Minnesota State University, Mankato

Curriculum Proposal

Please type or select the requested information. Print completed forms, add appropriate paper attachments, and route through MSU's curricular process for recommendations and decisions.

- **College**: Social and Behavioral Sciences
- **Department**: Geography
- **Program**: Geography
- **Type of Change**: Program Proposals
- **Proposed**:
  - Redesign-Add/Delete Program Option
- **Title Current**: None
- **Title Proposed**: Certificate in Geographic Information Science (GISc)
- **24-Char. Abbrev**: Cigis
- **Proposal #**: 3102
- **Effective Date of Change**: 09-07 (For Office Use Only)
- **Course Designator**
  - Number of Courses
  - Number of Credits

Include a course or program description for the Bulletin (30-40 words maximum for courses, 100 for programs):

Students will receive a fundamental knowledge and understanding of Geographic Information Systems (GIS) and Remote Sensing technologies with the option to focus more intensively on advanced GIS, Remote Sensing or Global Positioning Systems (GPS) principles and applications.

**Rationale or Justification for Change:**

The certificate will enhance the employability of our students (Geography and non-Geography majors) by certifying their competence in Geographic Information Science (GISc).

***For General Education or Cultural Diversity Courses Only***

**General Education Course:**

<table>
<thead>
<tr>
<th>GE Category #</th>
<th>GE Category Name</th>
<th>Maximum of 3 Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
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<td>N/A</td>
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<td>N/A</td>
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</tbody>
</table>

1. For Writing Intensive Courses, attach a description of the kind and quantity of writing.
2. For Upper Division Courses, include a description of the respects in which it is broad and general rather than narrow and specific, and so suitable as GE.

Attach paper copies of the following:

a. Syllabus or course outline.
b. Course's student learning outcomes associated with each GE competency or CD designation.
c. List of strategies to be used to assess students' achievement of each GE competency or CD designation.

***For New Courses***

- **Instructional Type**: Lecture
- **Grading Format**: [ ] Grade [ ] P/N
- **Course will be offered**:
  - [ ] Fall Semester
  - [ ] Spring Semester
  - [ ] Summer Session

- **Course content or title is similar to courses in other departments. (Attach copy of letter of agreement with other program(s) contacted. Indicate the nature of the discussions and/or resolution of differences or potential conflicts.)**

Attach paper copies of the following:

a. Syllabus or course outline.
b. Course's student learning outcomes.
c. A list of resources required to offer and support this course.
d. A description of how teaching this course will affect department staffing.
e. If 400/500 level course, an explanation of added expectations of graduate students.
Minnesota State University, Mankato
Curriculum Proposal

***For Program Proposals***

Attach paper copies of the following:

a. Student learning outcomes for the program.

b. Minutes from department and college curriculum meetings in which action was taken on this proposal.

c. Program Assessment Plan. Forms are available on the Academic Affairs Web site:

   http://www.mnsu.edu/acadafibra/forms/

d. List of program requirements for New programs, or a list of Current and Proposed program requirements for Redesigned programs.

e. A list of resources required to offer and support this program.

f. A description of how offering this program will affect department staffing.

g. A list of additional library holdings required for this program.

Please include rationale or any proposed changes in number of program credits.

***For Programs Requiring MnSCU Approval***

If any of the following changes are proposed, please fill out and attach MnSCU Program Approval Forms, which are available on the Academic Affairs Web site:

http://www.mnsu.edu/acadaf/Curriculum/currformsprocess.html

1. Creation of an entirely new program.

2. Redesign of existing programs, which takes any of the following forms:
   
   † Addition or deletion of a program option. Options are part of program design in which 30-50% of the courses are required as part of a common core for all students, and which offers curriculum alternatives greater than 50% of the total number of credits in the major. Options are appropriate to baccalaureate or masters programs.
   
   † Addition or deletion of a program emphasis. Emphases are part of program design in which more than 50% of the courses are required as part of a common core for all students, and which offers curriculum alternatives with a minimum of nine credits. Emphases are appropriate to associate and baccalaureate programs.
   
   † Change in program name.
   
   † Change in program CIP #.
   
   † Change in TOTAL program credits.
   
   † Change in degree award. For example, changing a B.A. to B.S.
   
   † Creation of a new degree award in a related academic area. Examples include creation of a certificate program from an existing degree program, or a new degree program from an existing degree program (e.g., Art History BA 'rom Art BA.)

3. Relocation of an existing program. This is a proposal to move an existing program from one site to be exclusively offered at another site, and requires closing the program offered at the original site. For example, a program offered both on-campus and through extended campus is to be offered only at the extended campus site.

4. Replication of an existing program. This is a proposal to offer an existing program at a new site, which may be an existing MnSCU-approved site, or another campus of the same institution. Replicated programs are offered at both the original site and the new location.

5. Suspension or reinstatement of a program. This proposal suspends admission of students into an existing program, and is good for three years. Reinstatement proposals request the reopening of student admissions into a given program.

6. Closure of a program. This proposal requests closure of an existing program and its from an institution's official inventory of academic programs. Unless a department seeks to re-open a suspended program, it should be closed within three years of suspension.
Minnesota State University, Mankato
Curriculum Proposal

***Signature Page***

Department
✓ Recommended (Category/ies) ____________________________
_ Not Recommended (Category/ies) ____________________________

Department Chair ____________________________ Date 2/5/07

Comments:

College Curriculum Committee
✓ Recommended (Category/ies) ____________________________
_ Not Recommended (Category/ies) ____________________________

Committee Chair ____________________________ Date 3/20/07

Comments:

College Dean
✓ Recommended (Category/ies) ____________________________
_ Not Recommended (Category/ies) ____________________________

Dean ____________________________ Date 3/27/07

Comments:

General Education Subcommittee
✓ Recommended (Category/ies) ____________________________
_ Not Recommended (Category/ies) ____________________________

General Education Subcommittee Chair ____________________________ Date

Comments:

Undergraduate Curriculum and Academic Policy Committee
✓ Recommended (Category/ies) ____________________________
_ Not Recommended (Category/ies) ____________________________

UCAP Faculty Chair ____________________________ Date 5/4/07

Comments:

Faculty Association Graduate Committee
✓ Recommended
_ Not Recommended

Faculty Association Graduate Chair ____________________________ Date

Comments:

Graduate Dean
✓ Recommended
_ Not Recommended

Graduate Dean ____________________________ Date

Comments:

Academic Affairs Council
✓ Recommended (Category/ies) ____________________________
_ Not Recommended (Category/ies) ____________________________

Assistant Vice President ____________________________ Date 5/14/07

Comments:

Senior Vice President and Vice President for Academic Affairs
✓ Approved (Category/ies) ____________________________
_ Not Approved (Category/ies) ____________________________

Sr. Vice President/ Vice Pres. Academic Affairs ____________________________ Date 5.14.07

Comments:
Learning Outcomes: Geographic Information Systems (GIS)
Core GIS courses introduces main concepts and basic principles of geographic information systems and their use in spatial analysis and information management. Intermediate GIS course provides a background in GIS-based spatial analysis and network analysis approaches with their capabilities, uses, and limitations.

