Providing Education in Global Positioning Systems
For
Iowa State University Students

Submitted to the University Computation Advisory Committee
by
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Department of Forestry

College of Agriculture

Steven E. Jungst
Project Leader

J. Michael Kelly, Chair
Department of Forestry

Kevin Kane, Director
GIS Support & Research Facility

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Project Overview and Expected Benefits

A. Provide a description and intended purpose for all project expenditures and identify expenditures from Central Pool Funds.

Description
The purpose of this project is to obtain funds for purchase of Global Positioning System (GPS) hardware and software (See Appendix I). This purchase will make it possible to develop a course that will provide ISU students with the opportunity to learn about the theory and use of GPS technology. All funds requested from the Central Pool will be used to purchase ten GeoExplorer 3 units, two Pathfinder Pro XR/XRS units and twelve external antennae (see budget). These receivers will make it possible to develop a 3-credit course that will accommodate 24 students each time the course is taught. The course will be taught annually during spring semester. It will use a hands-on format with the following expected student outcomes:

1) Demonstrate a basic understanding of the theory behind GPS.
2) Be able to plan and conduct a GPS data acquisition session.
3) Be able to post-process GPS data collected in the field to improve its accuracy,
4) Be able to transfer that data to a Geographic Information System (GIS) for use in construction of maps.
5) Be able to use GPS with real-time correction as a navigational aid.

Expected Benefits
At present, ISU students do not have access to a comprehensive course in the theory and use of GPS. Such a course would better prepare undergraduates whose careers will involve the collection and use of spatial data. Professions such as forestry, animal ecology, engineering, and community and regional planning are a few of the areas where graduates are likely to use GPS technology on their jobs. Further, graduate students who are conducting research that is dependent on spatial data would benefit from such a course. At present, they are left to their own devices to learn enough to be able to collect data with a GPS receiver. Although they may be successful in developing the skills necessary to collect and use data, they often don't have sufficient background to understand the limitations of such data.

Project Integration
The proposed course will make use of existing facilities under the direction of the Department of Forestry on the second floor of Bessey Hall. Aside from integrating well with existing space, the project integrates well with existing programs on campus. GPS provides a natural source of data for use in Geographic Information System applications. The GIS Support and Research Facility on campus will benefit by having a place to refer people who want to learn how to use GPS for data collection and entry into GIS. In addition, there has been preliminary discussion of the development of a GIS minor on campus. Although courses for that minor have not yet been selected, it is reasonable to believe that a GPS course could logically become part of such a minor.

B. Describe specifically how the proposed facilities or services will be made available to students
Students enrolled in the course will have access to the Forestry Department computer facilities in 227 Bessey Hall. Those computers will be equipped with the necessary software to allow for post-processing of GPS data. The computers are already equipped with Arc/View software for use when GPS data is downloaded for mapping purposes. Sufficient workstations are available in 227 to allow 10 students to work simultaneously.

The facility in 227 Bessey is open to students from 8 a.m. to 5 p.m. Monday through Friday. The GPS units used to support the class will be available during class times and for checkout outside of class hours as needed by the students.

The proposed course will be open to all students at ISU. However, students most likely to enroll in the proposed course are those whose professional careers will involve use of spatial data. Table 1 shows the departments most likely to have graduate and/or undergraduate students interested in enrolling in a course in GPS. Beyond those departments listed, any student who has a need to collect spatially referenced data would benefit from the proposed course.
Table 1
Departments & Colleges most likely to have students interested in GPS

