

EMWoG Telephone Conference Call
Thursday June 14, 2007, 4.00-5.00 pm EDT
Minutes and Action Items

Present: Phil Wannamaker, Rob Evans, Shane Ingate, Dean Livelybrooks, Adam Schultz, Martyn Unsworth.

Apologies: Gary Egbert, Kevin Mickus, Steve Park

Minutes of previous telecon

Will be deferred until next telecon (Jul 12, 2007).

Old Action Items (Outstanding)

- Status of EOS article (Park)
- Legacy MT data (Park)

- **Action:** Ingate to contact Park and encourage forward movement and updating (to reflect CascadiaEM) of the EOS paper, and to obtain legacy metadata.

EMWoG Membership

Group agrees that rotating new members through EMWoG will be beneficial. Because procurement is complete and field procedures are maturing, EMWoGs emphasis is shifting towards science and new members should be selected to actively participate in this dialog. Suggestions for new members include Paul Bedrosian (USGS), Chet Weiss (VaTech), Jim Craven (GSC) and Jose Romo (CICESE).

Group believes that rotating 1-2 members/year would be a good balance between bringing in new blood and maintaining corporate memory.

MT Lovefest Report

Schultz and Egbert provided a report on the LEMI (attached). It was generally felt that the workshop achieved all its goals, plus some.

Schultz reports that the firmware issue with the LEMI was resolved under warranty, and that LVIV will be shipping the firmware for Schultz to install.

Group did discuss CascadiaEM. The onset of winter in late Oct is a concern, and recommends that GSY commence in the NW and work towards the SE. The area west of the Cascades should be covered early. Idaho can be left until later.

Lovefest participants did note that the use of Russian buckets appeared new to the GSY engineers. The use of Russia buckets are optional for the short deployments, but they may be useful in dry deserts. Group advised wetting the ground with bentonite or kaolinite.

Strategies for working with USGS and FRD site

- **Action:** Ingate will contact Carol Finn at USGS. Schultz recommends a field trip to FRG to check it for suitability.

Future MT courses

Group discussed time, location and content of next instructional workshop. Suggestions include inversion and interpretation and joint MT-seismic inversion. Group does not feel the need to have another data collection/field-work tutorial. There is a preference for holding the tutorial the day prior to the IRIS Workshop (4-6 June, 2008).

The EarthScope National Office (ENO) at OSU should be involved in this.

2008 transportable experiment

Group spent some time discussing this concerns of USAAC and NSF; namely, engaging the broader community for input on targets for future transportable experiments. For 2008, EMWoG agreed that the Yellowstone hot spot is a high value target. It is believed that there is EMSOC support for YSHS as well.

Several ideas were floated:

- Seek funding from NSF to hold a pan-EarthScope workshop to decide transportable MT focus; given Shedlock's reluctance to fund additional GeoSwath workshops, it is not clear if this is viable.
- Ask EMWoG to make a handful of suggestions, and let EMSOC decide;
- A 2-step process of first distributing widely a request for concept proposals (~1 page), with the emphasis being on joint interpretation of MT and seismic data. Distribution should take place end of July, via IRIS, EarthScope and EM mailing lists. The second step would be to present the proposals to EMSOC for discussion at their Annual Meeting in December. EMWoG would endorse the EMSOC decision.
 - **Action:** Ingate to follow up on the last suggestion.

2007 Calendar

- [CascadiaEM, commence Jun]
- [CascadiaEM end, Oct?]
- IUGG Jul 2-13
- AGU abstracts due Sep 6
- GSA Oct 28-31
- IRIS CoCom/BoD Nov 6-8
- NSF Review of EarthScope Nov 14-15
- USAAC meeting Dec 8-9
- AGU Dec 10-14
- IRIS Workshop, Jun 4-6 2008, Stevenson, WA
- Induction Workshop, Sep 15-20 2008, Beijing

Next telecon (second Thursday of the month)

- Thu 12 Jul 2007 4-5 pm EDT.

Action Item Status from 5/10/07

- **Action:** Ingate to arrange and coordinate “MT Lovefest 2007”.
- **Resolution:** Completed.

Action Item Status from 5/10/07

- **Action:** Egbert to prepare a brief proposal to complete higher-level data products for the DMC through the end of the MREFC (Sep 2008).
- **Resolution:** Pending.

