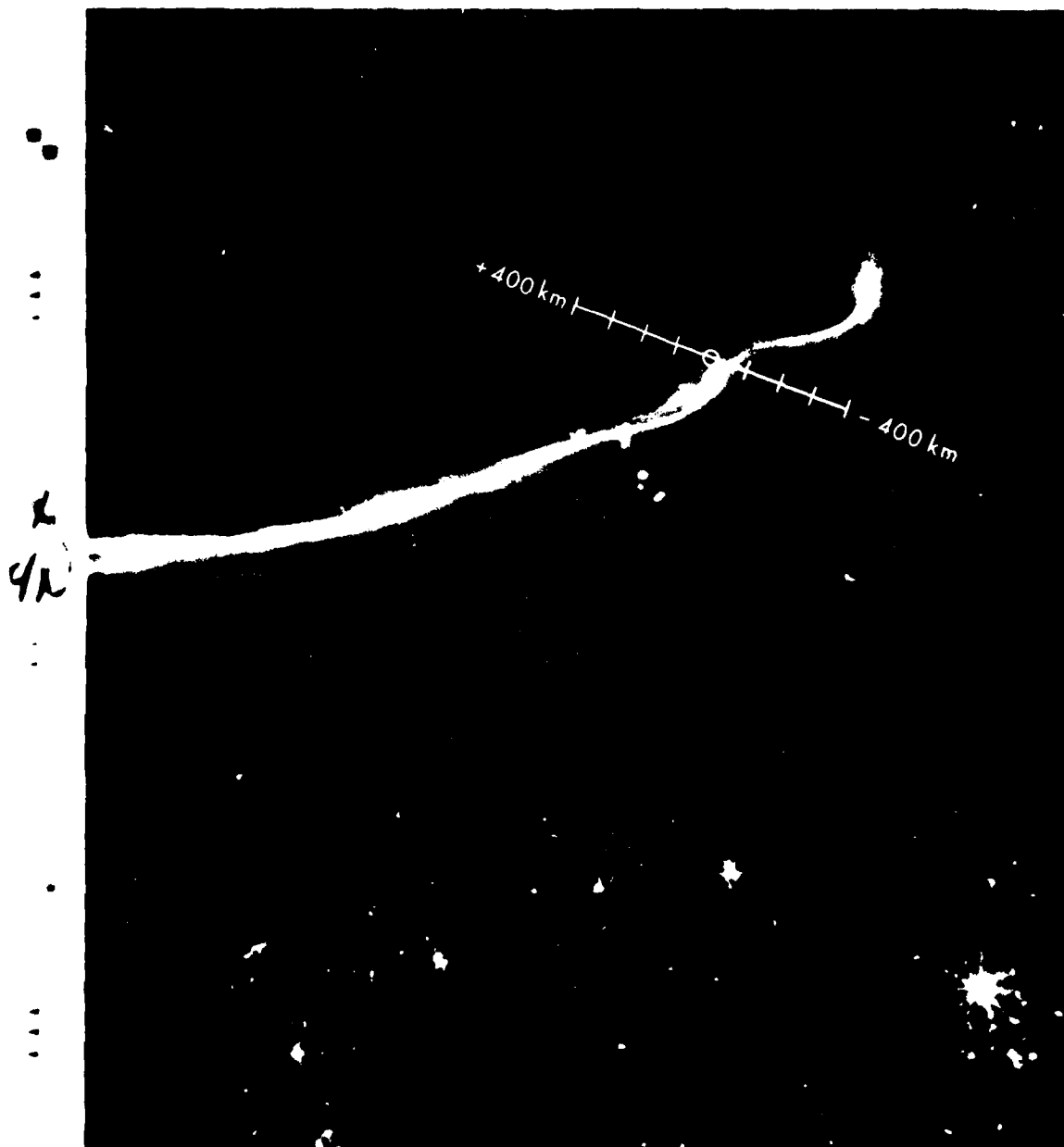


Figure 4-5. (a) Photograph of EF2, 11 June 1964.