• I. Student will understand main concepts and basic principles of geographic information systems, including:
  1. Projector/coordinate systems
  2. GIS data types
  3. Vector and raster data structure
  4. Spatial data model
  5. Spatial analysis
  6. Topology in spatial data
  7. Spatial interaction
  8. Location analysis
  9. Errors in GIS data
  10. Spatial Decision Supporting System

• II. Students will develop the skills of GIS through lab exercises and projects that address "real-world" GIS application problems, including:
  1. Analysis of spatial data
  2. Geovisualization
  3. Network analysis
  4. Making 2D and 3D maps
  5. ArcIMS mapping
  6. US Census data
  7. Accessibility measurement

Learning Outcomes: Remote Sensing (RS)
The core introductory remote sensing course introduces the main concepts and basic principles of remote sensing and how these are used in real world settings.

• I. Students will understand the core concepts of remote sensing (RS) including:
  1. Principles of electro-magnetic radiometry
  2. Principles of image interpretation and photogrametry
  3. Airborne remote sensing
  4. Multi-spectral remote sensing systems
  5. Thermal IR remote sensing
  6. LIDAR and microwave remote sensing
  7. Digital image processing
II. Students will develop skills of using remote sensing with "real world" situations, including:
   1. Remote sensing image interpretation, processing and analysis
   2. How to design and implement projects
   3. How to conduct research and communicate findings

Learning Outcomes: Global Positioning Systems (GPS)
The optional Digital Field Mapping course introduces main concepts and basic principles of global positioning systems and their use in information management.

I. Students will understand main concepts and basic principles of global positioning systems, including:
   1. GPS coordinate system
   2. Reference systems
   3. Types of GPS observable
   4. Basic principles of GPS operations
   5. GPS signal structure
   6. GPS error structure
   7. Differential GPS
   8. Post-processing

II. Students will develop the skills of digital field mapping with "real-world" GPS application problems, including:
   1. GPS data collection
   2. GPS error analysis
   3. Differential GPS receiver
   4. GPS data post-processing
   5. System integration with GIS
   6. Mobile GIS with ArcPad
   7. Auto navigation

Learning Outcomes: Advanced GISc applications
I. Additional applications from GIS and remote sensing and/or global positioning systems will be applied to more advanced geo-spatial projects including:
   1. Transportation network analysis's
   2. Natural resources applications
   3. Urban and regional planning
   4. Environmental hazards
   5. Crime analysis and social issues
Excerpt from the minutes for the meeting of 09 February 2007, Agenda Item #4.

4. **GISci certificate:** F Wilkerson moved to approve the GISc certificate program as edited at the last faculty meeting (26 January 2007). C Miller seconded the motion. Discussion included clarifying that the certificates will include an 18 credit minimum, and that Geog 670 will be included as a 4 credit course. Vote: All in favor, no opposed, motion carried unanimously.
<table>
<thead>
<tr>
<th>Student Learning Outcomes (performance, knowledge, attitudes)</th>
<th>Related College Goals</th>
<th>Related University Goals</th>
<th>Method(s) of Assessment (What is the assessment?)</th>
<th>Who Assessed (Students from what courses - population)</th>
<th>When Assessed (dates)</th>
<th>Standard of Mastery/ Criterion of Achievement</th>
<th>What is Hoped to Be Learned?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowledge of main concepts and principles in GIS</td>
<td>I, III, XI</td>
<td>5</td>
<td>Pre-test &amp; post-test</td>
<td>All students in program</td>
<td>Beginning and end of program</td>
<td>100% express at least “satisfactory” attainment in each area</td>
<td>Students will acquire key concepts and skills</td>
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<tr>
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<td>I, III, XI</td>
<td>5</td>
<td>Pre-test &amp; post-test</td>
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</tr>
<tr>
<td>3. Knowledge of main concepts and principles in RS</td>
<td>I, III, XI</td>
<td>5</td>
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<tr>
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<td>5</td>
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<td>Students will acquire key concepts/skills</td>
</tr>
<tr>
<td>5. Knowledge of main concepts and principles in GPS</td>
<td>I, III, XI</td>
<td>5</td>
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<td>All students in program</td>
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<tr>
<td>6. Skills to address real-world applications in GPS</td>
<td>I, III, XI</td>
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<tr>
<td>7. Project-based applications in advanced GISc</td>
<td>I, III, XI</td>
<td>5</td>
<td>Pre-test &amp; post-test</td>
<td>All students in program</td>
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</tr>
</tbody>
</table>

*What will department or program do with results of information? We will use this information to make appropriate adjustments to the certificate program as needed.*
Course List for Undergraduate Certificates:

<table>
<thead>
<tr>
<th>Core Required Courses (3 classes)</th>
<th>Undergraduate</th>
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</thead>
<tbody>
<tr>
<td>373 Intro. GIS (4)</td>
<td></td>
</tr>
<tr>
<td>473 Intermediate GIS (4)</td>
<td></td>
</tr>
<tr>
<td>474 Intro. RS (4)</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Optional Courses (Select 2 out of 7)</th>
<th>Undergraduate</th>
</tr>
</thead>
<tbody>
<tr>
<td>471 GPS (4)</td>
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<tr>
<td>475 Advanced RS (4)</td>
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<tr>
<td>479 GIS Practicum (4)</td>
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<tr>
<td>439 Transportation (4)</td>
<td></td>
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<tr>
<td>476 Spatial Statistics (3)</td>
<td></td>
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<tr>
<td>478 Spatial Analysis (3)</td>
<td></td>
</tr>
<tr>
<td>480 Environmental Hazards (3)</td>
<td></td>
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</table>

Minimum credits: 18 cr
Rationale for Just or Change:

Undergraduate:
(1) The certificate will enhance the employability of our students (geography and non-geography majors) by certifying the competence in geographic information science (GI\text{Sc}).

Graduate:
(1) The certificate will enhance the employability of our students (geography and non-geography majors) by certifying the competence in geographic information science (GI\text{Sc}).
(2) And second, the certificate provides a recruiting option aimed at working professionals or those holding an undergraduate degree seeking a career change.

Program description:

Undergraduate:
(1) Students will receive a fundamental knowledge and understanding of geographic information systems (GIS) and remote sensing technologies with the option to
(2) Focus more intensively on advanced GIS, Remote Sensing or GPS principles and applications.

Graduate:
(1) Focus more intensively on advanced GIS, Remote Sensing or GPS principles and applications.
(2) Students will receive fundamental knowledge of GIS, Remote Sensing and critical issues and/or trends within GI\text{Sc}.
Proposed Undergraduate Certificate: Geographic Information Science (GISc)

Resources. The Geography Department already possesses the lab hardware and software needed to offer the GISc certificates. See the following web page for detailed descriptions: http://sbs.mnsu.edu/geography/facilities/gislab.html

Staffing. The Geography Department has adequate staff to presently offer this certificate. We anticipate that future additional hiring line(s), if approved, may contain a GISc component to handle future growth/expansion.

