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Summary of Research
Final Report

SEMS: System for Environmental Monitoring and Sustainability

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Project Summary

The goal of this project was to establish a computational and data management system, SEMS, building on our existing system and MTPE-related research. We proposed that the new system would help support Washington University's efforts in environmental sustainability through use in:

(a) Problem-based environmental curriculum for freshmen and sophomores funded by the Hewlett Foundation that integrates scientific, cultural, and policy perspectives to understand the dynamics of wetland degradation, deforestation, and desertification and that will develop policies for sustainable environments and economies;

(b) Higher-level undergraduate and graduate courses focused on monitoring the environment and developing policies that will lead to sustainable environmental and economic conditions; and

(c) Interdisciplinary research focused on the dynamics of the Missouri River system and development of policies that lead to sustainable environmental and economic floodplain conditions.

Results of Project

Establishing the System

The SEMS facility has been established by the addition of several key pieces of hardware and software to our existing computer lab. Today SEMS consists of a file/data/web server; data processing server; 12 image and data processing workstations; and a variety of input and output devices (e.g., flatbed and slide scanners, digital camera, film recorder, large-format printer, network color laser printer, etc.) (see Figure 1).

Use in Freshman and Sophomore Environmental Curriculum

During the life of this grant, SEMS image processing (IP) software was used by 100 freshmen and sophomores in the Hewlett Program in Environmental Studies to focus on environmental sustainability problems of Mono Lake, California, the Missouri River, the Mojave National Preserve, and Hawaii (Arvidson and Johnson, 1998). The principal and co-investigators of this grant taught these courses. Class exercises challenged students to use advanced software for image manipulation (georeferencing, mosaiking) and real-time 3D data visualization. Eight of the students installed the image processing software on their own PCs and tied into SEMS via the university network. We feel this is a precursor of more diverse and distributed learning at the university. The Hewlett Program is described in more detail at http://wundow.wustl.edu/hewlett.

Use in Higher-level Undergraduate and Graduate Courses

SEMS has been used most intensively by senior-level undergraduate and graduate-level remote sensing classes. In the Spring 1998 semester, 12 students used SEMS as the computational foundation for a dozen interactive exercises utilizing Landsat, SPOT, AIRSAR, and several other data sets to illustrate techniques of image processing and geographic information systems. Twenty students are enrolled for the Spring 1999 semester remote sensing course. The remote sensing course is described in more detail at http://wundow.wustl.edu/epsc407.

In addition, several department graduate-level seminars have used SEMS as a basis for their image and data processing exercises.

Use in Interdisciplinary Research

Hewlett Program instructor and grant co-investigator William Lowry has begun working with us on environmental policy issues associated with anthropogenic changes to the Missouri River flood plain. He is using SEMS to understand the flood plain policy history as background information.

Hewlett Program instructor and grant co-investigator Glenn Stone has begun working with us to monitor the sustainability of agricultural practices in Nigeria using a combination of digitized aerial photographs and

SPOT images, combined with field work. Heretofore unavailable technology and methodology has been made available through use of SEMS.

Unanticipated Developments and Benefits

Equipment Purchases

Between the dates of proposal and award, the price fell on a number of budgeted hardware items, freeing funds for additional purchases. These additions included field equipment (digital camera, two-way radios); data acquisition and management hardware (CD recorders, CD duplicator, slide scanner); and computer system hardware (network color printer).

Solo Spirit Balloon Flight

In January and August, 1998, we were asked by Washington University Chancellor Mark Wrighton, on behalf of pilot Steve Fossett, to help establish and maintain mission control for Fossett's 1998 solo attempts to circumnavigate the globe in a balloon. In conjunction with the Jet Propulsion Laboratory, we integrated an aerobot payload onto the balloon to monitor atmospheric conditions during the flights (see Table 1). Undergraduate students, with support of the Missouri Space Grant Consortium, helped to manage mission control and to process the environmental data using the SEMS computational facility. In addition, the August web site was hosted on the SEMS web server, handling over 12 million requests from 126 countries and transmitting 3.3 terabytes of data (combined English and Spanish sites).

Table 1. Sensors on the Solo Spirit Aerobot Science Payload

Sensor	Measurements
Position Sensor (GPS)	Time, global position, ground speed, heading
Pressure Sensor	Atmospheric pressure in Pascals
Humidity Sensor	Relative humidity in percent
External Temperature Sensor	Temperature in degrees Celsius
Radiometer	Upwelling sky radiance
Vertical Wind Sensor	Vertical wind speed relative to the balloon

Impact this Grant Has Had on Our Institution

The establishment of the SEMS facility has positively impacted our laboratory and institution in the following ways:

- Students learn using real-world data and state-of-the-art processing techniques.
- We are able to serve more students and courses concurrently. The SEMS facility can support six classes totaling approximately 200 students in a given semester.
- SEMS is a dynamic entity. The equipment procured with this grant provides an excellent foundation for continued growth and improvement. We already are adding two classes of mass storage to SEMS in response to increased need.
- We are able to increase services to the scientific community by way of image processing and data serving.
- We are at the forefront of image processing technology and are able to advise others in our institution and scientific community regarding system design, implementation, and utilization.

