## Waveform data for ISMRMRD

Applications of waveform data can be categorised into those that require a close link with the acquisition time of k-space lines, and waveforms whose effect is predictable (usually preparation steps) that might more logically be in the XML header. For example;

Acquisition

* Physiology monitoring.
* Motion tracking.
* Compensation for long-term effects, e.g. long-term eddy currents, stimulated echoes (?).

Preparation

* Diffusion preparation gradients and RF (include 180’s) for;
  + calculations of b-value,
  + IVIM modelling (may need imaging gradients),
  + Eddy current calculations,
  + Maxwell gradient calculations,
  + Microstructure modelling – sensitivity of sequence to pore sizes etc.
* Generic preparation, e.g. inversion, T2PREP, fat sat, velocity, diffusion-sensitized (black blood). In some cases, the gradient waveform is less useful than its parameterisation e.g. b-value, delta and Delta, ASL labelling delay.

**Proposal**

Define generic waveform structure with fixed layout similar to that used for data. Should have the ability to hold multi-dimensional data and a flag/field to allow identification (e.g. is it gradient, RF flip angle, respiration signal, VECG, etc). This structure could be used within the acquisition section for physiology data etc, or in the XML header for preparation data.

With the k-space data, we need a flag/field to say which of the waveforms in the XML header was the preceding diffusion, or other, preparation scheme. Note diffusion would have multiple entries for different b-values and diffusion directions.

Note that it would be useful if the ISMRMRD file also held the waveforms that could enable a sequence diagram to be plotted – suggests a long-term requirement for representing gradients and RFs.

**Diffusion Waveforms**

* Vector valued gradients (3-elements).
* Flag or field to indicate the coordinate system (default magnet XYZ)
* Optional inclusion of imaging and crusher gradients (required for complete calculation of b-values, especially in low b applications such as IVIM).
* Flag/field to indicate if gradients have been reflected following each 180? Preferably gradients are not reflected and there is an additional waveform describing the RFs within the preparation.
* Currently the temporal discretisation steps will have to be equal (so no ability to add objects with differing durations).
* Flag/field to indicate origin of time axis (RF excitation, start of readout, effective echo time)?