Library Resources. No additional resources are needed. We already subscribe to GISc periodicals and books are acquired through library allocations made to the Geography Department.
Dr. Scott Olson, Provost
Minnesota State University
Mankato, MN 56001

Dear Dr. Olson,

On behalf of the Minnesota GIS/LIS Consortium, I would like to offer this letter of support for a certificate program in Geographic Information Science (GISe) at Minnesota State University (MSU) – Mankato. The GIS/LIS Consortium is a group of volunteer professionals dedicated to the education and expansion of GIS throughout Minnesota and the surrounding area. Each year, the Consortium hosts professionals from the Upper Midwest at its annual conference and workshops. Other events include offering cash scholarships to GIS students in Minnesota. Recently, GIS/LIS has awarded several scholarships to students from MSU.

As Chair of the 2007 GIS/LIS Board of Directors, I would like to submit this letter on behalf of the Board in supporting the GISe certificate program proposed by the Department of Geography. We feel this program would be a wonderful opportunity for students to expand their knowledge of GIS as they prepare for the workplace or advance in their current careers. Similar programs at St. Mary’s and St. Cloud State University have been very successful and popular with students. Professionals, who are currently practicing GIS, find certificate programs beneficial in gaining valuable knowledge and experience without the need to complete a full academic program. Many students from other disciplines and existing professionals can use a certificate in GIS to complement their existing studies and degrees.

MSU, Mankato has become known in the GIS community as an excellent institution to pursue education in GIS and a certificate program would only strengthen the Geography program in Mankato.

Sincerely yours,

Chad Martini,
Board Chair, Minnesota GIS/LIS Consortium
Marty--

URSI is supports the proposed GIScience Certificate from Geography with enthusiasm. We see this as a growing field, and are grateful that Geography is prepared to offer it. We anticipate that some of our students (particularly in planning) will want to consider such a certificate. We see no conflict between the courses/certificate program and the courses/programs in URSI.

Tony Filipovitch, Chair
Urban & Regional Studies Institute
Here's a supporting e-mail from Neala to get this off the ground.

Cheers,

Don

Donald A. Friend, Ph.D.
Professor and Chair
Director of Earth Science Programs

Department of Geography
Minnesota State University
7 Armstrong Hall
Mankato, MN 56001-6026
USA

507-389-2618 voice
507-389-2980 fax
don.friend@mnsu.edu

"I regard it as the foremost task of education to ensure the survival of these qualities: an enterprising curiosity, an undefeatable spirit, tenacity in pursuit, readiness for sensible self-denial and above all, compassion." (Kurt Hahn, founder of Outward Bcund)

-----Original Message-----
From: Neala Schleuning [mailto:Neala.Schleuning@so.mnsu.edu]
Sent: Monday, April 09, 2007 2:53 PM
To: Friend, Donald A
Cc: Blackhurst, Anne; Flannery, Brenda
Subject: Re: GIScience Certificate

Hi, Don,

It was good to visit with you this morning about your proposed GIScience Certificate. My understanding is that you will offer it at both the graduate and undergraduate levels, with the same 400/500 level courses.

I think the easiest way to do this would be to complete a "new program" application at the graduate level. At the same time, prepare a redesign at the undergraduate level in concert with the graduate level application. The reason we need to do a new program application at some level, is because none of this coursework is currently required in any of your geography degrees. The courses are offered, but not required.

It is much easier, as you might imagine, to redesign a degree down a level (grad to undergrad), than to go through the intricacies of justifying how and undergrad award will change to a grad level. I would be sure that you indicate that there will be different standards for the coursework at the graduate level.

https://mavmail.mnsu.edu/exchange/cmiller/Inbox/FW:~GIScience~Certificate~Fm
As we discussed, your application should focus on the core criteria of student interest, professional/occupational demand and unnecessary duplication (as well as addressing the others).

There are many ways of documenting student interest--you indicated, for example, that because these courses have been offered for many years, you have a lot of enrollment data. This will suffice.

BLS data on demand will work. If you need help, you can contact Bruce.Steuernagel@so.mnscu.edu. He is our unit's labor market analyst and he can help you.

On the unnecessary duplication question, I would identify existing programs in the state, and indicate that there are no programs in your region.

Contact me with any further questions you have.

Neala J. Schleuning, Ph.D.
Director of Academic Programs
Minnesota State Colleges & Universities
Wells Fargo Place
30 7th Street East, Suite 350
St. Paul, Minnesota 55101-7804
phone: 651-296-5793
fax: 651/296-3214
e-mail: Neala.Schleuning@so.mnscu.edu

>>> "Friend, Donald A" <donald.friend@mnsu.edu> 4/9/2007 1:30 PM >>>

Neala,

So good to speak with you this morning. Thanks for your help.

May I ask you a small favor? To efficiently move our application materials through our campus curriculum approval processes, could you please send me a short e-mail stating that based upon our conversations, the proposed GIScience Certificate program at MSU requires a new program application at the Graduate level and a program redesign application (based upon the graduate application) at the undergraduate level. And, furthermore, since all courses are pre-existing with students currently enrolled, that there is no need to initiate market surveys demonstrating need: if we supply existing US Dept of Labor and industry documentation as well as our enrollment information, that is sufficient documentation. Thanks.

For your information, I've attached a recent article in Nature describing the growth of GIScience and mapping careers and a US Dept of Labor website link that states clearly that GeoSpatial technologies are

one of the three hottest growth fields for the foreseeable future (http://www.careervoyages.gov/geospatialtechnology-main.cfm).

Best,

Don

______________________________
Donald A. Friend, Ph.D.
Professor and Chair
Director of Earth Science Programs

Department of Geography
Minnesota State University
7 Armstrong Hall
Mankato, MN 56001-6026
USA

507-389-2618 voice
507-389-2980 fax
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**Minnesota State Colleges and Universities**  
**NOTICE OF INTENT TO MAKE PROGRAM CHANGE**  
**Academic Program ListServ**

The Office of the Chancellor requires institutions to give notice of a proposed change in a program in order to allow 21 days for other MnSCU institutions to comment. Information given here will be posted to the AcadProg ListServ.

[This form is designed for electronic use. Familiarity with the Word table-making function will be helpful.]

<table>
<thead>
<tr>
<th>Institution</th>
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<th>Type of Proposed Change (Check one)</th>
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<td>____Redesign/clone</td>
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<tr>
<td>____Replication</td>
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<td>____Relocation</td>
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<td>____Suspension</td>
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<td>____Reinstatement</td>
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<thead>
<tr>
<th>8-Digit CIP # (6-Digit for New or Cloned Program)</th>
<th>Program Name</th>
<th>Award</th>
<th>Total Credits</th>
<th>Location</th>
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<tr>
<td>45.0702</td>
<td><em>Graduate Certificate in Geographic Information Science (GIsc)</em></td>
<td>Grad.Cert. in GIsc</td>
<td>18 cr.</td>
<td>MSU, Mankato</td>
<td>Fall 07 or Spring 08</td>
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</table>

**Brief Catalog Description of the Program (for New and Cloned Programs Only)**

Students will receive a fundamental knowledge and understanding of Geographic Information Systems (GIS) and Remote Sensing technologies with the option to focus more intensively on advanced GIS, Remote Sensing or Global Positioning Systems (GPS) principles and applications.