<table>
<thead>
<tr>
<th>Department</th>
<th>College</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture Engineering</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Agricultural systems Technology</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Agronomy</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Animal Ecology</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Entomology</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Forestry</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Horticulture</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Plant Health &amp; Protection</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>Engineering</td>
</tr>
<tr>
<td>Community &amp; Regional Planning</td>
<td>Design</td>
</tr>
<tr>
<td>Landscape Architecture</td>
<td>Design</td>
</tr>
<tr>
<td>Botany</td>
<td>Liberal Arts and Sciences</td>
</tr>
<tr>
<td>Ecology &amp; Evolutionary Biology</td>
<td>Liberal Arts and Sciences</td>
</tr>
<tr>
<td>Environmental Science</td>
<td>Liberal Arts and Sciences</td>
</tr>
<tr>
<td>Geology</td>
<td>Liberal Arts and Sciences</td>
</tr>
</tbody>
</table>

C. If the proposed project requires special new technologies, describe how these requirements will be met.
The new technology required for the proposal to succeed is the GPS hardware discussed earlier. The GPS receivers described collect information from orbiting satellites from which they compute their approximate location. Improved spatial accuracy is obtained either by receiving an additional correction signal in the case of the Pathfinder Pro units, or by downloading data to computers in the Forestry Department for post processing using software supplied with the GPS units. Funds requested in this proposal will be used to meet the GPS hardware needs for development of the course.

D. Identify university facilities that would be needed for the proposed project.
Rooms 225 Bessey and 227 Bessey will be used for the course. 225 will be used for the lecture portion of the course and 227 will be used for the post-processing and GIS portions of the course. Data collection activities associated with the class will be conducted on and around the ISU campus. Both 225 and 227 are under the direction of the Department of Forestry (See Appendix II). Five Gateway computers were added to the facility in 227 in December 1999. This addition was made, in part, to provide a facility that had sufficient computers to handle the proposed course in GPS. At present, 5 of the computers in that room have ArcView GIS software installed. When the GPS course is developed, 5 additional annual licenses will be purchased for ArcView for the new computers so that all have the software necessary to support the GPS course. The Forestry Department will purchase that software.

Support and Maintenance

The Department of Forestry will provide the necessary support for the course instructor's salary, as well as for class supplies and maintenance of equipment.

Budget

Table 2 (following page) shows the complete budget for the project. Funding at this level will make it possible to design a course that accomplishes all five of the expected student outcomes listed in the project description of this section. Table 3 itemizes the minimum feasible budget for the proposed project.
Table 2. Full Itemized Budget  
(Cost for the Entire Project)  

<table>
<thead>
<tr>
<th>Item</th>
<th>Central Pool</th>
<th>Forestry Dept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Trimble Navigation GeoExplorer 3 &quot;Educational Two-packs&quot;</td>
<td>$32,225</td>
<td></td>
</tr>
<tr>
<td>Each Two-pack includes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 GeoExplorer 3 GPS receivers,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 external batteries and carrying cases,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 battery rechargers,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 copies of Pathfinder Office software for data management and transfer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Trimble Navigation Pathfinder Pro XR/XRS &quot;Educational Two-pack&quot;</td>
<td>$15,495</td>
<td></td>
</tr>
<tr>
<td>Each Two-pack includes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Pathfinder Pro XR/XRS receivers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 copies of Pathfinder Office software</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Three meter antenna cables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 battery chargers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 sets of rechargeable batteries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 desktop Gateway computers to support GPS course (purchased Dec. 1999)</td>
<td></td>
<td>$12,449</td>
</tr>
<tr>
<td>10 Backup batteries for GPS Units</td>
<td></td>
<td>$400</td>
</tr>
<tr>
<td>10 external antennae kits for GeoExplorer 3’s</td>
<td></td>
<td>$1,950</td>
</tr>
<tr>
<td>2 vehicle antennae kits for Pathfinder Pro XR/XRS units</td>
<td></td>
<td>$590</td>
</tr>
<tr>
<td>Course Materials</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>10% of Jungst's salary for course development &amp; teaching</td>
<td></td>
<td>$9,070</td>
</tr>
<tr>
<td>Benefits for Jungst @ 23.17%</td>
<td></td>
<td>$2,100</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$50,260</td>
<td>$24,519</td>
</tr>
<tr>
<td>Project Total</td>
<td>$74,779</td>
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</tr>
</tbody>
</table>

