

Decimation and interpolation of exported MagArrow data

Raw Data

MagArrow data is imported into Survey Manager in the form of .MAGDATA files, downloaded from the MagArrow. The .MAGDATA file contains measurements from different sensors inside the MagArrow: 1000Hz magnetometer readings; accelerometer, gyro, compass, temperature readings; and GPS info.

MFAM assigns a fiducial number, or “FID” to each magnetometer reading, in a cycle from 1 to 1000 that repeats every second. In the instrument, the magnetometer readings and the GPS sentence data are synchronized so that the “FID-1” magnetometer record is matched with the GPS location and timing information.

Exports to CSV and Geosoft file formats

1000Hz un-filtered export

The 1000Hz export provides the original raw magnetometer data plus some simple interpolations:

- Magnetometer reading: The raw magnetic field values are exported without application of a filter. [While these raw measurements are the output of a filter inside the MFAM sensor: a 9-pole Butterworth low pass filter with a -3dB point at 400Hz, that filter is considered part of the sensor for this description.]
- Auxiliary sensors: Gyro, accelerometer, and temperature are acquired once per every 5 magnetometer readings, and are reported only when acquired. Compass readings are acquired one per every 10 magnetometer readings and are reported only when acquired.
- GPS NMEA sentence: Reported with the associated FID-1 mag record. A few individual fields from the GPS are also broken out from the GPS sentence and reported separately, without interpolation.
- Interpolated GPS fields: Time, date, latitude, longitude, and track (course over ground) are linearly interpolated between GPS readings.

Decimated exports

Each of the exports at frequencies from 10 Hz to 100 Hz is a decimation – data are filtered by a low-pass filter and then down-sampled to the target sample rate. Each low-pass filter (a different one for each decimation) is a symmetric finite impulse response (or FIR) filter, with the following design goals:

- -3dB attenuation at $0.75 * \text{Nyquist frequency}$ (e.g., the -3dB point for the 10Hz decimation is 3.75Hz)

- Significant attenuation of 50Hz and 60Hz signals.
- Reasonably flat response in the pass band.

These are linear phase (or zero phase, or constant group delay) filters. These filters are not Kalman filters. The filters are applied to fields in the decimations as follows:

- Magnetometer readings: Magnetometer readings are decimated: the FIR is applied, then the data are down-sampled to the target rate.
- Aux sensors: Aux sensors are first up-sampled to 1000Hz by linear interpolation of values between individual readings (which occur once every 5 mag readings for gyro, accelerometer, and temperature, and once every 10 mag readings for compass). Then these 1000Hz values are decimated in the same process as the magnetometer readings.
- Latitude and longitude are first up-sampled to 1000Hz by linear interpolation of values between successive GPS data (once per second), then these 1000 Hz values are decimated in the same process as the magnetometer readings.
- Time, date, and track are linearly interpolated as in the raw, unfiltered 1000Hz export.

Merging filtered and unfiltered data.

Some of the values in an individual line of data are filtered: mag readings, aux sensors, etc. Other measurements are not filtered: time and date, GPS sentences, record counters, and the simple interpolated fields. These two sets of values – filtered and unfiltered, must be reported in individual lines that contain values of both types. The question “How should the two sets of values be matched?” is addressed as follows:

A decimation filter has a *center*. For example, a single filter result that weighs 499 individual measurements running from record number 752 to record number 1250 (in DSP terms, it is the result of the convolution of 499 input values with 499 filter weights), is *centered* on record number 1001. The result is the “filtered value of record 1001”. In a single line along with this value should be the other filtered results centered on record number 1001 plus the unfiltered raw and interpolated values that were recorded as part of the original, raw record 1001.

The down-sampling part of decimation involves keeping some results and discarding others; down-sampling from 1000Hz to 100Hz includes discarding 9 out of 10 results. During exports, Survey Manager keeps the “FID 1” record, because it includes the original GPS information, then discards the next 9 records (if it’s a 100Hz decimation), and then repeats the pattern, each time starting with FID 1.

If you have questions about the MagArrow decimations, please contact your Geometric account manager.