Aqua GBAD Ephemeris and Attitude Data Converter

General

The Aqua GBAD Ephemeris and Attitude Data Converter creates ephemeris and attitude files from data packets in the Aqua spacecraft telemetry downlink. The program reads a Level-0 CCSDS Spacecraft Bus Telemetry Packet File containing Aqua APID 957 packets and stores the reformatted data in SDP Toolkit-compatible ephemeris and attitude files. These ephemeris and attitude files are required input to Geolocation and other higher level Aqua data products.

This program partially emulates the Aqua Spacecraft Ephemeris and Attitude Preprocessing (DPREP) to provide a quick-look capability to field-deployed ground stations. Therefore, some algorithms are different from or use approximations to DPREP and some statistical fields and quality checks are not implemented.

The input packet file can be created from the RT-STPS Sorcerer Node (See the RT-STPS documentation). The input APID 957 packet file format is described in "EOS PM-1 Spacecraft to EOS Ground System Interface Control Document", GSFC 422-11-19-03, Section 5, Telemetry Data Formats. A summary is provided in Appendix-C of this document.

A NORAD file provides orbital information required to compute house keeping and statistical values in the output file header and metadata records. These data are updated every few days. A more detailed description of NORAD files and the current values may be found at www.celestrak.com.

The ephemeris and attitude output file formats are described in Release 6A SDP Toolkit Users Guide for the ECS Project", 333-CD-600-001, Appendix L. Ephemeris and Attitude File Formats. A summary is also provided in Appendix-D and Appendix-E of this document.

The file names and other configurable parameters are specified in a configuration file as keyword-value pairs. The keywords and default values are listed in Appendix-A. The location of the configuration file is optionally specified on the command line.

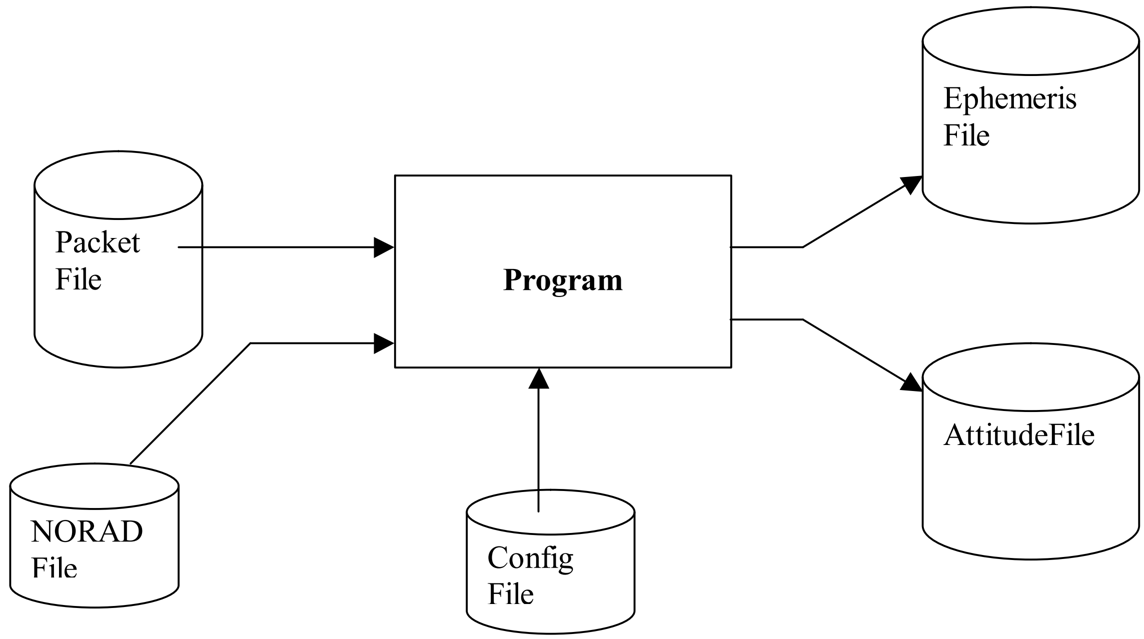
The program is written in the C++ programming language and compiled with the Standard Template Library into a single executable module.

Program Operation

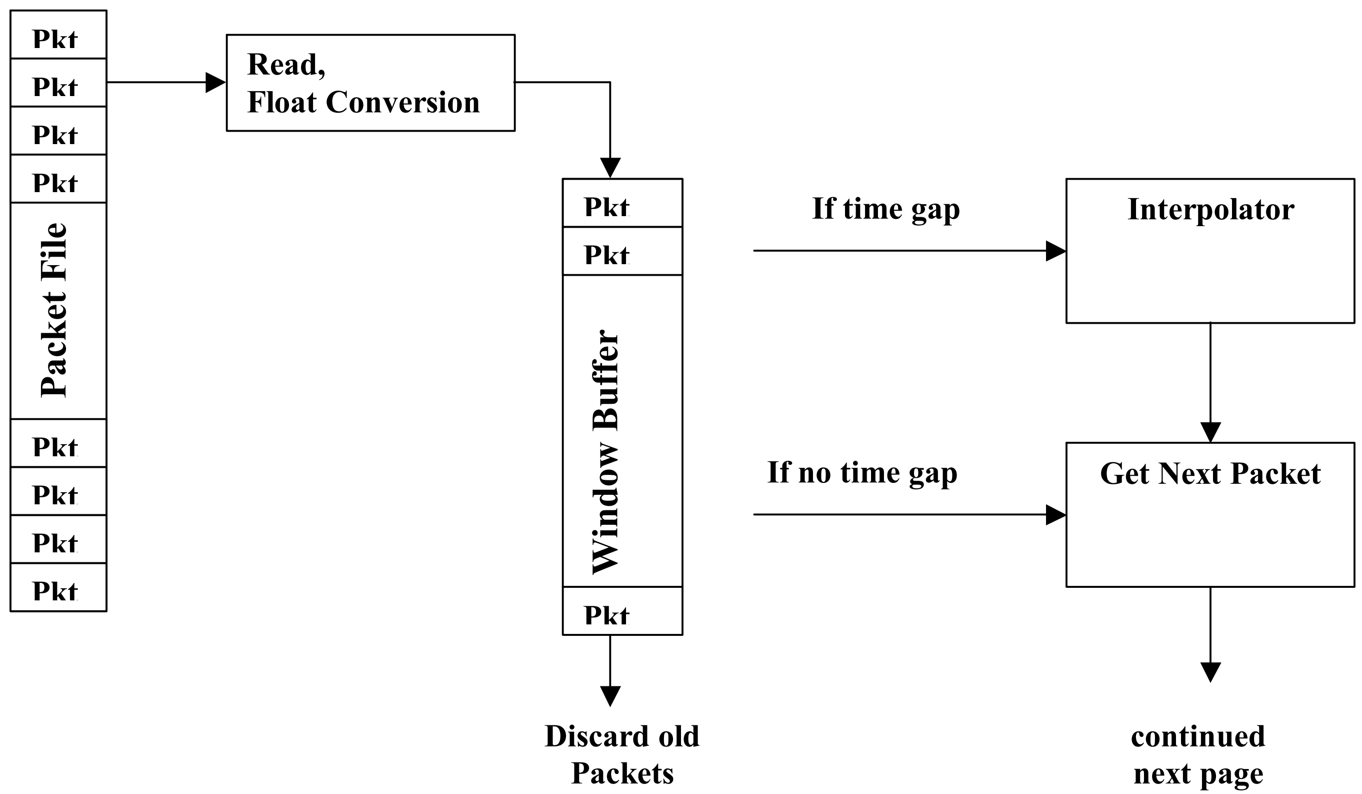
The program is invoked using the following command line format:

aqua_main --keyword1 value1 –keyword2 value2...

All keyword-value pairs are optional. Appendix-A describes the options. If the -configfile keyword and value are not present, ./localdata/configfile is assumed. The configfile may be empty or non-existent.