Financial Report on Expenditure of Grant Funds

SEMS Funded Acquisitions	
ALR Revolution Quad 6 NT Server	$33,890.00
Network Hardware	2,953.00
PCI Image Software	20,000.00
NT Server Software	5,388.00
Network Color Printer	4,893.00
Two-Way Radios	1,017.00
Misc., Shipping	530.00
Total SEMS	**$68,671.00**

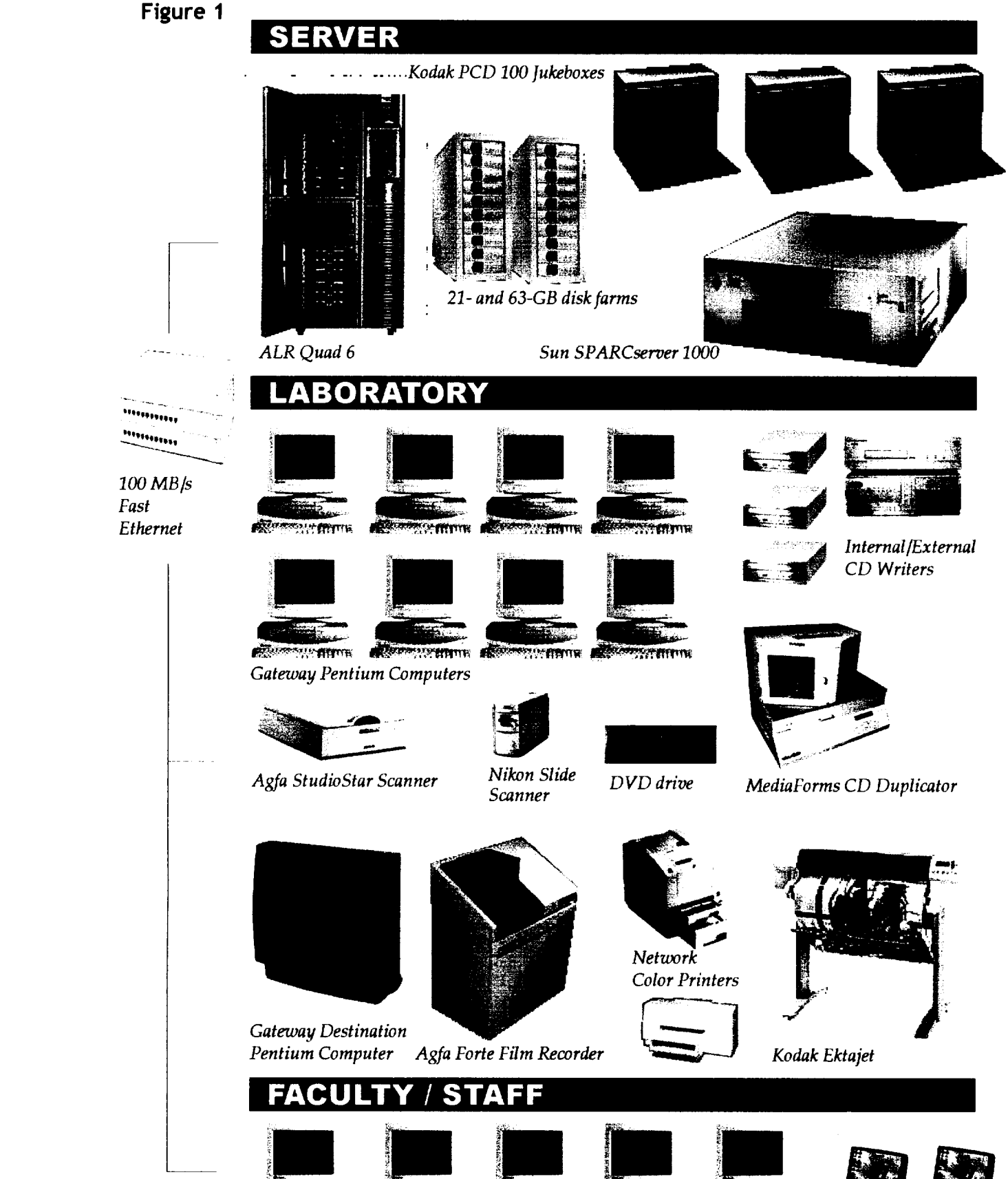
WU Cost Sharing	
Large-format Color Printer	11,049.00
Laptop Computer and Software	7,693.00
Film Recorder Software	1,796.00
Digital Camera	899.00
SCSI Interface Card	95.00
Slide Scanner	2,198.00
GIS Software	554.00
CD Rewriteable Drive (2)	1,390.00
CD Duplicator	4,326.00
Salaries and Benefits	23,028.00
Indirect Costs	12,895.00
Total WU	**$65,923.00**

References

Arvidson, R.E. and S.S. Johnson, Program in Environmental Sustainability Uses Interdisciplinary Approach to Cross-train Students. *Eos, Transactions*, American Geophical Union, v. 79, n. 46, November 17, 1998, pp. 557, 564.

Arvidson, R.E. et al., Aerobot Atmospheric Measurements on the Solo Spirit Balloon Mission. Submitted to *Eos*, December 1998.

Figure 1


SERVER
Kodak PCD 100 Jukeboxes
21- and 63-GB disk farms
ALR Quad 6
Sun SPARCserver 1000
LABORATORY
100 MB/s
Fast
Ethernet
Internal/External
CD Writers
Gateway Pentium Computers
Agfa StudioStar Scanner
Nikon Slide
Scanner
DVD drive
MediaForms CD Duplicator
Network
Color Printers
Gateway Destination
Pentium Computer
Agfa Forte Film Recorder
Kodak Ektajet
FACULTY / STAFF
Gateway Pentium Computers
Penitum Laptops