

## Guide to TBtool

### 1. What is TBtool?

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TBtool is a C-program developed at JPL to read Turbobinary files from SUNSAT and GPSMET and output the data in various formats. The SUNSAT data often has extra or missing bytes, and TBtool has been designed to correct these errors when possible.

### 2. How to install TBtool

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Please set up a directory for TBtool. Copy the following 6 files into this directory:

- Makefile
- TBtool.c
- TBtool.h
- configFlagTst.c
- parseCmd.c
- README
- PRN\_GPS

In this directory, type "make". If you want to uninstall TBtool, type "make clean".

The makefile of TBtool is platform-independent. This code has only been compiled under HP-UNIX.

### 3. How to run TBtool

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After your successful installation of TBtool, type "TBtool -h", you will see the following lines:

Simple reader for SUNSAT and GPSMET turbobinary data

Usage: ./TBtool -i file.trb -o output.file (other option tags)  
option: -i input file name (default is stdin)  
option: -o output file name (default is stdout)  
option: -a print the antenna state  
option: -b print low-rate binary data  
option: -C clean data (fix extra/missing byte errors where possible)  
option: -E end time filter  
option: -G print 1 Hz part of CA high-rate observation records  
option: -g print CA high-rate observation records (including 1 Hz)

option: -h this screen  
option: -I print 10s and 30s sampling records in streaming format  
option: -L print log occultation schedule records  
option: -O print the observation records in RINEX format  
option: -P print 1 Hz part of P-code high-rate observation records  
option: -p [PRN number] PRN filter  
option: -q [rcv name] print records in QM format  
option: -r PRN\_GPS file name  
option: -s print P-code high-rate observation records (including 1 Hz)  
option: -S start time filter  
option: -T print data status table  
option: -t [ca pca l1 p1 l2 p2 lc pc] data type option for QM format output  
option: -x add extra header lines from a specified file

Where:

See below for definitions of high-rate and low-rate data.

Option -i: Input file must be a pre-existing turbobinary format file

Option -o: If there is a pre-existing file with the same file name, TBtool will overwrite the file.

Option -a: Antenna state consists of antenna position and velocity based on GPS data.

Option -b: Low-rate (usually 10 or 30 second sampling) observation records are printed in hexadecimal binary format.

Option -C: TBtool will remove and repair (SUNSAT) records when possible.

Option -E: -E should be followed by integer time (GPS seconds past 6 Jan 1980 0:00 UT). Data following this epoch will not be output.

Option -G: Output 1-Hz part of CA high-rate observable records (see below).

Option -g: Output CA high-rate observable records (including 1 Hz part).

Option -h: Print this help screen.

Option -I: Output low-rate observables in streaming format.

Option -L: Output occultation schedule log records.

Option -O: Output low-rate observables in RINEX format.

Option -P: Output 1-Hz part of P-code high-rate observable records (see below).

Option -p: -p should be followed by PRN number. Output only records for specified PRN number.

Option -q: -q should be followed by receiving satellite name (MET, SUNSAT, etc.). Output records in QM format (instead of default output format). If no receiver name is provided, the receiver name is set to NONE in the qm file. QM format is often easier to read than the default high-rate output formats.

Option -r: Give the PRN\_GPS file name (including path). The default name is /goa/etc/PRN\_GPS. When option -q is selected, the PRN\_GPS file name must be provided (or use the default name). A PRN\_GPS file is supplied with the source code.

Option -s: Output P-code high-rate observable records (including 1 Hz part).

Option -S: -S should be followed by integer time (GPS seconds past 6 Jan 1980 0:00 UT). Data preceding this epoch will not be output.

Option -T: Append table of input data statistics to the output file.

Option -t: Used together with -q option to select the output types in QM file. -t should be followed by a list of the desired data types. See below. If no output type is selected, the QM file will be an empty file. For types ca, pca, option -G or -g must be used. For type l1, p1, l2, p2, lc and pc, option -g and -P must be used for 1 Hz data, option -s must be used for 50-hz or 10-hz data.

Option -x: Usually used together with the option tag -O. -x should be followed by an user-defined pre-existing file name. In this file, the user provides additional information for RINEX header lines. TBtool will include these header lines in the output RINEX file.

Multiple option tags are accepted. In this case, all the corresponding records will be printed to the output file. For example, "-G -P -T" will output both 1-Hz CA, P1, and P2 records and attach the statistics table at the end of the output file.

A compressed format input file (.gz file from gzip) and a piped input stream are also accepted. For example, the following two commands perform the same function:

```
TBtool -i testfile.trb.gz -o output.file -G
```

```
gzcat testfile.trb.gz | TBtool -o output.file -G
```

One advantage of the piped input stream is that user can concatenate several files together in input. The disadvantage of the piped input stream is that it can not be used with tag -C, because in the -C mode, TBtool performs back-and-forth checking using fseek, which is not suitable for the streaming input.

GPS tracking data sample rates:

The GPS satellites are tracked at low-rate (typically 10 or 30 seconds per sample) for orbit determination.