03/28/81

INITIATOR : C. DAVIDSON
 PROBLEM NO. : 1786
 MONITOR : R. MOBLE
 PROGRAMMER : H. FIDH, ROP RUN BY : C. DAVIDSON

EXPERIMENT : DNEP AURORA SPATIAL STRUCTURE
 DATA : TAPE 013474 DNEP72 PAGES 13474 JAN 11, 1980
 TEST CASE FOR ARC DATA BASE PROGRAM

10DNEP72 AURORA STRUCTURE REV 13474 JAN 11, 1980

SCAN	TIME	LAT	LONG	ALT	DIST	AZ	GAIN	
1228	20:26:49.391	69.72	319.41	829.1	100.0	154.23	00000000310740264067	KIDMAX 34 62 0'S -16 425
1229	20:26:49.170	69.74	319.37	829.1	100.0	154.28	00000000310740264067	KIDMAX 32 62 0'S -20 782
1230	20:26:48.750	69.76	319.34	829.1	100.0	154.17	00000000310740270067	KIDMAX 35 62 0'S -18 731
1231	20:26:48.329	69.78	319.31	829.1	100.0	154.14	00000000310740270067	KIDMAX 34 62 0'S -22 485
1232	20:26:47.908	69.81	319.27	829.1	100.0	154.12	00000000310740265067	KIDMAX 36 62 0'S -31 393
1233	20:26:47.487	69.83	319.24	829.1	100.0	154.09	00000000310740264067	KIDMAX 36 62 0'S -29 539
1234	20:26:47.067	69.85	319.20	829.0	100.0	154.06	00000000310740270067	KIDMAX 37 62 0'S -30 374
1235	20:26:46.646	69.87	319.17	829.0	100.0	154.03	00000000310740270067	KIDMAX 36 62 0'S -41 387
1236	20:26:46.226	69.89	319.13	829.0	100.0	154.00	00000000310740265067	KIDMAX 34 62 0'S -48 633
1237	20:26:45.805	69.92	319.10	829.0	100.0	153.97	00000000310740264067	KIDMAX 35 62 0'S -46 365
1238	20:26:45.384	69.94	319.06	829.0	100.0	153.94	00000000310740265067	KIDMAX 34 62 0'S -46 363
1239	20:26:44.964	69.96	319.03	829.0	100.0	153.91	00000000310740265067	KIDMAX 34 62 0'S -70 545
1240	20:26:44.543	69.98	318.99	829.0	100.0	153.88	00000000310740264067	KIDMAX 32 62 0'S -90 405
1241	20:26:44.122	70.01	318.96	829.0	100.0	153.85	00000000310740265067	KIDMAX 31 62 0'S -85 521
1242	20:26:43.701	70.03	318.92	829.0	100.0	153.82	00000000310740270067	KIDMAX 30 62 0'S -92 732
1243	20:26:43.280	70.05	318.89	828.9	100.0	153.79	00000000310740270067	KIDMAX 30 62 0'S -93 582
1244	20:26:42.860	70.07	318.85	828.9	100.0	153.76	00000000310740264067	KIDMAX 28 62 0'S -102 006
1245	20:26:42.439	70.09	318.82	828.9	100.0	153.73	00000000310740264067	KIDMAX 25 62 0'S -126 408
1246	20:26:42.019	70.12	318.78	828.9	100.0	153.70	00000000310740270067	KIDMAX 25 62 0'S -138 427
1247	20:26:41.598	70.14	318.74	828.9	100.0	153.67	00000000310740270067	KIDMAX 24 62 0'S -135 421
1248	20:26:41.178	70.16	318.71	828.9	100.0	153.64	00000000310740264067	KIDMAX 22 62 0'S -138 698
1249	20:26:40.757	70.18	318.67	828.9	100.0	153.61	00000000310740264067	KIDMAX 22 62 0'S -142 428
1250	20:26:40.336	70.20	318.64	828.9	100.0	153.58	00000000310740270067	KIDMAX 23 62 0'S -144 732

Figure 4-4. Short-Form Output of Program PIXEL 2.