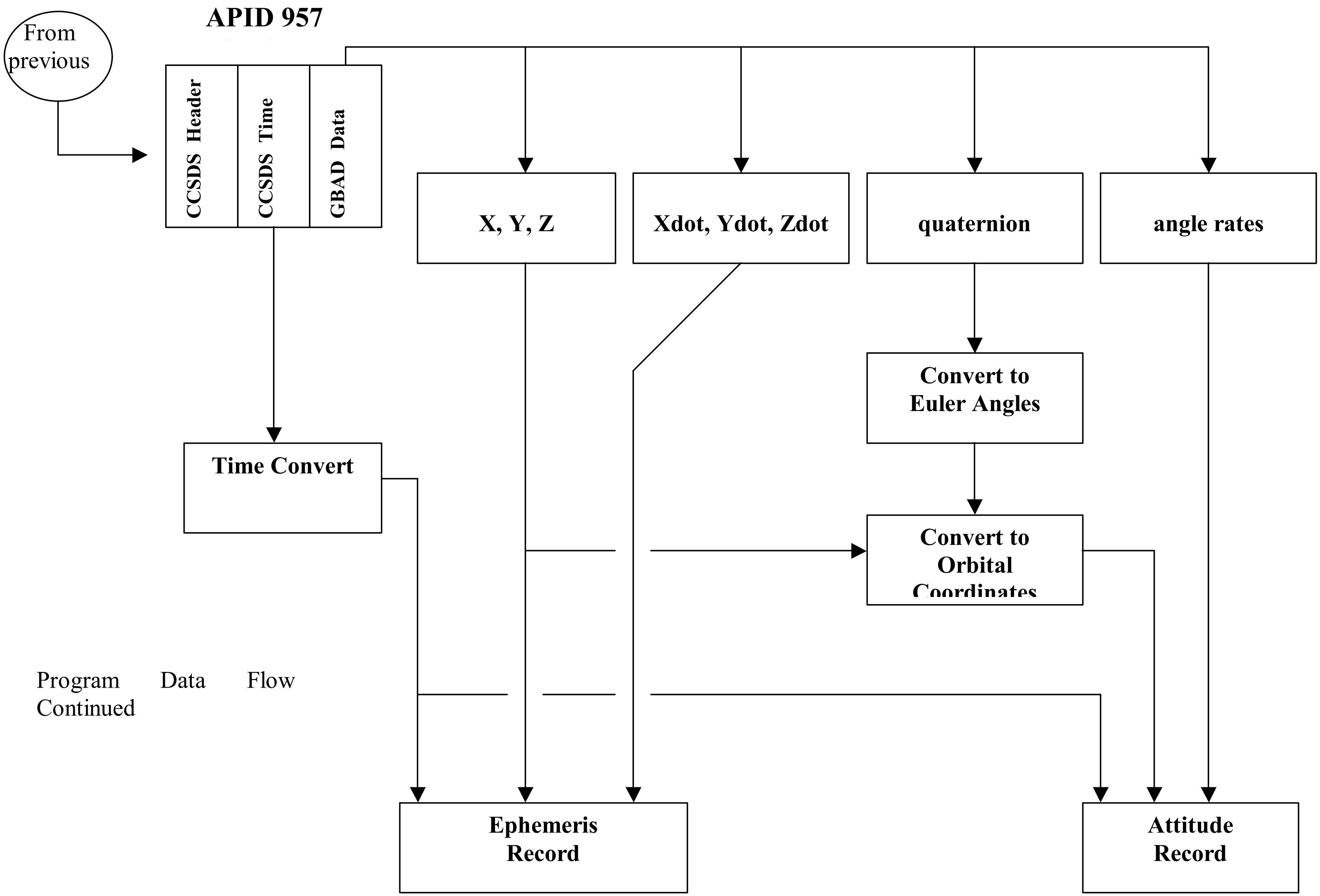


Program Input and Output Overview

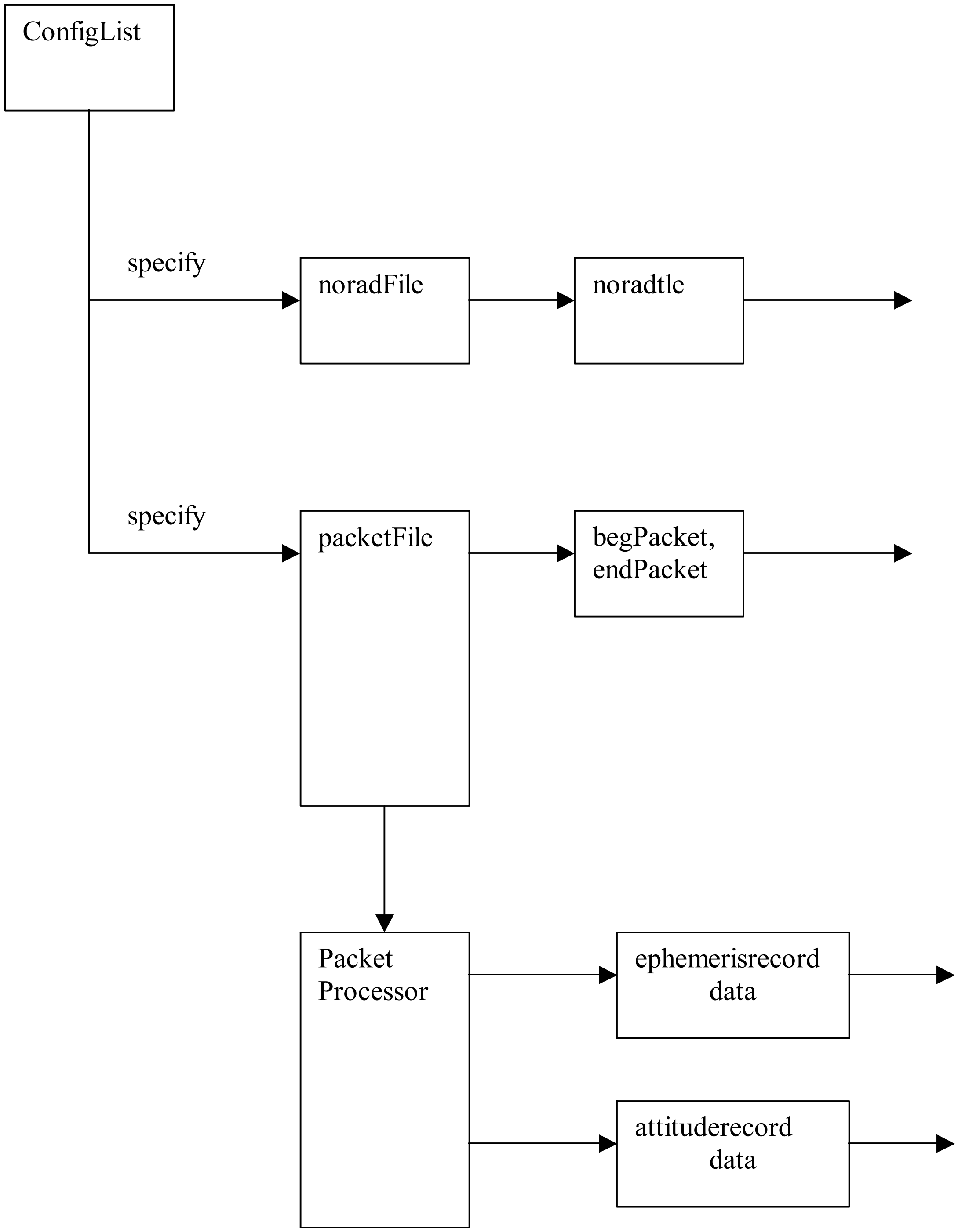


Program Data Flow

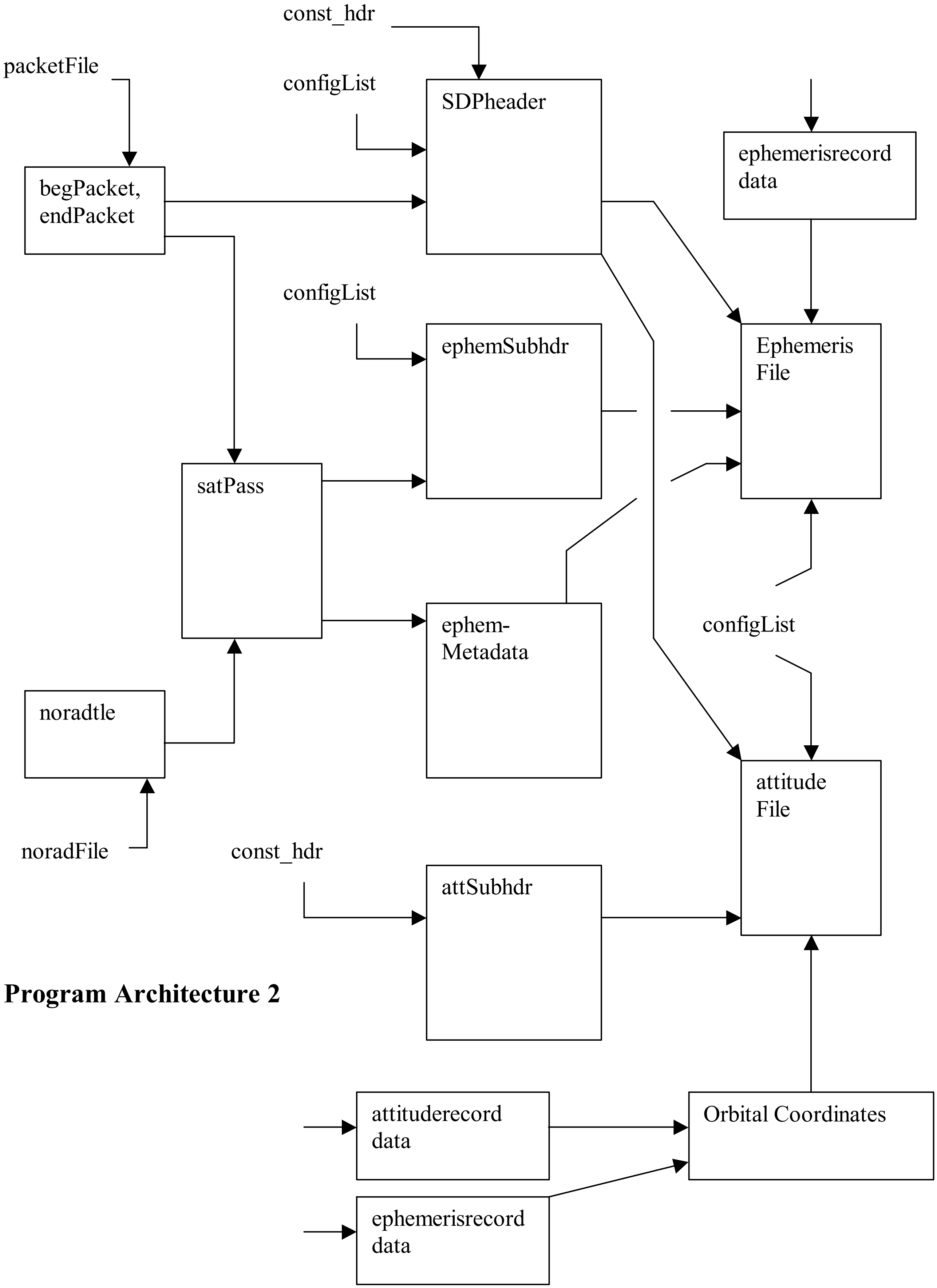
Packets are read from file into a sliding window buffer containing several packets. Small time gaps are filled by initializing interpolators with window buffer packets and creating interpolated packets.



Program Data Flow Continued



Program Architecture 1



Program Architecture 2

Program Description

CCSDS APID 957 or 967 Packets are read from the packet file. The packet file may contain other APID packets, and duplicate packets are permitted, but packets must be in time order and be complete. Each packet is stored internally as an instantiated gbadpacket object.

When a packet is read, time is converted from CCSDS CUC format to floating point TAI Julian Days since 1958, the Earth centered inertial x,y,z coordinates and velocities are converted from MIL1750 floating point format to IEEE 754 floating point meters and meters/sec, the attitude rates are converted from MIL1750 floating point format to IEEE 754 floating point radians/sec, and the quaternion components are also converted to IEEE floating point format. Appendix A contains more information on the input packet format.

Packets are stored internally in a 7-packet FIFO buffer. Packets are added at one end of the FIFO and removed from the other, they pass an examination point within the buffer. Generally, this point is near the middle of the buffer, but shifts to one end or the other of the FIFO at the beginning or end of the dataset.

If the time difference between the packet under examination and the previously examined packet (still in the buffer) is greater than 1 second and less than 59 seconds, a short gap is detected and the short-gap-precedes and short-gap-follows quality flags are set. The Neville interpolators (one interpolator for each parameter in the packet) are loaded. Each packet to be processed is then constructed by interpolation at advancing one-second intervals until the gap is traversed.

If the time difference between the packet under examination and the previously examined packet (still in the buffer) is greater than 59 seconds, a long gap is detected and the long-gap-precedes and long-gap-follows quality flags are set.

If there is no gap or if there is a long gap, the packet under examination is the packet used for further processing. Where there is a short gap, packets to be processed are generated by interpolation.

The time, position, and velocity vectors are read from the packet and written to the ephemeris record. When written, the time is converted to TAI93 time. Appendix F contains notes on time conversion.

The quaternion is converted to an attitude matrix and the position and velocity vectors are used to construct the orbital coordinate reference. The Euler angles are then computed in orbital coordinates and the time, angles and angle rates are written to the attitude record.