The GPS satellites are tracked at high-rate (typically 1, 10, or 50 samples/sec) for occultation measurements.

GPS tracking data types:

The GPS satellites broadcast CA-code and P-code at the L1 frequency, and P-code at L2.

There are 6 GPS ranging observables:

Pseudorange from tracking CA, L1 P-code (P1), and L2 P-code (P2).

Phase from tracking CA, P1, and P2.

Turbobinary high-rate data records:

The high-rate data are recorded in 1 second records in 3 types of turbobinary records: CA, P1, and P2. 10 or 50 Hz phase data are recorded as a polynomial plus an array of residuals to the polynomial.

High rate CA records contain the CA, P1, and P2 SNRs, L1 and L2 phase rate and acceleration, CA phase and pseudorange at the integer second epoch, plus the 50 or 10 Hz array of CA phase residuals and CA SNRs.

High rate P1 records contain the P1 pseudorange and phase (relative to CA) at the integer second epoch, plus the 50 or 10 Hz array of P1 phase residuals and SNR.

High rate P2 records contain the P2 pseudorange and phase (relative to CA) at the integer second epoch, plus the 50 or 10 Hz array of P2 phase residuals and SNR.

TBtool flags for selecting GPS tracking data rate, data type, and output format:

To output low-rate data, use the -I flag (streaming format) or the -O flag (RINEX format).

To output the 1-Hz component of the high-rate CA records (incl. P2 polynomial coefficients, etc.), use the -G flag.

To output all of the high-rate CA records, use the -g flag

To output the 1-Hz component of the P1 and P2 records, use the -P flag.

To output all of the high-rate P1 and P2 records, use the -s flag.

To output the high-rate data in qm format, use the -q and -t flags in addition to the -G, -g, -P and/or -s flags

To output the low-rate data in qm format, use the -q and -t flags in addition to the -I flag

-t data types are

ca: CA phase

pca: CA pseudorange

l1: P1 phase

p1: P1 pseudorange

l2: P2 phase

p2: P2 pseudorange

lc: ionosphere-free combination of P2 phase and CA phase

pc: ionosphere-free combination of P2 pseudorange and CA pseudorange

All of the SNR fields are voltage SNR for 1 second integration: (max signal)/(RMS noise).

#### 4. How to report bugs and make comments

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TBtool is a work in progress. Possible changes include:

(1) Improving cleanup of SUNSAT data: Currently a fairly complete cleanup is implemented for low-rate observables, CA high-rate observables, and antenna state. The high-rate SUNSAT P2 data has low-SNR and we typically do not use it, and no cleanup has been implemented.

(2) Read and output ephemeris information.

The user can report program bugs and make comments and suggestions through the webmaster.

#### 5. TBtool output format

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-a output

Antenna state (position and velocity computed by GPS receiver)

field 1: 91  
field 2: Earth-centered Earth-fixed coordinates X (km)  
field 3: Earth-centered Earth-fixed coordinates Y (km)  
field 4: Earth-centered Earth-fixed coordinates Z (km)  
field 5: Earth-centered Earth-fixed velocity X (km/s)  
field 6: Earth-centered Earth-fixed velocity Y (km/s)  
field 7: Earth-centered Earth-fixed velocity Z (km/s)  
field 8: Year  
field 9: Month (1-12)  
field 10: Day of month  
field 11: Hour  
field 12: Minute  
field 13: Second

Sample output

|    |             |             |            |             |             |             |      |   |   |    |    |       |
|----|-------------|-------------|------------|-------------|-------------|-------------|------|---|---|----|----|-------|
| 91 | 6286.30421  | 3316.70804  | -314.04784 | -0.69058845 | 1.94937572  | 7.03160623  | 1995 | 5 | 4 | 10 | 1  | 20.00 |
| 91 | 5783.41435  | 3737.34834  | 1776.01912 | -2.64298362 | 0.84587354  | 6.78580930  | 1995 | 5 | 4 | 10 | 6  | 20.00 |
| 91 | 4721.68543  | 3823.94363  | 3689.77564 | -4.38426763 | -0.26020920 | 5.86652103  | 1995 | 5 | 4 | 10 | 11 | 20.00 |
| 91 | 3191.42238  | 3590.44371  | 5237.33291 | -5.73990678 | -1.27321384 | 4.36513870  | 1995 | 5 | 4 | 10 | 16 | 20.00 |
| 91 | 1330.68844  | 3077.64004  | 6265.67693 | -6.56888140 | -2.11095193 | 2.43375974  | 1995 | 5 | 4 | 10 | 21 | 20.00 |
| 91 | -688.20905  | 2347.15336  | 6673.62579 | -6.78317058 | -2.71707261 | 0.26320366  | 1995 | 5 | 4 | 10 | 26 | 20.00 |
| 91 | -2674.50098 | 1473.83872  | 6421.47753 | -6.35247804 | -3.06049868 | -1.93019076 | 1995 | 5 | 4 | 10 | 31 | 20.00 |
| 91 | -4438.03173 | 537.95059   | 5534.78203 | -5.30862776 | -3.13553378 | -3.93195005 | 1995 | 5 | 4 | 10 | 36 | 20.00 |
| 91 | -5807.01797 | -382.18565  | 4101.35174 | -3.74141903 | -2.95958665 | -5.54470021 | 1995 | 5 | 4 | 10 | 41 | 20.00 |
| 91 | -6645.11211 | -1216.55734 | 2262.86613 | -1.79668818 | -2.57128698 | -6.60987030 | 1995 | 5 | 4 | 10 | 46 | 20.00 |