02/24/81

INITIATOR : C. DAVIDSON
 PROBLEM NO. : 1786
 MONITOR : R. HODGIE
 PROGRAMMER : N. FISH, RDP RUN BY : C. DAVIDSON

EXPERIMENT : ONDP ALRONAL SPATIAL STRUCTURE
 DATA : TAPE D13074 ONDPF2 PASS 13074 JUN 11, 1980
 TEST CASE FOR ANC DATA BASE PROGRAM

ONDPF2 ALRONAL STRUCTURE REV 12074 JUN 11, 1980

SCAN	TIME	LAT	LONG	ALT	CHIT	AZ	GAZI
1097	20:27:14.702	66.77	323.39	838.6	100.0	157.54	0000000031074024/067
0	U	LAT	LONG	AZI	OST	0	V
-732	56	66.52	301.93	132.21	-1275.1	-682	56
-731	56	66.53	301.95	132.19	-1273.4	-681	56
-730	59	66.54	301.98	132.17	-1271.6	-680	56
-729	58	66.55	301.54	132.15	-1269.9	-679	58
-728	57	66.56	301.53	132.13	-1268.1	-678	58
-727	56	66.57	301.55	132.11	-1266.3	-677	57
-726	59	66.58	301.57	132.09	-1264.5	-676	57
-725	59	66.59	301.60	132.06	-1262.8	-675	59
-724	58	66.60	301.62	132.04	-1261.0	-674	59
-723	58	66.61	301.65	132.02	-1259.2	-673	58
-722	58	66.62	301.67	132.00	-1257.4	-672	58
-721	58	66.63	301.70	131.98	-1255.6	-671	58
-720	60	66.65	301.72	131.96	-1253.7	-670	59
-719	60	66.66	301.75	131.94	-1251.9	-669	59
-718	59	66.67	301.77	131.91	-1250.1	-668	56
-717	57	66.68	301.80	131.89	-1248.2	-667	59
-716	61	66.69	301.82	131.87	-1246.4	-666	58
-715	59	66.70	301.85	131.85	-1244.5	-665	57
-714	59	66.71	301.87	131.82	-1242.7	-664	56
-713	61	66.72	301.90	131.80	-1240.8	-663	59
-712	60	66.73	301.92	131.78	-1239.0	-662	60
-711	59	66.75	301.95	131.76	-1237.0	-661	58
-710	57	66.76	301.98	131.73	-1235.1	-660	57
-709	57	66.77	302.00	131.71	-1233.2	-659	61
-708	57	66.78	302.03	131.69	-1231.3	-658	60
-707	58	66.79	302.06	131.67	-1229.4	-657	59
-706	60	66.80	302.08	131.64	-1227.5	-656	59
-705	58	66.81	302.11	131.62	-1225.6	-655	58
-704	59	66.83	302.13	131.60	-1223.6	-654	60
-703	59	66.84	302.16	131.57	-1221.7	-653	56
-702	57	66.85	302.19	131.55	-1219.8	-652	58
-701	59	66.86	302.22	131.53	-1217.8	-651	56
-700	59	66.87	302.24	131.50	-1215.9	-650	55
-699	58	66.88	302.27	131.48	-1213.9	-649	60
-698	59	66.90	302.30	131.45	-1211.9	-648	58
-697	57	66.91	302.32	131.43	-1209.8	-647	57
-696	58	66.92	302.35	131.41	-1208.0	-646	58
-695	58	66.93	302.38	131.38	-1206.0	-645	58
-694	58	66.94	302.41	131.36	-1204.1	-644	57
-693	59	66.95	302.43	131.33	-1202.1	-643	58
-692	60	66.97	302.46	131.31	-1200.1	-642	58
-691	56	66.98	302.49	131.29	-1198.1	-641	57
-690	57	66.99	302.52	131.26	-1196.1	-640	61
-689	59	67.00	302.55	131.24	-1194.0	-639	60
-688	59	67.01	302.57	131.21	-1192.0	-638	58
-687	59	67.03	302.60	131.19	-1189.9	-637	58

Figure 4-5. Long-Form Output of PIXEL 2.

ORP AIRCRAFT STRUCTURE STUDIES - ARC CALIBRATION DATA BASE

SATELLITE ORP72 PMS 12004 01/11/80

ARC PARAMETERS

LATITUDE 70.000 DEG N LONGITUDE 20.500 DEG W AZIMUTH 325.000 DEG E FROM N
 HALF-LENGTH 90.000 MILE HALF-WIDTH 2.000 MILE
 HEIGHT 100.000 MILE

CADZ = 10.000

TRANSFORM TO ARC COORDINATE MATRIX

-26.971 -22.712 -17.000
 -21.735 -19.221 -20.724
 .07049 -1.20117 -1.0417

FOLLOWING DATA PRINTOUT PER INTERFERING SCANS:

