# HQ AFWA

## DMSP Satellite
## Raw Sensor Data Record (RSDR)
## File Format Specification

(Version 1.0 updated, Final, 19 Jan 01)
(Replaces version 1.0 Final, 2 Nov 00)

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# SUMMARY OF CHANGES

Added cover page, table of contents, table of figures, summary of changes, glossary, and terms.

Figure 1.2 **note added " and refers to the ascending nodal crossing"

Para 1.1. Added paragraph header "General"

Para 1.2. Added paragraph header "Format"

Para 1.2.7-1.2.8 changed "a original" to "an original"

Para 1.2.16 changed (3.1) to (1.3.1)

Para 1.3. Added paragraph header "Document Data"

Para 1.3. Changed "followed by unmodified sensor data from the satellite" to "followed by unmodified sensor data from the satellite, with the exception of adding zero-filled records for missing seconds of data to maintain time continuity."

Para 2.1. Added paragraph header "Time Order"

Para 2.2.1. Added paragraph header "Valid Record"

Para 2.2.2. Added paragraph header "Corrected Record"

Para 2.2.3. Added paragraph header "Interpolated Record"

Para 2.2.4. Inserted paragraph for invalid Z Bits data " 2.2.4. Invalid Z Bits – Good Data. A record is considered to have invalid Z Bits with good data when the valid flag in SFDB is set to 1 and all or some of the Z Bits words contain zeros. The document data field will contain the value 4." Change dated 19 Jan 01

Para 2.2.5. Added paragraph header "Invalid Record" Changed paragraph number from 2.2.4 to 2.2.5. Change dated 19 Jan 01

Para 2.2.6. Added paragraph header "Filled Record" Changed paragraph number from 2.2.5 to 2.2.6. Change dated 19 Jan 01

Para 2.3. Added paragraph header "Multiple RSDR Files"

Para 2.4. Added paragraph header "Big Endian"

**Raw Sensor Data Record (RSDR) Files**
(Version 1.0, 2 Nov 00)

1. File Format.

1.1. General. The new RSDR file structure is composed of a header information block followed by a series of sensor documentation data and sensor data records (Figure 1.1). This format is intended to support DMSP Special Sensor data using AFWA's SDHS SFDB raw satellite data as a source of information. Each sensor will be uniquely extracted from SFDB and stored individually in a RSDR file.

1.2. Format. The file will be formatted in structured fixed length records: the first record will contain satellite, file and data information (the header) and subsequent records will contain sensor documentation with accompanied data. Figure 1.1 illustrates this format. Each record will be appended with 0 - 3 bytes of zeros to align the record to a four-byte boundary for easier processing. Each record of information in a RSDR file will be the same size, however, different files will have different record lengths depending on the size of the sensor data. The first 100 bytes of a RSDR contain the header (Figure 1.2). It will be followed by a sequence of zeros matching the data size of the sensor data so that the file header will be the same length as a sensor data record.

**Figure 1.1. New Format for Raw Sensor Data file**

| Record | Document Type (100 bytes) | Data (k bytes) | Fill (0 - 3 bytes) |
|---|---|---|---|
| 0 | File Header (See figure 1.2) | k Bytes of Zeros | 0 – 3 Zero Bytes |
| 1 | Document Data for sensor scan (See figure 1.3) | k Bytes of Sensor Data | 0 – 3 Zero Bytes |
| 2 | Document Data for sensor scan (See figure 1.3) | k Bytes of Sensor Data | 0 – 3 Zero Bytes |
| … | … | … | … |
| N | Document Data for sensor scan (See figure 1.3) | k Bytes of Sensor Data | 0 – 3 Zero Bytes |

k = # of 36-bit sensor data words * 3 (since they are stored as 3 16 bit shorts) * 2 (for short to byte conversion)
Thus a record will be 100 bytes + k bytes + (0 to 3) bytes and evenly divisible by 4.