**Description of Proposed Change**

Chief Academic Officer: [Signature]  
Date: 5-1-07

**Mall:**  
Program Review & Approval Unit  
MnSCU Office of the Chancellor  
500 World Trade Center  
30 E. 7th Street  
St. Paul, MN 55101

**Fax:** Program Review & Approval Unit  
651-296-3214

<table>
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<th>Posting Date</th>
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<tr>
<td>Notice ID #(#s)</td>
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<td>☑ New</td>
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<tr>
<td>☑ Suspension</td>
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<td>(info only)</td>
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Students will receive a fundamental knowledge and understanding of Geographic Information Systems (GIS) and Remote Sensing technologies with the option to focus more intensively on advanced GIS, Remote Sensing or Global Positioning Systems (GPS) principles and applications.

**Description of Proposed Change**

This change will create an undergraduate level GIScience certificate for students at Minnesota State University, Mankato.

Chief Academic Officer [Signature]  
Date 5/14/07

**Mail:**  
Program Review & Approval Unit  
MnSCU Office of the Chancellor  
500 World Trade Center  
30 E. 7th Street  
St. Paul, MN 55101

**Fax:**  
Program Review & Approval Unit  
651-296-3214

**Notice of Intent 2/1/02**
Minnesota State Colleges and Universities
NOTICE OF INTENT TO MAKE
PROGRAM CHANGE
Academic Program ListServ

The Office of the Chancellor requires institutions to give notice of a proposed change in a program in order to allow 21 days for other MnSCU institutions to comment. Information given here will be posted to the AcadProg ListServ.

(This form is designed for electronic use. Familiarity with the Word table-making function will be helpful.)

<table>
<thead>
<tr>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Proposed Change (Check one)</td>
</tr>
<tr>
<td><em>New</em></td>
</tr>
<tr>
<td>Suspension</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8-Digit CIP # (6-Digit for New or Cloned Program)</th>
<th>Program Name</th>
<th>Award</th>
<th>Total Credits</th>
<th>Location</th>
<th>Effective Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>45.0702</td>
<td>Undergraduate Certificate in Geographic Information Science (GISc)</td>
<td>Cert. in GISc</td>
<td>18 cr.</td>
<td>MSU, Mankato</td>
<td>Fall 07 or Spring 08</td>
</tr>
</tbody>
</table>

Brief Catalog Description of the Program (for New and Cloned Programs Only)
Students will receive a fundamental knowledge and understanding of Geographic Information Systems (GIS) and Remote Sensing technologies with the option to focus more intensively on advanced GIS, Remote Sensing or Global Positioning Systems (GPS) principles and applications.

Description of Proposed Change
This change will create an undergraduate level GIScience certificate for students at Minnesota State University, Mankato.

Chief Academic Officer [Signature]  Date 5-3-07

Mail: Program Review & Approval Unit  Fax: Program Review & Approval Unit
MnSCU Office of the Chancellor  651-296-3214
500 World Trade Center  St. Paul, MN 55101
30 E. 7th Street

Office Use Only  Posting Date

Notice of Intent 2/1/02
**Minnesota State Colleges and Universities**

**PROGRAM REDESIGN APPLICATION**

**RELATED POLICY or STATUTE:** MS 1996. Ch. 368, Sec. 33; MS 1995, Ch. 248, Article 11, Sec. 10; and MS 1996, Ch. 398, Sec. 38; Board Policy 3.14, 3.17, 3.19

[This form is designed for electronic use. You should have some familiarity with the Word table-making function. Enter your information in the correct box on the Tables below.] Please submit an individual form for each program you are redesigning. Multiple changes to the same program may be made on the same form. You may delete all the tables that do not apply to your redesign request.

### SECTION I: DESCRIPTION OF CURRENTLY APPROVED PROGRAM

<table>
<thead>
<tr>
<th>8-Digit CIP #</th>
<th>Program Name</th>
<th>Award</th>
<th>Cr Length</th>
<th>Location/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>(6-digit CIP# 45.0702)</td>
<td>Graduate Certificate in Geographic Information Science (GISc)</td>
<td>Grad. Cert. in GISc</td>
<td>18 cr. minimum</td>
<td>Minnesota State University, Mankato</td>
</tr>
</tbody>
</table>

Name of affiliated educational institution that offers one or more credits in this program: N/A

Is this award jointly offered: Yes No

### SECTION II: PROPOSED CHANGES TO PROGRAM

Effective start date/s: Fall 2007 or Spring 2008

Rationale for Proposed Change/s: This change will create a new undergraduate level GIScience certificate for students at Minnesota State University, Mankato that is modeled after our graduate level GIScience certificate.

### Section IIA: NAME CHANGE

Current: N/A

Proposed: N/A

### Section IIB: CIP CHANGE*

Current: N/A

Proposed: N/A

Current Program Outcomes: SEE ATTACHED

Proposed Program Outcomes: SEE ATTACHED

*Contact staff to determine whether change is permitted as a redesign, or whether a new program proposal is required.

### Section IIC: CHANGE CREDIT LENGTH WITHIN POLICY

Previous: N/A

Proposed: N/A

### Section IID: CHANGE CREDIT LENGTH TO EXCEED POLICY

Credit length beyond the policy limits will be approved only if one or more of the following conditions exist: a) the length is required by a state or national licensing body or other regulatory agency, accrediting association, or board; b) the program is employer-sponsored where the employer specifies the required credits as a condition for conferring the award; or c) a formal task analysis has been conducted within the last three years and the results endorsed by an advisory committee. Request for a program length in excess of policy from a professional association or advisory committee is not sufficient for approval.

Previous Length: N/A

Proposed Length: N/A
**PROGRAM REDESIGN APPLICATION**

**RELATED POLICY or STATUTE:** MS 1996, Ch. 368, Sec. 33; MS 1995, Ch. 248, Article 11, Sec. 10; and MS 1996, Ch. 398, Sec. 38; Board Policy 3.14, 3.17, 3.19

This form is designed for electronic use. You should have some familiarity with the Word table-making function. Enter your information in the correct box on the form. Please submit an individual form for each program you are redesigning. Multiple changes to the same program may be made on the same form. You may delete all the tables that do not apply to your redesign request.