SCAN (SCAN NUMBER)
 TIME (UT, SEC)
 SLAT (GEOGRAPHIC) SATELLITE LATITUDE (DEG)
 SLON (GEOGRAPHIC) SATELLITE LONGITUDE (DEG W)
 SLAT (GEOGRAPHIC) SATELLITE LATITUDE IN ARC COORDINATE SYSTEM (DEG)
 SLON (GEOGRAPHIC) SATELLITE LONGITUDE IN ARC COORDINATE SYSTEM (DEG W)
 SALT (SATELLITE ALTITUDE, M)
 SALT (SATELLITE TRACK ALTITUDE IN ARC SYSTEM, DEG E OF N)
 SARC (DISTANCE ALONG ARC TO INTERSECTION IN UNITS OF DEGS)
 SPDX (FUNCTIONAL PIXEL NUMBER AT INTERSECTION)
 APDX (NUMBER OF PIXELS SELECTED FOR DATA BASE)
 APDX (LARGEST ALPHANUMERIC PIXEL NUMBER OF GROUP SELECTED)
 FOLLOWED BY INTENSITIES IN COLORVALUES FOR THESE PIXELS

SCAN	TIME	SLAT	SLON	SLAT	SLON	SALT	SARC	SPDX	APDX	APDX
1229	73407.170	69.740	319.375	.172	-.374	829.164	199.731	-5.594	26.659	26
		.1280E+01	.1280E+01	.1112E+01	.0940E+00	.0940E+00	.0940E+00	.1112E+01	.0940E+00	
		.1870E+01	.1112E+01	.0940E+00	.1870E+01	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.0310E+00	.0310E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.7170E+00	.0310E+00	.0310E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.7720E+00	.1130E+01							
1230	73408.750	69.742	319.340	.194	-.372	829.093	199.728	-5.591	27.343	26
		.1870E+01	.1112E+01	.1870E+01	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.0940E+00	.1112E+01	.1870E+01	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.0940E+00	.7720E+00	.0940E+00	.0310E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.7720E+00	.0940E+00	.0940E+00	.1112E+01	.7720E+00	.0310E+00	.0940E+00	.0940E+00	
		.7170E+00	.6672E+00							
1231	73409.329	69.744	319.306	.216	-.370	829.061	199.725	-1.583	26.492	27
		.1197E+01	.1197E+01	.1197E+01	.1112E+01	.1280E+01	.1112E+01	.1112E+01	.1112E+01	
		.1197E+01	.1112E+01	.0310E+00	.1112E+01	.1870E+01	.1870E+01	.1870E+01	.1870E+01	
		.0310E+00	.7720E+00	.0310E+00	.0310E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.0310E+00	.7720E+00	.0310E+00	.0310E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.7170E+00	.0940E+00	.0940E+00	.7720E+00					
1232	73407.988	69.806	319.271	.229	-.370	829.078	199.722	.624	29.728	26
		.1112E+01	.1112E+01	.1112E+01	.1197E+01	.1197E+01	.1197E+01	.1197E+01	.1197E+01	
		.0940E+00	.7170E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.7720E+00	.0310E+00	.0310E+00	.7170E+00	.7170E+00	.7170E+00	.7170E+00	.7170E+00	
		.0310E+00	.0940E+00	.0940E+00	.0310E+00	.1870E+01	.0940E+00	.0940E+00	.0940E+00	
		.7170E+00	.0940E+00	.0940E+00						
1233	73407.407	69.820	319.237	.261	-.367	829.099	199.720	2.431	43.431	26
		.1112E+01	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.0940E+00	.7720E+00	.7720E+00	.0310E+00	.0310E+00	.0940E+00	.0940E+00	.0940E+00	
		.0310E+00	.7170E+00	.0940E+00	.1870E+01	.0310E+00	.0310E+00	.0310E+00	.0310E+00	
		.0310E+00	.0310E+00	.0310E+00	.6672E+00	.7170E+00	.0310E+00	.0310E+00	.0310E+00	
		.7170E+00	.7720E+00							
1234	73407.647	69.851	319.202	.283	-.375	829.140	199.725	4.433	42.112	27
		.0310E+00	.0310E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	.0940E+00	
		.0310E+00	.0310E+00	.0940E+00	.0940E+00	.7720E+00	.7720E+00	.7720E+00	.7720E+00	
		.0310E+00	.7720E+00	.0310E+00	.0310E+00	.7170E+00	.7170E+00	.7170E+00	.7170E+00	
		.7170E+00	.6672E+00	.6672E+00	.7720E+00	.0310E+00	.7720E+00	.7720E+00	.7720E+00	
		.7720E+00	.0310E+00	.0310E+00						
1235	73406.646	69.873	319.167	.305	-.363	829.187	199.722	4.439	36.797	26
		.7170E+00	.0940E+00	.7720E+00	.0310E+00	.0310E+00	.0310E+00	.0310E+00	.0310E+00	
		.7720E+00	.0310E+00	.0310E+00	.0310E+00	.7170E+00	.7170E+00	.7170E+00	.7170E+00	
		.7170E+00	.0310E+00	.7720E+00	.7720E+00	.7170E+00	.7170E+00	.7170E+00	.7170E+00	
		.6672E+00	.7720E+00	.6672E+00	.7720E+00	.0310E+00	.0310E+00	.0310E+00	.0310E+00	
		.7170E+00	.0310E+00							