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-G output

1 Hz data from high-rate CA records

field 1: "HR"

field 2: PRN number  
 field 3: GPS receiver channel  
 field 4: timetag (seconds past Jan 1 2000, 12:00 GPS time)  
 field 5: CA SNR  
 field 6: P1 SNR  
 field 7: P2 SNR  
 field 8: CA phase at integer second epoch (cycles)  
 field 9: CA range at integer second epoch (meters)  
 field 10: P1 phase rate (cycles/sec)  
 field 11: P2 phase rate (cycles/sec)  
 field 12: P1 phase rate rate (cycles/sec/sec)  
 field 13: P2 phase rate rate (cycles/sec/sec)  
 field 14: [catchbyte]--Number of bytes shifted, positive number means forward bytes, negative number means backward bytes.

#### Sample output

|          |   |            |     |     |     |                |                 |               |               |            |            |     |
|----------|---|------------|-----|-----|-----|----------------|-----------------|---------------|---------------|------------|------------|-----|
| HR prn27 | 1 | -147146599 | 236 | 159 | 184 | 9416188.629479 | 25965664.350148 | -23203.509766 | -18080.652344 | -13.077438 | -10.188417 | [0] |
| HR prn27 | 1 | -147146598 | 237 | 158 | 187 | 9439398.565040 | 25970081.598058 | -23216.048828 | -18090.425781 | -11.751696 | -9.162092  | [0] |
| HR prn27 | 1 | -147146597 | 234 | 158 | 188 | 9462620.708331 | 25974499.928175 | -23228.216797 | -18099.902344 | -11.823095 | -9.239312  | [0] |
| HR prn27 | 1 | -147146596 | 235 | 158 | 185 | 9485855.055287 | 25978921.204057 | -23240.541016 | -18109.503906 | -12.216711 | -9.522052  | [0] |
| HR prn27 | 1 | -147146595 | 233 | 158 | 186 | 9509101.867452 | 25983345.269456 | -23253.072266 | -18119.271484 | -12.314120 | -9.556822  | [0] |
| HR prn27 | 1 | -147146594 | 236 | 160 | 187 | 9532361.362369 | 25987771.026058 | -23265.904297 | -18129.269531 | -12.165772 | -9.490736  | [0] |
| HR prn27 | 1 | -147146593 | 235 | 157 | 191 | 9555633.461323 | 25992199.934351 | -23278.470703 | -18139.060547 | -12.788812 | -9.935824  | [0] |
| HR prn27 | 1 | -147146592 | 236 | 157 | 188 | 9578918.485639 | 25996630.890819 | -23291.292969 | -18149.052734 | -11.179694 | -8.698559  | [0] |
| HR prn27 | 1 | -147146591 | 237 | 156 | 184 | 9602215.541119 | 26001064.022617 | -23302.839844 | -18158.050781 | -11.374558 | -8.847549  | [0] |
| HR prn27 | 1 | -147146590 | 234 | 159 | 185 | 9625524.352557 | 26005500.018003 | -23314.980469 | -18167.517578 | -12.725374 | -9.878342  | [0] |

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#### -g output

High rate CA record data, including phase rates and accelerations needed to interpret 10 Hz and 50 Hz CA, P1 and P2 phase data.

1 Hz data are identical to -G output.

#### 1 Hz record

field 1: "HR"

field 2: PRN number

field 3: GPS receiver channel  
 field 4: timetag (seconds past Jan 1 2000, 12:00 GPS time)  
 field 5: CA SNR  
 field 6: P1 SNR  
 field 7: P2 SNR  
 field 8: CA phase at integer second epoch (cycles)  
 field 9: CA range at integer second epoch (meters)  
 field 10: P1 phase rate (cycles/sec)  
 field 11: P2 phase rate (cycles/sec)  
 field 12: P1 phase rate rate (cycles/sec/sec)  
 field 13: P2 phase rate rate (cycles/sec/sec)  
 field 14: [catchbyte]--Number of bytes shifted

10 Hz or 50 Hz data

field 1: "QR"  
 field 2: PRN number  
 field 2: PRN number  
 field 4: timetag (seconds past Jan 1 2000, 12:00 GPS time)  
 field 5: CA phase (cycles)  
 field 6: CA SNR  
 field 7: CA phase residual (divide by 8192 to get residual in cycles)  
 (if the record is "bad", i.e. the phase or range are out of normal range,  
 the field 1 becomes "Qr" and field 5 disappears)

Interpreting 50 Hz data (10 Hz is analogous):