Action Item Status from 12/11/06

- Schultz to contact M. Kitchens (GSY-USA) about privately-owned 80 acres in Michigan as a potential Backbone site.
- **Resolution:** *On-going*. Discussion with Kitchens have commenced, as well as with the ANSS operator in WI.
- Egbert to provide to GSY-USA MATLAB routines for plotting uploaded NIMS data when in the field. Egbert and GSY-USA to agree on a format for meta-data collected in the field.
- **Resolution:** *On-going*. GSY have indicated they want a single operating system for use in the field, and do not wish to toggle between DOS for communicating with the NIMS, and Linux for MATLAB. Schultz has converted *NIMSread* to run under Mac OS X.

Report on the LVIV LEMI
June 4-5, 2007
Adam Schultz, OSU

First off, while I was initially unclear about the need for an engineer to visit OSU to brief us on LEMI, in the end it turned out to be a useful exercise. Evgeny Klimovich also turned out to be extremely pleasant and knowledgeable, and it was good to include him along with Barry Narod, in the Lovefest. There was a good exchange of information all around. Klimovich's English language skills are reasonably good, and we had a very thorough exchange of ideas and information. We also share similar design principles and hit it off on an engineering level. For highly detailed discussions of low-level data formatting, we had the advantage of Anna Kelbert's fluency in Russian, which has helped to eliminate ambiguities in understanding more subtle aspects of the system.

First impressions:

1) Packaging. I think the LEMI has superior field-worthy packaging. A smaller Pelican case is used than the NIMS/NE (an even smaller one, without internal battery is being implemented next); the peli case lid opens to reveal a solid metal faceplate with a small LCD display and a couple of switches that can be used to start/stop the LEMI without the need to connect a PC or other field computer (all system parameters can be set either from the front panel, or remotely through a PC), and a sealed, hinged metal door that is secured over the CF card slot. This is more robust than the LEMI plexiglas cubes held in place by foam, and unsealed CF card slot. The sensor head is much smaller than the NIMS/NE and is completely filled with resin - with a claimed water resistance to 20 m immersion that Klimovich says has been lab tested. It has a convenient bubble level built into the exterior top of the sensor housing. A simple PVC leveling base and leveling tool was provided to enable the system to be installed in a BB vault. Klimovich and I worked in my lab to extend the length of the tool to reach to the bottom of the BB vaults. Confirmation of acceptable system operation can be obtained from the LEMI LCD display, where field values, and other system parameters can be viewed while the system is running. In contrast, the NIMS provides a time-limited set of flashing LEDs to indicate flash card formatting or initial GPS acquisition, but without a Win95/DOS field computer, there is no indication that the system is operating successfully. In my view the LEMI arrangement would aid a field contractor in confirming successful operations before leaving a site.

2) A new version of the LEMI sensor head is in development that includes an internal suspension/gimbal mount arrangement that would remove the need to level the sensor. This would be a fluid-filled sensor head. I have advised Klimovich that there can be difficulties with TSA shipping large fluid filled volumes, so they may want to consider installing a fill cap and drain system, and a mechanical lock, so the system could be shipped dry.

3) Tellurics. The LEMI is a true 24 bit system (at all frequencies for the magnetics, and for the tellurics it is ~24 bit at least if averaged to 0.5-1 Hz, since at 8 Hz I believe it is

closer to a 21 bit system when one examines the ADC data sheet). It appears to have greater dynamic range than the NIMS in E-field measurements, and the version I was sent can handle DC signals as large as +/- 2.5 V. Because of the 24 bit dynamic range, this is a fixed gain instrument. In contrast, the NIMS has manually set high and low gain modes for the E-field since it is a 16 bit system. We have twice run into problems running the NIMS at high gain in the presence of high levels of AC environmental noise (as is the case at Soap Creek, when intermittently such a source appears - possibly related to a pump house in another field on the same ranch). In high gain, the more limited dynamic range of the NIMS E-field amps leads them to saturate. This does not appear to be the case with the LEMI. The NIMS/NE has a 2-channel telluric system. The LEMI has a 4-channel telluric system. The NIMS has a bulkhead connector to attach the system to the telluric dipoles. The LEMI uses terminal posts - which were somewhat awkward. I understand a connector-based system is being used for the next version. Although we found the terminal posts awkward, they were located in a hinged metal lid that did afford them a degree of mechanical protection, and seemed better protected than the NIMS connectors.

