

Cooperative New Madrid Seismic Network
Saint Louis University

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Summary

This report highlights the activities of the Saint Louis University of the Cooperative New Madrid Seismic Network for 2000. The network provides locations of regional earthquakes, data for research and serves as a focal point for local and regional interest in earthquakes.

Progress has been made in creating a modern broadband digital seismograph network in the central U.S. Although the network is not complete, stations are running and providing coverage. With the exception of Kentucky, there are existing stations in the region covered by the member states of the Central United States Earthquake Consortium. A station in western Kentucky is planned.

Stations

The networks run by Saint Louis University consist of short-period and broadband stations.

Short Period Network

The purpose of the short period network is to provide sufficient recordings of small earthquake in the region to permit their location. In addition selected channels are used for analog displays on recording drums in the Saint Louis University Earthquake Center. The Saint Louis university short period network consists of stations feeding into two nodes: St. Louis and Cape Girardeau, Missouri. The number of stations are small, 10 or so, but are sufficient to locate earthquakes in south eastern Missouri.

The short-period analog systems feed into Southeast Missouri State University, Cape

Girardeau, Missouri and into Saint Louis University, St. Louis, MO. A USGS provided Earthworm data acquisition system is installed at both locations. These W/NT PC systems communicate with the Solaris Sparc Earthworm system at Saint Louis University and the University of Memphis, which also record broadband data streams.

Broadband Network

The broadband network has a significantly different purpose than either the University of Memphis or the Saint Louis University short period networks:

- Provide location capability over a broad region of the Central United States that have had significant earthquakes in the past;
- Provide monitoring in metropolitan areas
- Possess low data transmission costs
- Be maintainable
- Provide a continuous data stream for rapid location of local, regional and teleseismic events
- Provide a permanent archive record of ground motions in the region
- Record $M = 3+$ earthquakes on scale
- Have a stations within 100 km of any expected future significant event
- Provide data of high enough quality to challenge students' research.

The figure below shows the currently operating broadband stations in the region (see Table), as well as the tentative sites (triangles) for the remaining broadband stations of the SLU component of the CNMSN.