$dt = (50 \text{ Hz timetag}) - (1 \text{ Hz timetag})$

$dphase = \text{CA phase residual}$

$phasedot = \text{P1 phase rate}$

$phasedotdot = \text{P1 phase rate rate}$

$(50 \text{ Hz phase}) = (\text{CA phase at integer second epoch}) - dt * phasedot - .5 * dt * dt * phasedotdot + dphase/8192$

Sample beginning of output

```

HR prn27 1 -147146599 236 159 184 9416188.629479 25965664.350148 -23203.509766 -18080.652344 -13.077438 -10.188417 [0]
QR prn27 27 -147146599.50 9404588.519042 6104 80 0
QR prn27 27 -147146599.48 9405052.455707 6419 36 0
QR prn27 27 -147146599.46 9405516.404562 6420 49 0
QR prn27 27 -147146599.44 9405980.362309 6341 92 0
QR prn27 27 -147146599.42 9406444.322114 6413 109 0
  
```

```
QR prn27 27 -147146599.40 9406908.280679 6250 73 0
Qr prn27 27 -147146599.38 6063 82 0
Qr prn27 27 -147146599.36 6255 -11 0
```

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-I output

Low rate data (typically 10 second or 30 second sample rate)

```
field 1: "OBS"
field 2: sample interval (seconds)
field 3: PRN number
field 4: GPS receiver channel
field 5: timetag (seconds past Jan 1 2000, 12:00 GPS time)
field 6: CA SNR
field 7: P1 SNR
field 8: P2 SNR
field 9: CA phase (cycles)
field 10: CA range (meters)
field 11: P1 phase (cycles)
field 12: P1 range (meters)
field 13: P2 phase (cycles)
field 14: P2 range (meters)
field 15: [catchbyte]--Number of bytes shifted
```

Sample output

```
OBS 10s prn27 1 -147146600 235 157 185 9236524.790747 25961250.164438 9236524.791695 25961249.778115 7197289.680654
25961250.996020 3.033907 [0]
OBS 10s prn21 2 -147146600 177 117 109 14518528.269595 27322059.000449 14518528.273394 27322058.880414 11313125.250432
27322063.586606 17.531540 [0]
OBS 10s prn17 3 -147146600 439 290 320 17776823.365575 23281285.557101 17776824.366503 23281284.872182 13852068.815308
23281286.541614 1.719263 [0]
OBS 10s prn22 4 -147146600 277 190 234 44334381.973399 28596904.793149 44334381.974167 28596904.045223 34546234.207016
28596914.315467 48.074394 [0]
OBS 10s prn19 5 -147146600 319 212 180 26990986.644115 28552021.053384 26990986.642461 28552020.881856 21031896.656718
28552032.075766 52.601326 [0]
```

OBS 10s prn20 7 -147146600 76 48 63 -16131719.101969 25796764.679986 -16131719.101074 25796764.797741 -12570168.281752  
25796767.148384 -3.140388 [0]  
OBS 10s prn23 8 -147146600 326 220 219 7683008.403749 24163185.024135 7683008.403777 24163184.603791 5986757.073502  
24163186.141883 3.492755 [0]  
OBS 10s prn27 1 -147146590 236 158 187 9469057.578016 26005499.737361 9469057.579339 26005499.400901 7378484.011269  
26005500.564908 3.096887 [0]  
OBS 10s prn21 2 -147146590 177 116 110 14599896.486064 27337543.420354 14599896.490760 27337543.117130 11376528.491740  
27337548.105059 18.254997 [0]  
OBS 10s prn17 3 -147146590 438 289 325 18088442.518166 23340584.717933 18088443.519030 23340584.052322 14094888.900578  
23340585.760865 1.762424 [0]

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-L output

Occultation schedule log records

field 1: "SCHEDULE"  
field 2: timetag (seconds past Jan 1 2000, 12:00 GPS time)  
field 3: PRN number of occulting GPS satellite  
field 4: "1" (unused field)  
field 5: PRN number for reference GPS satellite  
field 6: Reference GPS ground receiver (See lists below for GPSMET and SUNSAT)  
field 7: latitude of the tangent point (degree), curvature not considered  
field 8: longitude of the tangent point (degree), curvature not considered  
field 9: height of the tangent point (km), curvature not considered

For GPSMET the ground receiver set used for occultation scheduling is:

1 GOL3  
2 KOK2  
3 FAI2  
4 TID2  
5 POTM  
6 MCM4

For SUNSAT the ground receiver set used for occultation scheduling is:

0 JPLM  
1 KOKB  
2 FAIR

```

3    TIDB
4    SANT
5    MCM4
6    CR01
7    GALA
8    GODE
9    GOLD
10   GUAM
11   HRAO
12   MADR
13   MKEA

