SITE SURVEY REPORT: MCGOVERN INSTITUTE AT MIT

Date: 5-6 March 2009
Location: McGovern Institute for Brain Research at M.I.T.
MIT Building 46
43 Vassar Street
Cambridge MA 02139

Attendees: Jim McKay, Elekta
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1. General

Potential environmental noise sources external to the building include:

☐ Cars on street – Yes, busy traffic on two sides
☐ Parking lot or garage – Yes, also elevator connected to this
☐ Loading dock for delivery trucks – No
☐ Railway or tram line - Yes, going through the building complex at ground level
☐ Subway – Yes, under the adjacent street
☐ Helicopter pad – No
☐ Construction site – No

Potential environmental noise sources internal to the building include:

☐ Nearby elevators – Yes
☐ Physical plant equipment – No
☐ HVAC ductwork – No
☐ Electric doors - No

The magnetometer was set up in several locations in the First Level of Building 46, to try and determine the best location for the MEG.

For details of the locations measured in the building, see Figures 1 & 2. Rooms 1153 and 1149 are unoccupied lab areas. Room 1145 is an office area with little free space, the magnetic field sensor was quite near a metal desk and the accelerometer was placed in the hallway outside the room to avoid the carpet. Room 1171 (labelled 1117 in Figure 2) is an office area for the technical support staff. It is fairly spacious so the magnetic field sensor was not too close to any metal, but the accelerometer had to be placed on a window sill to avoid the carpet. The measurements were done on March 5, 2009, a normal school day, between 9:30 AM and 1:30 PM EST. In this period the nearby elevators were busy with normal traffic volumes, and the loading bay had several deliveries. An additional measurement was done the following day in Room

1137, the Custodial Services Team Room, which was unoccupied at the time. Measurements were done between 12:20 and 1:20 PM. This room is just a bit to the left of the Ramp area shown at the top left of Figure 1 below.