**Figure 1.2. File Header**

| Byte | Contents | Source | Data Type* | Unit |
|---|---|---|---|---|
| 01 – 04 | Satellite ID (i.e. “5548”) | SFDB | ASCII | ASCII Value |
| 05 – 08 | Readout Revolution Number | SFDB | Long | Value |
| 09 – 12 | Beginning Data Revolution Number | Calculated | Long | Value |
| 13 – 16 | Ending Data Revolution Number | Calculated | Long | Value |
| 17 – 20 | Beginning Data R+ Number | SFDB | Long | Value |
| 21 – 22 | Orbital Inclination | SFDB | Short | Radian*8192 |
| 23 – 24 | Nodal Crossing Year** | SFDB | Short | Year (4 digit) |
| 25 – 26 | Nodal Crossing Julian Day** | SFDB | Short | Day (of Year) |
| 27 – 28 | Nodal Crossing Hour** | Calculated | Short | Hour (UTC) |
| 29 – 30 | Nodal Crossing Minute** | Calculated | Short | Minute (UTC) |
| 31 – 32 | Nodal Crossing Second** | Calculated | Short | Second (UTC) |
| 33 – 36 | Nodal Crossing Longitude | Calculated | Long | Radian*8192 |
| 37 – 40 | Record Start Time | Calculated | Long | Second (of day) |
| 41 – 44 | Record Stop Time | Calculated | Long | Second (of day) |

| | | | | |
|---|---|---|---|---|
| 45 – 48 | Number of sensor records | Calculated | Long | Value |
| 49 – 52 | Number of invalid records | Calculated | Long | Value |
| 53 – 56 | Number of bytes of sensor data per record | Calculated | Long | k (Fig 1.1) |
| 57 – 58 | Number of bytes of fill per record | Calculated | Short | Value (0 to 3) |
| 59 – 60 | Data Start Julian Date | SFDB | Short | Day (of Year) |
| 61 – 62 | RSDR Version Number | RSDR Doc | Short | Value |
| 63 – 64 | Blank | | Byte | 0 |
| 65 – 68 | Right Acension of the Ascending Node | SFDB | Long | Radian*8192 |
| 69 – 92 | Special Sensor Format Words | Satellite | 12 * Short | Value |
| 93 – 100 | Blank | | Byte | 0 |

**ASCII/bytes are 8 bits, short integers are 16 bits, long integers are 32 bits*

***Nodal times refer to the beginning data revolution and refer to the ascending nodal crossing*

1.2.1. Satellite ID. This will be a four-character identifier for the satellite that produced the data based on the I-bits provided by the satellite. Figure 1.2.1 relates current I-bits to used satellite IDs. The I-bits are limited to 4 bits, values 0 through 15, thus for DMSP flights 16 through 20 we'll need to start over with satellite identifiers of 1 through 5.

**Figure 1.2.1. I Bits**

| I Bits | Satellite Identification |
|---|---|
| 11 | 2546 |
| 12 | 3545 |
| 13 | 4547 |
| 14 | 5548 |
| 15 | 6549 |

1.2.2. Readout Revolution Number. This is the revolution of the satellite as it started playing back the data. It is a non-negative long integer that can be found in the header block of an original SFDB file.

1.2.3. Beginning Data Revolution Number. This is the revolution where the satellite started recording data. It is a non-negative long integer that is calculated based on the length of the data recorded and the ending revolution in 1.2.4.

1.2.4. Ending Data Revolution Number. This is the revolution where the satellite stopped recording data. It is a non-negative long integer that is calculated based on the ending fiducial, readout revolution (1.2.2), and readout time.

1.2.5. Beginning Data R+ Number. This is the R+ number of the revolution described in 1.2.3. It is a non-negative long integer between 0 and 14 inclusive that can be found in the header block of a original SFDB file.

1.2.6. Orbital Inclination Angle. Inclination is the angle between the orbital plane and the equatorial plane. The Inclination angle will be stored as a non-negative short integer representing a value between 0.0 and pi inclusive in radians multiplied by 8192.0.

1.2.7. Nodal Crossing Year. This is a four-digit non-negative short integer that represents the nodal crossing year found in the header block of an original SFDB file.