Figure 4-6. Output of Program ARCLDB

spherical shell containing the aurora at 100 km. In the photo (Fig 4-3), the right hand portion has been cropped, so that the center of the DMSP scans (the subsatellite track) is actually moved to the right and very nearly passes through the circle representing the center of the arbitrary scan. The arbitrary scan is centered at a latitude of 70° North and longitude of 320.5° West. It is taken at an azimuth of 325° east of north.

Fig 4-6 displays a small portion of the data base of pixels selected for each scan line near the intersection with the arbitrary scan. The calibration data was included as an input to this program, so that pixel values are given in equivalent kR of 4278 Å intensity.

Fig 4-7 shows the output of program ARCINT for the 800 km arbitrary scan intersection, using the data base created by ARCLDB for interpolation of pixel values near the intersection with each scan line. By comparing Fig 4-7 with the photo in Fig 4-3, one can readily see the intercept with the auroral arc. The intensity maximizes at approximately 6.4 kR at -58.5 km.

DWSP AURORAL STRUCTURE STUDIES AM LATERATION DATA BASE

SATELLITE DWSPF2 PASS 13474 01/11/80

ARC PARAMETERS

LATITUDE 70.000 DEG N; LONGITUDE 370.500 DEG W; AZIMUTH 325.000 DEG E FROM W
 HALF-LENGTH 400.000 KM; HALF-WIDTH 9.000 KM; DELS 2.000 KM
 HEIGHT 100.000 KM