### SECTION I: DESCRIPTION OF CURRENTLY APPROVED PROGRAM

<table>
<thead>
<tr>
<th>8-Digit CIP #</th>
<th>Program Name</th>
<th>Award Grad. Cert. in GISc</th>
<th>Cr Length 18 cr. minimum</th>
<th>Location/s</th>
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<tr>
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<td>Graduate Certificate in Geographic Information Science (GISc)</td>
<td></td>
<td></td>
<td>Minnesota State University, Mankato</td>
</tr>
</tbody>
</table>

Name of affiliated educational institution that offers one or more credits in this program: N/A

Is this award jointly offered: Yes [No]

### SECTION II: PROPOSED CHANGES TO PROGRAM

**Effective start date/s:** Fall 2007 or Spring 2008

Rationale for Proposed Change(s): This change will create a new undergraduate level GIScience certificate for students at Minnesota State University, Mankato that is modeled after our graduate level GIScience certificate.

### Section IIA: NAME CHANGE

Current: N/A Proposed: N/A

### Section IIB: CIP CHANGE*

Current: N/A Proposed: N/A

Current Program Outcomes: SEE ATTACHED

Proposed Program Outcomes: SEE ATTACHED

*Contact staff to determine whether change is permitted as a redesign, or whether a new program proposal is required.

### Section IIC: CHANGE CREDIT LENGTH WITHIN POLICY

Previous: N/A Proposed: N/A

### Section IID: CHANGE CREDIT LENGTH TO EXCEED POLICY

Credit length beyond the policy limits will be approved only if one or more of the following conditions exist: a) the length is required by a state or national licensing body or other regulatory agency, accrediting association, or board; b) the program is employer-sponsored where the employer specifies the required credits as a condition for conferring the award; or c) a formal task analysis has been conducted within the last three years and the results endorsed by an advisory committee. Request for a program length in excess of policy from a professional association or advisory committee is not sufficient for approval.

Previous Length: N/A Proposed Length: N/A
Learning Outcomes: Geographic Information Systems (GIS)
Core GIS courses introduces main concepts and basic principles of geographic information systems and their use in spatial analysis and information management. Intermediate GIS course provides a background in GIS-based spatial analysis and network analysis approaches with their capabilities, uses, and limitations.

- I. Student will understand main concepts and basic principles of geographic information systems, including:
  1. Projection/coordinate systems
  2. GIS data types
  3. Vector and raster data structure
  4. Spatial data model
  5. Spatial analysis
  6. Topology in spatial data
  7. Spatial interaction
  8. Location analysis
  9. Errors in GIS data
  10. Spatial Decision Supporting System

- II. Students will develop the skills of GIS through lab exercises and projects that address "real-world" GIS application problems, including:
  1. Analysis of spatial data
  2. Geovisualization
  3. Network analysis
  4. Making 2D and 3D maps
  5. ArcIMS mapping
  6. US Census data
  7. Accessibility measurement

Learning Outcomes: Remote Sensing (RS)
The core introductory remote sensing course introduces the main concepts and basic principles of remote sensing and how these are used in real world settings.

- I. Students will understand the core concepts of remote sensing (RS) including:
  1. Principles of electro-magnetic radiometry
  2. Principles of image interpretation and photogrametry
  3. Airborne remote sensing
  4. Multi-spectral remote sensing systems
  5. Thermal IR remote sensing
  6. LIDAR and microwave remote sensing
  7. Digital image processing
II. Students will develop skills of using remote sensing with "real world" situations, including:
   1. Remote sensing image interpretation, processing and analysis
   2. How to design and implement projects
   3. How to conduct research and communicate findings

Learning Outcomes: Global Positioning Systems (GPS)
The optional Digital Field Mapping course introduces main concepts and basic principles of global positioning systems and their use in information management.

I. Students will understand main concepts and basic principles of global positioning systems, including:
   1. GPS coordinate system
   2. Reference systems
   3. Types of GPS observable
   4. Basic principles of GPS operations
   5. GPS signal structure
   6. GPS error structure
   7. Differential GPS
   8. Post-processing

II. Students will develop the skills of digital field mapping with "real-world" GPS application problems, including:
   1. GPS data collection
   2. GPS error analysis
   3. Differential GPS receiver
   4. GPS data post-processing
   5. System integration with GIS
   6. Mobile GIS with ArcPad
   7. Auto navigation

Learning Outcomes: Advanced GISc applications
I. Additional applications from GIS and remote sensing and/or global positioning systems will be applied to more advanced geo-spatial projects including:
   1. Transportation network analysis's
   2. Natural resources applications
   3. Urban and regional planning
   4. Environmental hazards
   5. Crime analysis and social issues
State Rationale for Exceeding Policy Limits (Attach evidence as appropriate in an appendix): N/A

**Section IIIE: ADD CURRICULUM ALTERNATIVE(S)**

<table>
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<tr>
<td>Option or Emphasis or certificate that is a subcredential of existing award (choose one):</td>
<td></td>
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<tr>
<td>Courses unique to this alternative:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COURSE TITLE/NUMBER</th>
<th>Number of Credits</th>
<th>EXISTING COURSE/S</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
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*Change in Curriculum Alternative(s): If you are adding multiple alternatives to a single program, please identify each separately and list courses separately by copying and pasting this section as many times as necessary.

**Section IIEF: DELETE EXISTING CURRICULUM ALTERNATIVE(S)**

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<thead>
<tr>
<th>Name of Alternative: N/A</th>
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*Delete Curriculum Alternative(s): If you are deleting multiple alternatives, identify each separately. Add additional lines as necessary.

**Section IIG: AWARD CHANGE**

<table>
<thead>
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<th>Current Award: N/A</th>
<th>Proposed Award: N/A</th>
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<tr>
<td>List courses for both current award and proposed award</td>
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<table>
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<th>CURRENT AWARD: COURSE TITLE/NUMBER</th>
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<th>EXISTING COURSE/S</th>
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<table>
<thead>
<tr>
<th>PROPOSED AWARD: COURSE TITLE/NUMBER</th>
<th>Number of Credits</th>
<th>EXISTING COURSE/S</th>
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<td></td>
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</table>
**Section III: CREATE NEW AWARD IN RELATED ACADEMIC AREA**

Name: Undergraduate Certificate in GISc  
6-digit CIP: 45.0702  
Total Credits: 18 cr. minimum

Please list all courses for the new award below:

<table>
<thead>
<tr>
<th>COURSE TITLE/NUMBER</th>
<th>Number of Credits</th>
<th>EXISTING COURSE/S Yes/No</th>
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<tr>
<td>Core – Three required courses</td>
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<td></td>
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<tr>
<td>(12 cr.)</td>
<td></td>
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<tr>
<td>GEOG 373 Introductory GIS</td>
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</tr>
<tr>
<td>GEOG 473 Intermediate GIS</td>
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<td>Y</td>
</tr>
<tr>
<td>GEOG 474 Introductory Remote Sensing</td>
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<td>Y</td>
</tr>
<tr>
<td>Electives – Choice of two for</td>
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<td></td>
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<tr>
<td>6-8 cr.</td>
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<td></td>
</tr>
<tr>
<td>GEOG 439 Transportation Geography</td>
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<tr>
<td>GEOG 471 Digital Field Mapping with GPS</td>
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<td>Y</td>
</tr>
<tr>
<td>GEOG 475 Advanced Remote Sensing</td>
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<td>Y</td>
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<td>GEOG 476 Spatial Statistics</td>
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<tr>
<td>GEOG 478 Spatial Analysis</td>
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<td>Y</td>
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<td>GEOG 479 GIS Practicum</td>
<td>4</td>
<td>Y</td>
</tr>
<tr>
<td>GEOG 480 Environmental Hazards</td>
<td>3</td>
<td>Y</td>
</tr>
</tbody>
</table>

*Creating new awards in related academic areas*: Before completing this section, contact Academic Program staff to verify that you can make these proposed changes as redesigns. If you are adding awards in multiple related areas, identify each separately and list courses separately by replicating this table.