As each packet is processed, statistical and orbital information is collected to build the Ephemeris and Attitude file headers and the Ephemeris Metadata Records. The orbit revolution number and the mean motion are taken from a

NORAD file. Appendix G provides further information on the computation of metadata.

Program Installation

General

The "aqua" directory contains the complete program and is divided into the following subdirectories:

constlib	- mathematical and physical constants,
diaglib	- diagnostic programs not required for program operation,
localdata	- test data sets,
orbitlib	- orbital mechanics classes and procedures, and
timelib	- chronolgical classes and procedures.

The aqua directory and each of its subdirectories except constlib have makefiles.Each subdirectory makefile builds a library within the subdirectory. By example, orbitlib contains a library, "orbitlib.a".

Each makefile has a "clean" command to remove object files, and a "test" command for compiling test procedures. The test commands are not used in operational program compilation.

The aqua directory contains a master Makefile that can be used to build the entire program with a single command. See installation details below.

The -DMACHINE_SGI flag in the makefiles currently only effects the "aq_proc_formatconvert_x.c" procedures in the aqua directory. Machines conforming to the IEEE internal floating format (big endian) should leave this unchanged. These procedures may need to be modified and a new compiler directive added for other architectures.

The main program is "aqua_main" and is located in the aqua directory. The program currently is compiled and executed under Linux. The makefiles may have to be modified for compilation on other platforms.

The several programs in "diaglib" are not required for delivery or operation but may be helpful in development or problem isolation.

Installation Details

The aqua directory contains a master Makefile that can be used to build the entire program with a single command. To build the entire program, make the aqua directory the current directory and enter the command:

```
make –f   Makefile build
```

Messages noting that “linker input file unused because linking not done” are expected.

To remove all compiled libraries and object files, make the aqua directory the current directory and enter the command:

```
make –f  Makefile clean
```

Data Files:

The "localdata" subdirectory contains:

1. An input test GBAD APID 957 packetfile:
   P1540957AAAAAAAAAAAAAA02171132430001.PDS,

2. The Construction Record(not used by this program):
   P1540957AAAAAAAAAAAAAA02171132430000.PDS,

3. An input NORAD file providing orbit revolution information to the program:
   noradfile,

4. An input configfile providing configuration information to the program:
   configfile3,

5. A sample GBAD program output attitude file:
   attitudefile_02171132430001 ,

6. A sample output ephemeris file:
   ephemerisfile_02171132430001,

7. A small script file to run the program:
   runtest3, and

8. DPREP ephemeris and attitude files containing the time period of the packetefile:

   PM1ATTNR_00106202002160000000000
   PM1EPHND_00106202002120000000000

Program Execution

1. Edit configfile to conform to the current directory structure.

2. Rename the ephemeris and attitude sample files if they are to be retained for comparison

3. execute the "runtest3" procedure.

Appendix-A Program Configuration

Program Configuration			
Command Line			
	Keyword	**Default**	
	-configfile	"./configfile"	Path and name of input Configuration File
	-packetfile	""	overrides configuration file (see below)
	-noradfile	""	overrides configuration file (see below)
	-ephemerisfile	""	overrides configuration file (see below)
	-attitudefile	""	overrides configuration file (see below)
Configuration File			
	Keyword	**Default**	
	-version	"1.0"	Version number to appear in Ephemeris and Attitude File Headers
	-station	"GSFC"	Name of station generating dataset
	-packetfile	""	Path and name of input file containing APID 957 packets
	-noradfile	""	Path and name of input Norad Two-Line Element File
	-ephemerisfile	""	Path and name of output DPREP-format Ephemeris File
	-attitudefile	""	Path and name of output DPREP-format Attitude File
	-noradsatname	"AQUA"	Satellite name in NORAD file
	-sdpsatname	"EOSPM1"	Satellite name in Output file
	-listconfig	"no"	List program configuration
	Diagnostics not intended for normal execution:		
	-pkt_offset	"0"	packet start in input packet file
	-pkt_count	"0"	number of packets to process. all if 0.
	-diag_1	"no"	List first and last packets and Norad element set
	-diag_2	"no"	list satpasses parameters
	-diag_3	"no"	print major checkpoints in program
	-debug_1	"no"	list satpasses internal state
	-debug_2	"no"	not assigned
	-debug_3	"no"	not assigned

Sample Program Execution

Example script file to run program:

```
../aqua_main -configfile testconfigfile
```

Example configuration file "testconfigfile" listing:

```
-listconfig     yes

-ephemerisfile  ephemerisfile_0208232358001_gbad
-attitudefile   attitudefile_0208232358001_gbad
-packetfile     /home/charlie/charlie2/aqua/localdata/0208232358001_gbad.PDS
-noradfile      noradfile

-diag_1 yes
-diag_2 yes
-diag_3 yes
```

Example program execution listing:

```
GBAD AQUA 2002/08/28 13:53:31

Command Line Options---
-attitudefile
-configfile          configfilescott
-ephemerisfile
-listconfig
-noradfile
-packetfile

Config. File Options---
-attitudefile        attitudefile_0208232358001_gbad
-debug_1             no
-debug_2             no
-debug_3             no
-diag_1        yes
-diag_2        yes
-diag_3        yes
-ephemerisfile        ephemerisfile_0208232358001_gbad
-listconfig          yes
-noradfile           noradfile
-noradsatname          AQUA
-packetfile          /home/charlie/charlie2/aqua/localdata/0208232358001_gbad.PDS
```

```
-pkt_count           0
-pkt_offset          0
-sdpsatname          EOSPM1
-station             GSFC
-version             1.0


diag_1 Pkt Read Size = 126

diag_1 Beg Pkt
packet_ver. = 0
packet_APID = 957
packet_seq. = 12053
packet_size = 120
gbad_timetag   = 2452510.49882521  TAI seconds = 1408838298
gbad_position  = -6742763.31753540 815336.50650215 2002385.80149078
gbad_velocity  = 2225.10870271 851.62901446 7117.03515291
gbad_attitude  = 0.80079409 0.01138487 0.59341659 0.08034895
gbad_att_rates = 0.00001434 -0.00110473 0.00000389

diag_1 End Pkt
packet_ver. = 0
packet_APID = 957
packet_seq. = 12108
packet_size = 120
gbad_timetag   = 2452510.49946179  TAI seconds = 1408838353
gbad_position  = -6608996.79478455 860764.40935135 2390189.39572144
gbad_velocity  = 2637.78382033 799.82700890 6980.90925753
gbad_attitude  = 0.81774591 0.00907421 0.56983249 0.08062390
gbad_att_rates = -0.00010284 -0.00102253 0.00000618

diag_1 TLE
1 27424          02171.51589032 +.00001091 +00000+0 +25198-3      4
2 27424  98.1744 112.2617 0004733 106.6610 253.5118 14.57141308  6882

diag_2 SatPass[0]

Beg Orbit Rev = 1628  Time = 2452510.49882521
End Orbit Rev = 1628  Time = 2452510.49939234
Ascending  Node Time = 2452510.45751029
Descending Node Time = 2452510.49182405
Descending Longitude = 0.47292215
Keplerian  Elements  =
   7085461.44197074 0.00126639 1.71347037 3.06362032 1.32865990 11.24072664

normal termination
```

Appendix-B NORAD Two-Line Element Format

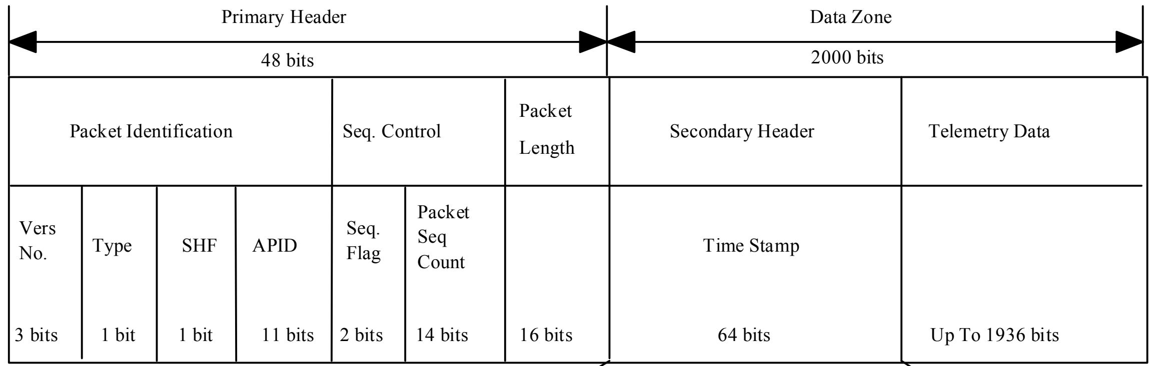
NORAD Two-Line Element Set Format				
Line 1				
Columns	**Name**	**Description**	**Units**	**Field Format**
01	LINNO	Line number of Element Data (Always 1 for Line 1)	none	X
02	blank			
03 - 07	SATNO	Satellite Number	none	XXXX
08	U	Unclassified	none	X
09	blank			
10 - 11	IDYR	International Designator (Last two digits of launch year)	Yr	XX
12 - 14	IDLNO	International Designator (Launch Number of year)	none	XXX
15 - 17	IDPNO	International Designator (Piece of Launch)	none	XXX
18	blank			
19 - 20	EPYR	Epoch Year (Last two digits of year)	Yr	XX
21 - 32	EPOCH	Epoch (Julian Day and Fractional portion of day)	Day	XXX.XXXXXXXX
33	blank			
34-43	NDOT2	First Time Derivative of Mean Motion	Rew/Day^2	+/-.XXXXXXXX
	BTERM	Ballistic Coefficient (not for SGP4)	m^2/kg	
		If NDOT2 > 1.0, then a postive value is assumed		
		without a sign.		
44	blank			
45 - 52	NDDOT 6	Second Time Derivative of Mean Motion	Rew/Day^3	+/-XXXXX-X
		Decimal point is between columns 45 and 46		
53	blank			
54 - 61	BSTAR	BSTAR drag term for SGP4		+/-XXXXX-X
	AGOM	Radiation Pressure		
		Decimal point is between columns 54 and 55		
62	blank			
63	EPHTYP	Ephemeris Type (specifies the ephemeris theory	none	X
		used to produce the elements)		
64	blank			
65 - 68	ELNO	Element Set Number for this set	none	XXXX
69	CKSUM	Check sum (modulo 10)	none	X
		Letters, blanks, periods = 0, minus sign(-) = 1.		

