TheaimoftheQIBAFMRITECHNICALCOMMITTEEISTODETAILATEADETAILEDPROFILEFORUSINGFUNCTIONALMRASQUANTITATIVEBIOMARKERFORIMAGINGFUNCTIONS. THEPROFILEISADOCUMENTDESCRIBINGCLAIMSTHEQUANTITATIVEPRECISIONTHATCANBEACHIEVEDWITHFMRIANDEQUIPMENTPROCEDURESPROVIDINGSOLUTIONSFORACHIEVINGTHOSECLAIMS.THEPROFILEALSOSPECIFIESCONFORMANCEPROCEDURESWHEREBY

Usersoftheprofilecanassesstheirabilitytomeettheprofile’sdataqualityconditions.TherimarycontextofusefortheFMIReqipmentandprocedurespecificationsforhowtoachievethoseclaims.AnimportantaspectofthebiomarkerprofileisidentifyingstandardizedimagingprocedurestherealizingreproducibilityquantitativeMRIresultsinaclinicalcontext.

ProfileStatus

ThefirstversionoftheFMIRIPROFILEESTABLISHEDTHECLAIMTHATTHECENTEROFMASCANBELOCATEDREPRODUCIBLYINBRANDACTIVATIONMAPS.Specifically:

**Biomarkermeasurer:**LocalT2*MRImeasurementchange—commonlyreferredtoastheBOLDFMIRsignal(they biomarkerismeasurablephysicalproperty)

**Contextofuse:**Preoperationalmappingofelfectforfocustreatmentplanning/guidance.

**Cross-sectionalmeasurement:**LocationofBOLDasbiomarkeralmofopticorx

**Index:**Thecenterofmassofactivation evokebyahandmovement

**Precision:**Thereisa95%probabilitythatthemeasuredCMA,±/−5mm,completestheCMA

**Conformance:**Proceduresandspecificationsforhowtoachievetheclaim.Forexample:

- Imaging sites requirements
- Appropriate imaging equipment satisfying QA specifications (duty cycle, SNR, stability)
- Appropriate peripheral equipment and stimulus delivery methodology.
- Appropriate image acquisition and analysis software for IMR.
- Experienced MR technologists for the imaging procedure.
- Tasks and methods:
  - Availability of appropriate behavioral tasks for eliciting brain activation of interest.
  - Procedures for training patients on task and verifying satisfactory pre-scan performance.
  - Procedures for verifying task performance during fMRI imaging.
- Data quality assurance (QA)
  - Procedures for assessing image QA metrics (head motion, NVU, signal consistency, etc)

**Specifiation:**ForaccurateQAvaluesconsistentwithachievingtheprofilecompliance

- Image analysis procedures
  - A standardized statistical image processing protocol to know to meet the claims.
  - A new fMRI biomarker profile for functional brain imaging.

We will use QIBA funding from NIH in 2015-16 on ground works to begin developing a biomarker profile for fMRI and MRS.

### DIGITAL REFERENCE OBJECT (DRO) DEVELOPMENT & RESULTS

**Head motion DROs**

Motion DROs were created using 2 different approaches: Both used synthetic time series with ideal fMRI signals in the presence of head motion. The DROs were created by introducing a known amount of translation or rotation and then resampled and analyzed using AFNI. Center of mass and activated detection for each DRO was compared to actual CM.

**Approach 1:** Used 2.5mm cubic voxels and added gaussian white noise plus an ideal fMRI response (Fig 1, legend) adjusted for a maximum SNR of 2. Synthetic head motion was introduced by creating a normalized motion vector over time (Fig 1 blue graph). Five amplitudes of the motion vector were applied as both a translation or rotation of the brain along/around each 3D head axis yielding 30 (6x5) new fMRI datasets that each incorporated a single type and amplitude of head movement. For head motions such as shown in Fig 1, that are not correlated with the fMRI task, significant deviations from the true CM were not observed below 6.6 mm or 6 degrees of translation/rotation (Fig 2).

**Approach 2:** Used high resolution 1mm cubic voxels and added translational head motion (e.g. Fig 3) at a 26 TR slice acquisition frequency (15 Hz) and resampled to 4mm cubic voxels to account for partial volume effects. In this approach, even small amounts of head motion reduced detection of true active voxels (Fig 4) and reduced the accuracy of CM localization (Fig 5). Motion correction did not make much difference. Conclusion: Synthetic DROs can be used to assess the effect of different types and amounts of head motion as a quantitative biomarker. More work is needed to identify the optimal methodology for creating motion DROs and for sampling the full parameter space of realistic types of head motion.

**Variable performance DROs**

**Problems:**Clinical MRI scans use repeated block-design tasks that, ideally, result in regular sinusoidal Biological Oscillations (BO) Activity (patient’s head, however, variable task-dependent BOLD oscillations (eg. Fig 6B). We introduce a “consistency index” QA metric, the correlation between observed oscillation and an ideal sinusoidal oscillation. **Performance DROs:** 400 synthetic DROs were created using different empirical performance-related waveforms (eg. Fig 6B) as activation weighting factors. **ROC analysis:** Each DRO was analyzed to create an activation t-map, which was then compared to the known true activation pattern to create receiver-operator characteristic (ROC) curves for detection and localization performance. **Results:** The 400 DROs that differed only in performance weighting curves yielded variable t-maps and associated ROC curves (Fig 7). Using the automated AMPLIF normalization algorithm (Vovodyc et al. 2006, MIR 24:127-61) (images below 20%) of peak activation improved detection as showed by increased area under the ROC curves (Fig 8). Plotting the area under each ROC curve in Fig 8 as a function of the performance consistency index showed a very strong correlation (Fig 9). Conclusion: ROC analysis shows that consistency index (which can be easily calculated for any real patient fMRI scan) can be used as a conformance QA parameter for fMRI.