1.2.8. Nodal Crossing Julian Day. This is a non-negative short integer between 1 and 366 inclusive that represents the nodal crossing Julian day found in the header block of an original SFDB file.

1.2.9. Nodal Crossing Hour. This is a non-negative short integer between 0 and 23 inclusive that represents the nodal crossing hour in Zulu.

1.2.10. Nodal Crossing Minute. This is a non-negative short integer between 0 and 59 inclusive that represents the nodal crossing minute.

1.2.11. Nodal Crossing Second. This is a non-negative short integer between 0 and 59 inclusive that represents the nodal crossing second.

1.2.12. Nodal Crossing Longitude. This is the longitude of the satellite as it crosses the equator. The nodal crossing longitude will be stored as a non-negative long integer representing a value between 0.0 and 2pi east inclusive in radians multiplied by 8192.0. The chronologically latest ascending nodal crossing longitude, based upon actual time span found in the pass, which is computed from the two-line element set. Consistency checks will be performed between the computed nodal longitude and the observed longitudes provided by either the SFDB or RT-Simple files. Should a pass not contain an ascending node time, the nearest (in time) ascending nodal longitude will be provided.

1.2.13. Record Start Time. This is a non-negative long integer between 0 and 86399 that identifies the earliest second of data in the RSDR based on the SSP timecode provided by the satellite and the earliest scan used in processing. This number can exceed 86399 by anywhere from a few milliseconds to a few seconds before the satellite resets the clock.

1.2.14. Record Stop Time. This is a non-negative long integer between 0 and 86399 that identifies the latest second of data in the RSDR based on the SSP timecode provided by the satellite and the latest scan used in processing. This number can exceed 86399 by anywhere from a few milliseconds to a few seconds before the satellite resets the clock.

1.2.15. Number of special sensor records. This is a non-negative long integer indicating how many records of data are stored in the RSDR.

1.2.16. Number of invalid records. This is a non-negative long integer indicating how many records of data stored in the RSDR have been flagged as invalid or filled (1.3.1).

1.2.17. Number of bytes of sensor data per record. This is a non-negative long integer indicating the number of bytes that are contained in one scan of the sensor per record.

1.2.18. Number of bytes of fill per record. This is a non-negative short integer between 0 and 3 inclusive that indicates how many zeros are appended to a data record to align the data to a four-byte boundary. This value will typically be 0 or 2.

1.2.19. Data Start Julian Date. This is a non-negative short integer between 1 and 366 inclusive that represents the Julian day the data was originally recorded.

1.2.20. RSDR Version Number. This is a non-negative short integer that represents the version number taken from this document. It will be stored as 0.8 to xx.0 multiplied by 10 to allow for incrementing a version number by tenths.

1.2.21. Right Ascension of the Ascending Node. (RAAN) The RAAN is an angle, measured at the center of the earth, from the vernal equinox to the ascending node. The RAAN will be stored as a non-negative long integer representing a value between 0.0 and 2pi east inclusive in radians multiplied by 8192.0.

1.2.22. Special Sensor Format Words. This is a copy of the format words provided by the satellite that will be valid for the entire RSDR. These Special Sensor Format Words are preserved from the original DMSP data stream via original SFDB data file. Since there are up to 12 special sensors on the spacecraft, twelve format words in the special data message are used to identify: (1) each sensor, (2) the number of 36 bit words in each block of data and (3) the location of the sensor's data (either in the LS or TS data line). See DMSP IS-YD 821, pages 30-32. The information is used in building the Simple Format Database file and the RSDR files. It will occupy 24 bytes of data.

1.3. Document Data. Each of the subsequent records will contain a 100-byte sensor documenting structure (Fig 1.3), followed by unmodified sensor data from the satellite, with the exception of adding zero-filled records for missing seconds of data to maintain time continuity. Timecodes will not be adjusted for physical sensor read offsets. C, G, H, M, P, Q, and Y bit fields are included for possible future OLS processing and will be zeroed for RSDR's containing special sensor data. Note: 'SFDB' labeled information is documented in the Interface Requirements Specification for the Ingest Subsystem to the Cloud Depiction and Forecast System II (140105); 'Satellite' labeled information is documented in DMSP Data Specifications (IS-YD-821).