```

#### Sample output

```

SCHEDULE 28235730 prn06 1 17 10 5.381609 159.875458 -75.519279
SCHEDULE 28235740 prn06 1 17 10 5.145270 160.117752 -105.005547
SCHEDULE 28235750 prn06 1 17 10 4.906345 160.361557 -134.816681
SCHEDULE 28235760 prn06 1 17 10 4.664803 160.606995 -164.938156
SCHEDULE 28235770 prn06 1 17 10 4.420576 160.854111 -195.373444
SCHEDULE 28236290 prn22 1 17 3 -22.398556 134.919571 76.952057
SCHEDULE 28236390 prn17 1 15 2 -32.540615 160.783401 -168.662064
SCHEDULE 28236400 prn17 1 15 2 -32.764042 161.170258 -197.271103
SCHEDULE 28236870 prn03 1 25 11 -54.948490 113.853928 72.650261
SCHEDULE 28236880 prn03 1 25 11 -54.932682 113.539459 40.097034
SCHEDULE 28236890 prn03 1 25 11 -54.917061 113.224792 6.998419
SCHEDULE 28236900 prn03 1 25 11 -54.901604 112.909843 -26.637777
SCHEDULE 28236910 prn03 1 25 11 -54.886288 112.594490 -60.806347

```

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#### -0 output

Low rate data (typically 10 second or 30 second sample rate) in RINEX format.  
See definition of RINEX format (<ftp://igscb.jpl.nasa.gov/igscb/data/format/rinex2.txt>)

#### Sample beginning of output

|             |                  |                      |                      |
|-------------|------------------|----------------------|----------------------|
| 2           | OBSERVATION DATA | GPS                  | RINEX VERSION / TYPE |
| TBtool v1.0 | bai              | Nov/08/2000 13:17:31 | PGM / RUN BY / DATE  |

|                                            |      |      |     |     |           |    |    |    |     |     |                      |
|--------------------------------------------|------|------|-----|-----|-----------|----|----|----|-----|-----|----------------------|
| 10                                         |      |      |     |     |           |    |    |    |     |     | INTERVAL             |
| 1                                          | 1    | 0    |     |     |           |    |    |    |     |     | WAVELENGTH FACT L1/2 |
| 4                                          | L1   | L2   | P1  | P2  |           |    |    |    |     |     | # / TYPES OF OBSERV  |
| SNR is mapped to signal strength [0,1,2-9] |      |      |     |     |           |    |    |    |     |     | COMMENT              |
| SNR:                                       | >500 | >100 | >50 | >10 | >5        | >3 | >1 | >0 | bad | n/a | COMMENT              |
| sig:                                       | 9    | 8    | 7   | 6   | 5         | 4  | 3  | 2  | 1   | 0   | COMMENT              |
| 1995                                       | 05   | 04   | 09  | 56  | 40.000000 |    |    |    |     |     | TIME OF FIRST OBS    |
| 1995                                       | 05   | 05   | 03  | 10  | 10.000000 |    |    |    |     |     | TIME OF LAST OBS     |

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# -P output

1 Hz data from high-rate P1 and P2 records. Data are recorded relative to CA, so what are actually recorded are:  
CA phase - P1 phase and CA pseudorange - P1 pseudorange (if they exist), and  
CA phase - P2 phase and CA pseudorange - P2 pseudorange

field 1: timetag (seconds past Jan 1 2000, 12:00 GPS time)  
field 2: PRN number  
field 3: "CA-L1" or "CA-L2"  
field 4: CA phase (converted to meters) minus P1 or P2 phase (converted to meters) at integer second epoch  
field 5: P1 or P2 SNR (obtained from high-rate CA records)  
field 6: "PCA-P1" or "PCA-P2"  
field 7: CA pseudorange minus P1 or P2 pseudorange (meters) at integer second epoch

# Sample output

|            |       |       |           |     |        |                     |
|------------|-------|-------|-----------|-----|--------|---------------------|
| -147146599 | prn27 | CA-L1 | -0.190635 | 159 | PCA-P1 | 0.487758333405548   |
| -147146599 | prn27 | CA-L2 | 0.417034  | 184 | PCA-P2 | -0.943443146136102  |
| -147146598 | prn27 | CA-L1 | -0.190320 | 158 | PCA-P1 | 0.807879838343409   |
| -147146598 | prn27 | CA-L2 | 0.418116  | 187 | PCA-P2 | -0.165289376732947  |
| -147146597 | prn27 | CA-L1 | -0.190192 | 158 | PCA-P1 | -0.0402960700970847 |
| -147146597 | prn27 | CA-L2 | 0.419802  | 188 | PCA-P2 | -1.10927778844107   |
| -147146596 | prn27 | CA-L1 | -0.190324 | 158 | PCA-P1 | 0.0505527178816002  |
| -147146596 | prn27 | CA-L2 | 0.420348  | 185 | PCA-P2 | -1.19672955976084   |
| -147146595 | prn27 | CA-L1 | -0.190306 | 158 | PCA-P1 | 0.426369211121202   |
| -147146595 | prn27 | CA-L2 | 0.421949  | 186 | PCA-P2 | -0.774933063057586  |
| -147146594 | prn27 | CA-L1 | -0.190485 | 160 | PCA-P1 | -0.129494766850936  |
| -147146594 | prn27 | CA-L2 | 0.422958  | 187 | PCA-P2 | -1.05675849413439   |

```
-147146593 prn27 CA-L1 -0.190150 157 PCA-P1 0.279249526481708
-147146593 prn27 CA-L2 0.423608 191 PCA-P2 -0.90123576716572
```

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-q output

QM format output.

