SeaWiFS Level-1A Data Products

1.0 Introduction

This document describes the specifications of the SeaWiFS Level-1A archive products which are produced and distributed by the NASA Goddard Space Flight Center's Ocean Discipline Processing System (ODPS). The products are implemented in the Hierarchical Data Format (HDF), and HDF terminology is used in this document.

These specifications are given in terms of the logical implementation of the products in HDF and are not a physical description of file contents. Therefore, HDF software must be used to create or read these products.

A SeaWiFS Level-1A product is generated from Level-0 data files. It contains all the Level-0 data (raw radiance counts from all bands as well as spacecraft and instrument telemetry), appended calibration and navigation data, and instrument and selected spacecraft telemetry that are reformatted and also appended. This product is stored as one physical HDF file.

Each product contains one type of Level-1A data. The type of the data is specified by the global attribute **Data Type**. The possible **Data Type** values are "GAC" for global-area coverage data, "LAC" for local-area coverage data, "LUN" for lunar calibration data, "SOL" for solar calibration data, "TDI" for data from a TDI check, "IGC" for data from an intergain calibration check, and "HRPT" for direct-readout data. (The generic term "LAC" is also used to refer to all full-resolution, recorded data, including lunar, solar, TDI, and IGC data.)

Note that GAC data are subsampled from full-resolution data with every fourth pixel of a scan line (from LAC pixels 147 to 1135) and every fourth scan line being recorded. Thus, GAC data are comprised of 248 pixels per scan line, whereas all other types are comprised of 1,285 pixels per scan line. Also note that HRPT data are collected at one of many HRPT stations (global attribute, **Station Name**), whereas all other data types are from dumps of the onboard flight data recorder. A catalog of all available HRPT stations is maintained on the SeaWiFS home page at http://seawifs.gsfc.nasa.gov/SEAWIFS/HRPT/HRPT_LOCATIONS.html.

The SeaWiFS Project also produces a “merged LAC” (MLAC) product, which consolidates all available full-resolution (LAC and HRPT) from a single orbit. In geographic regions with multiple HRPT stations, overlapping scenes are evaluated to select a single “best quality” scan in order to eliminate duplicate scans. MLAC data may also have gaps if non-contiguous LAC and HRPT data segments were collected in an orbit.

For GAC data, individual products are generated from each Level-0 GAC recording period (the Earth data collection portion of an orbit). Each such GAC product thus constitutes one scene. For HRPT data, each scene is comprised of one satellite pass. For recorded, full-resolution (e.g., LAC) data, each scene is comprised of a continuous recording of one data type. For MLAC data, each product contains the best available full-resolution data for a single orbit, without duplication.

2.0 Naming Convention

The form of a Level-1A file name is Syyyydddhhmmss.L1A_ttt, where S is for SeaWiFS, yyyydddhhmmss are the concatenated digits for the GMT year, day of the year, hours, minutes, and seconds of the first scan line, and ttt is a three- or four-character data type code. For HRPT data, the form is Syyyydddhhmmss.L1A_Hhhh, where hhh is a three-character code identifying the agency and location of the HRPT station. Examples of file names for each Level-1A data type are:

S2001277130655.L1A_GAC for GAC data
S2004066112047.L1A_LAC for LAC data
S2001103221441.L1A_MLAC for merged LAC data
S2004099105941.L1A_SOL for solar calibration data
S1998338002218.L1A_LUN for lunar calibration data
S2004137152325.L1A_TDI for TDI check
S2004141113305.L1A_IGC for intergain calibration check
S2003349160330.L1A_HNSG for NASA/GSFC HRPT data
(**Station Name** = "GSFC HRPT, NASA, MD")

3.0 Global Attributes

For global attributes that have constant values specific to this product type, the value is given.

3.1 Mission and Documentation

Product Name (character): the name of the product file (without path).

Title (character): "SeaWiFS Level-1A Data".

Data Center (character): for **Station Name** = "Wallops Flight Facility" or "GSFC HRPT, NASA, MD", "NASA/GSFC SeaWiFS Data Processing Center"; for all other HRPT stations, will be the same as **Station Name**.

Station Name (character): for all recorded data (GAC, LAC, SOL, LUN, TDI, IGC), "Wallops Flight Facility"; for HRPT stations, the station affiliation given on the web site; for MLAC data, “Merged LAC Product comprising data from multiple stations”

Station Latitude (4-byte real): for **Station Name** = "Wallops Flight Facility", 37.9272; for **Station Name** = "GSFC HRPT, NASA, MD", 38.9958; for all other HRPT stations, the station latitude is given on the web site.