2. Potential MEG Location Layouts and Magnetometer Setups

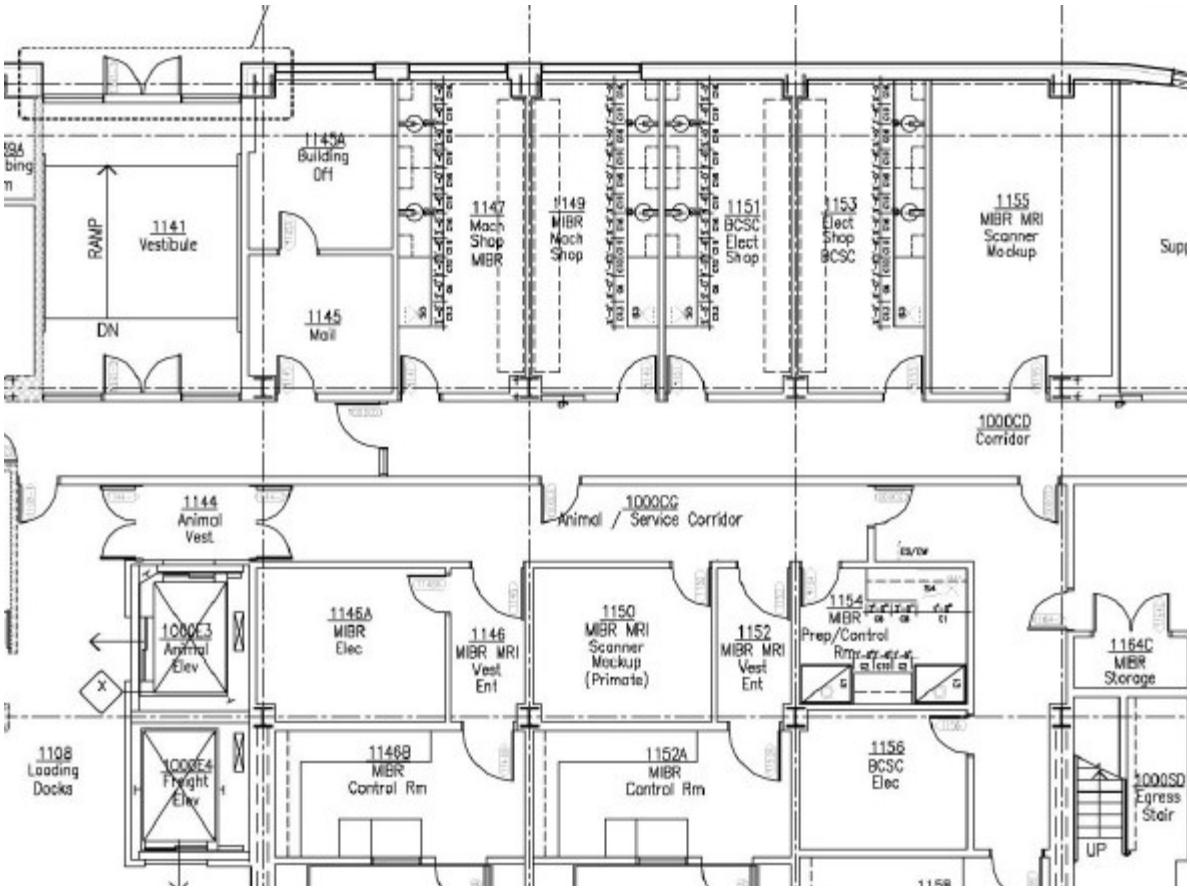

Figure 1: Building 46, 1st Level, Room 1145-1153 Layout

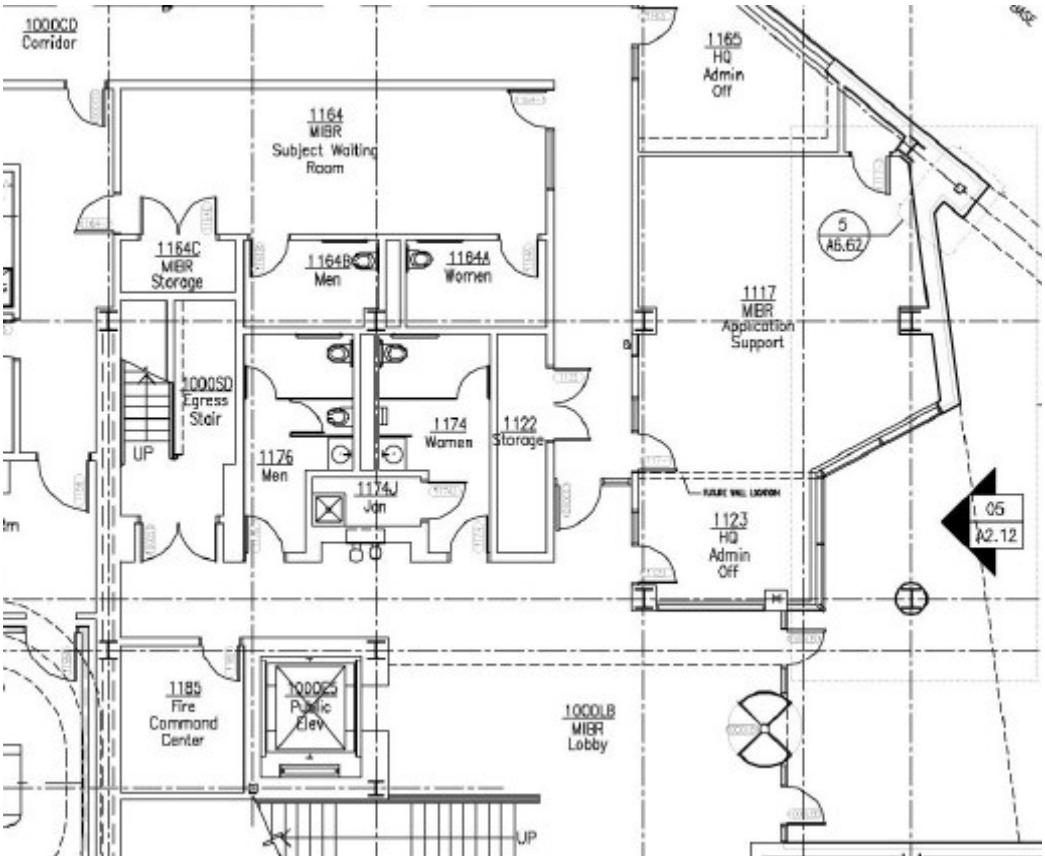

Figure 2: Building 46, 1st Level, Room 1171 (Shown as 1117) Layout

3. Methods

The measurement system consists of a three-axis fluxgate magnetometer (Bartington Instruments Mag03-MCL70), a single-axis accelerometer (PCB Piezoelectronics 39B12), Spectramag-6 data acquisition electronics (Bartington Instruments) supplemented with an Elekta designed low pass filter, and a laptop PC with data acquisition software (Bartington Instruments Spectramag6). The noise level of the fluxgate is about 1 x 10^{-11} T/sqrt(Hz).

Three different measurement recordings were employed: Spectral measurement for high frequency range (1000 Hz bandwidth), spectral measurement for low frequency range (20 Hz bandwidth) and a 30 min trace measurement. In the 30 min trace measurement, the signals are sampled at 52 Hz, while for the spectral measurements the sample rates are 45 Hz and 2000 Hz.

4. Results

For each location measured there are 4 plots shown in Appendices 1-10: magnetic field traces (magnetic field strength as a function of time) over a 30 minute span, wideband magnetic field spectra from 2-1000 Hz, low frequency magnetic field spectra from 0.05-30 Hz, and low frequency vibration spectra from 0.05-30 Hz. The results observed from analysis of these plots follows, with comparative data from other sites measured by Elekta Neuromag. The data is listed in the columns of the tables below, in geographical order to make the trends easy to spot. It should be noted that the comparative data ranges includes previous recordings made at MIT.

After the main recordings at each location on March 5, the magnetometer was set up in Room 1153 and recorded from 3:15PM to just after 6PM in hopes of measuring the effect of a freight train running along the tracks adjacent to the building. Unfortunately the only train that came by that afternoon was just before at about 3:05 PM so no informative data is available.