**Figure 1.3. Document Data Format**

| Bytes | Contents | Source | Data Type* | Unit** |
|---|---|---|---|---|
| 01 - 02 | Data Valid Flag | Calculated | Short | -1, 0, 1, 2, 3, 4 |
| 03 - 04 | Satellite Latitude | SFDB/Calculated | Short | Radian*8192 |
| 05 - 08 | Satellite Longitude (east) | SFDB/Calculated | Long | Radian*8192 |
| 09 - 12 | SATH Angle | SFDB/Calculated | Long | Radian*8192 |
| 13 - 14 | Quarter Orbit | Satellite | Short | 1, 2, 3, 4 |
| 15 - 16 | Satellite Crossing Angle | SFDB/Calculated | Short | Radian*8192 |
| 17 - 20 | Satellite Altitude | SFDB/Calculated | Long | Nautical Mile*1000 |
| 21 - 24 | Ephemeris Timecode | SFDB/Calculated | Long | Second*1024 |
| 25 - 28 | Sensors Timecode | SFDB/Calculated | Long | Second*1024 |
| 29 - 48 | Z Bits - Location Data Words | Satellite | Long * 5 | 32 bits structured |
| 49 - 52 | E Bits - Timecode | Satellite | Long | 32 bits structured |
| 53 - 54 | C Bits - Cold T Cal | Satellite | Short | 9 bits structured |
| 55 - 56 | G Bits - Gain Code | Satellite | Short | 9 bits structured |
| 57 - 58 | H Bits - Hot T Cal | Satellite | Short | 9 bits structured |
| 59 - 60 | I Bits - Vehicle Identity | Satellite | Short | 4 bits structured |

| | | | | |
|---|---|---|---|---|
| 61 – 62 | M Bits - Gain Code lin/log/submode | Satellite | Short | 4 bits structured |
| 63 – 64 | P Bits - PMT Cal | Satellite | Short | 8 bits structured |
| 65 – 66 | Q Bits - Line Sync Scanner Offset | Satellite | Short | 5 bits structured |
| 67 - 68 | Q Bits - Sub Sync Scanner Offset | Satellite | Short | 6 bits structured |
| 69 - 70 | Y Bits - T Channel Gain | Satellite | Short | 4 bits structured |
| 71 - 100 | Blank | | Byte | 0 |

**ASCII/bytes are 8 bits, short integers are 16 bits, long integers are 32 bits*
***Structured bits are right justified*

1.3.1. Data Valid Flag. This record will provide a status of the data. Figure 1.3.1 shows a list of valid flag identifiers. See Section 2.2 for more details on the application of these flags.

**Figure 1.3.1. Data Valid Flag Definitions**

| Flag Value | Meaning | Affect on documentation data | Affect on sensor data |
|---|---|---|---|
| -1 | Invalid data | Interpolated ephemeris | Zero-filled |
| 0 | Invalid data | Derived from SFDB | Copied from SFDB |
| 1 | Valid data | Derived from SFDB | Copied from SFDB |
| 2 | Valid data | Derived from SFDB with corrections made for errors | Copied from SFDB |
| 3 | Valid data | Derived from SFDB with interpolated ephemeris | Copied from SFDB |
| 4 | Valid data<br>Invalid Z Bits | Derived from SFDB with interpolated ephemeris with possible 0 filled Z Bit fields | Copied from SFDB |

1.3.2. Satellite Latitude (geodetic). This is a signed short integer representing a value between +/- pi/2 inclusive containing a Z-bit decoded satellite latitude corresponding to the nadir of the satellite. The latitude will be stored as value in radians multiplied by 8192.0.

1.3.3. Satellite Longitude (geodetic). This is a non-negative long integer representing a value between 0.0 and 2pi east inclusive containing a Z-bit decoded satellite longitude corresponding to the nadir of the satellite. The longitude will be stored as value in radians multiplied by 8192.0.

