TEOS 01 Soil Imaging—AMR design and testing

TEOS 01.1 Overview
The past year has seen the refinement of the prototype Automated MiniRhizotron (AMR) as well as the RootView software and the integration of those improvements into the creation of 14 production AMR units. We were also able to utilize the prototype unit to do science resulting in new discoveries by observing the previously unobservable. Along the way, upgrades to the database server and program interface (RootView) were made as was leveraging of existing infrastructure to improve data transmission and reliability.

TEOS 01.2 Approach
Balance the need for research and publication with the business of creating production quality instruments and accompanying software within a dwindling budget while making the best use of and maintaining existing resources.

TEOS 01.3 Systems/Experiments
Automated MiniRhizotron: Continued refinement of the prototype unit continued, resulting in improved accuracy and reliability. Many hours were spent on drawing revisions and testing so that these changes would be reflected in the production version of the device. Machining and assembly took place that uncovered manufacturing errors as well as drawing errors. While anticipated as part of a normal design process, the corrections resulted in a schedule slip that was slightly longer than originally projected. Fortunately, the delays resulted in a better product.

In parallel with the production of the AMR hardware, much attention was paid to the software necessary to run it. The original software approach for the project was to produce a one-computer controls one AMR. The control software (RootView) was to be run on a laptop (Host) or similar device near the AMR or, alternatively, using a remote desktop application from another location via the Internet. Images collected would be stored on the Host hard drive and eventually FTP’d to a remote database. As more researchers became interested in viewing the images and also as a way to reduce the per item cost of the production units, a new, web-based interface was written (RootView2) that allows multiple AMRs (up to three) to be hosted by one computer running a service which makes each AMR accessible, separately through a browser such as Internet Explorer or Safari from any Internet accessible location. Effort also went into archiving images on a central server in addition to leaving a reasonable backup on the Host hard drive. Perhaps the most useful and impressive new feature was the ability to access images through mosaics generated by each scan. This provides a graphical interface to researchers as opposed to locating images based on the previous Cartesian system.

Work was also begun on RootView3, which expands and extends many of the features developed in RV2. Some of the major enhancements include: better mosaic handling, image identification, selection and categorization of images, error checking and user warnings, a Google Earth API, database portability, providing compatibility with MS Windows Vista and System 7 operating systems, evaluation for modularizing the camera and motor controller code to allow substitution of other devices, support for higher image resolutions and magnifications of the HR2 camera, and finally, improved documentation.

Database/Data Collection/Data Storage
Many improvements were made to the Database Management System (DMS). It had been over five years since the code was originally written and there were a number of bugs and improvements that needed to be corrected and added to the program. Chief among these was automating the data uploads from sensors in the AMARSS soils transect and integrating those values into DMS. Other items included speeding up searches and fixing errors related to selecting sampling periods.

The DMS server was also upgraded allowing for both increased throughput and storage. The original server was installed in early 2004 and, due to the amount of data being processed and stored, was at its limits, both in terms of CPU performance and disk capacity. We experienced several failures due to insufficient storage space when trying to
re-index data records. More importantly, with more AMR units coming online, the new server has the capacity to handle the millions of images they produce. This would not have been possible with the old server.

AMR Prototype being bench tested.

AMR Prototype being demonstrated.

AMR Production Units subassemblies and parts.
Utilities and Networks

Work continued on maintaining the James Reserve’s CENS related network systems (wired and wireless), data storage systems, and the locally generated electrical power and distribution systems. With CENS field research declining in the coming years, effort has begun to transition the management and maintenance of permanent, CENS funded infrastructure to the UCR - James Reserve staff. A prime example is the PV power generation system consisting of many programmable modules. To maintain performance and longevity of components such as batteries, parameters and settings need to be understood by those managing the system.

Another major undertaking was the switchover by the James Reserve to the UCR Internet backbone. This required each device in our network (including dozens of CENS microservers) be reprogrammed with new IP addresses, including those devices in use by our CENS partners at other locations – all while trying to minimize data loss. The switchover also included a new server firewall, so rules and related information had to be reprogrammed. It is especially important to recognize the contribution by the NRS data manager, Kevin Browne, in this multi-week effort as well as the staff at UCLA CENS.
Collaborative Efforts Utilizing CENS Infrastructure
Planning and working with NEON to eventually install AMR units at 60 of their sites. We are completing two test units for the NEON testbed.

PV Power Generation System located at the James Reserve.

TEOS 01.4 Accomplishments
In early 2010, a Disclosure and Record of Invention was filed with UCR and, to meet the deadline for NEON supplier submissions, a company is being formed (RhizoSystems, LLC) to leverage the effort used in developing the AMR by commercializing it. With the discoveries made thus far using the prototype unit and with the limited marketing, sales, manufacturing and support capabilities of UCR for such an instrument, it appears that commercialization may be the best, fastest and most efficient way to make the AMR available to other researchers. Interest in participation in the company is strong. At inception, the company includes CENS staff, former staff, researchers and faculty as well as an experienced business consultant on its advisory board. Initial funding is coming from stakeholders with the goal of achieving major funding by working with the NSF through a STTR or SBIR program in conjunction with the UC.

- Construction and installation of 15 AMR production units is underway.
- Upgraded the DMS database and server.
- Supported and are transitioning the maintenance and management of the PV array and power infrastructure to the James Reserve staff.
- Completed work on the web-based version of the interface (RootView2) for the AMR.
- Developed specifications for and began work on RV3.
- Maintained the James Reserve CENS infrastructure including: the ISP switchover, wireless networks, power systems, servers, and communication systems.
- Deployed, maintained and supported various research programs at the James Reserve including: CMS, AMARSS, Cold Air Drainage, NIMS, and others.
- Designed and built a stand alone, portable, PV and communications array for use in field deployments.
- Added AC and Ethernet to NW Camera tower improving network reliability.
- Installed a system for cleaning the PV array increasing efficiency.

TEOS 01.5 Future Directions
- Complete work on RV3.
- Support production AMR units at various installed locations.
- Continue to support CENS and AMARSS infrastructure and experiments at the James Reserve.
- Develop other soil sensing and imaging sensors.