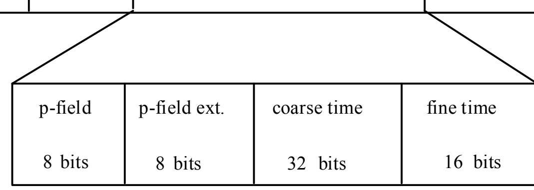
Line 2				
Columns	**Name**	**Description**	**Units**	**Field Format**
1	LINNO	Line number of element data (Always 2 for line 2)	none	X
2	blank			
03 - 07	SATNO	Satellite Number	none	XXXXX
08	blank			
09 -16	II	Inclination	degrees	XXX.XXXX
17	blank			
18 - 25	NODE	Right Ascension of the Ascending Node	degrees	XXX.XXXX
26	blank			
27 - 33	EE	Eccentricity	none	XXXXXXX
				Decimal point assumed before first digit
34	blank			
35 - 42	OMEGA	Argument of Perigee	degrees	XXX.XXXX
43	blank			
44-51	MM	Mean Anomaly	degrees	XXX.XXXX
52	blank			
53 - 63	NN	Mean Motion	Rev/Day	XX.XXXXXXXX
64 - 68	REVNO	Revolution Number at Epoch	Revolutions	XXXXX
69	CKSUM	Check sum (modulo 10)	none	X
		Letters, blanks, periods = 0, minus sign(-) = 1.		

NORAD Two-Line Element File Example

```
NOAA 9
1 15427U 84123A   01211.84279783 -.00000149  00000-0 -55248-4 0  9949
2 15427  98.7392 283.4447 0015627  43.6782 316.5626 14.14550910857865
NOAA 10
1 16969U 86073A   01212.00697873  .00000253  00000-0  12374-3 0  9733
2 16969  98.6806 198.9831 0011920 304.2643  55.7408 14.26328381772973
NOAA 11
1 19531U 88089A   01211.98694920  .00000124  00000-0  89035-4 0  8102
2 19531  98.9579 283.7702 0012285  15.7924 344.3629 14.13966730662570
NOAA 12
1 21263U 91032A   01212.00826423  .00000203  00000-0  10701-3 0  2608
2 21263  98.5739 203.2154 0011892 231.9861 128.0246 14.24068257530409
NOAA 14
1 23455U 94089A   01211.95370575  .00000222  00000-0  14500-3 0  8342
2 23455  99.1808 205.5436 0010040  27.2849 332.8848 14.12727981339315
NOAA 15
1 25338U 98030A   01211.99207961  .00000182  00000-0  98605-4 0  2984
2 25338  98.5991 238.2992 0010711 163.7909 196.3615 14.23618490167029
NOAA 16
1 26536U 00055A   01211.54355615  .00000439  00000-0  26728-3 0  4260
2 26536  98.8277 156.5400 0011482 109.5197 250.7604 14.11204367 44016
```

Appendix-C GBAD Packet Format





Notes:
1. Version # = 000
2. Type = 0
3. Secondary Header Flag = 1
4 APID = Allocated in Appendix B, Tables B-2.
5. Sequence Flag = 11 (Unsegmented)
6. Packet Sequence Count = Monotonically increasing number. The Sequence Count of the first packet following a controller power-up shall be zero (0).
7. Packet Length = Total number of octets in the Data Zone minus 1.
8. Secondary Header: Contains the time that the telemetry data in the packet was collected. The time tag shall be in CCSDS Unsegmented time code (CUC) where:
   p-field: bit 0 = 1, second octet is present
      bits 1-3 = 010 = Epoch time = Jan. 1, 1958
      bits 4-5 = 11 = 4 octets coarse time present
      bits 6-7 = 10 = 2 octets fine time present
   p-field extension bit 0 = 0 = no extension is present
      bits 1-7 = Number of Leap Seconds to convert TAI to UTC (Not used in EDOS processing.)
   T-field: Coarse time: bits 0-31 = no. of secs since Jan 1, 1958
   T-field: Fine time: bits 0-15 = Sub-seconds (LSB = 15.2 microseconds)
9. Telemetry Data Field: Contains up to 242 octets of data. When an odd number of data octets have been collected, a single fill octet of all zeros shall be appended to the data to force the packet to end on a 16-bit boundary.

	Packet Lengths					
	CCSDS Headers					**Total**
	Primary	**Secondary**	**Telemetry**	**Length Entry**		**Packet Size**
				(in data packets)		**(bytes)**
Aqua	6	8	112	8 + 112 - 1 = 119		126

Aqua Telemetry Data

Description	Notes	Resolution[1]	Units	Sampling Time[2]
Spacecraft Position(X, Y, Z)	The estimated spacecraft position, calculated using the hi-fidelity interpolation routine, of the spacecraft, expressed in the Earth Centered Inertial frame. (sc_position_eci)	DPFP	Meters	1 Second
Spacecraft Velocity (X, Y, Z)	The estimated spacecraft velocity, calculated using the hi-fidelity interpolation routine, of the spacecraft, expressed in the Earth Centered Inertial frame. (sc_velocity_eci)	DPFP	Meters/sec	1 Second
Attitude Quaternion (1, 2, 3, 4)	The estimated Earth Centered Inertial to Spacecraft Body frame attitude quaternion of the spacecraft. (ap_q_eci2body)	DPFP	none	1 Second
Attitude Body Rates (X, Y, Z)	The estimated attitude rates of the spacecraft, expressed in the Spacecraft Body frame. (body_rates)	SPFP	Rad/sec	1 Second
IRU Data Words (1-7)	word 1 – SIRU remote terminal status word word 2 – SIRU data valid word word 3 – gyro A integrated angle word 4 – gyro B integrated angle word 5 – gyro C integrated angle word 6 – gyro D integrated angle word 7 – gyro integration period (IRU_data_count)	bit-packed bit-packed integer integer integer integer integer	none none counts counts counts counts counts	1 Second
Status Word 3	Enable, on/off and direction bits of the magnetic torquer coils used for spacecraft momentum unloading (Status Word 3)	bit-packed	none	1 Second
Three-axis Magnetometer (primary X, Y, Z) (redundant X, Y, Z)	The raw measurement of the local magnetic field in TAM coordinates. (TAMcountsP, TAMcountsR)	Integer	counts	1 Second
Attitude Body Rates Time Tag	The absolute time tag associated with the IRU data and associated body rate (body_rate_time)	DPFP	Seconds	1 Second

Notes: 1) Denotes whether data is bit-packed, or expressed in integer format, Double Precision Floating-Point (DPFP) or Single Precision Floating Point (SPFP).

2) Time reference specifies the frequency at which the data is downlinked to the ground system.

3) The Attitude Body Rate Time Tag consists of two fields: the integer second and the fractional second fields. The units for both fields are seconds and both are 48 bit double precision floats. The two fields need to be added to obtain the total elapsed time. The time tags are not quantized with a scale factor and an LSB. A 48 bit double precision word consists of 1 sign bit, 8 exponent bits, and 39 fraction bits, ranging from ~$1.1e^{-38}$ to ~$3.4e^{38}$.

Aqua Telemetry Data (expanded)

Spacecraft Position			Spacecraft Velocity			Attitude Quaternion			
X	Y	Z	X	Y	Z	1	2	3	4
48 bits	48 bits	48 bits	48 bits	48 bits	48 bits	48 bits	48 bits	48 bits	48 bits

Attitude Body Rates			IRU Data						
X	Y	Z	1	2	3	4	5	6	7
32 bits	32 bits	32 bits	16 bits	16 bits	16 bits	16 bits	16 bits	16 bits	16 bits

TDE Cmds	Three-axis Magnetometer						Time Tag (IRU Body Rates)	
	P_X	P_Y	P_Z	R_X	R_Y	R_Z	Coarse	Fine
16 bits	16 bits	16 bits	16 bits	16 bits	16 bits	16 bits	48 bits	48 bits

NOTE: P = Prime
R = Redundant

MIL-STD-1750A

Floating Point Data

Floating point data shall be represented as a 32-bit quantity consisting of a 24-bit 2's complement mantissa and an 8-bit 2's complement exponent.

```
MSB                               LSB MSB             LSB
------------------------------------------------------
|S|                   Mantissa        |  Exponent        |
------------------------------------------------------
 0 1                                23 24              31
```

Floating point numbers are represented as a fractional mantissa times 2 raised to the power of the exponent. All floating point numbers are assumed normalized or floating point zero at the beginning of a floating point operation and the results of all floating point operations are normalized (a normalized floating point number has the sign of the mantissa and the next bit of opposite value) or floating point zero. A floating point zero is defined as $0000\ 0000_{16}$, that is, a zero mantissa and a zero exponent (00_{16}). An extended floating point zero is defined as $0000\ 0000\ 0000_{16}$, that is, a zero mantissa and a zero exponent. Some examples of the machine representation for 32-bit floating point numbers are shown in Table III.

Table III. 32-Bit Floating Point Numbers

Decimal Number	Hexadecimal Notation
	Mantissa Exp
0.9999998×2^{127}	7FFF FF FF
0.5×2^{127}	4000 00 7F
0.625×2^{4}	5000 00 04
0.5×2^{1}	4000 00 01
0.5×2^{0}	4000 00 00
0.5×2^{-1}	4000 00 FF
0.5×2^{-128}	4000 00 80
0.0×2^{0}	0000 00 00
-1.0×2^{0}	8000 00 00
$-0.5000001 \times 2^{-128}$	BFFF FF 80
-0.7500001×2^{4}	9FFF FF 04

Extended Precision Floating Point Data

Extended floating point data shall be represented as a 48-bit quantity consisting of a 40-bit 2's complement mantissa and an 8-bit 2's complement exponent. The exponent bits 24 to 31 lay between the split mantissa bits 0 to 23 and bits 32 to 47. The most significant bit of the mantissa is the sign bit 0, and the least significant bit of the mantissa is bit 47.

```
 ---------------------------------------------------
 | |       Mantissa         |         |   Mantissa       |
 |S|          MS            |Exponent|      LS          |
 ---------------------------------------------------
  0 1                    23 24     31 32            47
```

Some examples of the machine representation of 48-bit extended floating point numbers are shown in Table IV.

