README Document for

Nimbus 2 HRIR
High Resolution Infrared Radiometer
Level 1 Data Products:
HRIRN2L1
HRIRN2IM

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Version 1.2

James Johnson

Revision date	Changes	Author
02/03/2009	Initial version	Jean-Jacques Bedet
01/31/2017	Product correctly named L1 instead of L2	James Johnson
06/28/2017	Updated URLs in section 4 and 6	James Johnson

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1 Introduction

1.1 Brief Background

This document applies to the Nimbus II High Resolution Infrared Radiometer (HRIR) Level-1 data.

The HRIR instrument maps the Earth's cloud cover at night and measures the temperatures of cloud tops and terrain features.

The Nimbus II was launched on May 15, 1966 on a Thrust Augmented Thor (TAT)/ Agena B vehicle. Three instruments were on board of the spacecraft.

- An Advanced Vidicon Camera System (AVCS) provided clouds in the earth atmosphere and, in clear areas, terrestrial features on the earth's surface (only during day-time).
- A Medium Resolution Infrared Radiometer (MRIR) measured the electromagnetic radiation emitted and reflected from the earth and the atmosphere in five selected wavelengths (6.4-6.9, 10-11, 14-16, 5-30, 0.2-4.0 microns)
- A High Resolution Infrared Radiometer (HRIR) was available to provide earth cloud cover (nigh-time) and to measure the temperatures of cloud tops and terrain features.

The orbit of the satellite can be characterized by the following:

- near-circular orbit with apogee of 1179 km
- perigee height of 1095 km
- inclination of 100.311 degrees
- nodal period of 108.17 minutes
- near sun-synchronous

The Nimbus II HRIR data are available from 16 May 1966 (Day of year 136) through 13 November 1966 (Day of year 319).

1.2 Brief Background on Instruments

The High Resolution Scanning Radiometer (HRIR) is a single scanning radiometer, using a 3.5 - 4.1 micron filter and PbSe photoconductive detector cell radiatively cooled to -75 deg C. This provides measurements of blackbody temperatures between 210K – 330K with a noise equivalent of ~1 degree C for a 250K background. The scanning is coincident with spacecraft velocity vector resulting in no yaw error. The scan mirror is inclined to 45 degrees to the axis of rotation (scans perpendicular to flight path) and the scan rate operation is 44.7 revolutions per minute which provides a scan line separation of 8.3 km. The Instantaneous field-of-view of 8.7 milliradians provides ground resolution of 8 km at an altitude of 1110 km. The performance was excellent until orbit 2455 when the tape recorder failed. There is a faint 200-Hz interference observed during pre-launch, associated with AC noise on bus power. The overall calibration is in good agreement with pre-launch measurements. The HRIR detector, after stabilizing at -76°C post launch, exhibits a warming trend and became nominal at -65°C. The overheating detector cell decreased the signal to noise ratio from 20 to 8.

The HRIR instrument is illustrated in Figure 1

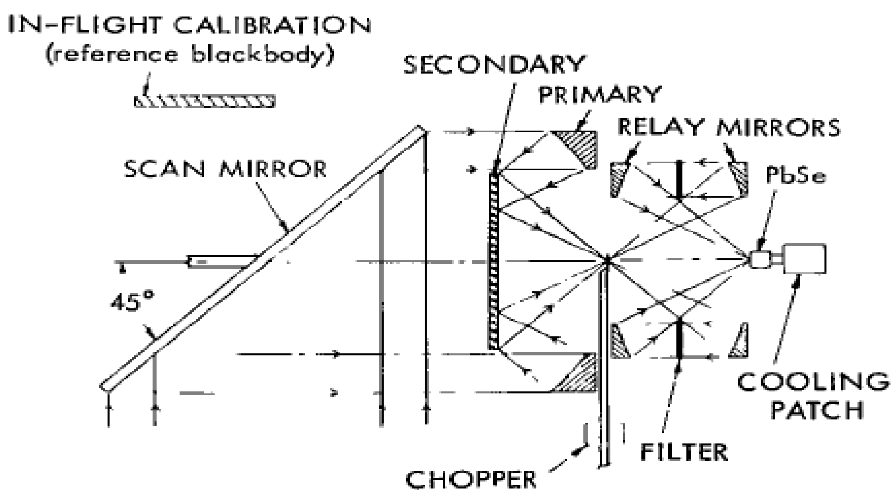

Figure 1: Nimbus II HRIR instrument

1.3 Brief Background on Algorithms

The Nimbus II HRIR data was generated from the spacecraft telemetry, attitude data, orbital data. Digitized radiation data, and the Nimbus radiometer calibration package. The data are were created on IBM computers using a 36 bit architecture. Further information can be found on the Nimbus II Users' guide.