GAIN = 18.600

ISOLAR = 4 IPLIT = 0 DELINT = 2.800

DWSP AURORAL STRUCTURE

S(KM)	INT(KR)	S(KM)	INT(KR)	S(KM)	INT(KR)	S(KM)	INT(KR)	S(KM)	INT(KR)
-403.20	.70	-263.20	.95	-123.20	1.09	16.80	.71	156.80	.71
-400.40	.67	-260.40	.87	-120.40	1.08	19.60	.81	159.60	.80
-397.60	.78	-257.60	1.06	-117.60	1.11	22.40	.73	162.40	.80
-394.80	.77	-254.80	1.14	-114.80	1.15	25.20	.79	165.20	.69
-392.00	.80	-252.00	.95	-112.00	1.29	28.00	.78	168.00	.76
-389.20	.73	-249.20	.84	-109.20	1.33	30.80	.76	170.80	.73
-386.40	.80	-246.40	1.07	-106.40	1.08	33.60	.69	173.60	.63
-383.60	.84	-243.60	1.06	-103.60	1.19	36.40	.74	176.40	.66
-380.80	.79	-240.80	.96	-100.80	1.49	39.20	.81	179.20	.74
-378.00	.78	-238.00	.82	-98.00	1.59	42.00	.87	182.00	.68
-375.20	.80	-235.20	.79	-95.20	1.62	44.80	.74	184.80	.78
-372.40	.81	-232.40	.85	-92.40	1.81	47.60	.71	187.60	.75
-369.60	.91	-229.60	.78	-89.60	1.93	50.40	.70	190.40	.73
-366.80	.71	-226.80	.96	-86.80	1.96	53.20	.80	193.20	.70
-364.00	.93	-224.00	1.01	-84.00	1.89	56.00	.72	196.00	.72
-361.20	.86	-221.20	.88	-81.20	2.31	58.80	.77	198.80	.76
-358.40	1.02	-218.40	1.05	-78.40	2.26	61.60	.84	201.60	.71
-355.60	.84	-215.60	1.02	-75.60	2.44	64.40	.76	204.40	.74
-352.80	.83	-212.80	1.01	-72.80	3.45	67.20	.80	207.20	.72
-350.00	.77	-210.00	.93	-70.00	3.91	70.00	.75	210.00	.72
-347.20	1.09	-207.20	.83	-67.20	4.10	72.80	.76	212.80	.76
-344.40	.84	-204.40	.89	-64.40	4.08	75.60	.67	215.60	.75
-341.60	.92	-201.60	1.04	-61.60	4.50	78.40	.83	218.40	.68
-338.80	.84	-198.80	1.05	-58.80	6.44	81.20	.87	221.20	.65
-336.00	.84	-196.00	1.21	-56.00	4.29	84.00	.73	224.00	.62
-333.20	1.04	-193.20	1.02	-53.20	3.84	86.80	.69	226.80	.67
-330.40	.92	-190.40	.96	-50.40	2.74	89.60	.94	229.60	.77
-327.60	.93	-187.60	.79	-47.60	2.64	92.40	.64	232.40	.76
-324.80	.98	-184.80	.87	-44.80	2.32	95.20	.95	235.20	.71
-322.00	.88	-182.00	1.10	-42.00	2.17	98.00	.71	238.00	.68
-319.20	.79	-179.20	.78	-39.20	2.33	100.80	.69	240.80	.64
-316.40	1.04	-176.40	1.06	-36.40	2.66	103.60	.69	243.60	.62
-313.60	.91	-173.60	.86	-33.60	1.36	106.40	.71	246.40	.62
-310.80	1.06	-170.80	.96	-30.80	1.62	109.20	.66	249.20	.71
-308.00	.93	-168.00	.92	-28.00	1.16	112.00	.70	252.00	.73
-305.20	.96	-165.20	1.09	-25.20	1.15	114.80	.65	254.80	.74
-302.40	1.09	-162.40	.98	-22.40	1.09	117.60	.72	257.60	.64
-299.60	1.15	-159.60	.97	-19.60	.94	120.40	.84	260.40	.68
-296.80	.89	-156.80	.91	-16.80	.83	123.20	.70	263.20	.67
-294.00	1.15	-154.00	1.10	-14.00	.93	126.00	.75	266.00	.66
-291.20	1.03	-151.20	1.09	-11.20	1.02	128.80	.75	268.80	.67
-288.40	1.14	-148.40	1.02	-8.40	.82	131.60	.66	271.60	.67
-285.60	.95	-145.60	.84	-5.60	.83	134.40	.76	274.40	.72
-282.80	1.02	-142.80	.88	-2.80	.84	137.20	.69	277.20	.72
-280.00	1.20	-140.00	1.00	0.00	.80	140.00	.61	280.00	.71
-277.20	.94	-137.20	.89	2.00	.78	142.80	.73	282.80	.63
-274.40	.86	-134.40	1.06	5.00	.88	145.60	.64	285.60	.66
-271.60	1.07	-131.60	.85	8.00	.77	148.40	.67	288.40	.67
-268.80	.82	-128.80	1.04	11.20	.85	151.20	.68	291.20	.64
-266.00	.82	-126.00	.92	14.00	.79	154.00	.61	294.00	.68

Figure 4-7. Output of Program ARCINT.

5. CONCLUSIONS

Auroral data taken by night time sensors on DMSP has been used in the past to provide information on structure and global motion. Most of this data was extracted from photographic transparencies which had been synthesized by AFGWC from digital information. In this effort we have developed techniques for using digital data directly, thus maintaining the full system capability of the DMSP. In addition, by correlation with calibrated aircraft and ground photometers, we have calibrated the night time sensors on DMSP F1 and F2. This, then, yields calibrated downward looking auroral and airglow sensors with global coverage.

The computer techniques which have been developed should allow prediction of intensity levels seen by other satellites viewing portions of the regions covered by DMSP. As future DMSP satellites are launched, the technique will allow study of spatial frequencies in aurora and airglow and should add considerably to the data base on global aurora and airglow intensity variations.