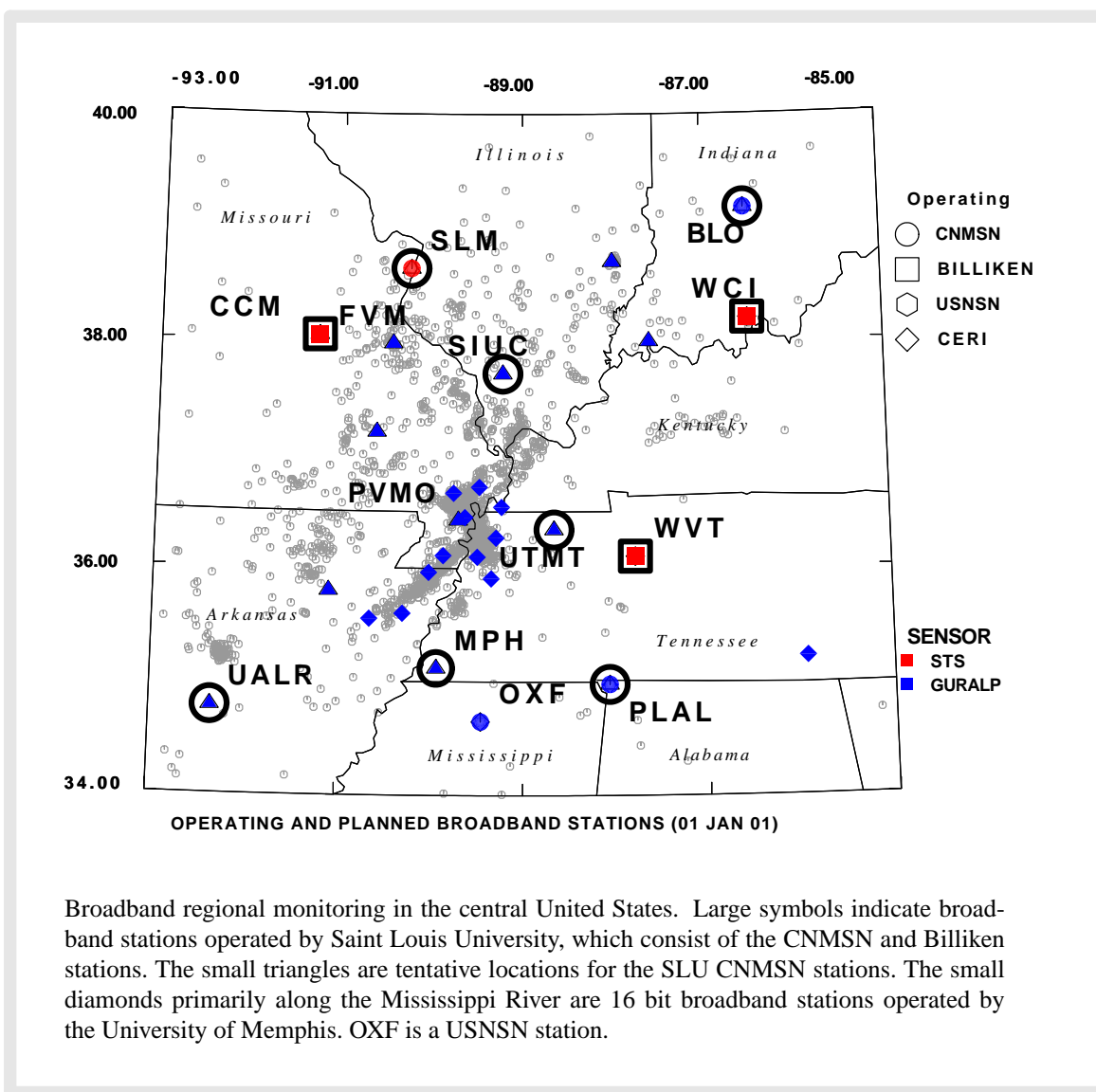
Data flow

Because of the wide distribution of stations, multiple modes of data transfer from the field site to the analysis and archiving site are used. These are indicated in the data flow diagram below.

All acquisition units consist of a Quanterra data acquisition system, which has enough local storage for 5 days of continuous compressed 24 bit data from 3 components at 20 Hz. and several months for the 1 Hz data stream. Communication with the Quanterra can be done through a serial link, by telephone or satellite dialup. The preferred method to acquire the data is to run a COMSERV/DACOMMO link between a SPARC and the Quanterra over another serial/ethernet port. The data flow continuously to the Sparc where the data are de-multiplexed into sample rate/channel disk files, e.g., BHZ or LHZ. The Sparc is also capable of running other processes, such as an Earthworm ring buffer and the USNSN *vdl* transfer protocol.

At all remote sites with Sparcs, e.g., BLO, MPH and UALR, complete data for each day are transferred to the Saint Louis University Earthquake Center by *ftp*.

The purchase of newer used Sparcs for the field sites was accomplished in 2000. This was necessitated by the fact that Earthworm requires a threads library that is part of Solaris 2.7, which can only run on somewhat newer Sparc architecture. The Earthworm process *q2ew* works well, as does the *export_scn* that permits us to transfer our BLO data stream into the Indiana University Antelope process. At present we have no plans to accept data from their PEPP stations, even though this would be an obvious next step in designing a



regional system.

Saint Louis University is awaiting the delivery of the new Earthworm global associator developed by Carl Johnson before embarking on automatic locations. Presently, our earthworm data stream is being fed directly to the University of Memphis *folkworm* which is attempting automatic locations. Seismic station installation has been delayed for some very important reasons:

Sensors:

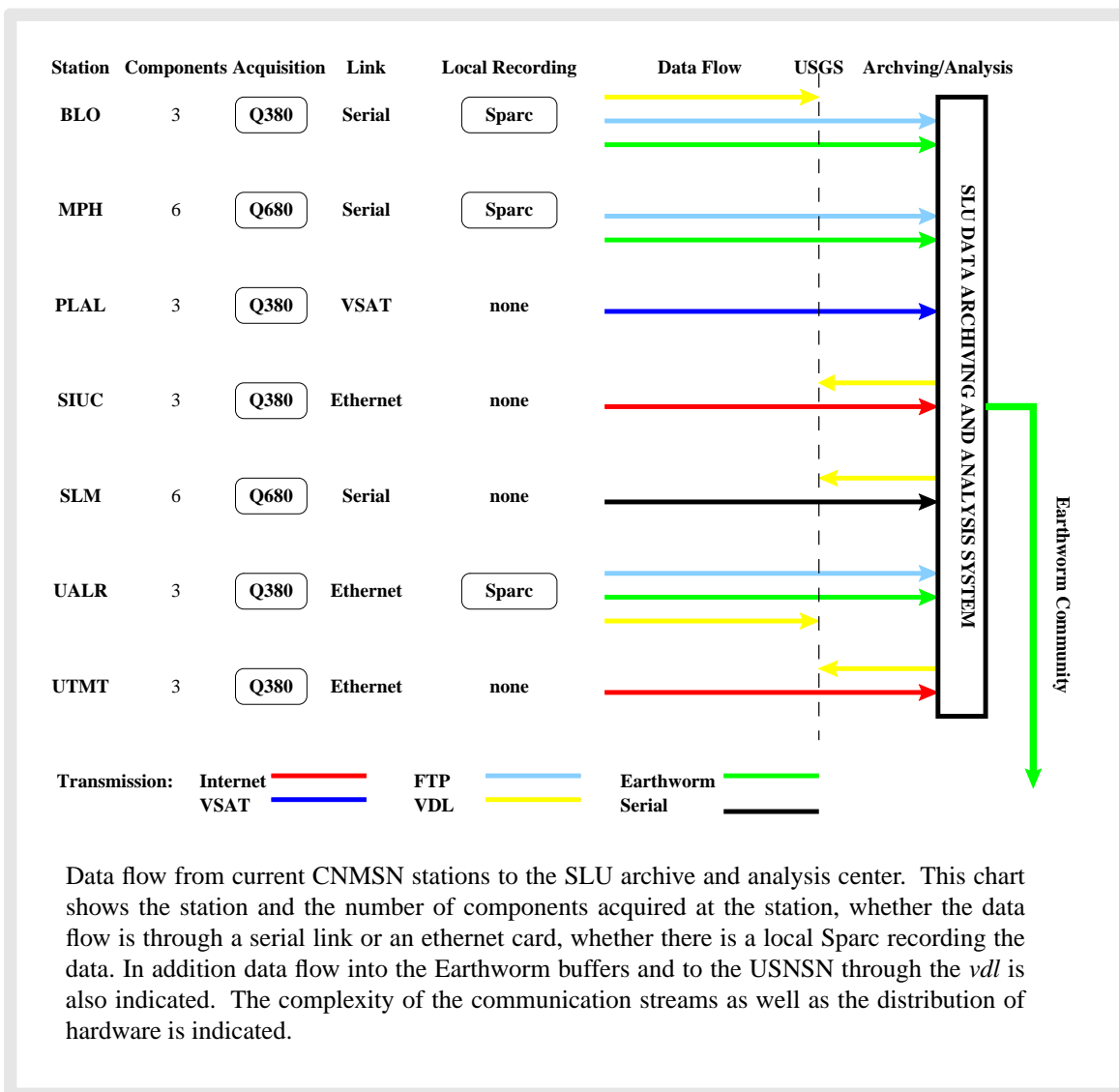
We had major stability problems with 12 of the 15 broadband sensors that we purchased for the network. During the summer of 1998, we implemented an automatic daily seismogram generation which deposits images on our web server for daily review. We later improved the presentation on the web page. In addition we established procedures for evaluation the noise response of sensors received from the manufacturer by comparing the performance against a reference sensor on the same pier (SLM). This performance evaluation of sensors is crucial to the success and usefulness of the broadband data.