4) Magnetics. The NIMS as I recall uses a 16 bit DAC to null out most of the main field, then a 16 bit ADC to digitize the remaining field within a range where the fluxgate operates more linearly. With proper calibration, such a system is capable of returning total values of the magnetic field, including baseline values (although not observatory standard baselines which require calibration against a proton standard etc.). The LEMI is similar, but rather than a hybrid DAC/ADC, it uses two 16 bit DACs, with 10 bit overlap, to give 24 bit DAC control. It is entirely a nulling instrument, so the DAC generates a field to zero out the Earth's field entirely. The compounded 24 bit DAC value is the field value. This in my view is an excellent way to do things - nulling instruments are always operating in the most linear range of the sensor. It too provides total baseline values (Klimovich insisted that it was true baseline, with low drift, but we cant substantiate this yet). The NIMS/NE we've received have RMS noise in the range 16-18 pT/Sqrt(Hz) @ 1 Hz. The LEMI purports to have RMS noise of 7 pT/Sqrt(Hz) @ 1Hz. We need to appraise this independently, but from the short time series records obtained in the field, the claim may be substantiated. At this point it seems to be a very quiet instrument. Certainly the E-field amplifier noise at 1 Hz sampling is no more than +/- 1 bit (this was observed this week). In contrast to the NIMS, the LEMI system and sensor head temperatures are physical rather than arbitrary.

5) Data structures. The NIMS uses a binary hex format for both flash card storage and RS232 serial transmission. The LEMI uses a binary format for flash card storage, but has been modified at my request to stream ascii data over the RS232 serial line. Each data point has a unique time/date stamp. The NIMS is controlled in the field using a DOS or Windows95 computer, since the user interface is written in the Forth language, and requires access to a hardware address for the PC's serial port that became unsupported in newer versions of Windows. Other interfaces are in development in Italy, but we have not been able to use these successfully. The LEMI has a user interface that is an executable Windows program that works under Windows XP, and presumably all other versions of Windows after Win95/98. The same program is also used to read data from the flash

cards and to convert it into an ASCII stream. The NIMS user interface is character-based. The LEMI user interface is graphical, with real-time display of time series plots as they are acquired. The NIMS writes a single data.bin file to the flash card, which contains internal metadata. The LEMI writes a new data file, appended to the flash card, every time a new job is started, or on each GMT day boundary. The name of the flash card files are based on the serial number of the LEMI unit with a file number appended, from 000 to 255. Since there can be no more than 255 "day files" per flash card (a limitation of the file system), continuous unattended operation for more than 255 days would present a problem. Klimovich is now aware of this problem, and will implement a modification to the control software so the number of days/"day file" can be set to something greater than one. For instance, 255 2-day-long files, would permit more than 1 year of continuous unattended operation. The LEMI files also contain metadata derived from the GPS time and position stamp - so once the flash card files are read and converted into ASCII, their file names are modified to include unique metadata information. This is an advantage over the LEMI, where the file naming convention is more primitive.

6) IP access - I have connected the LEMI to a serial port server that outputs continuous LEMI data through 128.193.69.11 port 4001 (also known as mtbb_a.oce.orst.edu). This is a test connection - it will be up/down intermittently as we try different configurations - but I have been able to stream data from the LEMI on to the Internet (Note - at this moment access to this location is through a VPN tunnel - so you will not be able to get in to it). The ASCII interface to the data stream makes testing IP access straightforward, since any telnet session can display it. To do something similar for NIMS would involve socket-based programming.

7) Both NIMS and LEMI were installed at Soap Creek and run overnight. The NIMS operated with the Hungarian Pb-PbCl₂ electrodes installed in Russian buckets with our own Kaolinite/NaCl-H₂O paste. The LEMI operated with Ukrainian Cu-CuSO₄ electrodes installed directly in the ground, after wetting with CuSO₄ solution. The LEMI was initially operated without a GPS antenna for the overnight run. The LEMI has a GPS antenna. In the morning the LEMI was outfitted with its GPS antenna and another, shorter run was initiated. I prefer the Pb-PbCl₂ electrodes, and am happy enough with the Booker electrodes, with the Hungarian electrodes as commercially-available alternatives.