A reduced budget is possible by deleting the Navigation Pathfinder Pro XR/XRS "Educational Two-pack" and related vehicle antennae kits. This deletion reduces the cost to the Central Pool by $16,085. **However**, it also reduces by 4, the number of students served each time the class is taught. In addition, it makes it impossible to demonstrate the improved real-time accuracy of GPS through the use of a received correction signal since the GeoExplorer 3 units aren't capable of receiving such a signal. It also makes it impossible to achieve outcome number 5 listed in the project description. The minimum feasible budget for the project is shown in Table 3.

Table 3. Itemized Budget  
(Cost of Minimum Feasible Project)  

<table>
<thead>
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</tr>
<tr>
<td>Benefits for Jungst @ 23.17%</td>
<td></td>
<td>$2,100</td>
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<tr>
<td>Subtotal</td>
<td>$34,175</td>
<td>$24,519</td>
</tr>
<tr>
<td>Project Total</td>
<td>$58,694</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX I

GPS Receiver Descriptions
GeoExplorer 3

Handheld GPS mapping and GIS data collection/maintenance system

The GeoExplorer® 3 handheld GPS system allows you to collect and maintain spatial data for GIS databases. It is the ideal solution for mapping and managing spatial data in many applications, including natural resource mapping, environmental studies, and the creation and maintenance of utility and urban asset databases.

The GeoExplorer 3 system lets you map points, lines and areas quickly and easily. You can also record customized attribute information about these features. This field data can then be incorporated seamlessly into your GIS as you build and administer your database.

Greater All-Around Productivity

The GeoExplorer 3 system increases your productivity both in the field and in the office.

The system's graphical map and navigation displays let you see your current location and plan your activities for best efficiency. An integrated digital compass provides accurate bearings and distances to keep you on track, whether you are moving or stationary.

Its small, lightweight design makes the GeoExplorer 3 system extremely portable and unobtrusive in difficult terrain. There is no need to carry spare batteries because the internal long-life battery lasts an entire working day and can be recharged overnight. Its wide operating temperature range and rugged, water-resistant casing let you use it in all weather conditions. The clear display and backlight allow viewing from a wide variety of angles at all light levels.

The intuitive graphical interface and interactive CD-ROM training guide help your field crew quickly become proficient.

Back in the office, the powerful GPS Pathfinder® Office software makes processing the field data simple and intuitive, freeing your GIS technicians for other work.

Easy GIS Data Maintenance

With Trimble’s Beacon-on-a-Belt, or BoB™ differential correction receiver, the GeoExplorer 3 system becomes a precise differential GPS tool for real-time mapping and maintenance of GIS data without the need for differential postprocessing. You can also upload features from your GIS to the GeoExplorer 3 system and verify or update the positions and attributes, ensuring that your GIS always contains the most accurate and up-to-date information available.

The BoB receiver sits securely on your belt or inside a vehicle, providing differential corrections to the GeoExplorer 3 system in real-time. Because it is cable-free, the unit cannot become entangled in brush or branches.

Drawing on Trimble’s extensive knowledge of GPS mapping and navigation, the GeoExplorer 3 system is the most productive, intuitive, and compact system available to meet your GIS data collection and data-maintenance needs.
GeoExplorer 3
Handheld GPS Mapping System

FEATURES

• Collection of point, line, and area features with attribute information
• 1 to 5 meter precision after differential correction*
• Integrated high-performance 12-channel GPS receiver and antenna
• Cable-free real-time link to Beacon-on-a-Belt (BoB) differential correction receiver
• Rugged and water-resistant design
• Carrier phase processing for sub-meter precision
• Creation and storage of multiple data dictionaries in the office or directly on the unit
• Upload of existing data for data maintenance (relocation, verification, and update)
• Real-time map display
• Graphical satellite skyplot
• Graphical navigation screens
• Internal digital compass for navigation at low velocity
• Password protection and pre-field setup of parameters using the Configuration Manager
• National and custom coordinate system support
• NMEA output
• All-day internal rechargeable battery
• Two-level backlit screen with 160 x 160 pixel graphical display
• Selectable English, French, German, Spanish, Portuguese, and Russian language interface