**SECTION III: REDESIGNED PROGRAM SUMMARY**

**Program Requirements:**
Complete this section if the number of credits in the award has increased from the previous design, or if it is a new award.

Use the following headings to provide information on each of the components in the program. List all credit totals required for the students to graduate, including prerequisites. If this application is for multiple awards (AAS and/or diplomas and/or certificates) duplicate this table and list requirements for each award separately.

<table>
<thead>
<tr>
<th>Program Component</th>
<th>Previous Credits</th>
<th>Proposed Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education/Liberal Studies</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Prerequisites</td>
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<td>n/a</td>
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<tr>
<td>Major-Core</td>
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<td>12 cr.</td>
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<tr>
<td>Major-Alternative (see above)</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Major-Restricted Electives</td>
<td>6-8 cr.</td>
<td>6-8 cr.</td>
</tr>
<tr>
<td>Required Minor (or est. 20 credits)</td>
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<td>n/a</td>
</tr>
<tr>
<td>Free Electives</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>TOTAL PROGRAM CREDITS</strong></td>
<td>18cr. minimum</td>
<td>18 cr. minimum</td>
</tr>
</tbody>
</table>

Program Name: Undergraduate Certificate in GISc  
Award: GISc Certificate
SECTION IV: APPROVAL VERIFICATION

Application Author: Donald A. Friend
Title: Professor and Chair, Department of Geography
Campus: Minnesota State University, Mankato
Phone and E-Mail: 507-389-2618 donald.friend@mnmsu.edu

Approval Chief Academic Officer: [Signature]
Approval of President: [Signature]
Signature of cooperating institution's president for joint awards: [Signature]

SECTION V: APPENDICES/SUPPORTING DOCUMENTATION

A. Institution Curriculum Committee Membership and Minutes showing recommendations (required) (Included)
B. Occupational/Professional Demand Data (required, if adding a certificate or AAS to an AS). (Included)
C. Copies of Agreements with Institutions (Joint and Articulated degrees) (required, if applicable) (N/A)
D. Justification for Exceeding Program Credit Lengths set in Policy (required, if applicable) (N/A)
E. Evidence of business/industry support (required for occupational programs, optional for others) (Included)
F. Letters of Support (optional) (Included)
Appendix A:
Institution Curriculum Committee Membership and Minutes showing recommendations
Excerpt from the minutes for the meeting of 09 February 2007, Agenda Item #4.

4. **GISc certificate**: F Wilkerson moved to approve the GISc certificate program as edited at the last faculty meeting (26 January 2007). C Miller seconded the motion. Discussion included clarifying that the certificates will include an 18 credit minimum, and that Geog 670 will be included as a 4 credit course. Vote: All in favor, no opposed, motion carried unanimously.
Appendix B:
Occupational/Professional Demand Data

Geospatial Technology* - Industry Overview

Want a truly 21st century career that combines interests in the Earth, space, and high technology? How about an emerging field where new "offshoot" opportunities are occurring all the time?

The geospatial industry acquires, integrates, manages, analyzes, maps, distributes, and uses geographic, temporal and spatial information and knowledge. The industry includes basic and applied research, technology development, education, and applications to address the planning, decision-making, and operational needs of people and organizations of all types.

Within Geospatial Technology, Photogrammetrists and Remote Sensing Specialists use pictures and other information from satellites, planes, and ground sensors to plot and gather data about where things are on Earth. Geographic Information Systems Analysts then review and turn this data into maps and decision-making tools.

And where might Geospatial Technology professionals, technologists, and technicians actually work? In addition to local, state, and federal government agencies, these skilled individuals can be found employed in the private and non-profit sectors in a wide-range of related scientific and technical fields, such as agriculture and soils; archeology; biology; cartography; ecology; environmental sciences; forestry and range; geodesy; geography; geology; hydrology and water resources; land appraisal and real estate; medicine; transportation; urban planning and development, and more.


* The term 'geospatial industry' is not all-inclusive. It may refer to mapmakers, academics, and others engaged in such activities.

Source: http://www.careervoyages.gov/geospatialtechnology-main.cfm
<table>
<thead>
<tr>
<th>TITLE</th>
<th>INDUSTRY</th>
<th>SOC CODE</th>
<th>PROJECTED NEED (1000's)</th>
<th>PROJECTED GROWTH PERCENT</th>
<th>BOTTOM WAGE</th>
<th>MWN</th>
<th>TOP WAGE</th>
<th>HIGH SCHOOL OR LESS PERCENT</th>
<th>SOME COLLEGE PERCENT</th>
<th>COLLEGE OR HIGHER PERCENT</th>
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<tbody>
<tr>
<td>Production, Planning, and Expediting Clerks</td>
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<td>93</td>
<td>7.7</td>
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<td>Mechanical Engineers</td>
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<td>57</td>
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<td>21</td>
<td>32</td>
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<tr>
<td>Transportation, Storage, and Distribution Managers</td>
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<td>Surveyors</td>
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<td>22</td>
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<td>17.8</td>
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<tr>
<td>Mechanical Engineering Technicians</td>
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<td>12.3</td>
<td>14</td>
<td>21</td>
<td>32</td>
<td>28.2</td>
<td>54.0</td>
<td>17.8</td>
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<td>Environmental Engineering Technicians</td>
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<td>17.8</td>
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<td>171021</td>
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<td>45</td>
<td>3.1</td>
<td>3.9</td>
<td>93.0</td>
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In Demand Geospatial Technology Occupations  
U.S. Bureau of Labor Statistics  
http://www.careervoyages.gov/geospatialtechnology-main.cfm
Mapping opportunities

Scientists who can combine geographic information systems with satellite data are in demand in a variety of disciplines. Virginia Gewin gets her bearings.

Forest fires ravaging southern California, foot-and-mouth disease devastating the British livestock industry, the recent outbreak of severe acute respiratory syndrome (SARS) — all of these disasters have at least one thing in common: the role played by geospatial analysts, mining satellite images for information to help authorities make crucial decisions. By combining layers of spatially referenced data called geographic information systems (GIS) with remotely sensed aerial or satellite images, these high-tech geographers have turned computer mapping into a powerful decision-making tool.