8) I understand that the NIMS exhibited evidence of amplifier saturation at times (Gary* is better situated to discuss this), probably related to operation overnight at high gain in the presence of intermittent, high AC noise levels. The LEMI did not appear to show evidence of this problem. There were errors in the LEMI averaging algorithm (to generate 1 Hz data from 8 Hz raw data) that were evident, with related errors in sample timing. There were no such errors evident in NIMS data. The LEMI averaging algorithm error, we understand, is due to a hastily written piece of code that involves mixed float/integer operations, and should be easily fixed. There may also be errors in the acquisition algorithm when GPS is not present - this is being investigated. Our impression is that all such errors are minor and should be easily resolvable.

9) Klimovich will provide a new circuit board containing the revised firmware for LEMI once these errors have been eliminated from the code.

10) In discussions with Narod about BB MT instrument design, we concluded that his scheme to power up/power down the BB instrument was very inconvenient, and would interfere with smooth servicing operations. He has suggested replacing a connector and introducing an on/off switch into the data logger box that will sit in the top section of one of the instrument vaults. This seems to be a good idea, and there may be minor cost implications. In the midst of those discussions, Narod indicated that upon reflection, there is the possibility that his present BB MT instrument design may admit a ground loop when an RS232 antenna is connected, and that this may require optically isolating the RS232 system from the rest of the NIMS. These discussions are on-going.

11) The NIMS data, despite episodic amplifier saturation(?) appeared to produce good response functions (Gary to elaborate). The LEMI data require format conversion software to permit analysis to be concluded. I believe Anna Kelbert may be working on this.

12) Summary. A very successful event for the academic participants, the GSY staff, and also for the Ukrainian and Canadian vendors. The Soap Creek test site has the right combination of easy access, both wet and dry soil conditions, and intermittent environmental noise to prove a useful test site, and allows us to fully test a reasonably large range of operating conditions. The NIMS worked as before, and the LEMI, in its initial deployment, appears to be a fine instrument with several advantages. Once firmware revisions are undertaken, the LEMI may prove to be a reliable, and in some ways superior long-period MT instrument. I also understand that a version of the system can be provided for broadband MT using coils alone, or both induction coils and fluxgate. EMSOC to take note...

-Adam

***Note added by G. Egbert, 6/7/07**

There were no problems with saturation with the NIMS. I believe the issue of the high AC potentials was discussed initially as a possible (but ultimately incorrect) explanation of the failure of the LEMI to produce good electric field data (the problem was a firmware bug). Before we looked at the NIMS data there were concerns raised that this might have also saturated the NIMS electronics on high gain, but this proved to be incorrect; the data were fine. The other time when high gain was suspected to be a problem at the soap creek tests also proved to be a firmware problem, that time in the NIM-NE. So I don't think we have seen saturation (though Barry himself was concerned that the AC level at the test site would saturate the NIMS on high gain!)

Response by A. Schultz, 6/7/07

Thanks for the update Gary. Glad to hear the NIMS amps didn't saturate despite Barry's thinking it would. To clarify one point - we never thought the LEMI amps would saturate; rather initially we thought that the 20-30 mV AC I saw when I connected a

multimeter to the Ukrainian electrodes was indicative of a poorly grounded electrode, since that sort of AC noise infiltration has been observed previously from poor grounding. The slightly strange time series on the LEMI was then initially interpreted as resulting from a poorly grounded electrode. It was later that Evgeny figured out he had an averaging problem in his conversion from 8 Hz to 1 Hz.

When we later had Thor connect a multimeter to the Hungarian electrodes that were feeding the NIMS, we saw similar levels of AC noise from the completely independent telluric array, which indicated that this was environmental noise, rather than poor electrode coupling. When Barry heard there was 30 mV of AC noise, he thought that the amp would saturate. So glad that neither system saturated.

EMWOGers - Our LEMI is now streaming data to the internet, and it is accessible from outside OSU on port 4001 of IP address 128.193.69.11.

You can telnet to that, i.e. "telnet 128.193.69.11 4001"

The LEMI is currently averaging over 6 seconds, and is located in my lab (so there is no input to the E field channels - they are just floating, and the magnetometer is in a noisy lab environment). If you do connect to the instrument, please do so only for short bursts since it is set to permit only one telnet session at a time at the moment.