2 Data Organization

2.1 Granularity

The Nimbus II HRIR were originally archived on 1740 7-track tapes. The data were stored in 36-bit IBM binary format. A Canadian company (JBI) was contracted to restore to disks all 1740 Nimbus II HRIR tapes. The content of each tape was written using a proprietary format (TAP) that allowed "bad" bytes or records to be flagged. Since tapes may contain several files and in some cases several orbits, the content of each file on a tape was retrieved and stored in a separate file using the same TAP format.

The Nimbus II HRIR tapes were archived at the Washington National Records Center. The tape recovery process involved using specially developed tape drives, bit detection and processing techniques to read the 800 bpi, 7-track tapes and store the recovered data in TAP(tape emulation format).

The status of the Nimbus II HRIR data restoration can be summarized as:

- Covered 6 months of observations
- Out of 1740 backup tapes, 1703 were restored.
- 23 tapes had missing orbit documentation
- 2 tapes could not be read
- All other tapes could be read properly even though some may have "bad" records or bytes.

Because a tape may contain multiple files, and in some cases multiple orbits, each tape was read and the content of each file stored on a separate file on disk. The overall TAP format and data on tape was preserved. Using tape file as the smallest entity, the status of the Nimbus II restoration is

- 2470 TAP files were archived and ingested at the GSFC DISC
- Several files that could not be read correctly are being restored from other backup tapes

2.2 File Naming Convention

The Nimbus II HRIR level 1 data are named according to the following convention:

Nimbus2-HRIR-<*YYYYMMDD*>_<*hh-mm-ss*>_<*orbit*>_<*version*>.TAP where:

YYYYMMDD is the starting date when the data was collected from the satellite and

YYYY: starting 4 digit calendar year (e.g. 1966)

MM: starting 2 digit month (e.g. 02 for February)

DD: starting 2 digit day of the year (e.g. 04 for day four)

hh-mm-ss is the starting time when the data was collected from the satellite and

hh : starting 2 digit hour (0-23) (e.g. 02 for hour 2)

mm: starting 2 digit minute (0-59) (e.g., 09 for 9 minutes)

ss: starting 2 digit seconds (0-59) , (e.g. 11 for 11 seconds)

orbit is the orbit number

version is a 3 digit number (e.g. 001)

2.3 File format (TAP)

2.3.1 TAP Bytes

Each byte restored from a 7-track tape is stored in a byte as described in the following Figure 2 . The 7th bit is flagged to 1 when a byte was not restored correctly, otherwise it is set to 0. The 6th bit is the tape parity bit as stored on tape.

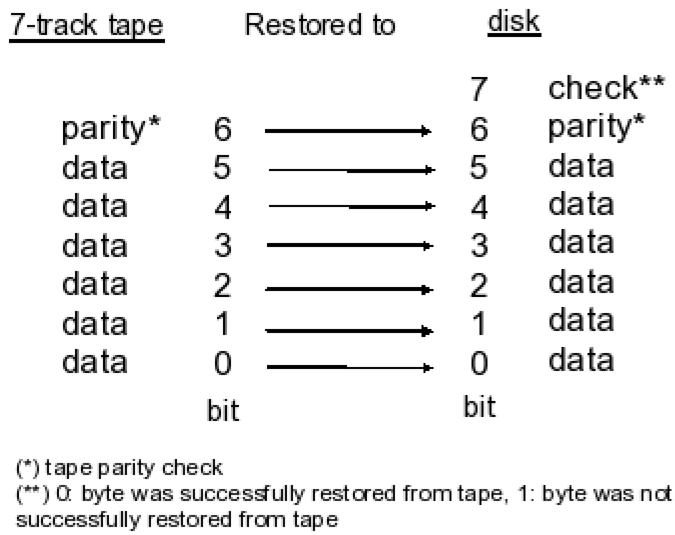

Figure 2: Data restoration process

2.3.2 TAP Headers

TAP headers are interleaved between the Nimbus II HRIR data records to indicate the length of the following and preceding data records. A TAP header is a 4 byte record which follows the following convention.