Operating Broadband Stations in the New Madrid Region
As of 01 January 2001

Station	Lat(°)	Lon(°)	Sensor	Operator
OXF	34.65	-89.45	Guralp	USNSN
CCM	38.05	-91.25	STS-1	Billiken/IRIS
WCI	38.2	-86.5	STS-1	Billiken,USNSN
WVT	36.106	-87.775	STS-1	Billiken,USNSN
SLM	38.64	-90.24	STS-2	SLU/CNMSN
BLO	39.172	-86.522	Guralp	SLU/CNMSN
MPH	35.12	-89.93	Guralp	SLU/CNMSN
FVM	37.98	-90.43	Guralp	SLU/CNMSN (2001)
PLAL	34.979	-88.063	Guralp	SLU/CNMSN
UTMT	36.342	-88.657	Guralp	SLU/CNMSN
SIUC	37.715	-89.217	Guralp	SLU/CNMSN
PVMO	36.4253	-89.6994	Guralp	SLU/CNMSN (2001)
UALR	34.7753	-92.3436	Guralp	SLU/CNMSN
GLAT	36.2694	-89.2876	Guralp	CERI
GNAR	35.9652	-90.0178	Guralp	CERI
HALT	35.9106	-89.3395	Guralp	CERI
HBAR	35.5550	-90.6572	Guralp	CERI
HENM	36.7160	-89.4717	Guralp	CERI
HICK	36.5409	-89.2288	Guralp	CERI
LNXT	36.1013	-89.4913	Guralp	CERI
LPAR	35.6019	-90.3002	Guralp	CERI
PARM	36.6635	-89.7522	Guralp	CERI
PEBM	36.1131	-89.8623	Guralp	CERI
PENM	36.4502	-89.6280	Guralp	CERI
SWET	35.2163	-85.9320	Guralp	CERI

During 2000 we received 4 replacement sensors and one repaired sensor. Of these we returned the repaired sensor for further work since it has excessive internal noise. At present we have CMG3-ESP sensors at MPH, UTMT, PLAL, BLO and SIUC; an STS-2 purchased from Union Pacific Foundation funds is at SLM; the UALR site has a CMG-40T. The MPH site also has a Kinemetrics FBA-3 accelerometer feeding into its 6 component Quanterra.

A sensor at the remote PLAL site is problematic, since we have now had two sensors fail. This site consists of our Quanterra Q380 and our CMG3-ESP sensor with USGS provided power conditioning and VSAT telemetry. The original ESP placed at the site failed -- the factory replaced pivots and the DC/DC Converter. Our recently acquired new CMG3-ESP has also failed, first with one component going dead, and recently a second component. We have asked the factory to assist us by providing an insight into the



failure. If the failure can be related in any way to the power system at PLAL, that must be repaired before we sacrifice any more ESP's at the site.

Until we have the replacement sensors, we have no additional sensors to install at new sites. Thus the network installation is delayed.

We had a major problem at our site at Southeast Missouri State University, Cape Girardeau, Missouri. The seismic vault was contaminated sometime during the past 5 years by a leak of Americium from a chemistry lab above the seismic vault. The environmental cleanup consisted of physically removing all seismic equipment from the vault. We lost 3 short period sensors, telemetry electronics and analog display recorder electronics. In addition personnel having spent time in the vault were scanned for contamination. The USGS lost a strong motion recorder too. Perhaps university insurance can reimburse us for our losses.

Hardware Upgrades

Eric Haug's implementation of a 386BSD system to function as a internet packet filter was successful. This system sits between the Quanterra 380 and the host university's backbone to transmit only specific packets to the Quanterra so that the network address translation table does not overflow, and the processor to hang. This will significantly improve the reliability of Q380's with ethernet cards. Testing in the lab shows that this system works very well. The first field installation of this was be at the UTMT station at the end of April, 2001. The UTMT site has been plagued by the Q380 processor hanging up, which could only be resolved by a manual restart of the entire system. The only requirement on our part is that the host university must provide an additional network address and that we must notify them of the ethernet hardware ID. The April installation demonstrated what we expected - there was a lot of traffic on the local internet subnet. The packet filter seems to work. Unfortunately the installation hole (in a crawl space between two university buildings) was inundated by ground water and the sensor disturbed.