Table IV. 48-Bit Extended Floating Point Numbers

Decimal Number	Mantissa (MS)	Exp	Mantissa (LS)
0.5×2^{127}	400000	7F	0000
0.5×2^{0}	400000	00	0000
0.5×2^{-1}	400000	FF	0000
0.5×2^{-128}	400000	80	0000
-1.5×2^{127}	800000	7F	0000
-1.0×2^{0}	800000	00	0000
-1.0×2^{-1}	800000	FF	0000
-1.0×2^{-128}	800000	80	0000
0.0×2^{0}	000000	00	0000
-0.75×2^{-1}	A00000	FF	0000

Sample APID 957 Packet Figure A

CCSDS Header | Coarse Time | Fine Time | X Pos

0b bd c5 4100 77 ae 00 51 c4 75 16 80 1f 53 39 83 15 c1 a9

Y Pos | Z Pos | X Vel | Y Vel

b4 21 6d 17 43 86 b6 0b 59 17 bd 79 aa 09 8a 0c d1 7f 45 e3

Z Vel | Q1 | Q2

31 0d 3b c3 ac 3b 51 0d ef fb 98 4e 4d ff 86 04 61 bb 97 ff

Q3 | Q4 | Rate 1 | Rate 2

5e 21 5d 1d 02 00 c0 c5 66 b8 68 ff 01 ad 51 c4 75 1f 16 00

Rate 3

40 0e a6 00 e6 21 24 86 90 3d 0c f2 b8 17 60 f7 71 a4 14 ef

58 00 bc 00 aa a9 81 a2 3c 3b 98 31 26 32 06 3b 06 55 09 20

08 00 08 00 08 00

Sample APID 957 Packet Figure B

0b bd c5 41 00 77 ae 00 51 c4 75 16 80 1f 53 39 83 15 c1 a9

b4 21 6d 17 43 86 b6 0b 59 17 bd 79 aa 09 8a 0c d1 7f 45 e3

31 0d 3b c3 ac 3b 51 0d ef fb 98 4e 4d ff 86 04 61 bb 97 ff

5e 21 5d 1d 02 00 c0 c5 66 b8 68 ff 01 ad 51 c4 75 1f 16 00

40 0e a6 00 e6 21 24 86 90 3d 0c f2 b8 17 60 f7 71 a4 14 ef

58 00 bc 00 aa a9 81 a2 3c 3b 98 31 26 32 06 3b 06 55 09 20

08 00 08 00 08 00 0b bd c5 42 00 77 ae 00 51 c4 75 17 80 1f

53 0e 85 15 77 9e b4 32 e8 17 da 4e b5 f6 6b 17 4c b5 a9 fd

4e 0c 10 e9 45 f9 84 0d 27 4c ac 51 28 0d f3 07 98 66 7d ff

0d 47 61 ac b8 ff c6 88 5d 24 3f 00 d2 44 66 c4 b3 ff 48 2b

51 c4 75 1f 17 00 40 0e a6 00 e6 21 24 86 8c eb 26 f2 b9 59

60 f7 a6 d6 d8 ed 58 00 bc 00 a9 f6 76 15 48 67 98 37 63 3c

06 35 06 52 09 1d 08 00 08 00 08 00 0b bd c5 43 00 77 ae 00

51 c4 75 18 80 1f 52 e3 81 15 10 c9 b4 44 6a 17 05 2b b5 e1

82 17 52 75 a9 f1 17 0c a9 f3 46 0f d1 0d e3 0d ac 67 06 0d

19 9f 98 7e 93 ff 0d f4 61 9d d5 ff 3a 1d 5d 2b 77 00 7f 42

66 d0 f1 ff c3 af 51 c4 75 1f 18 00 40 0e a6 00 e6 21 24 86

84 09 2c f1 b7 03 a3 f7 51 c6 65 f1 58 00 bc 00 a9 42 6a 99

54 92 98 3f a0 44 06 37 06 52 09 1e 08 00 08 00 08 00 0b bd

c5 44 00 77 ae 00 51 c4 75 19 80 1f 52 b8 76 15 90 57 b4 55

CCSDS Time Code Conversion Example
(See Apppendix F)

Decode CCSDS Time Field from the packet header:

AE 20 51 E8 B6 A6 80 1F

The CCSDS Time Field is divided this way:

```
08-bit p-field     = AE
08-bit p-extension = 20
32-bit coarse time = 51 E8 B6 A6    (TAI seconds from 01 Jan 1958)
16-bit fine   time = 80 1F
```

The p-field is not used directly in time computation but is included here for completeness:

```
     01234567 bit
AE = 10101110

bit  0   = 1        p-field extension is present
bits 1-3 = 010      Epoch time is 01 Jan 1958
bits 4-5 = 11       4 bytes of coarse time present
bits 6-7 = 10       2 bytes of fine time present
```

The p-field extension is also included here only for completeness:

```
     01234567 bit
20 = 00100000

bit  0   = 0        no extension is present
bits 1-7 = 0100000  leap seconds to convert TAI to UTC (not used for
EDOS)
```

The coarse time is the number of seconds since 01 Jan 1958:

51 E8 B6 A6 (hex) = 1374205606 seconds.

The fine time contains the sub-second. The Least significant bit is 15.2 micro seconds:

80 1F (hex) = 32799 * 15.2e-06 = 0.4985448 seconds.

The total number of seconds since 01 Jan 1958 is therefore

1374205606.4985448 seconds, or
1374205606.4985448 / (86400 secs/day) = 15905.1574826 TAI days.

Appendix-D Ephemeris File Format

Ephemeris File Overview

Record Type	Record Declaration	Number of Records
Ephemeris Header	PGSt_ephemHeader	1
Universal References	char parentUR[256]	nURs (found in header record)
Ephemeris Records	PGSt_ephemRecord	nRecords (found in header record)
Orbit Metadata	PGSt_ephemMetadata	nOrbits (found in header record)

Ephemeris Header

// Type	Name	Meaning
char	spacecraftID[24];	// Spacecraft Name
char	asciiTimeRange[48];	// Start stop times to nearest hour or better, in ASCII[11]
char	source[32];	// Source of the data[12]
char	version[8];	// Version number (default = 1)
PGSt_double	startTime;	// Ephemeris dataset start time, secTAI93
PGSt_double	endTime;	// Ephemeris dataset end time, secTAI93
PGSt_real	interval;	// Expected interval between records, SI seconds[13]
PGSt_uinteger	nURs;	// Number of input dataset universal references
PGSt_uinteger	nRecords;	// Number of ephemeris records
PGSt_uinteger	nOrbits;	// Number of orbits spanned, including fragments
PGSt_uinteger	orbitNumberStart;	//Number of first orbit or part orbit in file
PGSt_uinteger	orbitNumberEnd;	//Number of last orbit or part orbit in file
char	keplerRefFrame[8];	// Reference Frame: e.g. "TOD", "TOR" or "J2000" of the Keplerian Elements[14]
PGSt_double	keplerElements[6];	// Osculating Keplerian elements at epoch [14]
PGSt_double	keplerEpochTAI;	// TAI 93 Epoch of the Reference Frame[14,15]
PGSt_real	qaParameters[16]	// Ephemeris data quality processing parameters
PGSt_real	qaStatistics[4];	// Quality assurance statistics
char	spare[216];	// Pad to 512 bytes

13 This is the normal interval as in the original data stream, not accounting for data gaps, clock error, etc.
14 These three fields are not required to be populated - but if one is, all three should be
15 *If the reference frame is B1950 or J2000, this field can be unpopulated. If it is "TOD" or "TOR" the value should be supplied, since the last Keplerian element itself is the time at which they osculate to the orbit, while the reference frame may be defined at a somewhat different tim*e. Note that this reference frame applies only to the elements of orbit only; the actual ephemeris is converted to J2000 by DPREP. The elements give only a thumbnail view of the orbit, so the actual ephemeris data should be used when accuracy is required.

Ephemeris Record Format

// Type	Name	Meaning
PGSt_double	SecTAI93;	// Date and time as seconds from 1-1-93, secTAI93
PGSt_double	Position[3];	// X component of position vector, meters
PGSt_double	Velocity[3];	// X component of velocity vector, meters/sec
PGSt_uinteger	QualityFlag;	// Ephemeris data quality flag.
char	spare[4];	// Pad structure to 64 bytes

Ephemeris Metadata Format

// Type	Name	Meaning
PGSt_uinteger	orbitNumber;	// Orbit number, from beginning of mission
char	spare[4];	// Pad previous element to 8 bytes
PGSt_double	orbitAscendTime;	// Time of upward TOD equator crossing, secTAI93
PGSt_double	orbitDescendTime;	// Time of downward TOD equator crossing, secTAI93
PGSt_double	orbitDescendLongitude;	// Orbit down-crossing terrestrial longitude, radians

Appendix-E Attitude File Format

Attitude File Overview

Record Type	Record Declaration	Number of Records
Attitude Header	PGSt_attitHeader	1
Universal References	char parentUR[256]	nURs (found in header record)
Attitude Records	PGSt_attitRecord	nRecords (found in header record)

// Type	Name	Meaning
char	spacecraftID[24];	// Spacecraft Name
char	asciiTimeRange[48];	// Start and stop times to nearest hour or better, in ASCII[11]
char	source[32];	// Source of the attitude data[12, 16]
char	version[8];	// Version number (default = 1)
PGSt_double	startTime;	// Attitude dataset start time, secTAI93
PGSt_double	endTime;	// Attitude dataset end time, secTAI93
PGSt_real	interval;	// Expected Interval between records, SI second[13]
PGSt_uinteger	nURs;	// Number of input dataset universal references.
PGSt_uinteger	nRecords;	// Number of attitude records
PGSt_uinteger	eulerAngleOrder[3];	// Order of rotations as a permutation of 1=x,2=y,3=z
PGSt_real	qaParameters[16];	// Attitude data quality processing parameters
PGSt_real	qaStatistics[4];	// Quality assurance statistics
char	spare[280];	// Pad structure to 512 bytes[1]

Attitude File Header

Attitude File Record Format

// Type	Name	Meaning
PGSt_double	secTAI93;	// Date and time as seconds from 1-1-93, secTAI93
PGSt_double	eulerAngle[3]	// Euler angle, radians
PGSt_double	angularVelocity[3]	// Angular rate about body, radians/s
PGSt_uinteger	qualityFlag;	// Attitude data quality flag
char	spare[4];	// Pad structure to 64 bytes[16]

Appendix F – Notes on Time conversion
(See earlier CCSDS Time Code Conversion Example)

