**RESOURCES**

MRN is a world-class research organization located in Albuquerque, New Mexico with state-of-the-art imaging, genetics and information technologies and services. MRN is headquartered in Pete and Nancy Domenici Hall on the north (medical school) campus of the University of New Mexico (UNM). MRN staff includes roughly 160 employees, 20 graduate students, and 60 volunteers. Domenici Hall is also home to two state-of-the-art animal research facilities: UNM’s Biomedical Research and Integrative Neuroimaging (BRaIN) Center, a neuroimaging facility for basic studies of central nervous system pathophysiology in animal models; and UNM’s Neurobiology Research Facility (NRF). In addition, Domenici Hall provides all of the human research space for UNM’s Departments of Neurology and Psychiatry – both part of UNM’s Health Science Center (HSC), and clinical space for the Department of Neurology’s Clinical Neuroscience Center (CNC). Resource sharing and collaboration between UNM and MRN are encouraged by this proximity, as well as by joint academic appointments. Together, UNM and MRN form a unique neuroimaging center for advancing neuroscience research.

MRN also benefits from being in the geographic epicenter of a large and diverse research and R&D community in New Mexico: Air Force Research Laboratory, Honeywell, Intel, Johnson & Johnson, Los Alamos National Laboratory, National Center for Genome Research in Santa Fe, Sandia National Laboratories, and The Santa Fe Institute.

**Space**

MRN occupies 33,000 square feet in Pete and Nancy Domenici Hall and 7,000 square feet in UNM’s Science & Technology Park (STP).

LaboratoryMRN has separate laboratory and associated control rooms for a 3T Siemens Trio magnetic resonance (MR) scanner, a 1.5T Siemens Avanto mobile MR scanner, an Elekta Neuromag whole-head magnetoencephalographic (MEG) scanner, and two high-resolution electroencephalographic (EEG) systems. MRN also has a neurogenetics core facility. In addition, three large computer laboratories are dedicated to data acquisition and analysis for spectroscopy, functional MRI (fMRI), molecular MRI (mMRI), diffusion tensor imaging (DTI), EEG, MEG, and genetics.

Clinical UNM HSC, located on the UNM campus, is the largest academic health complex in the state – focusing on education, research, and patient care. MRN and UNM HSC interface operations to combine patient clinical care with MRI scanning, and clinical trials and research. MRN is also affiliated with the UNM Center on Alcoholism, Substance Abuse, and Addictions (CASAA), a leader in the development and evaluation of cost-effective behavioral treatments for substance-use disorders. Within MRN, five private assessment rooms (all equipped with closed doors and sound screens) are available to research staff. Six additional testing rooms are located at MRN’s auxiliary office location in UNM’s Science & Technology Park (STP).

Office MRN research investigators and their staff are housed in Domenici Hall with a small contingent housed in a separate suite adjacent to administrative staff in STP. Principal Investigators have private fully-equipped offices. More junior-level staff share private office space. In addition, cubicles and an open area with 12 individual, high-performance workspaces is utilized by graduate students, postdoctoral investigators, and visiting scientists. Administrative offices for Accounting, HR, Contracts & Grants, Directors and Officers are located at an auxiliary location (STP) and include additional meeting rooms, access to large conference facilities, and “hot desks” for visitors (e.g. auditors). As mentioned, included in the auxiliary space are five private offices for PIs and research staff who do not require daily access to the scanners and other labs.

**Information Technology Facilities**

MRN's computing infrastructure consists of approximately 400 computers and more than 250 TB of network-attached storage that consolidates all research data to facilitate easy access and retrieval. Desktop workstations are fed by gigabit Ethernet connections to a 10Gbps connected data center that houses core services as well as multiprocessor compute servers. Much of the services infrastructure is virtualized saving power and cooling as well as facilitating flexibility regarding maintenance, backup and restoration of services.