Station Longitude (4-byte real): for **Station Name** = "Wallops Flight Facility", -75.4753; for **Station Name** = "GSFC HRPT, NASA, MD", -76.8511; for all other HRPT stations, the station latitude is given on the web site.

Mission (character): "SeaStar SeaWiFS".

Mission Characteristics (character): "Nominal orbit: inclination = 98.2 (Sun-synchronous); node = 12 noon local (descending); eccentricity = <0.002; altitude = 705 km; ground speed = 6.75 km/sec".

Sensor (character): "Sea-viewing Wide Field-of-view Sensor (SeaWiFS)".

Sensor Characteristics (character): "Number of bands = 8; number of active bands = 8; wavelengths per band (nm) = 412, 443, 490, 510, 555, 670, 765, 865; bits per pixel = 10; instantaneous field-of-view = 1.5835 mrad; pixels per scan = 1285; scan rate = 6/sec; sample rate = 7710/sec". Note: Pixels per scan, scan rate, and sample rate are given for the sensor; effective rates for GAC data are lower due to subsampling.

Data Type (character): "GAC", "LAC", "LUN", "SOL", "TDI", "IGC", or "HRPT". MLAC products also have a date type of HRPT.

Replacement Flag (character): "ORIGINAL" if this is the first version of this product delivered to the DAAC; otherwise, it is set to the name of the product to be replaced (superseded) by the present product.

Software ID (character): identifies version of the operational software used to create this product.

Processing Time (character): local time of generation of this product; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Input Files (character): the name of the Level-0 file (without path) from which the current product was created. This information is stored in the product as part of its processing history.

Processing Control (character): all input and processing control parameters used by the calling program to generate the product. Vertical bars or carriage return characters serve as parameter information delimiters. This information is stored in the product as part of its processing history.

Processing Log (character): not used.

3.2 Data Time

Start Time (character): start GMT of the first scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

End Time (character): start GMT of the last scan line of the scene; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Scene Center Time (character): start GMT of the center scan line of the scene; concatenated

digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Node Crossing Time (character): GMT of descending node crossing; concatenated digits for year, day-of-year, hours, minutes, seconds, and fraction of seconds in the format of YYYYDDDHHMMSSFFF.

Start Year (2-byte integer): GMT year of first scan line of the scene.

Start Day (2-byte integer): GMT day-of-year of first scan line of the scene.

Start Millisec (4-byte integer): GMT milliseconds-of-day of the first scan line of the scene.

End Year (2-byte integer): GMT year of last scan line of the scene.

End Day (2-byte integer): GMT day-of-year of last scan line of the scene.

End Millisec (4-byte integer): GMT milliseconds-of-day of the last scan line of the scene.

Start Node (character): "Ascending" or "Descending"; describes node direction at the start of the scene.

End Node (character): "Ascending" or "Descending"; describes node direction at the end of the scene.

Orbit Number (4-byte integer): orbit number of the scene.

NORAD Line 1 (character): not used.

NORAD Line 2 (character): not used.

3.3 Data Characteristics

Pixels per Scan Line (4-byte integer): 248 if **Data Type** = "GAC", else, 1285.

Number of Scan Lines (4-byte integer): number of scan lines in the scene.

LAC Pixel Start Number (4-byte integer): the LAC pixel number corresponding to the first pixel in scan lines of this product; 147 if **Data Type** = "GAC", else, 1.

LAC Pixel Subsampling (4-byte integer): the subsampling rate for the pixels in this product relative to LAC scan lines; 4 if **Data Type** = "GAC", else, 1.

Scene Center Scan Line (4-byte integer): number of the center scan line (1-relative) of the scene, relative to first scan line.

Filled Scan Lines (4-byte integer): not used.

FF Missing Frames (4-byte integer): frame formatter missing frames count for the Level-0 source file.

SDPS Missing Frames (4-byte integer): not used.

3.4 File Metrics

Gain 1 Saturated Pixels (4-byte integer, array size 8): number of saturated pixels for Earth gain 1 for each band.

Gain 2 Saturated Pixels (4-byte integer, array size 8): number of saturated pixels for Earth gain 2 for each band.

