Twelve-Month Interim Report
August 28, 2012
Project: DCE-MRI Phantom Fabrication, Data Acquisition and Analysis, and Data Distribution
(HHSN268201000050C-Project #6a)
PI: Edward F. Jackson, PhD

The 6-month (extended to 12-month deliverable) has been completed as far possible. The Project Leader has taken the output from the existing DCE-MRI Phantom Analysis Software (from VirtualScopics) and has developed an Excel workbook that:

1) takes as input each of the validated software output files (the variable flip angle data T1 calculations and the DCE-MRI acquisition signal intensity and SNR calculations, with and without intensity corrections using the body coil:phased array coil ratio map data),
2) sorts the data from the VirtualScopics-defined regions-of-interest (ROIs) to the physical phantom ROIs,
3) calculates and graphs the relevant parameters for the R1 calculations (converted from the T1 data) and also computes Bland-Altman limits of agreement (for the R1 measurements), and
4) calculates and graphs the relevant parameters for the DCE signal intensity *vs*. R1 analyses and the DCE signal intensity stability analyses.

An example Excel workbook printout using example source results files (*.txt files) generated by the VirtualScopics code (and used as input for the Excel workbook calculations in tabs 1 and 2) is attached. The first two tabs of the workbook provide the analyses discussed above. The next two tabs are the "input spreadsheets" where the user would import the raw output from the VirtualScopics code (the attached *.txt files). The final tab provides the VirtualScopics ROI to physical phantom ROI mapping.

This is the extent that can be provided for this deliverable, as any additional capability will rely on VirtualScopics code modifications. If the variable TR and variable TI data curve fitting issues previously mentioned are addressed by VirtualScopics in a future release of the code, the calculations can be quickly incorporated into the Excel workbook. (In that case, there would be two additional R1 analysis tabs, completely analogous to the first tab for the variable flip angle R1 analyses.)

Note: The phantom data analyzed using the VirtualScopics code thus far have been limited to those obtained on GE scanners. It has not yet been possible to fully analyze Siemens data using the current VirtualScopics code (this has been referred to Dr. Ashton at VirtualScopics). In addition, the image intensity scaling necessary to correctly calculate the results from Philips data has not yet been incorporated in the VirtualScopics code. (The scaling factor issue was only recently discovered.)

VFA R1 Analysis (Using Output from VirtualScopics QIBA Code)

No Correction

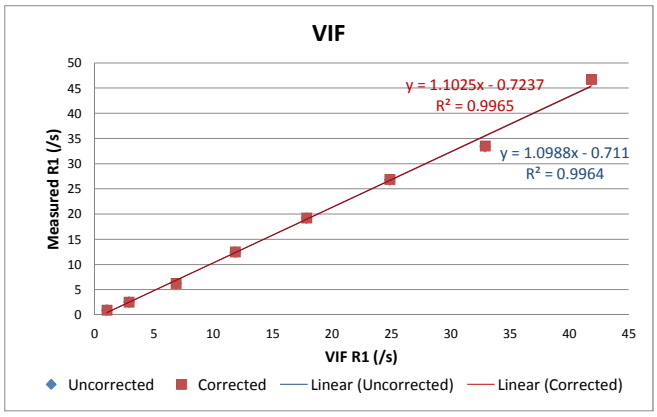
	VIF		Rotation 1		Rotation 2		Rotation 3		Ave Across Rotations			
Phantom ROI	R1 (/s)	M0	R1 (/s)	M0	R1 (/s)	M0	R1 (/s)	M0	R1 (/s)	Stdev (/s)	M0	Stdev
1	0.95	3238	2.03	1950	1.02	4661	1.43	3730	1.49	0.51	3447	1378
2	2.55	3693	1.62	3636	1.85	4331	1.25	3999	1.57	0.30	3989	348
3	6.25	4373	1.71	3856	2.81	3329	1.82	3028	2.11	0.61	3405	419
4	12.49	4796	2.69	4755	2.27	4253	4.26	2101	3.08	1.05	3703	1410
5	19.22	4276	5.67	3145	3.28	2845	5.04	3036	4.67	1.24	3009	152
6	26.82	4303	5.20	3985	7.02	2580	4.72	3374	5.65	1.21	3313	705
7	33.43	3773	6.32	3160	11.81	2322	6.72	4800	8.28	3.06	3427	1260
8	46.61	3120	11.75	2928	10.25	3534	15.08	3493	12.36	2.47	3318	339
	Stdev M0:	588		835		870		791			290	