The APID 957 telemetry downlink packets are time-tagged using the CCSDS CUC format (See Appendix C). The GBAD program stores input packet data in gbadpacket objects (See Program Description). Gbadpacket objects return time as TAI days:

$$T_{tai} = (Coarse\_time + Fine\_time * 15.2e\text{-}6) / 86400.0 + 2436204.5$$

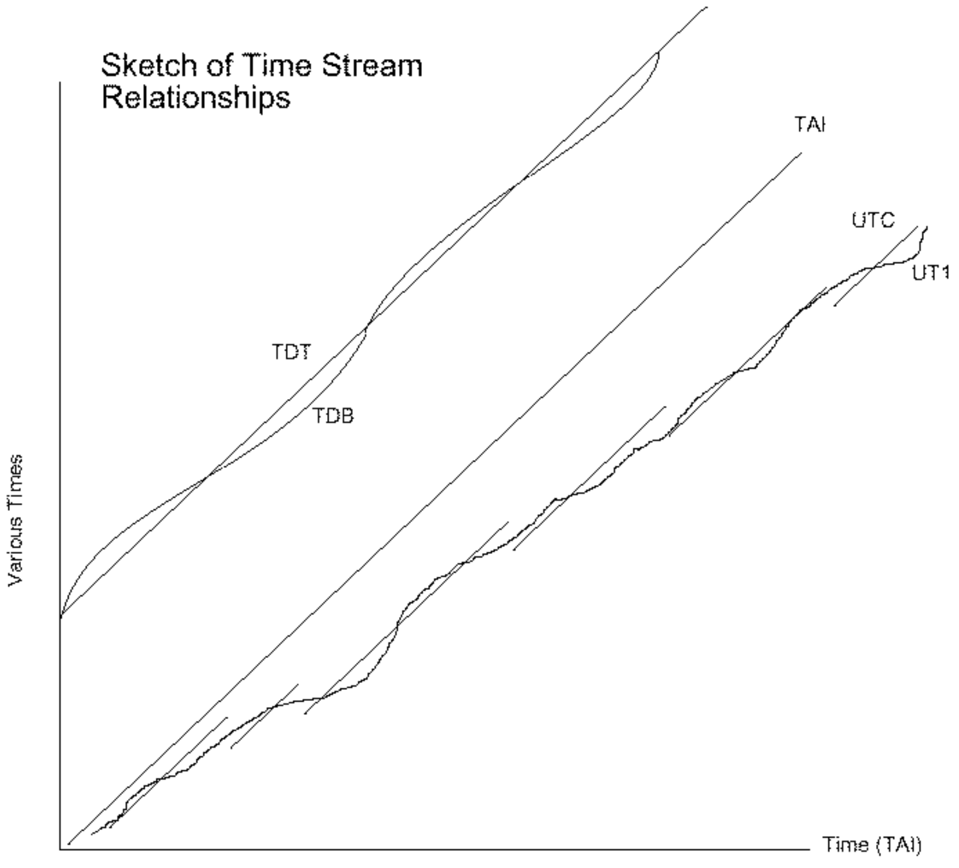
where 2436204.5 is the TAI start date.

Ephemeris Records are written from ephemeris record objects. Times are converted to seconds since 1993:

$$T_{ephemeris} = (T_{tai} - 2448988.5003125) * 86400$$

where 2448988.5003125 is 01 January 1993 JD. A quadratic approximation to the difference between UTC and TAI times is used to convert between these times. This is conversion is required for computations involving the epoch time for the NORAD Two Line Element sets. NORAD Epoch days begin at midnight UTC. By example 98001.00000000 corresponds to 0000UT on 01 Jan 1998. See "Satellite Times, Frequently Asked questions: Two-Line Element Set Format, Dr. T.S. Kelso, www.celestrak.com.

The following summary notes and the two figures are largely from 445-TP-002-002 "Theoretical Basis of the SDP Toolkit Geolocation Package for the ECS Project", May 1995, "Section 4.0 Time Streams and Time Transformations".



From “Theoretical Basis of the SDP Toolkit Geolocation Package”

Some useful time constants:

TAI time begins 01 Jan 1958

= TAI second 0
= 2436204.5 JD UTC (GTDS, 3.5.1)

DPREP start time 01 Jan 1993

= 2448988.5 JD UTC
= 2448988.5003125 JD TAI (SDPTK, 4.81)

= 12784.0003125 Days TAI
= 1104537627 seconds TAI

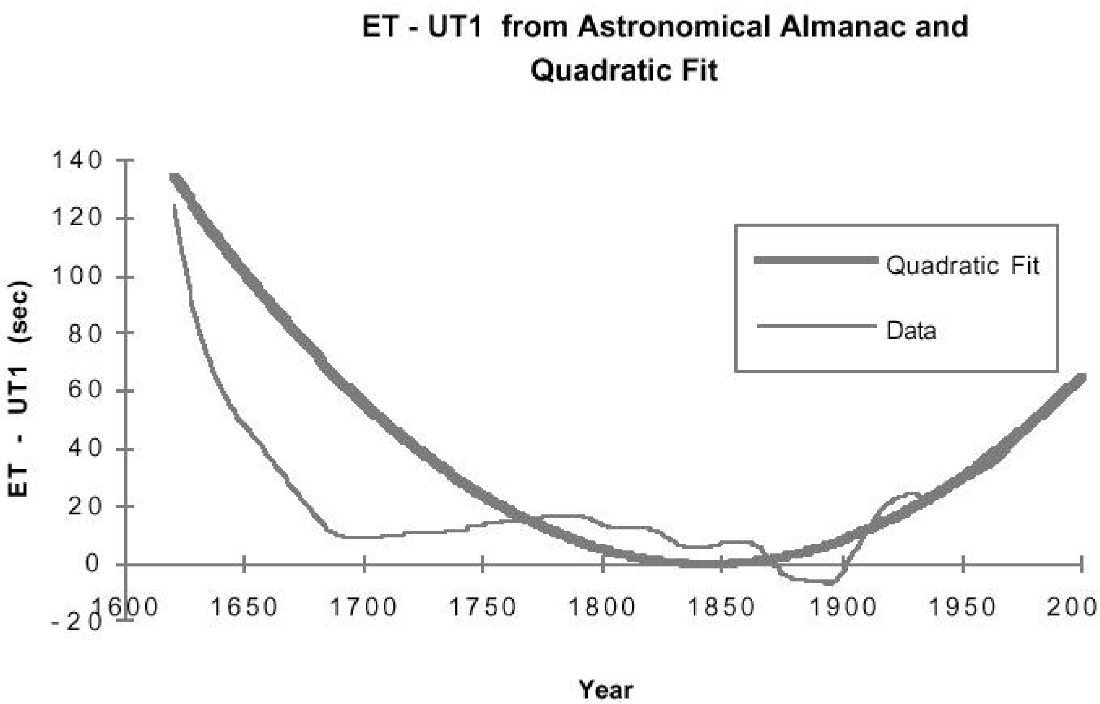
TDT = TAI + 32.184 seconds
|TDT – TDB| < 0.0017 seconds (TDB was formerly ET)

|UT1 – UTC| < 0.9 seconds

$$ET - UT1 \sim \frac{1}{2}(0.537)\frac{(year - 1844)^2}{100} = f(year)$$

$$TAI \sim UT1 + f(year) - 32.184\,\text{sec}$$
$$UT1 \sim TAI - f(year) + 32.184\,\text{sec}$$

$$year = 365.25\,days$$



The above may be rewritten as:

$$year = 365.25\,days$$
$$\Delta F(days) = f(year / 365.25) - 32.184\,\text{sec}$$

$$TAI \sim UT1 + \Delta F(days)$$
$$UT1 \sim TAI - \Delta F(days)$$

For 01 Jan 1958:

$\Delta F(2436204.5) = 2.714260$ seconds. The correct value is 0.

For 01 Jan 1993:

$\Delta F(2448988.5) = 27.4302326604$ seconds = 0.0003174795 days.

The correct value is 27 seconds or 0.0003125 days.

Either UTC or TAI days may be used as the independent variable with negligable difference in the computed delta.

Appendix G – Notes on Ephemeris Metadata Records

The Ephemeris Metadata Records, are not used directly for geolocation but are generated only for compatibility with the DAAC. The methods here are approximate.

The orbital parameters required for writing the Ephemeris Metadata records are largely computed from the NORAD Two Line Element Set. The mean elements in a Two Line Element set are not identical to the true or osculating elements. However, for a nearly circular orbit, they are, with the exception of the mean anomaly and the argument of perigee, close to the true values.

The disparity between the mean and osculating anomaly and perigee can be sidestepped by noting that the sum of the mean anomaly and perigee is nearly equal to the sum of the osculating elements.

The following are read from the Two Line Element Set:

$\mathrm{Re}\,v$, the revolution number at Epoch

$\dot{M}$, the mean motion (rad/day),

N, the Right Ascension of the ascending node (rad),

ω, the argument of perigee (rad),

M, the mean anomaly (rad), and

T_e, the epoch day, UTC.

The TAI epoch time, T_{tai} is computed from T_e (See Appendix F), and the orbit begin time, T_{beg}, and the orbit end time, T_{end}, are obtained from the first and last packets in the orbit.

$$T_{tai} = T_e + \Delta F(T_e).$$

The ascending node time of the epoch is approximately:

$$T_{epasc} = T_{tai} - \left(\frac{\omega + M}{\dot{M}} \right).$$

The number of revolutions in the pass is:

$$\Delta \operatorname{Re} v = \left(T_{beg} - T_{epasc}\right)\left[\frac{\dot{M}}{2\Pi}\right],$$

and the Ascending and Descending Node times for the current orbit are:

$$T_{asc} = T_{epasc} + \Delta \operatorname{Re} v\left(\frac{2\Pi}{\dot{M}}\right), \text{ and}$$

$$T_{dsc} = T_{asc} + \left(\frac{\Pi}{\dot{M}}\right).$$

The beginning and ending orbit revolution numbers are:

$$\operatorname{Re} v_{beg} = \operatorname{Re} v + \left(T_{beg} - T_{epasc}\right)\left[\frac{\dot{M}}{2\Pi}\right], \text{ and}$$

$$\operatorname{Re} v_{end} = \operatorname{Re} v + \left(T_{end} - T_{epasc}\right)\left[\frac{\dot{M}}{2\Pi}\right].$$

The Longitude of the Descending Node is:

$$L_{dsc} = N + \Delta N - Gha\left(T_{dsc} - \Delta F\left(T_e\right)\right) + \Pi$$

Where

$$\Delta N = \dot{N}\left(T_{dsc} - T_{epasc}\right), \text{ and}$$

the angular velocity of the Right Ascension, $\dot{N}$, is ~ 0.01728 rad/day.
Gha is the Greenwich Hour Angle as a function of time.

Appendix H- **Notes** on Attitude angles

QuaternionToAttitudeMTx.c

Construct an attitude matrix **A**, from quaternion (See "Satellite Attitude Determination and Control", Wertz, section 12.1) :

A_{11} = +q1*q1 - q2*q2 - q3*q3 + q4*q4
A_{12} = 2 * (q1*q2 + q3*q4)
A_{13} = 2 * (q1*q3 - q2*q4)

A_{21} = 2 * (q1*q2 - q3*q4)
A_{22}= -q1*q1 + q2*q2 - q3*q3 + q4*q4
A_{23} = 2 * (q2*q3 + q1*q4)

A_{31} = 2 * (q1*q3 + q2*q4)
A_{32} = 2 * (q2*q3 - q1*q4)
A_{33} = -q1*q1 - q2*q2 + q3*q3 + q4*q4

q1 is the first component. q4 is the scalar component.