- A number greater than zero indicates the length of a record
- A negative number indicates that a record has bytes that could not be restored from tapes and filled with zeros. The length of a record is obtained by taking the absolute value.
- a zero indicates the start of a file
- Two consecutive TAP headers with zero values are used to specify the end of a file.
- A data record is preceded by a header and followed by a header listing the length of the data record

2.3.3 Nimbus II HRIR Word

The basic unit of the Nimbus II data is a word which is a 36-bit IBM binary word. This means that in order to extract a 36-bit word from the restored files, six bytes (8-bits) must be read, the 6^{th} and 7^{th} bit removed from each byte, and the remaining bits of each byte combined.

To preserve space while maintaining a good resolution, a scaling technique was used when the data was originally created and stored on 7-track tapes. The idea was to multiply a number by a factor before storing the value to tape. Nimbus II data can be converted back to the initial value by dividing the stored value on tape by 2**(35-B), where B is the scaling factor listed on the Nimbus II Data record format tables.

A word of 36 bits with a scaling factor of B is converted by using the relation:
value = (integer value of 36 bits) / (2**(35-B))

When a word is divided in two ½ Word (WordD, and WordA), the actual values are converted by using the relation:

A wordD of 18bits with a scaling factor of B is converted in real by using the relation:
value = (integer value of 18 bits) / (2**(17-B))
A wordA of 18bits with a scaling factor of B is converted in real by using the relation:
value = (integer value of 18 bits) / (2**(35-B))

The scaling factor is mentioned and used in tables describing the Nimbus II HRIR records.

2.4 Data Structure Inside File

Two TAP 4 byte headers are stored before and after each Nimbus II HRIR records. The first Nimbus II HRIR record is an orbit data document record (102 bytes) followed by multiple data records. A Nimbus II data record is composed of a Data record documentation followed by several swath data records. The length of a data record (L) in words can be computed using the relation.

L = (swaths per records)*(words per swath) + (number of nadir angles) + 7

The overall structure of the Nimbus II files is depicted in Figure 3

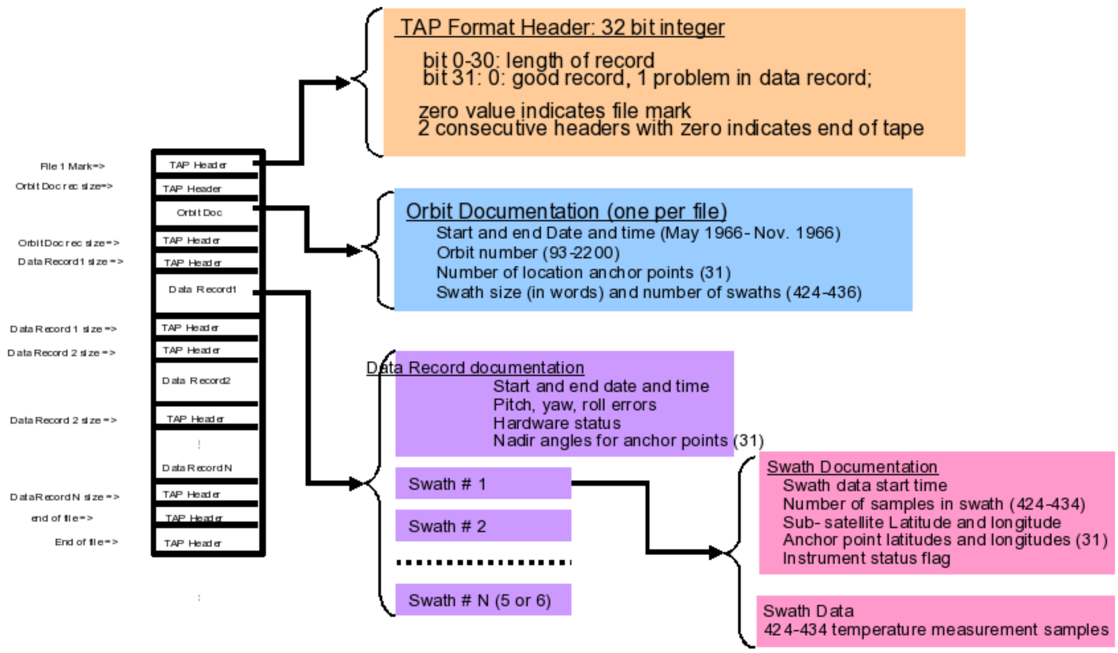

Figure 3: Nimbus II HRIR data structure

2.5 Key Metadata Fields

These are most likely to be used by users:

Temporal

- start Date / Time
- end Date/ Time

Geolocation

- latitude
- longitude

3 Data Contents

Described below are all the parameters associated with the Nimbus II HRIR files.