Gain 1 Non-Saturated Pixels (4-byte integer, array size 8): number of pixels not saturated for gain 1 for each band.

Gain 2 Non-Saturated Pixels (4-byte integer, array size 8): number of pixels not saturated for gain 2 for each band.

Zero Pixels (4-byte integer, array size 8): number of pixels, for each band, with value of 2 or less after subtraction of corresponding **dark_rest**.

Mean Gain 1 Radiance (4-byte real, array size 8): average radiance counts for pixels of gain 1 for each band.

Mean Gain 2 Radiance (4-byte real, array size 8): average radiance counts for pixels of gain 2 for each band.

3.5 Scene Coordinates

Latitude Units (character): "degrees North"; units used for all latitude values in this product.

Longitude Units (character): "degrees East"; units used for all longitude values in this product.

Scene Center Latitude (4-byte real): latitude of the nadir point of the scene's center scan line.

Scene Center Longitude (4-byte real): longitude of the nadir point of the scene's center scan line.

Scene Center Solar Zenith (4-byte real): solar zenith angle of the nadir point of the scene's center scan line.

Upper Left Latitude (4-byte real): latitude of the upper left scene corner.

Upper Left Longitude (4-byte real): longitude of the upper left scene corner.

Upper Right Latitude (4-byte real): latitude of the upper right scene corner.

Upper Right Longitude (4-byte real): longitude of the upper right scene corner.

Lower Left Latitude (4-byte real): latitude of the lower left scene corner.

Lower Left Longitude (4-byte real): longitude of the lower left scene corner.

Lower Right Latitude (4-byte real): latitude of the lower right scene corner.

Lower Right Longitude (4-byte real): longitude of the lower right scene corner.

Northernmost Latitude (4-byte real): northernmost latitude of all scan line end points.

Southernmost Latitude (4-byte real): southernmost latitude of all scan line end points.

Westernmost Longitude (4-byte real): westernmost longitude of all scan line end points.

Easternmost Longitude (4-byte real): easternmost longitude of all scan line end points.

Start Center Latitude (4-byte real): latitude of center pixel for first scan line.

Start Center Longitude (4-byte real): longitude of center pixel for first scan line.

End Center Latitude (4-byte real): latitude of center pixel for last scan line.

End Center Longitude (4-byte real): longitude of center pixel for last scan line.

Orbit Node Longitude (4-byte real): longitude of scene's orbit descending node (longitude at equatorial crossing of day-side node).

4 Data Objects

Of the following six groups of data objects, four -- Scan-Line Attributes, Raw SeaStar Data, Converted Telemetry, and Navigation -- contain data that are functions of scan lines. That is, each data object within these groups has data for each scan line and is therefore dimensioned by the value of the global attribute, **Number of Scan Lines**.

4.1 Scan-Line Attributes

The following data objects are SDSs belonging to the Vgroup "Scan-Line Attributes". Attributes of the SDSs are shown in **bold**.

msec (4-byte integer, array size **Number of Scan Lines**): **long_name** = "Scan-line time, milliseconds of day"; **valid_range** = (0,86399999); **units** = "milliseconds".

eng_qual (byte, array size **Number of Scan Lines** x 4): **long_name** = "Engineering data-out-of-range flags"; set bits indicate instrument analog telemetry values out of range; see Table 1.

s_flags (byte, array size **Number of Scan Lines** x 4): **long_name** = "Scan-line quality flags";
byte 1: sum of frame formatter bit error count and SDPS bit errors detected in this scan line;
byte 2: corrupted telemetry flag; set if bit errors were detected for this scan line and this is the first minor frame (containing ACS and GPS telemetry) in the major frame;
byte 3: for GAC data, the number (1 to 15) of the GAC line within the major frame;
byte 4: number of synchronization bits used for the bit error count divided by 5; taken from the first two bytes of Level-0 record.

s_satp (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Number of saturated pixels per band".

s_zerop (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Number of zero pixels per band".

slat (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan start-pixel latitude"; **valid_range** = (-90.,90.).

slon (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan start-pixel longitude"; **valid_range** = (-180.,180.).

clat (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan center-pixel latitude"; **valid_range** = (-90.,90.).

clon (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan center-pixel longitude"; **valid_range** = (-180.,180.).

elat (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan end-pixel latitude"; **valid_range** = (-90.,90.).

elon (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan end-pixel longitude"; **valid_range** = (-180.,180.).

csol_z (4-byte real, array size **Number of Scan Lines**): **long_name** = "Scan center-pixel solar zenith angle"; **valid_range** = (0.,180.).

tilt (4-byte real, array size **Number of Scan Lines**): **long_name** = "Tilt angle for scan line"; **valid_range** = (-20.1,20.1); positive values indicate aft tilts and negative values indicate forward tilts; **units** = "degrees".

