**Experiment design for Phase II Phantom Study (updated 10.Oct.2014)**

1. Use only phantoms from CIRS
    a. Phantom materials from University of Wisconsin not yet ready
2. One phantom of each material type will be created. Separate test samples poured from the same mixture of source materials will be created for independent dynamic mechanical property testing. Methods for independent testing are described below.
3. Three material types will be created. Those materials with have sound speed, acoustic attenuation, shear wave phase velocity at 200Hz and shear wave velocity dispersion (velocity gradient) at 200Hz comparable to mildly—moderately fibrotic liver tissue.
    a. Provide target values for each phantom
4. Phantoms will be shipped to Duke University for initial calibration (using ARFI techniques)
5. Phantoms will be shipped sequentially to a group of labs for measurement using a variety of commercial and experimental shear wave elastography systems. The proposed sequence (including initial and final calibration) is (as of 10.Oct.2014):
    a. Duke (Palmeri, Rouze: Verasonics)
    b. Philips (New York)
    c. Philips (Bothell, WA)
    d. Siemens (Issaquah, WA; arrived 7.Oct.2014)
    e. Toshiba (Tustin, CA)
    f. Mayo-Rochester (Chen: Verasonics;  Ehman: Siemens MRI)
    g. University of Wisconsin (Hall: SSI, Siemens, GE; GE MRE?)
    h. Southwoods Imaging Center (Barr: SSI, Siemens, Philips)
    i. Massachusetts General Hospital (Samir, Dhyani: Fibroscan, SSI, Siemens)
    j. DC VA (Garra: Philips)
    k. Duke (Palmeri, Rouze: Verasonics)
6. The experimental protocol is more concise than that used in the Phase I Phantom Study and is described below.

Experimental protocol for Phase II Phantom Study

A single participant, using a single transducer for each imaging system, will make all measurements described below:

1. For each imaging system, shear wave speed (SWS) measurements will be recorded using the protocol defined by the manufacturer of that system. This involves 10 measurements at equivalent, but spatially uncorrelated, positions in the phantom (lift off and relocate the transducer several times measuring at the same depth). Report individual measurement results which will be summarized later.
2. The manufacturer will specify which ultrasound transducer to use in these experiments and verify that the systems involved are using the desired software version.
3. The phantoms have flat contact surface. For those transducers that have a curved contact surface (i.e., curved linear arrays), room-temperature salt water (4.5g/100mL, as described below) will be used to provide continuous acoustic coupling between the transducer and phantom.
    a. Acoustic window membrane issue: discolored – delamination?
4. SWS measurements will be made at three depths for each system: 3.0, 4.5, and 7.0 cm deep. Nominally, this depth will be to the center of the region of interest for SWS estimation.
    a. Add a depth that is the elevational focal depth for that transducer.
    b. There is no need to randomize these measurements.
    c. Individual measurement results will be recorded in an Excel spreadsheet that will be provided.
5. Two other participants measure at 4.5cm with all systems. SWS measurements will be recorded on separate spreadsheets.

***Additional suggestions from Dr. Xie regarding working with the phantoms:***

1. Take a picture of the top of the phantoms when you receive them so we can assess the delamination at each site
2. Record the temperature of the room/coupling fluid
3. When moving phantoms during experiments, please don't just grab the black top rim, instead, hold the main body of the phantom
4. If saline is used to couple the phantom and the probe, please remove saline using a syringe after finishing experiments. Please do not turn phantoms up-side-down to discard saline
5. Please do not leave phantoms without cover in air for an extended period of time
6. Please ensure to use the original packing material (phantom covers, plastic bags, etc.) for storing and shipping phantoms.

***And I will do these two steps when I ship phantoms to the next site:***

1. Take another set of pictures of the top of the phantoms when you are ready to ship phantoms to next participant
2. Ship phantoms via ground

**Coupling solution for scanning the flat phantom surface with curved linear arrays**

In the Phase I phantom study we (re)learned that refraction as the acoustic pulses travel through the coupling medium into the phantom can cause errors in acoustic beam spacing and therefore shear wave speed estimates. To minimize this effect during the Phase II phantom study we have agreed to use salt water (sodium chloride in distilled (or deionized) water as the coupling medium. The chart below shows that, for coupling to a phantoms with a sounds speed of about 1540 m/s (as in the case of the Phase II phantoms), salinity of 45ppt (4.5g of salt in 100mL of water) is appropriate.

The equation used for saline is found in from J.R. Lovett, J. Acoust. Soc. Am. 63, 1713-1718, 1978 (equation 3). The equation for sound speed in pure water is found in GS Kell, J. Chem. Engng. Data (1975), also in Kaye and Laby (5th) p29. The Lovett equation suggests we need a salinity of about 45 (4.5g of NaCl in 100mL of water; NB: sea water has salinity of about 35).