QM format consists of 8 header lines followed by several data lines. The header consists of

Line 1: Number of ground stations, number of satellites

Line 2: Names of ground stations

Line 3: Names of satellites

Line 4: File epoch (seconds past 1 Jan 2000 12:00 GPS time)

Lines 5-8 should be ignored.

Each data line consists of

Field 1: Time (seconds after File epoch)

Field 2: Receiver name

Field 3: Transmitter name

Field 4: Data type

Field 5: 1 = Sat-Sat      2 = Grn-Sat      3 = Sat-Grn    (Sat = satellite, Grn = ground)

Field 6: Phase epoch (beginning of current continuous phase arc) This field should be ignored (seconds after File epoch)

Field 7: Sigma on first observable

Field 8: Number of observables following

Field 9 etc.: Observable data

Date types (as indicated in Field 4) and corresponding observable fields are

L1: P1 or CA phase observable

Observable 1: phase transformed to range (km)

Observable 2: SNR

P1: P1 or CA pseudorange

Observable 1: pseudorange (km)

L2: P2 phase observable

Observable 1: phase transformed to range (km)

Observable 2: SNR

P2: P2 pseudorange

Observable 1: pseudorange (km)

LC: ionosphere-free combination of CA phase and P2 phase

Observable 1: phase transformed to range (km)

Observable 2: CA phase (transformed to range) minus P2 phase (transformed to range) (km)

Observable 3: Effective SNR (combination of CA and P2 SNRs)

PC: ionosphere-free combination of CA pseudorange and P2 pseudorange

Observable 1: pseudorange (km)

-----

Sample output for flags -q MET -G -t ca pca

0 2

MET GPS37  
-147135224.00

10

2

1

1 3 4 5 2

|          |     |       |    |   |          |            |   |                  |     |
|----------|-----|-------|----|---|----------|------------|---|------------------|-----|
| 0.000000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 8059.35757284292 | 378 |
| 0.000000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 28328.6643242594 |     |
| 1.000000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 8064.87139652922 | 377 |
| 1.000000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 28334.1781349455 |     |
| 2.000000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 8070.38342764698 | 375 |
| 2.000000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 28339.6906534258 |     |
| 3.000000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 8075.89373607376 | 375 |
| 3.000000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 28345.2009036466 |     |
| 4.000000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 8081.40237336429 | 378 |
| 4.000000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 28350.7096523181 |     |
| 5.000000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 8086.90927002737 | 376 |
| 5.000000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 28356.2165665109 |     |

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Sample output for flags -q MET -g -t ca pca

0 2

MET GPS37  
-147107853.50

10

2

1

1 3 4 5 2

|          |     |       |    |   |          |            |   |                  |                  |
|----------|-----|-------|----|---|----------|------------|---|------------------|------------------|
| 0.000000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.23708404417 | 98.5337030007342 |
| 0.020000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.36509461895 | 107.515531470481 |
| 0.040000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.49308255341 | 89.1712885788799 |
| 0.060000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.62108452649 | 83.728909463737  |
| 0.080000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.74909575295 | 95.2987224078171 |
| 0.100000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.87709702225 | 131.987208191018 |
| 0.120000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7769.00510020451 | 124.984426672233 |
| 0.140000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7769.13309301148 | 112.387031657462 |
| 0.160000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7769.26109899758 | 79.8469327522365 |
| 0.180000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7769.38910039245 | 109.570695611863 |
| 0.200000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7769.51709807882 | 95.2606638126063 |
| 0.220000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7769.64510313702 | 95.9076599311897 |
| 0.240000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7769.77309489304 | 104.927546996147 |
| 0.260000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7769.90109650642 | 110.331867516079 |
| 0.280000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7770.02908788387 | 88.790702626772  |
| 0.300000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7770.15707973408 | 84.0333782254233 |
| 0.320000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7770.28508448467 | 122.168090626634 |
| 0.340000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7770.4130784186  | 102.415679712235 |
| 0.360000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7770.54107649551 | 115.850363821643 |
| 0.380000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7770.66907016703 | 115.774246631222 |
| 0.400000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7770.79705862014 | 98.2672928342586 |
| 0.420000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7770.92504552506 | 98.1150584534155 |
| 0.440000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.05304828047 | 101.007511689435 |
| 0.460000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.18104279767 | 127.22988378967  |
| 0.480000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.30902645177 | 109.190109659755 |
| 0.500000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 27185.3593258294 |                  |
| 0.500000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.43702521302 | 97.4680623348321 |
| 0.520000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.56502179889 | 88.4481752698749 |
| 0.540000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.693003503   | 122.472559388321 |
| 0.560000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.82098718977 | 116.230949773751 |