4.2 Raw SeaStar Data

The following data objects are SDSs belonging to the Vgroup "Raw SeaStar Data". Attributes of the SDSs are shown in **bold**.

sc_id (2-byte integer, array size **Number of Scan Lines** x 2): **long_name** = "Spacecraft ID"; first word includes frame number; second word specifies data mode.

sc_ttag (2-byte integer, array size **Number of Scan Lines** x 4): **long_name** = "Spacecraft time tag"; binary representation of spacecraft time.

sc_soh (byte, array size **Number of Scan Lines** x 775): **long_name** = "Spacecraft state-of-health data"; raw state-of-health telemetry data.

inst_tlm (2-byte integer, array size **Number of Scan Lines** x 44): **long_name** = "SeaWiFS instrument telemetry"; raw instrument and ancillary telemetry data, subcommutated depending on minor frame number and line number within frame.

l1a_data (2-byte integer, array size **Number of Scan Lines** x **Pixels per Scan Line** x 8): **long_name** = "Level-1A data"; **valid_range** = (0,1023); **units** = "radiance counts"; dimensions are scan lines x pixels x bands.

start_syn (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Start-synch pixel"; 8 synch words that indicate the start of the scan line.

stop_syn (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Stop-synch pixel"; 8 synch words that indicate the end of the scan line.

dark_rest (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Dark-restore pixel"; zero-level measurement (in counts) for each band taken from back side of scan.

gain (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Band gain settings"; **valid_range** = (0,3); values are 0 = Earth gain 1, 1 = solar gain 2, 2 = Earth gain, 3 = lunar gain.

tdi (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Band time-delay and integration settings"; **valid_range** = (0,255); detector combination used for each band.

4.3 Converted Telemetry

The following data objects are SDSs belonging to the Vgroup "Converted Telemetry". Attributes of the SDSs are shown in **bold**.

inst_ana (4-byte real, array size **Number of Scan Lines** x 40): **long_name** = "Instrument analog telemetry"; 32 instrument analog telemetry data converted to physical units (last 8 word locations are spares); see Table 1.

inst_dis (byte, array size **Number of Scan Lines** x 32): **long_name** = "Instrument discrete telemetry"; 24 instrument discrete telemetry data, unpacked 1 bit per byte (last 8 byte locations are spares); see Table 2.

sc_ana (4-byte real, array size **Number of Scan Lines** x 40): **long_name** = "Spacecraft analog telemetry"; selected spacecraft analog telemetry data converted to physical units (last 2 word locations are spares); see Table 3.

sc_dis (byte, array size **Number of Scan Lines** x 40): **long_name** = "Spacecraft discrete

telemetry"; selected spacecraft discrete telemetry data; see Table 4.

scan_temp (2-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Detector temperature counts"; **valid_range** = (0,255); digitized scan temperature for each band.

side (2-byte integer, array size **Number of Scan Lines**): **long_name** = "Mirror side for scan line"; **valid_range** = (0,1).

4.4 Navigation

The following data objects are SDSs belonging to the Vgroup "Navigation". Attributes of the SDSs are shown in **bold**. See the *SeaWiFS Postlaunch Technical Report Series*, volume 16 for a description of methods used for the operational navigation of SeaWiFS data.

orb_vec (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Orbit position vector at scan line time"; orbit position vector interpolated to the time of the scan line; **valid_range** = (-7200.,7200.); **units** = "kilometers"; used to determine spacecraft position for geolocation.

l_vert (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Local vertical vector in ECEF frame"; local vertical (geodedic) vector at the spacecraft position, in the ECEF frame; **valid_range** = (-1.,1.); used to determine roll and pitch of spacecraft.

sun_ref (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Reference Sun vector in ECEF frame"; unit Sun vector in the Earth-cetered, Earth-fixed (ECEF) frame; **valid_range** = (-1.,1.); used for computing solar zenith and azimuth angles.

att_ang (4-byte real, array size **Number of Scan Lines** x 3): **long_name** = "Computed yaw, roll, pitch"; **valid_range** = (-180.,180.); relates spacecraft position to orbit reference frame.

