GTSM Data Timing Conventions:

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GTSM data timing is designed to operate with or without GPS signals. When GPS signals are available, timing of all data streams is from the GPS 1 Hz square pulse.

The four measurement system channels run independently ie are not synchronously controlled by a central timing system. Internally, they produce a tagged and validated sample every 10 milliseconds. The GPS one second marker is provided to all channels simultaneously, and the next available data point from each channel is tagged as falling within the new second ie is the beginning of the next second.

Each 10 millisecond sample is itself the mean of over-sampled data from the previous reported sample to the sample being taken. The raw input to the ADC is the output of a six pole filter set at 32 Hz.

The main 20 Hz data stream is then built from a symmetric running mean of the 5 points around the reported time of the sample (two before, one on the mark and two after). This mean is the best estimate of the value at the time mark. This process gives good (predictable) bandwidth with maximum noise reduction at the sampling rate and is very CPU efficient.

The primary 20 Hz data is then field stored in one minute long bottles initially then later tarred into one hour archive files at the field site, which Unavco later tar again to 24 hour files prior to archive. The bottle timing mark is the time for the first sample in the bottle. The minute bottle is named SITEDDDHHmmCHx_20, and the first data point in the bottle has a time stamp of DDDHHmm:00.00. As an example, and using the prior paragraph, the first data point in a minute bottle named say SITEDDDHH38CHx_20 is the running mean from minute 37 second 59 and 970 milliseconds to minute 38, second 00 and 20 milliseconds.

Similarly, the first data point in a file named SITEDDD15CHx (which contains 1 Hz data by definition of the bottle name) will be the running mean of all samples between hour 14, minute 59, second 59 and 500 milliseconds to hour 15, minute 0, second 0 and 500 milliseconds. Also the last data point in that hour long bottle will begin at 15 hours 59minutes 58seconds and 500 milliseconds and end at 15 hours 59 minutes 59 seconds and 500 milliseconds.

Thus for all sampling rates (20Hz, 1Hz and 10 minute) samples reported at time mark T represent symmetric averages of appropriate length about a point in time T- 5 milliseconds.

If a 20 Hz sample cannot be produced (in particular if fewer than 3 of the 10 millisecond reading are validated, or if other processes which require suppression of the data stream are current), it is recorded as the missing data symbol which happens to be 999999, so that there will always be 20 sample intervals in the second.

Individual samples are good to 10 milliseconds (assuming Version 1.15) which is also the maximum timing error when GPS is available. They are good to the same

precision as the first point in the bottle. The data logger clock time stamp is synchronized to the GPS time stamp every hour to maintain this precision.

The GPS pulse tagged sample can only ever be the third sample of the five 10 millisecond samples used to produce a particular 20 Hz value.

The GPS one second pulses are applied to all sensors every second in the manner noted above. The naming synchronism between named logger time and named GPS time occurs every hour. This hourly checked time structure is used for all file naming and for determining the first point in minute bottles. No correction is applied to times within the minute as this is not needed for 20 Hz data.

As an additional aside, timing across bottles for the different channels at any site is the same to within one 10 millisecond sample (ie all channels have the same time). Site to site timing for Version 1.12 and below allowed the possibility of larger than 20 millisecond error because synchronization occurred when the one second GPS message arrived at the logger not at the one second square wave itself whereas the samples were tagged on the square wave itself. If in these early version one needs a time shift to line up precisely with the long period data, the time shift must be the same on all four channels.