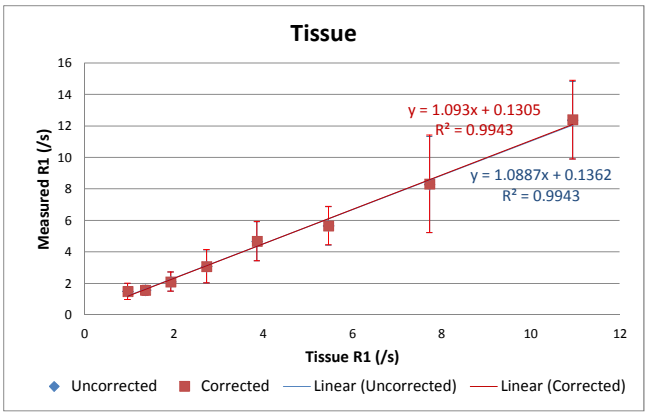
Actual R1 (/s)		Average R1 (/s)		Difference R1 (/s)	
VIF	Tissue	VIF	Tissue	VIF	Tissue
1.05	0.97	1.00	1.23	-0.100	0.524
2.92	1.37	2.74	1.47	-0.379	0.205
6.86	1.93	6.55	2.02	-0.618	0.177
11.86	2.73	12.18	2.90	0.630	0.341
17.86	3.87	18.54	4.27	1.365	0.800
24.88	5.47	25.85	5.56	1.947	0.180
32.89	7.73	33.16	8.01	0.540	0.551
41.84	10.94	44.23	11.65	4.772	1.419
			Limits of agreement:	3.42	0.83

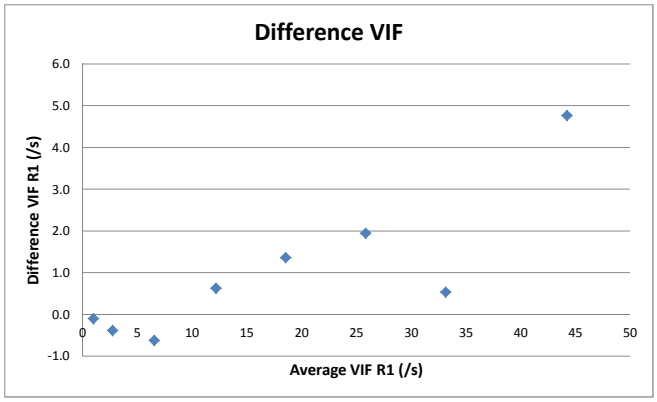
With Correction

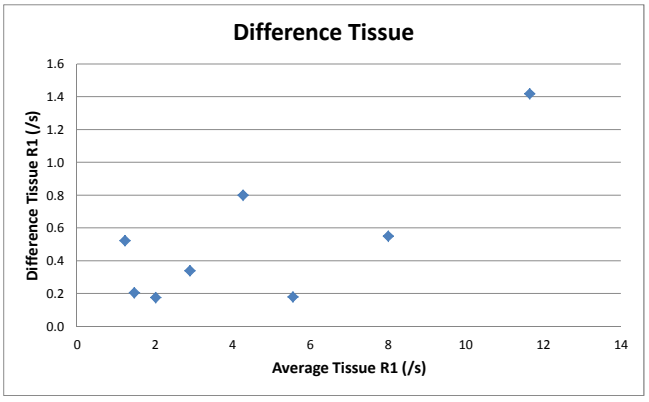
	VIF		Rotation 1		Rotation 2		Rotation 3		Ave Across Rotations			
Phantom ROI	R1 (/s)	M0	R1 (/s)	M0	R1 (/s)	M0	R1 (/s)	M0	R1 (/s)	Stdev (/s)	M0	Stdev
1	0.95	3977	2.04	2007	1.01	3636	1.42	3254	1.49	0.51	2966	852
2	2.55	4048	1.62	2907	1.85	3283	1.24	3527	1.57	0.30	3239	312
3	6.25	4228	1.71	3396	2.81	2890	1.81	3031	2.11	0.61	3106	261
4	12.52	4251	2.69	3586	2.27	3620	4.28	2066	3.08	1.06	3091	887
5	19.27	4163	5.69	2691	3.29	3099	5.06	2483	4.68	1.25	2758	313
6	26.91	4131	5.21	3473	7.04	2380	4.73	3185	5.66	1.22	3013	567
7	33.56	3940	6.34	3198	11.89	2139	6.73	3603	8.32	3.10	2980	756
8	46.75	3628	11.78	2713	10.27	3041	15.14	2770	12.40	2.49	2841	175
	Stdev M0:	202		526		537		525			152	