-----

Sample output for flags -q MET -P -t p1 p2

0 2

MET GPS37  
-147107853.50

10

2

1

1 3 4 5 2

|          |     |       |    |   |          |            |   |                  |
|----------|-----|-------|----|---|----------|------------|---|------------------|
| 0.500000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 27185.3581440463 |
| 0.500000 | MET | GPS37 | P2 | 1 | 0.000000 | 0.0000e+00 | 1 | 27185.358962204  |
| 1.500000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 27191.7567826824 |
| 1.500000 | MET | GPS37 | P2 | 1 | 0.000000 | 0.0000e+00 | 1 | 27191.7578073017 |
| 2.500000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 27198.1544093542 |
| 2.500000 | MET | GPS37 | P2 | 1 | 0.000000 | 0.0000e+00 | 1 | 27198.1553678729 |
| 3.500000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 27204.5503119307 |
| 3.500000 | MET | GPS37 | P2 | 1 | 0.000000 | 0.0000e+00 | 1 | 27204.551497092  |
| 4.500000 | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 27210.9453788554 |
| 4.500000 | MET | GPS37 | P2 | 1 | 0.000000 | 0.0000e+00 | 1 | 27210.9462392964 |

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Sample output for flags -q MET -s -t l1 l2 p1 p2

0 2

MET GPS37  
-147107853.50

10

2

1

1 3 4 5 2

|          |     |       |    |   |          |            |   |                  |                  |
|----------|-----|-------|----|---|----------|------------|---|------------------|------------------|
| 0.000000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.2371285281  | 59.2572327431993 |
| 0.000000 | MET | GPS37 | L2 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.23647795478 | 217.657106010505 |
| 0.020000 | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.36514940504 | 69.266643283637  |
| 0.020000 | MET | GPS37 | L2 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.36448326608 | 205.897000090372 |



|                  |     |       |    |   |          |            |   |                  |                      |
|------------------|-----|-------|----|---|----------|------------|---|------------------|----------------------|
| 0.040000         | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.49312301869 | 65.3466079769257     |
| 0.040000         | MET | GPS37 | LC | 1 | 0.000000 | 0.0000e+00 | 3 | 7768.49411186622 | 0.000639729414615431 |
| 25.0759423642062 |     |       |    |   |          |            |   |                  |                      |
| 0.060000         | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7768.6211199278  | 79.390229609707      |
| 0.060000         | MET | GPS37 | LC | 1 | 0.000000 | 0.0000e+00 | 3 | 7768.62209891095 | 0.000633347711300303 |
| 30.0127274278476 |     |       |    |   |          |            |   |                  |                      |
| .....            |     |       |    |   |          |            |   |                  |                      |
| 0.440000         | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.05309651592 | 71.9688035436031     |
| 0.440000         | MET | GPS37 | LC | 1 | 0.000000 | 0.0000e+00 | 3 | 7771.05410877151 | 0.000654873131679778 |
| 27.4374460329912 |     |       |    |   |          |            |   |                  |                      |
| 0.460000         | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.18109264755 | 61.845217217533      |
| 0.460000         | MET | GPS37 | LC | 1 | 0.000000 | 0.0000e+00 | 3 | 7771.1821120278  | 0.000659482390801713 |
| 23.6851121549085 |     |       |    |   |          |            |   |                  |                      |
| 0.480000         | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.30906774169 | 78.0581787773294     |
| 0.480000         | MET | GPS37 | LC | 1 | 0.000000 | 0.0000e+00 | 3 | 7771.31006534045 | 0.0006453909791162   |
| 29.4977695817272 |     |       |    |   |          |            |   |                  |                      |
| 0.500000         | MET | GPS37 | P1 | 1 | 0.000000 | 0.0000e+00 | 1 | 27185.3581440463 |                      |
| 0.500000         | MET | GPS37 | PC | 1 | 0.000000 | 0.0000e+00 | 1 | 27185.3568793971 |                      |
| 0.500000         | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.43707379691 | 52.7492129621543     |
| 0.500000         | MET | GPS37 | LC | 1 | 0.000000 | 0.0000e+00 | 3 | 7771.43809753558 | 0.000662302047203411 |
| 20.347324825118  |     |       |    |   |          |            |   |                  |                      |
| 0.520000         | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.56508134696 | 72.6157996621865     |
| 0.520000         | MET | GPS37 | LC | 1 | 0.000000 | 0.0000e+00 | 3 | 7771.56612447641 | 0.00067484680130292  |
| 27.6288578643455 |     |       |    |   |          |            |   |                  |                      |
| 0.540000         | MET | GPS37 | L1 | 1 | 0.000000 | 0.0000e+00 | 2 | 7771.69305263278 | 70.903162877701      |
| 0.540000         | MET | GPS37 | LC | 1 | 0.000000 | 0.0000e+00 | 3 | 7771.6940634938  | 0.000653970922030567 |
| 26.9948385982567 |     |       |    |   |          |            |   |                  |                      |

=====

-s output

Output high-rate P1 and P2 data. It consists of 1 Hz records plus higher rate records