Natural-resource managers aren’t the only ones to take notice. From military planning to real estate, geospatial technologies have changed the face of geography and broadened job prospects across public and private sectors.

Earlier this year, the US Department of Labor identified geotechnology as one of the three most important emerging and evolving fields, along with nanotechnology and biotechnology. Job opportunities are growing and diversifying as geospatial technologies prove their value in ever more areas.

The demand for geospatial skills is growing worldwide, but the job prospects reflect a country’s geography, mapping history and even political agenda. In the United States, the focus on homeland security has been one of many factors driving the job market. Another is its vast, unmapped landscape. While European countries are integrating GIS into government decision-making, their well-charted lands give them little need for expensive satellite imagery.

**AN EXPANDING MARKET**

All indications are that the US$15-billion worldwide geospatial market will grow to $30 billion by 2005 — a dramatic increase that is sure to create new jobs, according to Emily DeRocco, assistant secretary at the US Department of Labor’s employment and training division. NASA says that 26% of its most highly trained geotech staff are due to retire in the next decade, and the National Imagery and Mapping Agency is expected to need 7,000 people trained in GIS in the next three years.

Of the 140,000 organizations globally that use GIS, most are government agencies — local, national and international. A ten-year industry forecast put together last year by the American Society for Photogrammetry & Remote Sensing (ASPRS) identified environmental, civil government, defence and security, and transportation as the most active market segments.

Business at the Earth-imagery provider Space Imaging, of Thornton, Colorado, increased by 70% last year, says Gene Colabatistto, executive vice-president of the company’s consulting service. To keep up momentum, the company plans to hire more recruits with a combination of technical and business skills. Colabatistto cites the increased adoption of GIS technologies by governments as a reason for the rise.

He adds that the US military, the first industry to adopt GIS and remote sensing on a large scale, has spent more than $1 billion on commercial remote sensing and GIS in the past two years.

**LOOKING DOWN IS LOOKING UP**

The private sector hasn’t traditionally offered many jobs for geographers, but location-based services and mapping — or ‘geographic management systems’ — are changing the field. “The business of looking down is looking up,” says Thomas Lillesand, director of the University of Wisconsin’s Environmental Remote Sensing Center in Madison, Wisconsin.

Imagery providers such as Digital Globe of Longmont, Colorado, also need more GIS-trained workers as markets continue to emerge. Spokesman Chuck Herring says that the company has identified 54 markets in which spatial data are starting to play a role.

The Environmental Systems Research Institute (ESRI), in Redlands, California, sets the industry standards for geospatial software. Most of its 2,500 employees have undergraduate training in geography or information technology, although PhDs are sought after to fill the software-development positions. Many private companies, including the ESRI and Space Imaging, offer valuable work experience to both graduate and final-year undergraduate students.

Graduates in natural-resource management note that GIS and remote-sensing skills are becoming as important as fieldwork. GIS platforms, which manipulate all forms of image data, are transforming...
disciplines such as ecology, marine biology and forestry.

"Science has discovered geography," says Doug Richardson, executive director of the Association of American Geographers (AAG). Many of the National Science Foundation’s multidisciplinary research programmes now include a geospatial component.

**SKILLED LABOUR**

Some universities are offering two-year non-thesis master’s programmes in geospatial technologies, including communication and business courses — perfect for professionals who want to build on existing skills or move into a new field. The non-profit Sloan Foundation has funded several geospatially related professional master’s programmes. In addition, numerous short courses are available to bring professionals up to speed. Indeed, the ESRI alone trains over 200,000 people a year. AAG and ASPRS conferences also offer training sessions.

Although technical skills are important, Richardson stresses that employees need a deep understanding of underlying geographic concepts. "It's a mistake to think that these technologies require only technician-oriented functions," he says.

Throughout the European Union (EU), the many top-quality graduate geography programmes remain the primary training grounds. Recently, a few pan-European projects have also emerged, including a new international institute designed to train future geographers. Building on a collaboration between the European Space

**Web links**

- Environmental Systems Research Institute
- Association of American Geographers
- American Society for Photogrammetry & Remote Sensing
- The Vespucci Institute
- Global Monitoring for Environment and Security
- Intelligence.jrc.ec.eu.int/space/bavno/bavno.html
- UNI GIS
- www.unigis.at/en
- www.careervoyages.org
- www.sloan.org
- www.sciencesmasters.com

Remote-Sensing Industry Strong and Growing over Next Decade

The future of geospatial technologies is looking better than ever. In a comprehensive review of the international remote-sensing market for aerial and spaceborne sensors and associated geospatial technologies, growth of the industry over the next decade looks strong, with the Satellite sector expecting large demand internationally and the Aerial Digital sector predicting the highest revenue growth of all the sectors worldwide.

Conducted by the National Oceanic and Atmospheric Administration (NOAA), the study includes more than 1,500 online surveys and 250 personal interviews. The surveys and interviews provide a sample from the following eight remote sensing project sectors: Academic End Users, Aerial Digital, Aerial Film, Aerial Sensor, Commercial End User, Government End User, Satellite, and Software/Hardware Providers. Although the survey was focused on Canada, Europe, and the United States, the survey results also represented global input, with respondents from Africa, Asia, Australia, Central America, and South America.

In addition to the remote-sensing technology data usage and budgetary data collected, this study also includes a 5- and 10-year analysis of the political, economic, and technical trends impacting the remote-sensing industry globally. These factors will shape the development of the industry by influencing end user demand for data, data availability, pricing, and applications.

Technical, Environmental, Economic, and Political Trends Impact Industry Development

All of the respondents were asked to identify the technical advances they see impacting their businesses in the years 2010 and 2015. In 2010, Technology Integration, Greater
Ground Resolution, and Greater Horizontal and Vertical Accuracy were the top three advances selected. In 2015, Greater Ground Resolution continued to be a primary concern; however, Greater Computer Processing Speed and Better Processing Software were the second and third most frequently selected trends.

There was more diversity in the top selections for the 2015 technical advances than in 2010. The Software/Hardware sector chose Greater Computer Processing Speed, and the Academic sector chose Continued Increased Channels and Bands. These selections reflect the specific interests of each sector. For example, the ability to collect more channels and bands in the imagery would provide new opportunities for research in the academic world, while the software/hardware industry is focused on the speed and efficiency of its products.

Based on the 1,547 survey responses, the Political, Economic, and Environmental trends that are likely to have the greatest impact over the next 10 years include National Defense/Homeland Security, Endangered Species/Natural Resources/Heritage Protection, and Global Warming. Some of these trends could have negative effects on certain sectors while having positive effects on others. It depends on whether the respondent is producing data and services or using data and services. For example, the increased interest in homeland security may result in restricted access data distribution, but the demand for data from the government will spur growth among data providers.

The geographic comparisons between sectors indicated more pronounced differences in the Political, Economic, and Environmental trends than in the Technical Advances. Canada and the United States were most concerned about National Defense/Homeland Security, while the other sectors were split geographically between Remote-Sensing Data Becoming a Commodity, Required Cadastral Mapping, Expansion of the European Union, and Licensing Issues.