Computing Environment and Applications Scientific end users are able to access MRN’s network, enabling sharing of data across Windows, Linux, and Macintosh platforms. The data center houses several large shared memory systems (48 and 24 cores with up to 160 GB RAM) as well as Linux compute clusters and grid computing capability. Additionally, over 30 image-analysis and neuroinformatics applications are installed and administered uniformly across all workstations. Data center power is filtered and backed by a 3 phase APC Symmetra PX 60 kW n+1 Uninterruptible Power Supply (expandable to 80 kW n+1). Data center air conditioning and power is protected by a diesel generator for emergency power, and all power and cooling systems are monitored by IT staff 24/7.

Network All desktop workstations communicate with MRN’s data center and network-attached storage via dual, redundant fiber links. MRN is connected to the Internet (and Internet2) via a gigabit fiber link on UNM's campus which connects to various regional networks at 10Gbps. A privately managed backup Internet connection provides business continuity in the event of an extended outage. A Virtual Private Network allows researchers and collaborators to access MRN computing resources remotely through a secure encrypted link. Our VPN utilizes Cisco System’s Clean Access Manager to protect MRN’s network by only allowing fully patched systems with updated anti-virus scanners onto the network. MRN’s internal network is also fully Cisco based and follows best practices for fault tolerance employing a full mesh topology between the core and edge networks.

Acquisition/Storage Data acquisition computers across all modalities (1.5T Mobile, 3T, MEG, EEG) have standardized stimulus delivery systems i.e. pupilometry, audio, video and time coding. The mobile data acquisition system includes a group of centrally managed, remotely operated PGP encrypted tablet PCs used for psychological assessment, digital video and document imaging in forensic populations.

MRN’s storage and backup infrastructure must be dynamic and expandable, fault tolerant and highly available to meet the needs of the organization. With these goals in mind MRN IT has deployed a multi-vendor solution consisting of dual 250TB EMC Celerra/CLARiiON NS960 high availability filers with continuous replication between them and a 40TB Sun/Oracle ZFS filer for additional project scratch storage. Storage is accessible via SAN and NAS topologies over a fully meshed Cisco based fibre-channel fabric and IP network. Research data is stored in a self documenting directory hierarchy (both raw and processed).

Backup Disaster preparedness (backup and recovery) is a major role of the IT infrastructure. The backup schedule consists of daily snapshots, monthly, and annual archival, as well as mail server archive. Six times during the day, and once nightly a "snapshot" backup of data is taken. The nightly snapshots, which include study volumes and home directories, are retained for two days. A newly acquired FalconStor Virtual Tape Library solution capable of backing up 250TB will take full archival backups at the beginning of every month and then export them to tape via 8 streaming tape drives in an Overland Neo 8000 robotic tape library to be removed to our off-site disaster recovery facility. Virtualization plays a key role in providing business continuity in the event of a disaster. MRN has a cluster of VMware servers at the ready to continue processing our day to day administrative and operations tasks. The second EMC NS960 will also be housed at the DR facility. In addition, a full backup of all data is performed mid-month, and remains on-site. Each off-site tape set remains out of circulation for one year. An annual backup is performed in May, and held off-site for five years. Electronic mail is journaled and archived for six years outside of the MRN facility. The external website is backed up daily and incorporated into the above tape sets. The off-site co-location facility is a guarded bank vault requiring positive biometric (fingerprint and photographic) identification for access with redundant power and networking infrastructure.

**Research Operations (RO)** RO services include project development support, data acquisition, image analysis, and neuroinformatics services at MRN. RO services improve the efficiency of PI’s by minimizing repetitive tasks, implementing standard scan protocols, and providing an automated level one data analysis.

Project Development Support All administrative forms and processes (e.g., IRB, HIPAA certification, scanner safety certification, CITI training, and subject recruitment) are standardized and available online thorugh the MRN intranet. Research Operations personnel are available to support all administrative aspects of project implementation.

Data Acquisition Services are available to assist researchers with the technical aspects of data collection. For example, MRN employs two full-time certified licensed MR technologists, who are available for scan sessions during the day, as well as evenings and weekends. In addition, training on stimulus delivery equipment is available, and MR physicists and engineers are also available to discuss and customize MR sequences. Paradigm development services are available for researchers using EPrime (Psychology Software Tools Inc, www.pstnet.com), Presentation (Cortech Solutions Inc, www.cortechsolutions.com), or CIRC software for stimulus delivery. All data is archived on a secure, HIPAA-compliant database (e.g., research participant data, scan and behavioral data and notes about the scan).