sen_mat (4-byte real, array size **Number of Scan Lines** x 3 x 3): **long_name** = "ECEF-to-sensor-frame matrix"; **valid_range** = (-1.,1.); relates sensor scan plane to Earth-fixed reference frame (3x3 matrix, in column-major order).

scan_ell (4-byte real, array size **Number of Scan Lines** x 6): **long_name** = "Scan-track ellipse coefficients"; defines scan-track geometry in sensor frame.

nflag (4-byte integer, array size **Number of Scan Lines** x 8): **long_name** = "Navigation flags"; in the 8-integer array, the integers represent, respectively: navigation failure flag; orbit flag; Sun sensor flag; Earth sensor flag; spacecraft attitude uncertainty flag; time code flag; tilt data flag; and navigation warning flag. All flags may have the value 0 for valid or 1 for invalid. The tilt data flag only may also have the value of 2 to indicate a changing tilt. Note that the failure flag is only to 1 if the orbit flag, time code flag or tilt data flag are set to 1.

4.5 Sensor Tilt

The following data objects are SDSes belonging to the Vgroup "Sensor Tilt". Attributes of the SDSs are shown in **bold**.

ntilts (4-byte integer): **long_name** = "Number of scene tilt states".

tilt_flags (2-byte integer, array size 20): **long_name** = "Tilt indicators"; **valid_range** = (-1,3); tilt flags corresponding to each tilt state in the scene; possible values are 0 for nadir tilt, 1 for forward tilt, 2 for aft tilt, and 3 to indicate a changing tilt angle; -1 indicates an unknown state; contains **ntilts** valid values.

tilt_ranges (2-byte integer, array size 20 x 2): **long_name** = "Scan-line number ranges of scene tilt states"; first and last scan line numbers (1-relative) corresponding to each tilt state in the scene; contains **ntilts** valid values.

tilt_lats (4-byte real, array size 20 x 2 x 2): **long_name** = "Latitudes of tilt-range scan line end points"; **valid_range** = (-90.,90.); latitudes of the end pixels for the scan lines of **tilt_ranges** (dimensions are **ntilts** x first/last scans x start/end pixels); contains **ntilts** valid values.

tilt_lons (4-byte real, array size 20 x 2 x 2): **long_name** = "Longitudes of tilt-range scan line end points"; **valid_range** = (-180.,180.); longitudes of the end pixels for the scan lines of **tilt_ranges** (dimensions are **ntilts** x first/last scans x start/end pixels); contains **ntilts** valid values.

4.6 Calibration

The following data objects are SDSes belonging to the Vgroup "Calibration". These fields are no longer filled in the Level-1A product, but are retained for historical reasons.

entry_year (2-byte integer): **long_name** = "Calibration entry year"; the year (4 digits) that the entry used for this Vgroup's data was made in the sensor calibration table.

entry_day (2-byte integer): **long_name** = "Calibration entry day-of-year"; the day-of-year that the entry used for this Vgroup's data was made in the sensor calibration table.

ref_year (2-byte integer): **long_name** = "Calibration reference year"; 1997; the year of the calibration reference time.

ref_day (2-byte integer): **long_name** = "Calibration reference day-of-year"; 64; the day of year of the calibration reference time.

ref_minute (2-byte integer): **long_name** = "Calibration reference minute-of-day"; 720; the minute of day of the calibration reference time.

mirror (4-byte real, array size 2 x 8): **long_name** = "Mirror-side correction factors"; mirror side-0 and -1 correction factors for calibration of the eight bands (dimensions are sides x bands).

t_const (8-byte real, array size 8): **long_name** = "Time-dependent correction constant terms"; time-dependent correction constant terms for all bands.

t_linear (8-byte real, array size 8): **long_name** = "Time-dependent correction linear coefficients"; time-dependent correction linear coefficients for all bands.

t_quadratic (8-byte real, array size 8): **long_name** = "Time-dependent correction quadratic coefficients"; time-dependent correction quadratic coefficients for all bands.

cal_offs (4-byte real, array size 8): **long_name** = "Calibration system offsets"; calibration system offsets for all bands.

counts (4-byte real, array size 8 x 4 x 5): **long_name** = "Digital counts of calibration knees"; **valid_range** = (0,1023); digital counts (zero-offsets corrected) corresponding to each calibration knee for all gains and bands (dimensions are bands x gains x knees).

rads (4-byte real, array size 8 x 4 x 5): **long_name** = "Radiances of calibration knees"; radiances corresponding to each calibration knee for all gains and bands (dimensions are bands x gains x knees).