Actual R1 (/s)		Average R1 (/s)		Difference R1 (/s)	
VIF	Tissue	VIF	Tissue	VIF	Tissue
1.05	0.97	1.00	1.23	-0.104	0.525
2.92	1.37	2.74	1.47	-0.378	0.203
6.86	1.93	6.56	2.02	-0.609	0.177
11.86	2.73	12.19	2.91	0.657	0.347
17.86	3.87	18.56	4.27	1.410	0.812
24.88	5.47	25.89	5.56	2.030	0.194
32.89	7.73	33.22	8.03	0.660	0.584
41.84	10.94	44.30	11.67	4.909	1.456
			Limits of agreement:	3.51	0.85









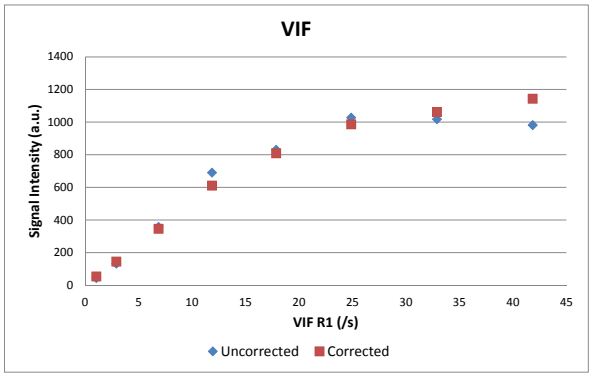
DCE Analysis (Using Output from VirtualScopics QIBA Code)

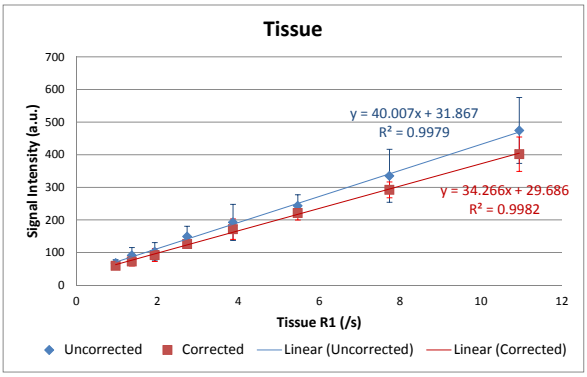
No Correction

	VIF Signal Intensity				Rotation 1 Signal Intensity				Rotation 2 Signal Intensity				Rotation 3 Signal Intensity				Ave Across Rotations				Actual R1 (/s)	
Phantom ROI	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV**	SNR	VIF	Tissue
1	44.0	0.38	0.86	30.7	56.1	0.24	0.42	50.7	68.8	0.32	0.47	38.6	77.3	0.42	0.54	53.8	67.4	10.70	15.87	47.7	1.05	0.97
2	132.4	0.33	0.25	75.9	82.6	0.55	0.67	43.6	118.4	0.38	0.32	75.7	72.9	0.25	0.35	44.4	91.3	23.99	26.27	54.6	2.92	1.37
3	357.8	0.39	0.11	208.7	94.2	0.39	0.42	50.0	133.5	0.83	0.62	108.2	79.5	0.39	0.49	39.9	102.4	27.93	27.28	66.0	6.86	1.93
4	689.9	0.36	0.05	450.3	184.2	0.36	0.20	110.7	139.7	0.33	0.24	84.9	123.3	0.50	0.41	102.4	149.1	31.48	21.12	99.3	11.86	2.73
5	829.9	0.97	0.12	608.1	242.3	1.03	0.42	214.3	132.8	0.42	0.32	63.6	202.4	0.65	0.32	123.8	192.5	55.42	28.79	133.9	17.86	3.87
6	1027.4	0.92	0.09	738.6	280.8	0.78	0.28	180.7	234.6	0.89	0.38	164.6	214.7	0.76	0.36	101.2	243.4	33.92	13.94	148.8	24.88	5.47
7	1018.0	1.02	0.10	624.9	266.1	0.48	0.18	141.8	314.9	0.33	0.11	241.8	424.6	0.53	0.13	236.8	335.2	81.19	24.22	206.8	32.89	7.73
8	981.6	3.37	0.34	610.7	402.0	1.38	0.34	228.4	431.2	1.81	0.42	195.6	589.8	0.63	0.11	428.1	474.3	101.06	21.31	284.0	41.84	10.94
Averages:			0.24				0.37				0.36				0.34				22.35			