1.3.4. SATH Angle. This is the angle in the orbital plane between the spacecraft position vector at the ascending node and the spacecraft position vector corresponding to the current second of data, measured in the direction of flight. SATH is an angle between inertial positions and will be between 0 and 2pi radians from ascending node to ascending node. The SATH angle will be stored as a non-negative long integer representing a value between 0.0 and 2pi inclusive in radians multiplied by 8192.0.

1.3.5. Quarter Orbit. Quarter orbit when data was actually collected. Values range from 1 to 4.

1.3.6. Satellite Crossing Angle. This is a non-negative short integer representing a value between 0 and pi inclusive containing a Z-bit decoded satellite crossing angle. The crossing angle will be stored as value in radians multiplied by 8192.0.

1.3.7. Satellite Altitude. This is a non-negative long integer representing a Z-bit decoded satellite altitude in nautical miles. The altitude will be stored as value in nautical miles multiplied by 1000.0.

1.3.8. Ephemeris Timecode. This is a non-negative long integer between 0 and 86399 corresponding to the second of the day the latitude, longitude, crossing angle, and altitude are valid. This number can exceed 86399 by anywhere from a few milliseconds to a few seconds before the satellite resets the clock. The timecode will be stored as value in seconds multiplied by 1024.0.

1.3.9. Sensors Timecode. This is the SSP time code preserved from the satellite data stream via original SFDB data file. This value is a non-negative long integer between 0 and 86399 corresponding to the second of the day the sensor was read. It is used in the calculation of fiducial start and stop times. This number can exceed 86399 by anywhere from a few milliseconds to a few seconds before the satellite resets the clock. The SSP time code will be stored as value in seconds multiplied by 1024.0.

1.3.10. Z Bits. These are the 5 32-bit words that 1.3.1 - 1.3.6 are derived from. They are preserved from the spacecraft. The sensor records are at approximately one second intervals but the Z-bits values are updated approximately every 2 seconds, therefore approximately every other set of Z-bits words will be a repeat of the values in the previous sensor record.

1.3.11. I Bits. This is a 4-bit value used to identify the satellite's internal identification. It is used to identify the satellite in Figure 1.2.1. The I-bits are limited to 4 bits, values 0 through 15, thus for DMSP flights 16 through 20 we'll need to start over with satellite identifiers of 1 through 5.

1.3.12. C, E, G, H, M, P, Q, and Y bits. These are bits preserved from the satellite for application use of visual and infrared imagery. They are not used in the construction of the RSDR's.

2.0. RSDR Processing

2.1. Time Order. The time order of data records in an RSDR will be reverse chronological. The time order of the data within a record will be chronological.

2.2. Validating a record of data.

2.2.1. Valid Record. A record is considered valid when the valid flag in SFDB is set to 1 and no modifications and/or corrections need to be made. The document data field will contain the value 1.

2.2.2. Corrected Record. A record is considered corrected when errors in SFDB occurred, but are repaired. VIS and IR channel Z bits will be cross-referenced and sequence tested to detect errors. The document data field will contain the value 2.

2.2.3. Interpolated Record. A record is considered interpolated when the document data ephemeris is updated and/or refined from the information provided in the Z Bits. These updates would affect the Latitude, Longitude, Crossing Angle, and Altitude fields. The document data field will contain the value 3.

2.2.4. Invalid Z Bits – Good Data. A record is considered to have invalid Z Bits with good data when the valid flag in SFDB is set to 1 and all or some of the Z Bits words contain zeros. The document data field will contain the value 4.

2.2.5. Invalid Record. A record is considered invalid when the valid flag in SFDB is set to -1 and no modifications are performed. The document data field will contain the value 0.

2.2.6. Filled Record. A record is considered filled when a zero-filled data record is inserted where a skip in the timecode or ephemeris sequence is detected. The document data field will contain the value -1.

2.3. Multiple RSDR Files. Multiple RSDR files will be created for a single SFDB file if the SSP format words within the file change and remain consistent at the new configuration (Figure 1.2, Number of bytes of sensor data per record). Each RSDR file using the new configuration will have a different filename using the same rev number. This happens very rarely in a satellite's lifetime.