Table 1. Converted instrument analog telemetry in **inst_ana**.

Array Indices	Description	Units
1 - 4	Focal plan assembly temperatures	degrees C
5	Telescope motor temperature	degrees C
6 - 7	Tilt base and platform temperatures	degrees C
8	Half angle motor temperature	degress C
9 - 10	Power supply input current (A and B sides)	amps
11 - 12	Analog power voltage (+15V and -15V)	volts
13	5V logical power voltage	volts
14	Power supply temperature	degrees C
15	B1/B2 postamp temperature	degrees C
16	Servo drive temperature	degrees C
17 - 20	Servo power voltage (+30V, +21V, -21V, +5V)	volts
21	Angular momentum compensator speed	rpm
22 - 23	Tilt motor positions (platform and base)	degrees

24	28V heater power	volts
25 - 26	Telescope motor current (A and B sides)	amps
27 - 28	Half angle motor current (A and B sides)	amps
29 - 30	Servo phase error (A and B sides)	millirad
31 - 32	Angular momentum compensator motor current (A and B)	amps
33 - 40	Spares	

Table 2. Converted instrument discrete telemetry in **inst_dis**.

Array index	Description and convention
1	Servo selected (1 = A)
2	Angular momentum compensator on (1 = on)
3	Servo A locked (1 = true)
4	Servo B locked (1 = true)
5	Timing selected (1 = A)
6	Tilt A selected (1 = true)
7	Tilt B selected (1 = true)
8	Tilt telemetry on (1 = on)
9	Stow on (1 = on)
10	Stow aligned (1 = on)
11	Heaters status (1 = enabled)
12	Solar door open (1 = open)
13	Analog power on (1 = on)
14	Tilt platform limit (1 = true)
15	Tilt base limit (1 = true)
16	Tilt nadir aligned (1 = true)
17	Tilt aft aligned (1 = true)
18	Tilt forward aligned (1 = true)
19	Earth mode data on (1 = Earth mode, 0 = solar mode)
20	Half angle mirror side (1 = side 2)
21	Image data sync (1 = true)
22	Angular momentum compensator at speed (1 = true)
23-32	Spares

Table 3. Converted spacecraft analog telemetry in **sc_ana**.

Array Indices	Description	Units
1 - 3	GPS orbit position vector (ECEF frame)	km
4 - 6	GPS orbit velocity vector (ECEF frame)	km/sec
7-9	ACS attitude angles yaw, roll, pitch	degrees
10 - 11	Digital Sun sensor A outputs	n/a
12 - 13	Digital Sun sensor B outputs	n/a
14 - 15	Digital Sun sensor C outputs	n/a
16 - 17	Horizon sensor A angles (phase and chord)	degrees
18 - 19	Horizon sensor B angles (phase and chord)	degrees
20	GPS dilution-of-precision	n/a
21	GPS time-tag fractional second	second
22	Momentum wheel 1 speed	rpm
23	Momentum wheel 1 current	amp
24	Momentum wheel 2 speed	rpm
25	Momentum wheel 2 current	amp
26 - 28	Torquer 1 commanded levels (x, y, z)	amp-m^2
29 - 31	Torquer 1 commanded levels (x, y, z)	amp-m^2
32 - 35	Magnetometer 1 field values (x,y,z,r)	nanotesla
36 - 38	Attitude angle rates (yaw, roll, pitch)	degree/sec
39 - 40	spares	

Table 4. Converted spacecraft discrete telemetry in **sc_dis**.

Array Indices	Description
1 - 3	DSS Sun presence flags (A, B, C)
4 - 6	DSS status (A, B, C)
7 - 8	HS A status
9 - 10	HS B status
11	Number of GPS satellites visible
12	Number of GPS sateliites tracked
13	GPS receiver status
14 - 15	GPS time tag year
16	GPS time tag month
17	GPS time tag day
18 - 20	GPS time tag hour, minute, second
21 - 24	DSS A time tag (milliseconds of week)
25 - 28	DSS B time tag (milliseconds of week)
29 - 32	DSS C time tag (milliseconds of week)
33 - 36	HS A time tag (milliseconds of week)
37 - 40	HS B time tag (milliseconds of week)