Table 2 (page 16) describers in details all the parameters associated with an orbit. There is one orbit documentation record per file.

Table 3 (page 18) describes in details all fields in a record documentation. There is one data record documentation per data record

Table 4 (page 19) describes in details all fields in a swath data record. There are multiple swath data records in a single data record.

4 Data Services

The data product landing pages provide information about the data, as well as links to download the data files and relevant documentation:

https://disc.gsfc.nasa.gov/datacollection/HRIRN2L1_001.html

https://disc.gsfc.nasa.gov/datacollection/HRIRN2IM_001.html

5 Data Organization

5.1 Geolocation

The Nimbus pointing accuracy is better than 1 degree in pitch and roll with 1 degree pointing error that corresponds to a sub-satellite geo-location error of 20 km. The HRIR radiometer scans the earth in a clockwise direction from right to left. Each earth scan is defined by a family of mirror nadir angles. For each mirror angle, the latitude and longitude of the corresponding point on the earth's surface is recorded. The position of individual samples between two anchor points is determined by interpolation.

The latitude and longitude of the corresponding point on the earth's surface are used as references in computation of positions for each sample. There is still no information available describing how many anchor points were used for a swath. Using landmarks (e.g. Lake Michigan) it seems that 11 anchor points centered around the subsatellite points were used, instead of the 31 points. This issue is still being investigated.

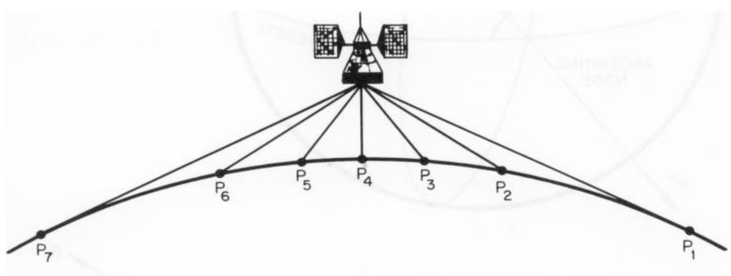

Figure 4: Nimbus II anchor points

6 More Information

6.1 Point of Contact

URL: https://disc.gsfc.nasa.gov/

Name: GES DISC Help desk support group

email: gsfc-help-disc@lists.nasa.gov

phone: 301-614-5224

fax: 301-614-5268

Address: Goddard Earth Sciences Data and Information Services Center

Code 610.2

NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

6.2 References

- Nimbus II users' guide, July 1966
- The Nimbus II advanced vidicon camera system data ; world montage catalog , 20 May through 31 August 1966
- The medium II medium resolution infrared pictorial data catalog volume 1 15 May through 21, June 1966
- The radiation balance of the earth-atmosphere system over both polar regions obtained from radiation measurements of th nimbus II meteorological satellite, September 1967
- Nimbus II flight evaluation and engineering report, Launch through orbit 5275, February 1969

7 Appendices

7.1 Example of a C Routine to Read TAP Headers

Following is an example on how to extract the record length from the TAP headers

```
int ReadHeader(ifd)     /* read header */
int ifd;

/* This function reads a TAP header (4 bytes) and return
   the size in bytes of the next record to read
     input
            ifd: file reference
     output
            reclen: size of the next record in bytes
*/

{
unsigned char     bytebuf[200];
int   j, size, value,reclen,signbit;

     size = read( ifd, bytebuf, 4) ;      /* read header */

     value = 0;
     for (j=0 ; j<=3 ; j++ )
         {
              value = value << 8;           /* shift left by 8 bits */
              value = value | bytebuf[j];
         }
     reclen = value;
     return reclen;
}
```