This effort was necessary because 5 of our Q380 systems have Ethernet cards and 3 are installed: UTMT, UALR and SIUC. Although we have had no trouble with UALR and SIUC, we will probably place this packet filter there too to protect the Quanterra. Robust testing seems to indicate that the solution works and that we can expect much more reliable data flow through these systems.

Our experience is that there are very valid reasons to place a computer adjacent to the Quanterra: a SPARC to run COMSERV/DACOMMO (European developers are trying to do this with LINUX and a PC), Earthworm and VDL and to limit access to the Quanterra by only permitting access through SSH. The extra local storage provides yet another required layer of redundancy to robust data archiving.

A 150 Gb RAID was installed for accessing the broadband data. The broadband data are also archived on CDROM's

The instrument response history is given in IRIS dataless SEED format at

<ftp://ftp.eas.slu.edu/pub/CNMSN/nmrspn/>

Digital data are available in one-day SEED station-component archives at

http://www.eas.slu.edu/Earthquake_Center/NM/data_archive/

Field Sites

Site preparation was completed for the Portageville, Missouri field station. The instrument site pad, shelter and AC power was installed at the end of March, 2001. We are now arranging a frame really connection to this site which requires University approval.

A noise study was performed at an alternate site near Bloomington, Indiana, by running an STS-2 and Q380. The site was an astronomical observatory outside the city. Compared to the existing BLO site, the vertical component noise was significantly less at frequencies greater than 1.0 Hz. No evaluation could be made at lower frequencies because the sensor was in the telescope building; the instrument was very sensitive to operations of the telescope. If such a site were used, the instrument would have to be away from the telescope building.

We replaced the Q380 disk drive at PLAL, and the Sparc at MPH. The CMG3-ESP at PLAL as replaced by a CMG-40T when the ESP stopped working.

Plans for 2001

- Install field sites at FVM, PVMO and a hard rock site in Sam Baker State Park (37.0° N, 90.9°W). Also install a communication node at the CERI/SLU New Madrid data collection node. Communication from these sites to the data center will initially be by spread spectrum over a 50 mile link from FVM to St. Louis. The other sites will use frame relay. For FVM we may either redirect the transmit antenna 180° to shoot the signal 10 miles to the Mineral Area Community College, or use frame relay. Frame relay will cost about \$2400 per field site annually.

The University of Memphis has a data node in a concrete building attached to a cable TV company's tower just SW of the city of New Madrid, Missouri. The University of Memphis currently has an Earthworm system working there whose data are accessed by DSN. They are in the process of completing their own microwave link to connect their 5 nodes directly to Memphis which will improve the real time location capability. The purpose of our frame relay connection to that site is twofold. First, we wish to acquire the broadband data streams from their stations in the Mississippi Embayment. Second, but most importantly, we wish to ensure a redundant data stream for earthquake location in case of telemetry failure due to an earthquake or to non-seismic causes.

We have purchased Multitech FRAD's that will work. We must negotiate with the Saint Louis University Information Technologies connections and must allay their concerns about these field data streams being network security holes.

The FVM site hopefully will have the next CMG3-ESP. The PVMO site will have our currently working CMG3-ESP broadband sensor and a CMG-5 accelerometer.