With Correction

	VIF Signal Intensity				Rotation 1 Signal Intensity				Rotation 2 Signal Intensity				Rotation 3 Signal Intensity				Ave Across Rotations			
Phantom ROI	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV**	SNR
1	53.6	0.46	0.86	30.1	57.6	0.24	0.42	50.9	53.2	0.25	0.48	37.6	66.8	0.38	0.56	51.6	59.2	6.93	11.71	46.7
2	144.6	0.36	0.25	74.4	65.5	0.44	0.68	42.4	88.6	0.28	0.32	73.2	63.8	0.23	0.36	43.3	72.6	13.87	19.10	52.9
3	345.9	0.38	0.11	207.6	82.7	0.35	0.42	48.6	114.9	0.72	0.62	104.6	79.3	0.39	0.50	39.4	92.3	19.66	21.29	64.2
4	610.4	0.33	0.05	436.9	138.4	0.28	0.20	107.6	118.7	0.28	0.24	83.4	121.3	0.50	0.41	101.7	126.1	10.70	8.49	97.6
5	808.6	0.94	0.12	604.9	206.0	0.87	0.42	208.0	144.6	0.46	0.32	62.5	164.9	0.53	0.32	121.1	171.8	31.30	18.21	130.5
6	985.8	0.89	0.09	730.1	245.0	0.69	0.28	177.3	216.3	0.83	0.38	161.3	202.8	0.73	0.36	99.8	221.4	21.55	9.73	146.1
7	1061.7	1.06	0.10	622.5	269.5	0.49	0.18	140.8	288.9	0.30	0.11	239.5	317.9	0.40	0.12	230.9	292.1	24.39	8.35	203.7
8	1143.6	3.93	0.34	602.6	373.1	1.28	0.34	226.9	369.4	1.55	0.42	193.0	462.4	0.50	0.11	414.4	401.6	52.65	13.11	278.1
Averages:			0.24				0.37				0.36				0.34				13.75	





* Percent coefficient of variation across all timepoints in the DCE acquisition

** Percent coefficient of variation across all three pseudorotations of the tissue compartments

VirtualScopics VFA T1 Measurement Output (With and Without Ratio Map Correction)

	No Correction				Corrected		
Region	T1	M0	MMSE	Region	T1	M0	MMSE
1	37.2824	4302.6	111.258	1	37.1671	4130.96	111.652
2	52.0224	4275.53	59.7945	2	51.9021	4163.34	60.396
3	80.0468	4795.95	55.1008	3	79.8764	4250.64	45.9115
4	160.109	4373.15	26.446	4	159.88	4228.14	25.5333
5	392.875	3693.45	8.57352	5	392.7	4048.44	10.5667
6	1053.15	3238.41	1.77331	6	1056.78	3977	2.76342
7	21.4533	3119.85	514.659	7	21.3902	3628.26	744.428
8	29.9091	3772.73	236.41	8	29.8017	3939.94	278.193
9	192.26	3985.23	8.93477	9	191.831	3473.3	7.16749
10	701.014	3730.19	1.17358	10	702.105	3253.92	0.94721
11	356.274	3328.92	1.0065	11	355.932	2889.91	0.820393
12	176.254	3144.84	0.843118	12	175.71	2691.11	0.691806
13	66.3136	3493.18	2.5285	13	66.0414	2770.21	1.4237
14	541.362	4331.27	2.71792	14	541.671	3282.76	1.63347
15	372.185	4754.53	7.46144	15	371.968	3585.63	4.39587
16	148.796	4799.7	23.2879	16	148.552	3603.37	13.7714
17	983.377	4660.73	2.23805	17	986.285	3636.43	1.42292
18	585.433	3856.46	3.57964	18	585.423	3396.42	2.88235
19	211.864	3374.02	14.6127	19	211.428	3185.49	13.6448
20	97.543	3534.06	64.4874	20	97.3277	3040.76	49.9005
21	615.816	3635.96	4.76722	21	616.515	2906.96	3.15966
22	198.256	3036.12	17.2186	22	197.736	2482.82	12.1204
23	84.6579	2322.3	28.268	23	84.1268	2138.89	26.8214
24	493.001	1949.64	1.14976	24	490.927	2007.05	1.31276
25	234.47	2101.34	4.46314	25	233.638	2066.25	4.64547
26	142.444	2580.18	18.771	26	141.995	2379.99	17.0717
27	85.1247	2927.66	60.1963	27	84.923	2713.02	54.1118
28	550.941	3028.25	3.68737	28	551.318	3030.94	3.82669
29	304.439	2844.78	6.09679	29	304.2	3098.61	7.45598
30	158.214	3160.23	10.9688	30	157.823	3198.24	11.9604
31	802.746	3998.94	2.16194	31	804.391	3526.52	1.75654
32	439.865	4253.33	5.19146	32	439.636	3620.06	3.90614