7.2 Example on How to Read a 36-bit Binary Word using C

Below is an example of a C routine to extract the 36 bit word (out of 6 unsigned bytes), remove the most significant bits of each byte and store the content into a long long interger.

```
long long GetWord (initval,len)
unsigned char  initval[];     /* buffer containing the binary data */
int len;                      /* number of bytes */

/*   this function removes the 2 most significant bits of each byte
     and concatenates the "len" bytes (with the 2 bits removed)
     into an integer
     input
          initval array containing the bytes
          len     number of bytes to clean and concatenate
     output
          value   integer containing the bytes cleaned and concatenated
*/
{
int j,pos;
unsigned char  byteclean;
long long value,signbit,res, signval;

   value = 0;
   pos=0;
   signval = 1;
   for (j=0 ; j<len ; j++ )
      {
         if ( j == 0 )
            {
               signbit = initval[pos] & 0x20;   /* get sign bit */
               if ( signbit == 32 )
                  {
                     value = value << 5;  /* shift left by 5 bits
                                             to remove sign bit */
                     signval = -1;
                     byteclean = initval[pos] & 0x1f;
                     value = value | byteclean;
                  }
               else
                  {

                     value = value << 6;  /* shift left by 6 bits
                                             to remove sign bit */
                     byteclean = initval[pos] & 077; /* remove the 2
                                               most significant bits */
                     value = value | byteclean;
                  }
            }
         else
            {
               value = value << 6;        /* shift left by 6 bits */
               byteclean = initval[pos] & 077;   /* remove the 2 most
                                                    significant bits */
               value = value | byteclean;
            }
         pos++;
      }

   value = value*signval;
   return value;
}
```

7.3 Description of Metadata Fields

Following is a list of the XML metadata fields and a brief description for the Nimbus II HRIR data.

Table 1: XML Metadata Fields

field	**Description**	**Value**
Longname	Long product name	HRIR/Nimbus-2 Level 1 Meteorological Radiation Data
Shortname	Short product name	HRIRN2L1
VersionID	Version ID of the ingested data product, not the processing version.	001
GranuleID	Granule ID (same as the name of the file).	Example: Nimbus2-HRIR_1966m0801t141638_o01043_v001.TAP
Format	File Format (see section on TAP for a full description).	TAP
Checksum Type	Type of checksum	CRC32
Checksum Value	Value of the checksum using cksum	Example: 3378917185
SizeBytes DataGranule	Total size of the data granule in bytes	Example: 4855962
InsertDateTime	Date and time when the granule was inserted into the DISC. The date is YYYY-MM-DD and the time is in hh-mm-ss format	Example: 2009-02-02 17:20:44
RangeBeginning Date	Begin date when the data was collected. The date is in YYYY-MM-DD format	Example: 1966-08-01
RangeBeginning Time	Begin time of date when the data was collected. The time is in hh-mm-ss format	Example: 14:16:38
TimeCoverage EndDateTime	End date when the data was collected. The date is in YYYY-MM-DD format	Example: 1966-08-01
RangeEnding Time	End time of date when the data was collected. The time is in hh-mm-ss format	Example: 15:11:08

field	Description	Value
Platform ShortName	Acronym or short name of the satellite or platform.	Nimbus2
Instrument ShortName	Acronym or short name of the instrument.	HRIR
SensorShortName	Name of the sensor	HRIR
Gpolygon PointLatitude	Latitudes of the polygons that represent the satellite coverage. Rectangles have been selected in this case. Each point of a rectangle is identified by its latitude and longitude	Example: -80.000000 -90.000000 -90.000000 -80.000000
Gpolygon PointLongitude	Longitudes of the polygons that represent the satellite coverage. Rectangles have been selected in this case.Each point of a rectangle is identified by its latitude and longitude	Example: 180.000000 180.000000 -180.000000 -180.000000
Orbit	Satellite orbit number. There is one orbit per file. A given orbit may have several files (partial orbits or data collected from different stations)	Example: 1043
Average Elevation	Average elevation in km of the satellite during an orbit	Example: 1140.915
Station Code	DAF Station identification code	Example: 2
Elapsed_Min_Time	Duration in minutes of data collected during an orbit	Example: 25

7.4 Description of Orbit Documentation Records

This record is unique for each file and provides information on the starting and end Date/time for a file, size and number of swaths, orbit number, and the number of anchor points used to identify the geo-location of the data.