Appendix 11, 12 & 13 contain pictures of the magnetometer setup in each location.

Trace deviation (nT peak-peak) in 30 minute recording:

Room 1171 Measured	Room 1153 Measured	Room 1149 Measured	Room 1145 Measured	Room 1137 Measured	Minimum from other sites	Typical	Maximum from other sites
6000	5000	4300	3400	3700	50	500	3500

Spectral noise levels (nTrms/√Hz) vs. Frequency (Hz):

Freq.	Room 1171 Measured	Room 1153 Measured	Room 1149 Measured	Room 1145 Measured	Room 1137 Measured	Minimum from other sites	Typical	Maximum from other sites
0.1	695	536	255	95	282	0.2	8	400
1.0	20.	28.2	22.8	1.15	15	0.03	1	30
10.0	0.38	0.16	0.12	0.08	0.11	0.02	0.2	20
100.	0.02	0.02	0.05	0.04	0.03	0.007	0.15	0.7

Power line fundamental and harmonic levels observed:

Freq.	Room 1171 Measured	Room 1153 Measured	Room 1149 Measured	Room 1145 Measured	Room 1137 Measured	Minimum from other sites	Typical	Maximum from other sites
60	9.95	2.86	10.1	24.3	833	3	130	500
120	0.97	0.25	1.07	0.69	191	0.25	2.7	10
180	2.71	0.69	1.88	5.71	274	1.1	51	300
240	0.34	0.11	0.42	0.34	147	.05	1.0	3.5
300	1.24	0.40	0.71	0.61	72	0.15	14	80

Vibration Spectral noise levels (mm/s^2 rms/$\sqrt{Hz}$) vs. Frequency (Hz):

Freq.	Room 1171 Measured	Room 1153 Measured	Room 1149 Measured	Room 1145 Measured	Room 1137 Measured	Minimum from other sites	Typical	Maximum from other sites
0.1	0.6	0.04	0.1	0.1	0.13	0.5	2.6	10
1.0	0.6	0.04	0.1	0.03	0.1	0.03	0.5	0.75
10.0	1.2	0.06	0.2	0.05	0.2	0.03	0.3	0.7

There is an obvious decreasing trend in the trace deviation amplitudes as the measurement location moves down the corridor away from Room 1171, until Room 1137 where it increases compared to Room 1145. The same is true, to a greater extent, for the low frequency spectral noise levels. The trace deviation amplitudes are well above the limits given for the MaxShield and passive 2-layer MSRs (as given in the Elekta Neuromag Site Planning Guide, Oct. 2008, p. 7) at all locations. The spectral noise amplitudes are also above the limits except for Room 1145, which is acceptable for MaxShield but just above the limit for a 2-layer MSR.