VirtualScopics DCE Measurement Output (With and Without Ratio Map Correction)

No Correction

Source ROI	Average	Stdev	%COV	SNR
1	1027.4	0.92	0.090	738.6
2	829.9	0.97	0.117	608.1
3	689.9	0.36	0.053	450.3
4	357.8	0.39	0.109	208.7
5	132.4	0.33	0.249	75.9
6	44.0	0.38	0.857	30.7
7	981.6	3.37	0.344	610.7
8	1018.0	1.02	0.100	624.9
9	280.8	0.78	0.279	180.7
10	77.3	0.42	0.545	53.8
11	133.5	0.83	0.622	108.2
12	242.3	1.03	0.424	214.3
13	589.8	0.63	0.106	428.1
14	118.4	0.38	0.321	75.7
15	184.2	0.36	0.198	110.7
16	424.6	0.53	0.125	236.8
17	68.8	0.32	0.472	38.6
18	94.2	0.39	0.418	50.0
19	214.7	0.76	0.355	101.2
20	431.2	1.81	0.419	195.6
21	82.6	0.55	0.671	43.6
22	202.4	0.65	0.319	123.8
23	314.9	0.33	0.106	241.8
24	56.1	0.24	0.422	50.7
25	123.3	0.50	0.409	102.4
26	234.6	0.89	0.381	164.6
27	402.0	1.38	0.344	228.4
28	79.5	0.39	0.491	39.9
29	132.8	0.42	0.319	63.6
30	266.1	0.48	0.182	141.8
31	72.9	0.25	0.349	44.4
32	139.7	0.33	0.238	84.9

With Correction

Source ROI	Average	Stdev	%COV	SNR
1	985.8	0.89	0.090	730.1
2	808.6	0.94	0.117	604.9
3	610.4	0.33	0.054	436.9
4	345.9	0.38	0.109	207.6
5	144.6	0.36	0.250	74.4
6	53.6	0.46	0.861	30.1
7	1143.6	3.93	0.344	602.6
8	1061.7	1.06	0.100	622.5
9	245.0	0.69	0.280	177.3
10	66.8	0.38	0.564	51.6
11	114.9	0.72	0.623	104.6
12	206.0	0.87	0.421	208.0
13	462.4	0.50	0.107	414.4
14	88.6	0.28	0.320	73.2
15	138.4	0.28	0.201	107.6
16	317.9	0.40	0.125	230.9
17	53.2	0.25	0.475	37.6
18	82.7	0.35	0.425	48.6
19	202.8	0.73	0.358	99.8
20	369.4	1.55	0.420	193.0
21	65.5	0.44	0.678	42.4
22	164.9	0.53	0.320	121.1
23	288.9	0.30	0.105	239.5
24	57.6	0.24	0.417	50.9
25	121.3	0.50	0.411	101.7
26	216.3	0.83	0.383	161.3
27	373.1	1.28	0.344	226.9
28	79.3	0.39	0.496	39.4
29	144.6	0.46	0.320	62.5
30	269.5	0.49	0.183	140.8
31	63.8	0.23	0.359	43.3
32	118.7	0.28	0.236	83.4

Phantom	VS Code
VIF1	6
VIF2	5
VIF3	4
VIF4	3
VIF5	2
VIF6	1
VIF7	8
VIF8	7
R1-1	24
R1-2	21
R1-3	18
R1-4	15
R1-5	12
R1-6	9
R1-7	30
R1-8	27
R2-1	17
R2-2	14
R2-3	11
R2-4	32
R2-5	29
R2-6	26
R2-7	23
R2-8	20
R3-1	10
R3-2	31
R3-3	28
R3-4	25
R3-5	22
R3-6	19
R3-7	16
R3-8	13