Table 2: Orbit Documentation Record

Word No.	Quantity	Units	Scaling	Remarks
1	Dref	-------	B=35	number of days between 0 hour on 9/1/57 and zero hour on the day of launch)
2	Date	MMDDYY	B=35	Date of interrogation for this orbit (MMDDYY 2/5/64 is (020504) in octol. Date of interrogation seems to be the processing date.
3	Nimbus Day	----------	B=35	Start day of the year (1966) for this file (orbit)
4	Hour	hh	B=35	Start hour for this file(orbit)
5	Minute	mm	B=35	Start minute for this file(orbit)
6	Second	ss	B=35	Start seconds for this file(orbit)
7	Nimbus Day	------------	B=35	End day of the year (1966) for this orbit
8	Hour	hh	B=35	End hour for this orbit
9	Minute	mm	B=35	End minute for this orbit
10	Second	ss	B=35	End seconds for this orbit
11	Mirror Rotation	Deg/Sec	B=26	Rotation rate of radiometer mirror
12	Sampling Frequency	Samples /Sec	B=35	Digital sampling frequency per second of vehicle time
13	Orbit Number	------------	B=35	Orbit Number
14	Station Code	------------	B=35	Data Acquisition Facility (DAF) Station identification
15	Swath Block size	------------	B=35	Number of 36-bit words per swath
16	Swaths/records	-------------	B=35	Number of swath per record
17	Number of locator points	--------------	B=35	Number of anchor points per swath for which latitudes and longitudes are computed

7.5 Description of Data Record Documentation

The data documentation record provides information describing the subsequent swath data records.

Table 3: Data Record Documentation Record

Word No.	Quantity	Units	Scaling	Remarks
1D	Nimbus Day	-------	B=17	Start Day of the year for this data record
1A	Hour	hh	B=35	Start hour for this data record
2D	Minute	mm	B=17	Start minute for this data record
2A	Second	ss	B=35	Start seconds for this data record
3D	Roll Error	Degrees	B=14	Roll Error at start Date/time (word 1 and 2) for this record
3A	Pitch Error	Degrees	B=32	Pitch Error at start Date/time (word 1 and 2) for this record
4D	Yaw Error	Degrees	B=14	Yaw Error at start Date/time (word 1 and 2) for this record
4A	Height	Km	B=35	Height of the spacecraft at start Date/time (word 1 and 2) for this record
5D	Detector Cell temperature	Degrees K	B=17	Measured temperature of detector cell at start Date/time (word 1 and 2) for this record
5A	Electronics temperature	Degrees K	B=35	Measured temperature of electronics at start Date/time (word 1 and 2) for this record
6D	24V supply	Volts	B=14	Measured Voltage at start Date/time (word 1 and 2) for this record
6A	20 V supply	Volts	B=32	Measured Voltage at start Date/time (word 1 and 2) for this record
7D	Reference Temperature A	Degrees K	B=17	Measured temperature of housing at start Date/time (word 1 and 2) for this record

Word No.	Quantity	Units	Scaling	Remarks
7A	Reference Temperature B	Degrees K	B=35	Measured temperature of housing at start Date/time (word 1 and 2) for this record
8	Nadir Angle	Degrees	B=29	Nadir angle corresponding to the first anchor point and measured in the plane of the radiometer
-----				

N	Nadir Angle	Degrees	B=29	Nadir angle corresponding to the last anchor point and measured in the plane of the radiometer

7.6 Description of a Swath Data Record

Table 4: Swath Data Record

Word No.	Quantity	Units	Scaling	Remarks
(N+1)D	seconds	ss	B=8	Seconds elapsed since the start of the Date/time of this data record
(N+1)A	Data population	-------	B=35	Number of data points in this swath
(N+2)D	Latitude	Degrees	B=11	Latitude of the subsatellite point for this swath
(N+2)A	Longitude	Degrees	B=29	Longitude of the subsatellite point for this swath, positive westward 0 to 360
(N+3)	Flags	------	------	Reserved for flags describing this swath
(N+4)D	latitude	Degrees	B=11	Latitude of viewed point for the first anchor point
(N+4)A	Longitude	Degrees	B=29	Longitude of viewed point for the first anchor point
-----				

Word No.	**Quantity**	**Units**	**Scaling**	**Remarks**

(N+3+M)D	latitude	Degrees	B=11	Latitude of viewed point for the Mth anchor point
(N+3+M)A	Longitude	Degrees	B=29	Longitude of viewed point for the Mth anchor point
(N+4+M)D	HRIR Data	Degrees	B=14	HRIR temperature measurement
(N+4+M)A	HRIR Data	Degrees	B=32	HRIR temperature measurement