* Without postprocessed or real-time differential correction, all GPS receivers are subject to degradation of position and velocity precision under the U.S. Department of Defense-imposed Selective Availability (S/A). Precision may be degraded so that 95% of positions are within 100 meters (330 feet) of the truth. The above precision values assume tracking of 4 satellites (5 satellites for carrier phase), a PDOP of ≤6, SNR ≥4 and reasonable multipath conditions. Ionospheric conditions, multipath signals, or obstruction of the sky by buildings or heavy tree canopy may degrade precision by interfering with signal reception. Real-time precision assumes a standard RTCM SC-104 format broadcast from a Trimble reference station.

STANDARD ACCESSORIES

• Office support module for data download and battery recharging
• Serial clip with standard DE-9 connector (allows data in/out and recharging away from support module)
• Carrying pouch, hand strap, and neck lanyard
• GPS Pathfinder Office software—mission planning, data import and export, differential correction, plotting, data dictionary creation
• Operation Guide CD including interactive tutorial
• Quick Start card

OPTIONAL ACCESSORIES

External power kit
Includes rechargeable camcorder battery, vehicle cigarette lighter adapter, and soft shoulder pack

External antenna kit
Magnetic or range pole mount

RTCM/NMEA splitter cable
For simultaneous RTCM input and NMEA output with the datalogger, this cable is not required if RTCM input from BoB receiver in wireless mode

Hard carrying case
Rugged hard case with room for both the GeoExplorer 3 system and BoB differential correction receiver

HANDHELD SPECIFICATIONS

Size
20.6 cm L x 9.4 cm W x 5.1 cm H
8.1” L x 3.7” W x 2.0” H

Weight
0.64 kg (1.4 lbs.) with battery
1.0 W (normal)
1.4 W (low backlight)
2.0 W (bright backlight)

Operating temperature
–10°C to +50°C (14°F to 122°F)

Storage temperature
–20°C to +70°C (–4°F to 158°F)

Humidity
Up to 99% non-condensing

Casing
Wind-driven rain and dust resistant per IP 55

Communications
Dual EIA-RS-232 serial connection via support module or serial clip

Display
160 x 160 pixel graphical LCD with 2-level backlight, anti-fog and brightness enhancing coatings, angled for easy viewing

Beeper
Single frequency piezoelectric

Digital compass
Magneto-resistive dual-axis with 8-point resolution

Battery
Internal Li-Ion, rechargeable in unit, 11 watt-hours

Keypad
Metal dome with high tactile feedback, protected on/off key, protective coating

Internal radio
916 MHz license-free (in US) with built-in antenna—OOK modulation

Storage
Data
1 megabyte (32,000 positions excluding data dictionaries, waypoints, and other data)

Waypoints
1,000 named locations

ORDERING INFORMATION

GeoExplorer 3c GPS System
39100-00-ENG

with Beacon-on-a-Belt differential correction receiver
Available soon

GeoExplorer 3c GPS System
39100-50-ENG

Does not include data maintenance support, cable-free link to BoB receiver, real-time map display, or national/custom coordinate system support

with Beacon-on-a-Belt differential correction receiver
Available soon

External power kit
39001-00

External antenna kit
39002-00

RTCM-In / NMEA-Out splitter cable
39142

Hard carrying case
39292-00

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APPENDIX II

Scaled drawing of

Rooms 225 and 227 Bessey Hall
Appendix I. Scaled Sketch of Rooms 225 and 227 Bessey Hall

Scale 1" = 12.5 feet.