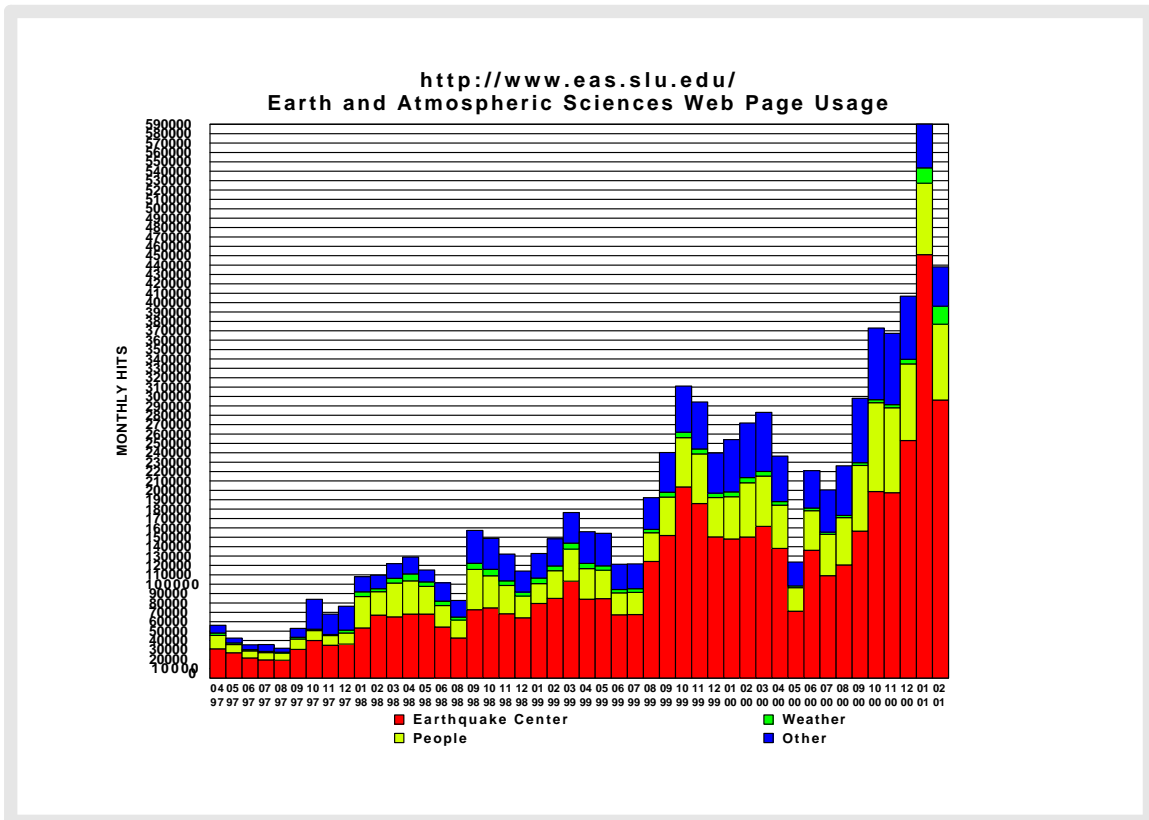
- Archive data at IRIS DMC. All broadband data acquired since the installation of the first station in 1998 is preserved on CDROM. Except for the instrument history at SLM, the instrument history files are in dataless SEED. We will make this a priority in 2001.
- Complete station installation. Unfortunately, this requires sensors. During April, 2001 we will perform noise studies at the University of Western Kentucky telescope site outside Bowling Green, Kentucky. This site has internet and will be upgraded to a T1 line. Modern telescopes perform data acquisition remotely. This site, as does the University of Indiana site, requires careful assessment because of the ground noise induced by the operating telescope. An alternative site in the area is an environmental monitoring station operated on leased land by the Mammoth Cave National Park; there is internet at this site as well as knowledgeable personnel.
- Continue system integration with Earthworm as a means of providing automatic locations.

Education

The Earthquake Center web address

http://www.eas.slu.edu/Earthquake_Center/

serves the public. The following figure illustrates the prominence of requests to the Earthquake Center on the Department's web server. We handle many inquiries by Email or telephone concerning earthquakes. These requests cover the gamut of concern about local hazard, study assignments for elementary school students to a request on how to respond to a disaster. The figure indicates continued interest in the earthquake information provided by the Earthquake Center page.



Future

This network will evolve into the U.S. Advanced National Seismic System. The PI chairs the advisory committee for the Mid-America portion of the ANSS. Its web address is

<http://www..anss-ma.org/>