(N+K)D	HRIR Data	Degrees	B=14	HRIR temperature measurement
(N+K)A	HRIR Data	Degrees	B=32	HRIR temperature measurement

7.7 File Format (TAP)

7.7.1 Definition of Flags Describing each HRIR swath

Table 5: Swath Flag Definition

Flag	Bit	Definition	Yes	No
1	35	Summary Flag. All checks defined by flags 2 through 12 are satisfactory. (Each flag is zero)	0	1
2	34	Consistency check between sampling rate, vehicle time, and ground time is satisfactory.	0	1
3	33	Vehicle time is satisfactory	0	1
4	32	Vehicle time has been inserted by flywheel	1	0
5	31	Vehicle time carrier is present	0	1
6	30	Vehicle time has skipped	1	0
7	29	Vehicle time frame sync interrupt by hardware did not occur	1	0
8	28	Sync pulse recognition was satisfactory	0	1
9	27	Dropout of data signal was detected	1	0
10	26	Ground time has new pattern	1	0
11	25	Ground time is discontinuous	1	0
12	24	Swath size satisfactory when compared with the theoretical swath size	0	1
13	23	End of tape was detected on the spacecraft	1	0

7.7.2 Definition of Flags for Individual Measurements

Table 6: Nimbus II individual measurement flags

Prefix	TAG	Definition	Yes	No
S	18	The particular measurement is below the earth space threshold	1	0
1	19	unassigned		
2	20	unassigned		

7.8 Quality Assurance Procedures

7.8.1 Data Producer QA

The Data Producer's QA information can be found in the XML metadata file under the section ProducersQA. The information begins with the following:

```
Record No, Bytes, Bad bytes
0,filemark
1,84,0
2,filemark
3,102,0
4,11928,0
  :
<n-1>,11928,0
<n>,filemark
```

On each line there are 3 comma separated numbers: the first is the record number, the second is the record length in bytes, and the third is the number of bad bytes. The first Record #0 is a filemark which separates different files. Record # 1 has 84 bytes - this is the BCD header length. If the number of bad bytes is 0, this indicates the header is good. If the number is non-zero, there are bad bytes in the header. Record # 2 marks the end of the BCD header, and the start of the next file record. Record #3 has 102 bytes - this is the data header length. If the number of bad bytes is 0, this means all bytes are good, if the number is non-zero, there are bad bytes in the header. Record #4 is 11928 bytes. This is the nominal data record length. If the number of bad bytes is 0, that indicates this data record is good, if the number is non-zero, there are bad bytes in the data record. From this point, all subsequent records are data records and should have a length of 11928 with no bad bytes. A final filemark will indicate the end of the file. Sometimes the data are split into different orbits or orbit section files, and this will be noted with another filemark

7.8.2 Physical QA

Each restored file was read and its corresponding orbit documentation was extracted and used to derive the file name and to create a XML metadata file.

For each file the number of "bad" bytes, parity errors, "bad" records was derived.

Plots of each swath was generated (with and without a world map) and some were compared with published papers.

7.8.3 Science QA

HRIR data were examined and validated using Nimbus2 HRIR documentation

Nimbus II HRIR Confirms Airborne Lake Temperature Surveys October 1966 – October 1967

7.9 Image Files

The **HRIRN2IM** data product contains scanned negatives of photofacsimile 70mm film strips from the Nimbus-2 High-Resolution Infrared Radiometer. The images show orbital nighttime (3.5 to 4.1 microns) cloud cover and the Earth's surface measured as brightness temperatures. Each orbital swath picture is gridded with geographic coordinates and covers a distance approximately from the south pole to the north pole (day) and the north pole to the south pole (night). The images are saved as JPEG 2000 digital files. About 7 days of images are archived into a TAR file. The processing techniques used to produce the data set and a full description of the data are contained in section 3.4.1 of the " Nimbus II User's Guide."

These images can be used to supplement the radiance data files from the **HRIRN2L1** data product. The image files can be viewed with any application that supports the JPEG 2000 format

7.10 Acronyms

DAF: Data Acquisition Facility

EOS: Earth Observing System

GES DISC: Goddard Earth Sciences Data and Information Services Center

GSFC: Goddard Space Flight Center

HRIR: High Resolution Infrared Radiometer

L1: Level 1 Data

NASA: National Aeronautics and Space Administration

QA: Quality Assessment

UT: Universal Time