2.4. Big Endian. RSDR data in the header (Section 1.2) and document data (Section 1.3) will be "big endian." Since all of the data will be integer form, real value specifications are not required.

2.5. Filename convention. Each RSDR will follow a filenaming convention to uniquely identify the data.

**Figure 2.5.1. Filename Format**

**f***ii_rrrrr_yyyyjjjhhmm_ss_xx***.dat**

where *ii* is the DMSP satellite two digit identification (see Figure 2.5.2),
*rrrrr* is the playback revolution number,
*yyyy* is the year the RSDR was created,
*jjj* is the julian day (1 - 366) of the year the RSDR was created,
*hhmm* is the hour (0 - 23) and minute (0 - 59) of the day of ingest into AFWA,
*ss* is a sensor identification (see Figure 2.5.3),
and *xx* indicates number of reships (00 will be used for original transmission).

**Figure 2.5.2. Satellite Identifications**

| Satellite | Flight ID | RSDR ID |
|---|---|---|
| WX2546 | F-11 | 11 |
| WX3545 | F-12 | 12 |
| WX4547 | F-13 | 13 |

| | | |
|---|---|---|
| WX5548 | F-14 | 14 |
| WX6549 | F-15 | 15 |

**Figure 2.5.3. Sensor Identifications**

| Sensor | RSDR ID |
|---|---|
| SSMI | mi |
| ** SSMIS | ms |
| SSM/T-1 | t1 |
| SSM/T-2 | t2 |
| SSIES/IES2 | i2 |
| SSIES/IES3 | i3 |
| SSJ4 | j4 |
| SSBX | bx |
| SSM | mm |
| SSZ | zz |
| SSUSI | si |
| SSULI | li |
| SSF | ff |
| SSJ5 | j5 |

***Example***: F14_12345_19993151830_mi_00.dat

**Note: Special Sensor SSMI/S data originating in both channels of the SFDB will be combined into one SSMI/S RSDR file.

## GLOSSARY

| | |
|---|---|
| AFWA | Air Force Weather Agency |
| DMSP | Defense Meteorological Satellite Program |
| ID | Identification |
| IR | Infrared Radiation |
| RSDR | Raw Sensor Data Record |
| SDHS | Satellite Data Handling System |
| SFDB | Simple Format Data Base |
| SIMPLE | Not an acronym, is a name. |
| SSBX | Special Sensor Gamma Ray Particle Detector |
| SSF | Special Sensor Laser Threat Detector, Replaces SSZ for 5D3 |
| SSP | Special Sensor Data Package |
| SSIES/IES2/IES3 | Special Sensor Ion Scintillation Monitor |
| SSJ4/J5 | Special Sensor Precipitating Electron and Ion Spectrometer |
| SSM | Special Sensor Magnetometer |
| SSM/I | Special Sensor Microwave /Imager |
| SSMI/S | Special Sensor Microwave Imager/Sounder |
| SSM/T1 | Special Sensor Microwave Temperature sounder |
| SSM/T2 | Special Sensor Microwave water vapor sounder |
| SSULI | Special Sensor Ultraviolet Limb Imager |
| SSUSI | Special Sensor Ultraviolet Spectrographic Imager |
| SSZ | Special Sensor Laser Threat Detector |
| VIS | Visual |

## TERMS

Julian Day — The Julian day begins at 00Zulu.

R+ Number — R+0 is the reference rev that occurs once per day with its ascending nodal crossing value between 68.00 and 93.45W. R+X (X=1-15) identifies a specific rev following the reference rev with X indicating the number of revs following the reference rev. Each revs ascending nodal crossing longitude is 25.4 degrees longitude from the previous R+X ascending nodal crossing longitude. Most days have 14 revs (R+0 to R+13) and once every four to five days 15 revs (R+0 to R+14). On 14 rev days, R+14 is R+0 for the next day; on 15 rev days, R+15 is R+0 for the next day.