InertialToOrbitalMtx.c

Orbital Coordinates from position ($\vec{P}_I$) and velocity vector ($\vec{V}_I$) in inertial coordinates.

$\vec{Y}$ is negative orbit normal or $-\vec{h}$, the momentum vector.
$\vec{Z}$ is toward Earth center.
$\vec{X}$ is in the direction of $\vec{Y} \times \vec{Z}$.

$$\vec{Z} = -\frac{\vec{P}_I}{\left|\vec{P}_I\right|}$$

$$\vec{Y} = -\frac{\vec{P}_I \times \vec{V}_I}{\left|\vec{P}_I \times \vec{V}_I\right|}$$

$$\vec{X} = \frac{\vec{Y} \times \vec{Z}}{\left|\vec{Y} \times \vec{Z}\right|}$$

Then the rotation from orbital to inertial coordinates is (see Wertz, section 12.1):

$$R = \begin{bmatrix} x_1 & x_2 & x_3 \\ y_1 & y_2 & y_3 \\ z_1 & z_2 & z_3 \end{bmatrix}$$

Euleranglesinorbitalframe.c

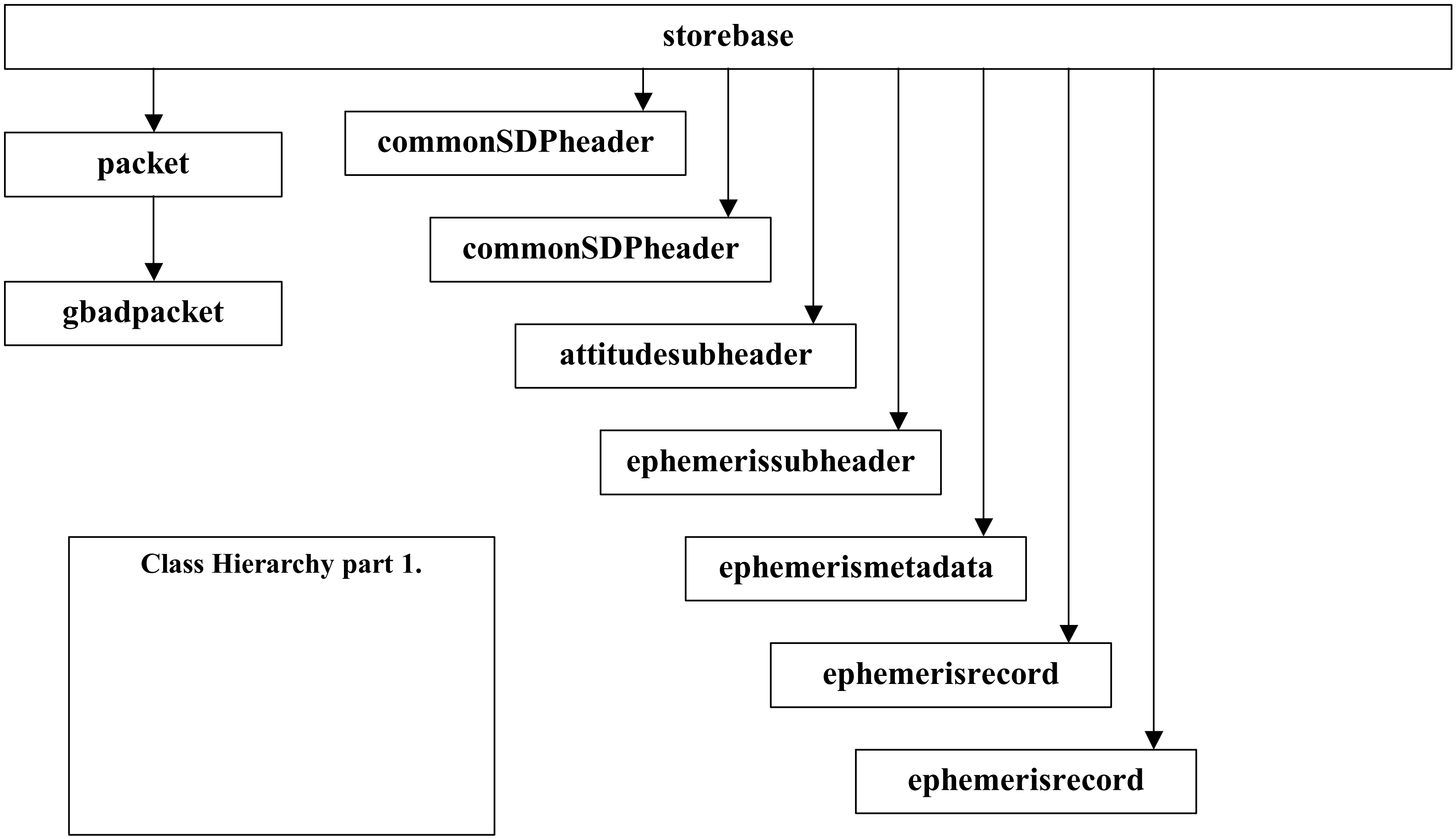
The attitude matrix in orbital coordinates is:

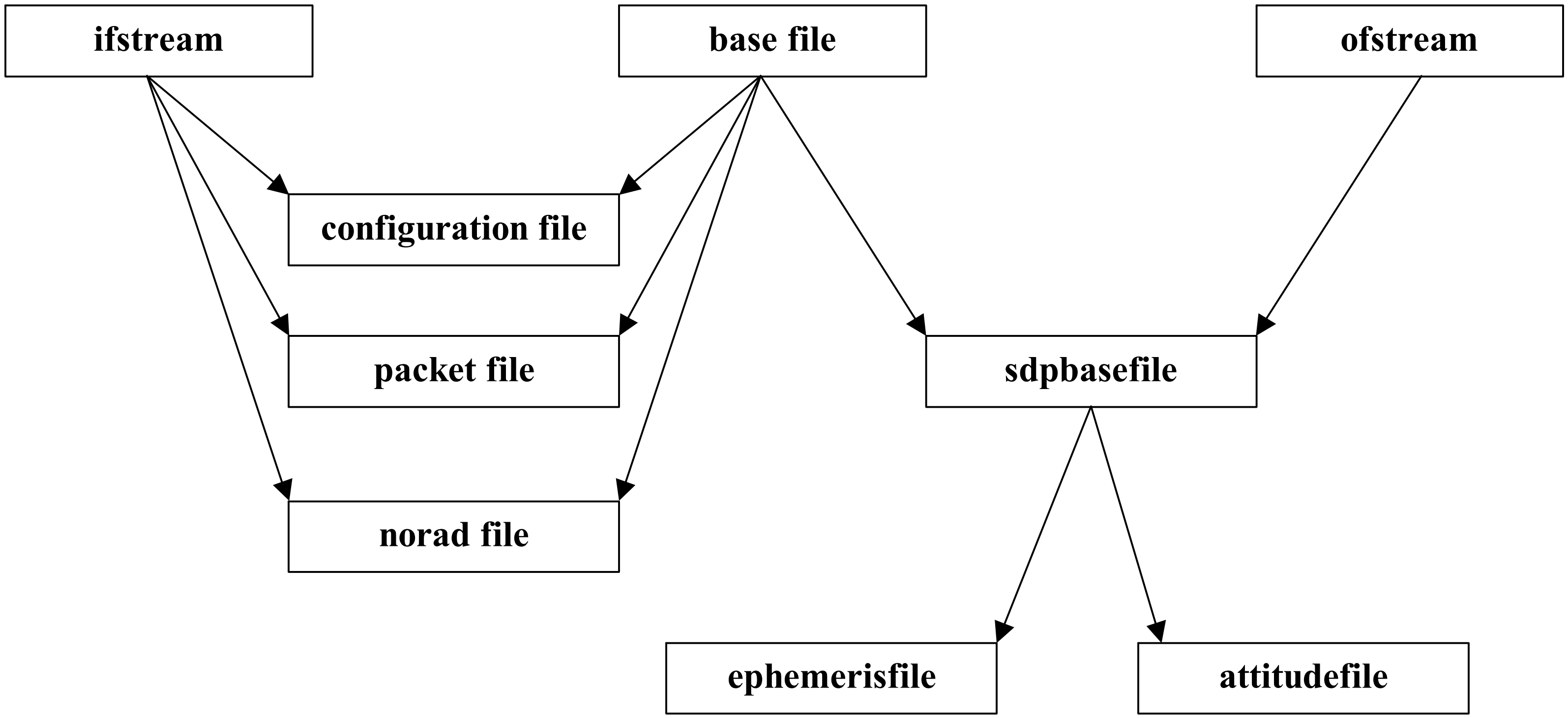
$$A' = AR^T$$

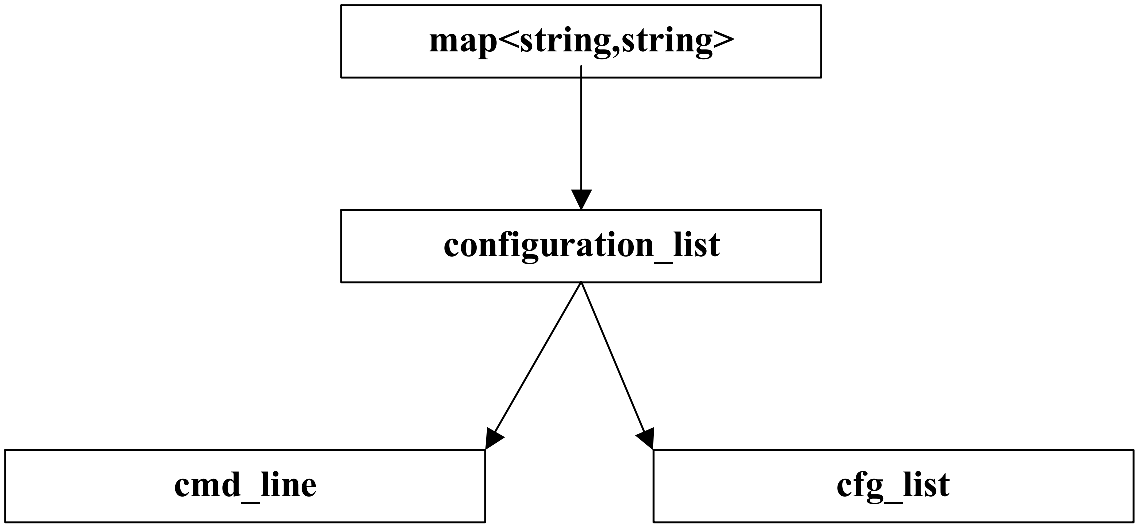
And using small angle approximations (see Wertz, section 12.2, eq. 12-24a):

$$A' \approx \begin{bmatrix} 1 & \phi & -\psi \\ -\phi & 1 & \theta \\ \psi & -\theta & 1 \end{bmatrix} = A_{312}(\phi, \theta, \psi)$$

$\phi = A'_{12}$
$\theta = A'_{23}$
$\psi = A'_{31}$


storebase
packet
gbadpacket
commonSDPheader
commonSDPheader
attitudesubheader
ephemerissubheader
ephemerismetadata
ephemerisrecord
ephemerisrecord
Class Hierarchy part 1.


ifstream
base file
ofstream
configuration file
packet file
sdpbasefile
norad file
ephemerisfile
attitudefile


map<string,string>
configuration_list
cmd_line
cfg_list

Diagnostic Programs

These programs are not required for GBAD Converter execution and resources are not allocated for their support, but they may be useful diagnostic tools.