All the locations except Room 1137 have below typical power line spectral levels. Room 1137 has very high levels which would lead to the belief that there is likely a high current AC power line in its vicinity. For this reason this location would be unacceptable based on the power line fields alone.

All the locations have similar vibration spectral noise levels overall. The vibration levels are all quite low and should not influence the MEG location selection process.

5. Comparison and Recommendations

Site Summary:

Site	Trace fluctuations	Magnetic field spectral noise	Magnetic field interference and power line levels	Vibration spectral noise and spectral peaks	Ceiling height
Room 1171	Very high	Very high at low freq.	Low	Low	Not measured
Room 1153	Very high	Very high at low freq.	Low	Low	Not measured
Room 1149	Very high	Very high at low freq.	Low	Low	Not measured
Room 1145	Very high	High at low freq.	Low	Low	Not measured
Room 1137	Very high	Very high at low freq.	Very high	Low	Not measured

Site compatibility with MSR options:

Site	MaxShield MSR or standard 2-layer passive MSR	2-layer MSR with active cancellation	3-layer MSR
Room 1171	Not sufficient	Maybe OK	OK
Room 1153	Not sufficient	Maybe OK	OK
Room 1149	Not sufficient	Maybe OK	OK
Room 1145	Not sufficient	OK	OK
Room 1137	Not sufficient	Maybe OK	OK

Based on the measured data and the observations made:

1. The best location on the 1st level of the McGovern Center is Room 1145. This is the only location where it appears that a 2-layer shielded room would clearly be sufficient.
2. Recommended MSR option: The noise levels observed are high enough in this building to make the heavier and more expensive standard 2 layer and 3 layer shielded rooms necessary. A MaxShield MSR is definitely not recommended, and if a 2-layer MSR is chosen it would be necessary to

include coils for active cancellation of the environmental magnetic fields (as used in the MaxShield MSRs).

3. Work required at the site: To include addition of walls to front of MSR and to surround noisy MEG electronics, new ductwork, new electrical conduit, new suspended ceiling and flooring, and provision of a Helium gas exhaust pipe to outside the building. The floor load specifications should be checked by a structural engineer. Compressed air will be required for the operation of the MSR door. AC power circuits and air conditioning would also be required to accommodate the system.
4. Reception of the MEG and MSR equipment crates does not appear to be difficult.

Appendices

APPENDIX 1 – Room 1153, 30 minute magnetometer signal plots and high freq. spectrum

APPENDIX 2 – Room 1153, Spectral Plots for magnetometer and accelerometer, Low frequency ranges

APPENDIX 3 – Room 1149, 30 minute magnetometer signal plots and high freq. spectrum

APPENDIX 4 – Room 1149, Spectral Plots for magnetometer and accelerometer, Low frequency ranges

APPENDIX 5 – Room 1145, 30 minute magnetometer signal plots and high freq. spectrum

APPENDIX 6 – Room 1145, Spectral Plots for magnetometer and accelerometer, Low frequency ranges

APPENDIX 7 – Room 1171, 30 minute magnetometer signal plots and high freq. spectrum

APPENDIX 8 – Room 1171, Spectral Plots for magnetometer and accelerometer, Low frequency ranges

APPENDIX 9 – Room 1137, 30 minute magnetometer signal plots and high freq. spectrum

APPENDIX 10 – Room 1137, Spectral Plots for magnetometer and accelerometer, Low frequency ranges

APPENDIX 11 – Room 1153 and 1149, Magnetometer Setups

APPENDIX 12 – Room 1145 and 1171, Magnetometer Setups

APPENDIX 13 – Room 1137, Magnetometer Setups