1 Hz records have the same format as the -P output

Higher rate (10 or 50 Hz) phase records:

field 1: "L1" or "L2" indicate P1 or P2 phase

field 2: sampling frequency (50 Hz or 10 Hz)

field 3: timetag (seconds past Jan 1 2000, 12:00 GPS time)  
field 4: PRN number  
field 5: P1 phase (L1 cycles) or P2 phase (L2 cycles)  
field 6: phase residual (relative to polynomial) (For L1, divide by 16384 to recover L1 phase residual in cycles relative to P1 phase polynomial. For L2, divide by 8192 to recover L2 phase residual in cycles relative to P2 phase polynomial.)  
field 7: SNR

#### Sample output

```
-147107853 prn07 CA-L1 -0.000638 59.2572 PCA-P1 11.8178313951906
L1 50Hz -147107853.500 07 40822361.623424 266 59.2572
L1 50Hz -147107853.480 07 40823034.344226 -621 69.2666
L1 50Hz -147107853.460 07 40823706.932747 612 65.3466
L1 50Hz -147107853.440 07 40824379.567025 1048 79.3902
L1 50Hz -147107853.420 07 40825052.295524 -107 50.7321
L1 50Hz -147107853.400 07 40825724.952227 -133 66.907
L1 50Hz -147107853.380 07 40826397.592799 58 64.3951
.....
L1 50Hz -147107852.620 07 40851956.193258 798 50.4276
L1 50Hz -147107852.600 07 40852628.792108 -172 62.7586
L1 50Hz -147107852.580 07 40853301.322641 -70 66.8309
L1 50Hz -147107852.560 07 40853973.867926 -257 74.1001
L1 50Hz -147107852.540 07 40854646.396897 -224 63.1392
L1 50Hz -147107852.520 07 40855318.852058 971 72.6539
-147107853 prn07 CA-L2 0.602195 217.657 PCA-P2 3.63625419734203
L2 50Hz -147107853.500 07 31809629.780890 -123 217.657
L2 50Hz -147107853.480 07 31810153.941241 -82 205.897
L2 50Hz -147107853.460 07 31810678.079939 -200 232.728
L2 50Hz -147107853.440 07 31811202.232017 -190 219.141
L2 50Hz -147107853.420 07 31811726.383925 -163 209.17
.....
L2 50Hz -147107852.620 07 31832690.485578 -181 208.028
L2 50Hz -147107852.600 07 31833214.549116 -124 217.581
L2 50Hz -147107852.580 07 31833738.595395 -190 223.061
L2 50Hz -147107852.560 07 31834262.662744 -65 213.547
L2 50Hz -147107852.540 07 31834786.708562 -98 217.581
L2 50Hz -147107852.520 07 31835310.763243 -40 213.356
```

=====

-T output

#### File statistics

Line 1: File name  
Line 2 field 1: Number bytes read  
Line 2 field 2: Number bytes ignored  
Line 3 field 1: Number 10s/30s samples read  
Line 3 field 2: Number of bad 10s/30s samples  
Line 4 field 1: Number 1 Hz samples read  
Line 4 field 2: Number of bad 1 Hz samples  
Line 5 field 1: Number 50 Hz/10 Hz L1 samples XXXXX  
Line 5 field 2: Number XXXXXXXX  
Line 5 field 3: Number XXXXXXXX  
Line 6 field 1: Number 1 Hz L1-L2 samples read  
Line 6 field 2: Number of bad 1 Hz L1-L2 samples  
Line 6 field 3: Number of mismatched 1 Hz L1-L2 samples  
Line 7 field 1: Number antenna state records read  
Line 7 field 2: Number of bad antenna state records  
Line 8 field 1: Number ephemeris records read  
Line 8 field 2: Number of bad ephemeris records  
Line 9 field 1: Number occultation schedule records read  
Line 9 field 2: Number of bad occultation schedule records  
Line 10 field 1: Beginning of data (seconds past Jan 1 1980 0:00)  
Line 10 field 2: End of data (seconds past Jan 1 1980 0:00)  
Line 11+ field 1: PRN number  
Line 11+ field 2: Number of low rate records for PRN  
Line 11+ field 3: Beginning of low rate data for PRN  
Line 11+ field 4: End of low rate data for PRN

#### Sample beginning of output

File name = [/genesis/genesis/database/level0/gpsmet/y1995/log\_95.125\_03.00.out]  
File size = [12558336] byte read = [12569593] unknown byte = [1315161]  
10s low rate data (records): total = [45477] bad = [0]  
1 hz high rate L1 data (records): total = [13387] bad = [0]  
50 hz L1 data (samples): total = [0] unrepaired = [0] junk = [0]

high rate CA-L1 data (records): total = [13387] bad = [0] mismatch = [0]  
high rate CA-L2 data (records): total = [13387] bad = [1] mismatch = [1]  
Antenna status data (records): total = [206] bad = [0]  
Ephemeris data (records): total = [245] bad = [0]  
Occultation Schedule data (records): total = [880] bad = [0]  
data span: from [483616600] to [483678610]  
sat prn = [1] usage = [1539] span: from [483617660] to [483677520]  
sat prn = [2] usage = [2520] span: from [483616770] to [483676500]

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