A List of the several diagnostic program command-line formats and examples of each follows.

```
DumpAttitude   -file filename -beg [0] -cnt [all]
DumpEphemeris  -file filename -beg [0] -cnt [all]

DumpNorad      -noradfile filename  \
               -noradsatname satellite name

DumpPacket     -file file_name  -pkt [0] -sat [AQUA]

ListPackets    -file filename \
               -beg [0] -cnt [all] -sat [AQUA] \
               -check [no]

ListPktHeaders -file ../localdata/mixedpkts \
               -beg [0] -cnt [all]
```

DumpAttitude -file filename -beg [0] -cnt [all]

Command line:
DumpAttitude -file ../localdata/attitudefile_0208232358001_gbad -cnt 10

Listing
Attitude File Diagnostic
Attitude File opened: ../localdata/attitudefile_0208232358001_gbad

Spacecraft = EOSPM1
Source = GSFC
Version = 1.0
Time Range = 2002-08-23T23:57:43Z to 2002-08-23T23:58:38Z
Interval = 1.000000
No. Records= 57
No. U. Refs= 0

Angle order= 3 1 2

QA Parameters
0 +0.000000
1 +0.000000
2 +0.000000
3 +0.000000
4 +0.000000
5 +0.000000
6 +0.000000
7 +0.000000
8 +0.000000
9 +0.000000
10 +0.000000
11 +0.000000
12 +0.000000
13 +0.000000
14 +0.000000
15 +0.000000

QA Statistics
0 +0.000000
1 +0.000000
2 +0.000000
3 +0.000000

Julian-Date Angle Velocities
2452510.49882521 +0.000000 -0.000026 -0.000020 +0.000014 -0.001105 +0.000004
2452510.49883679 +0.000003 +0.000062 -0.000018 +0.000048 -0.001103 +0.000008

2452510.49884836	+0.000005	+0.000013	-0.000017	-0.000091	-0.001109	+0.000016
2452510.49885994	+0.000006	-0.000004	-0.000018	+0.000062	-0.001105	-0.000006
2452510.49887151	+0.000008	+0.000063	-0.000017	-0.000062	-0.001103	+0.000009
2452510.49888308	+0.000010	-0.000025	-0.000010	-0.000069	-0.001018	+0.000001
2452510.49889466	+0.000013	+0.000024	-0.000013	+0.000105	-0.001022	-0.000003
2452510.49890623	+0.000016	+0.000048	-0.000027	-0.000116	-0.001114	+0.000011
2452510.49891781	+0.000018	-0.000023	-0.000019	+0.000007	-0.001013	-0.000003
2452510.49892938	+0.000019	+0.000058	-0.000031	+0.000059	-0.001102	-0.000004

DumpEphemeris -file filename -beg [0] -cnt [all]

Command Line:
DumpEphemeris -file ../localdata/ephemerisfile_0208232358001_gbad -cnt 10

Listing:

```
Ephemeris File Diagnostic
Ephemeris File opened: ../localdata/ephemerisfile_0208232358001_gbad

Spacecraft = EOSPM1
Source     = GSFC
Version    = 1.0
Time Range = 2002-08-23T23:57:43Z to 2002-08-23T23:58:38Z
Interval   = 1.000000
No. Records= 57
No. U. Refs= 0

 tellg() = 140


Beg. Orbit =  1628
End  Orbit =  1628
Orbit Cnt. =     1

Ref. Frame = J2000

Keplerian Elements
7085461.441971 0.001266 1.713470 3.063620 1.328660 11.240727

 tellg() = 512

QA Parameters
 0 +0.000000
 1 +0.000000
 2 +0.000000
 3 +0.000000
 4 +0.000000
 5 +0.000000
 6 +0.000000
 7 +0.000000
 8 +0.000000
 9 +0.000000
10 +0.000000
11 +0.000000
12 +0.000000
13 +0.000000
14 +0.000000
```

15 +0.000000

QA Statistics
 0 +0.000000
 1 +0.000000
 2 +0.000000
 3 +0.000000

tellg() before Universal Refs = +512
tellg() after Universal Refs = +512

Beg Record = 0
Rec Count = 10

Julian Date, Position, Velocity QaFlag
2452510.49882521 -6742763.32 +815336.51 +2002385.80   +2225.11 +851.63 +7117.04
2452510.49883679 -6740534.18 +816187.66 +2009501.60   +2232.68 +850.71 +7114.78
2452510.49884836 -6738298.72 +817037.94 +2016615.46   +2240.26 +849.79 +7112.51
2452510.49885994 -6736054.69 +817887.25 +2023726.61   +2247.83 +848.88 +7110.23
2452510.49887151 -6733802.27 +818735.66 +2030835.59   +2255.39 +847.96 +7107.95
2452510.49888308 -6731543.44 +819583.15 +2037942.39   +2262.96 +847.04 +7105.66
2452510.49889466 -6729276.18 +820429.73 +2045046.90   +2270.52 +846.12 +7103.36
2452510.49890623 -6727002.52 +821275.40 +2052149.21   +2278.08 +845.19 +7101.05
2452510.49891781 -6724720.34 +822120.12 +2059248.99   +2285.64 +844.27 +7098.73
2452510.49892938 -6722431.76 +822963.92 +2066346.56   +2293.19 +843.35 +7096.41

tellg() after ephemeris records = 4160
  record count = 57

MetaData 1   tellg() = 4192
Orbit No. = 1628
Ascending Node Time = 2452510.45751029 TAI = 304297101.88885778
Descending Node Time = 2452510.49182405
Descending Node Long.= 0.47292215

DumpNorad -noradfile filename -noradsatname satellite name

Command Line:

DumpNorad -noradfile ../localdata/noradfile

Listing:

```
DumpNorad
-noradfile          ../localdata/noradfile
-satname             AQUA


file Dump

line1 = 1 27424U 02022A   02171.51589032  .00001091  00000-0  25198-3 0   696
line2 = 2 27424  98.1744 112.2617 0004734 106.6610 253.5118 14.57141308  6883

class Dump
1 27424           02171.51589032 +.00001091 +00000+0 +25198-3       4
2 27424  98.1744 112.2617 0004733 106.6610 253.5118 14.57141308  6882
```

DumpPacket -file ../localdata/0208232358001_gbad.PDS -pkt 0 -sat AQUA

Listing:
Packet File Diagnostic
packet number is : 0
Spacecraft name is: AQUA
Packet File opened: ../localdata/0208232358001_gbad.PDS
APID 957 packet count: 55

CCSDS Header   0b bd ef 15 00 77   (hex)

packet_ver. = 0
packet_APID = 957
packet_seq. = 12053
packet_size = 120

CCSDS Time Stamp
    ae 20 53 f9 2a 9a 80 21   (hex)
    1408838298   (TAI)
    32801 = 0.498575
    2452510.49882521   (JD)
    2002/08/23 23:58:18

Position
    99 1d 15 17 51 4a
    63 87 44 14 0d 51
    7a 37 47 15 34 ba
    -6742763.31753540 815336.50650215 2002385.80149078

Velocity
    45 88 de 0c 9f 87
    6a 74 20 0a e2 f0
    6f 34 23 0d ff 20
    2225.10870271 851.62901446 7117.03515291

Angle
    66 80 6b 00 bb 9b
    5d 43 cb fa e5 a4
    4b f5 13 00 2b 35
    52 46 ff fd 0c 9a
    0.80079409 0.01138487 0.59341659 0.08034895

Angle Rate
    78 48 74 f0
    b7 99 a5 f7
    41 37 81 ef
    0.00001434 -0.00110473 0.00000389

ListPackets -file filename -beg [0] -cnt [all] -sat [AQUA] -check [no]

Command Line:

ListPackets -file ../localdata/0208232358001_gbad.PDS -cnt 5

Listing

```
Packet File Diagnostic
-beg        0
-check      no        (check packet times)
-cnt        5
-file       ../localdata/0208232358001_gbad.PDS
-sat        AQUA

Packet File opened: ../localdata/0208232358001_gbad.PDS
APID 957 packet count: 55


0001 0957 0120 12053 2452510.498825
-6742763.317535 +815336.506502 +2002385.801491   +2225.108703 +851.629014
+7117.035153
+0.800794 +0.011385 +0.593417 +0.080349   +0.000014 -0.001105 +0.000004

0002 0957 0120 12054 2452510.498837
-6740534.179886 +816187.664339 +2009501.598793   +2232.683609 +850.712475
+7114.775288
+0.801111 +0.011367 +0.592992 +0.080319   +0.000048 -0.001103 +0.000008

0003 0957 0120 12055 2452510.498848
-6738298.718323 +817037.944073 +2016615.457855   +2240.256352 +849.794939
+7112.507303
+0.801424 +0.011310 +0.592568 +0.080344   -0.000091 -0.001109 +0.000016

0004 0957 0120 12056 2452510.498860
-6736054.691299 +817887.253954 +2023726.610870   +2247.826115 +848.876503
+7110.231446
+0.801737 +0.011261 +0.592144 +0.080356   +0.000062 -0.001105 -0.000006

0005 0957 0120 12057 2452510.498872
-6733802.266937 +818735.657890 +2030835.592575   +2255.393466 +847.957100
+7107.947543
+0.802053 +0.011238 +0.591718 +0.080335   -0.000062 -0.001103 +0.000009
```

ListPktHeaders -file ../localdata/mixedpkts -beg [0] -cnt [all]

Command Lin:e

ListPktHeaders -file ../localdata/0208232358001_gbad.PDS -cnt 5

Listing:

Packet File Diagnostic
-beg 0
-cnt 5
-file ../localdata/0208232358001_gbad.PDS

packet_ver. = 0
packet_APID = 957
packet_seq. = 12053
packet_size = 120

packet_ver. = 0
packet_APID = 957
packet_seq. = 12054
packet_size = 120

packet_ver. = 0
packet_APID = 957
packet_seq. = 12055
packet_size = 120

packet_ver. = 0
packet_APID = 957
packet_seq. = 12056
packet_size = 120

packet_ver. = 0
packet_APID = 957
packet_seq. = 12057
packet_size = 120