Image Analysis MRN has developed an automatic analysis pipeline for most of its imaging data. Automation scripts check the network archive drive and archive new data the morning following a scan. The scripts generate an email to the PI’s so they can see all daily scans. The automation scripts subsequently perform a standard level-1 data analysis utilizing software packages such as MATLAB (MathWorks-MATLAB, www.mathworks.com), statistical parametric mapping (SPM), GIFT/ICA, AFNI, FSL, FreeSurfer ([Athinoula A. Martinos Center for Biomedical Imaging](http://www.nmr.mgh.harvard.edu), Massachusetts General Hospital, Boston, MA), and LCModel (Stephen Provencher, Oakville, ON, Canada). The type of data collected determines which software is used: SPM for fMRI data; SPM voxel-based morphometry (VBM) and FreeSurfer for MP-Rage anatomical data; FSL analysis tools for diffusion tensor imaging (DTI) and arterial spin labeling (ASL) data; and LCModel analysis for magnetic resonance spectroscopy (MRS) data. Upon completion of the automated analyses for the entire scan session, an email is generated to notify the researcher. These automated emails are monitored by Research Operations staff for scan problems and/or data analysis failures.

Neuroinformatics MRN’s Neuroinformatics (NI) Core provides advanced services to the organization’s investigators and collaborators. The NI core applies informatics techniques (derived from applied mathematics, computer science, and statistics) to analyze and organize information associated with large data sets. The key services provided by the core include data organization/automation and algorithm development. The core also provides production tools and service on those tools, as well as significant research and development of new features and software tools. The tools are tuned to the needs of more than 184 active and 175 archived research projects – and over 300 internal and external researchers.

The NI core has made a large investment in developing and maintaining high-quality clinical data acquisition capabilities – such as tablet PC-, web-, and paper-based data-entry tools for clinical and behavioral assessments. In addition, the NI core provides tools for tracking research participant flow (e.g., study coordinators are granted a view of where each research participant is in the course of a study), IRB compliance and reporting, and protocol compliance.

One of the primary roles of the core is to archive and maintain meta-data on MRN’s large amount of heterogeneous translational neuroscience data – to provide researchers with the means to access and use the data they need. In addition, the core integrates acquisition and analysis of meta-data for MEG, EEG, and genetic data sources into the data management and analysis capabilities of the NI tools – which greatly enhance the multi-modal data mining capability of the NI tools. Web-based portals have been developed for assessing quality assurance (QA) of raw and analyzed data and provide access to the results such that investigators may review and address outliers and artifacts. NI facilitates internal and external data exchange by recommending data hierarchies for storage, tracking data provenance for analyses, and assisting with data sharing.

**Library Facilities**

MRN investigators have both physical and on-line access to UNM’s extensive library and research resources, including UNM’s 44,000 square foot Health Sciences Library and Informatics Center with more than 2200 serials subscriptions.

**Animal Research Facilities**

UNM’s BRaIN Center and NRF occupy 11,000 and 12,000 square feet, respectively, within Domenici Hall – immediately adjacent to MRN’s space. These animal research facilities provide the capabilities for studying mechanistic features of interesting phenomena identified in MRN’s human neuroimaging and genetics facility.

BRaIN Imaging Center The BRaIN Center has the following resources: an MRI core with a 4.7T 40 cm bore animal MR scanner; an electron paramagnetic resonance (EPR) core with an EPR imager for imaging concentration changes of free radicals in vivo in animal models up to the size of a rat brain; an optical/electrophysiology core with a 2-photon laser scanning microscope, a photodiode array, and a patch-clamp system; a cellular and molecular biology core equipped for analysis of mRNA and protein; and a surgical core with aseptic and non-aseptic surgical suites for small and large animals, and an animal holding facility for longitudinal studies.

Neurobiology Research Facility (NRF) Researchers at NRF perform cellular and molecular biological analyses of CNS pathophysiology.