Geospatial companies throughout the industry will need to take into consideration trends in all of the areas mentioned and assess for themselves how to best meet the needs of their domestic and international customers.

Government and Commercial Usage of Data and Software Continue Upward Trend
Since government agencies represent a significant revenue source for many geospatial companies (and were also the largest sector responding to the survey, globally), the Government sector was broken out by government units—Local, State/Provincial, Federal/National Civil, and Federal/National Defense—to provide added visibility into their needs. In 2010, Local, State/Provincial, and Federal/National Defense selected National Defense/HomeLand Security as having the largest impact on the way in which they operate. In 2015, the emphasis changed somewhat for the State/Provincial respondents. They selected, along with the Federal/National Civil unit, Global Warming and Endangered Species/Natural Resources/Heritage Protection as the most important impacts.

In 2010, 32 percent of Federal/National Defense respondents, 20 percent of Federal/National Civil, 13 percent of State/Provincial, and 18 percent of Local predicted budgets of $50,000 or more. There was a slight increase in budgets projected by 2015, with the most significant change predicted by State/Provincial respondents, which could represent the Canadian and United States governments’ expectations for continued budget increases for Homeland Defense/National Security programs.

To indicate potential demand for geospatial data, sectors were asked to select which types of data they use from more than 25 choices. Among the Academic, Government, and Commercial sectors, the top three types of data selected as most used were GIS Data, Processed Imagery, and Digital Orthophotos. These types of data are commonly used in a variety of GIS applications, such as municipal planning, vegetation analysis, and transportation management.

The least-used types of data are Unprocessed Lidar and Unprocessed Hyperspectral, with usage percentages ranging from 11 percent to 22 percent in all the sectors. These findings are in line with the fact that these datasets are still somewhat new and
processing lidar and hyperspectral data requires different training and technology.

Raw imagery usage ranged from a high of 65 percent (Academic) to a low of 45 percent (Government). Unprocessed imagery is more appropriate for use by academics in research, while government employees are more likely to purchase processed data to use in their project applications.

In responses about software preferences, ESRI was clearly the software of choice, not only for the Government End User sector but also in all sectors and in all geographic areas. ESRI response rates averaged 87 percent across all sectors and 86 percent among government end users.

**Strong Growth Predictions in All Remote-Sensing Sectors**

Overall, the aerial and spaceborne sectors indicate steady growth during the coming decade. The Aerial Digital, Aerial Film, Aerial Sensor, and Satellite sectors were asked to project their revenues in 2005, 2010, and 2015, broken out between United States and international sources and by department and company. The Aerial Digital respondents predicted particularly strong revenue growth, with 26 percent of the respondents selecting the United States company revenue category of "greater than $10 million" in 2005, increasing to 58 percent in 2015, and 25 percent selecting the international company revenue category of "greater than $10 million" in 2005, increasing to 44 percent in 2015.

The companies in the Aerial Digital and Aerial Sensor sectors overall selected larger revenue levels than Aerial Film and Satellite. By the year 2010, the Aerial Digital and Aerial Sensor sectors project an increase in market demand for their products and services, as indicated by increasing revenue and employee projections.

The international market is a key market for the Satellite sector. In 2005, 22 percent of the Satellite sector respondents selected the international departmental category of "greater than $5 million" in revenue, and 30 percent of the respondents selected the international company revenue category of "greater than $5 million." However, the Aerial
Digital sector projects an increase in international activity, so by 2010, its percentages of high-earning departments and companies are similar to those of the Satellite sector.

**Future Technology Impacts and Developments**

The ongoing challenge in the remote-sensing industry is to make high-quality data accessible to more users—for an affordable price. The use of maps, aerial photos, and digital aerial and satellite imagery has already evolved dramatically during the past three decades—from primarily scientific and academic applications to commercial use in the media and on the Internet. Widespread consumer application of geospatial data has evaded the remote-sensing industry thus far, but there are several technology developments that have the potential to broaden the access and use of geospatial data. NOAA focused part of its analysis on the impact of related geospatial technologies on the remote-sensing industry over the next 10 years with 250 personal interview respondents selecting the following top three impacts.

One way of increasing the supply of remotely sensed data is through increased use of microsatellites. Until recently, remote-sensing satellite programs were thought to be too expensive for most developing countries (India being the major exception). However, advancements in microsatellite technology have made the cost more affordable, and a growing number of countries are acquiring their own satellites, many through technology transfers or collaborative agreements with academic research institutions in other countries. Developing countries benefit from the less expensive access to remote-sensing assets. It is a matter of national pride to have a space program and allows workers to be trained to establish a new high-tech industry while also providing some independence from foreign data sources.

<table>
<thead>
<tr>
<th>Geospatial Data Usage</th>
<th>Commercial</th>
<th>Government</th>
<th>Academic</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS Data</td>
<td>50%</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>Processed Imagery</td>
<td>80%</td>
<td>78%</td>
<td>79%</td>
</tr>
<tr>
<td>Digital Orthophotos</td>
<td>73%</td>
<td>75%</td>
<td>67%</td>
</tr>
</tbody>
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Familiarity and easy accessibility makes use of the above types of geospatial data the most widespread. Advances in the development of microsatellite technology may begin to address the recurring concern of the survey respondents for greater revisit capability of satellites to ensure greater data availability at reduced prices.

Remote-sensing technology developers have also refined the use of the spectrum to expand detection limits in wavebands, spectral resolution, and spatial resolution. Spectral imaging involves dividing the electromagnetic spectrum into narrow spectral bands,
primarily in ultraviolet; visible; and shortwave, midwave, and longwave infrared. Multispectral imaging provides few bands, hyperspectral more bands, and ultraspectral many bands. Spectral imaging data allows extraction of features not detectable in conventional imagery.

As developments in hyperspectral and advanced imaging technologies continue, they are likely to yield a cross-fertilization of technologies that will also find their way back into the traditional remote-sensing arena. As part of the entire imaging science field, remote sensing can be expected to continue to grow and expand its overall customer base as these technologies are incorporated and new applications emerge from their use.

Just in the past few years, the value of remotely sensed data has been recognized by several heavy hitters in the Web services/search industry. Microsoft and Google, with combined annual revenue of more than $42 billion, have developed online mapping services called MSN Virtual Earth and Google Earth, respectively. The competition to capture the loyalty of consumers through fast, easy, up-to-date keyword searches linked to geographic data and maps has advanced awareness and demand more than any other trend recently. Others, such as Yahoo! Maps, have also recently entered the lineup to provide online mapping services.

Microsatellites, hyperspectral and advanced imaging, and online mapping services are just a few of the technological improvements focused on broadening the access to and use of geospatial data. Combining improved data capabilities and lower-cost data with mapping tools that are more user-friendly is essential for demand to grow outside of the traditional mapping market and will thereby help increase the size of the entire remote-sensing industry.

Remote-Sensing Research to Focus on Asia

In addition to continuing to work with the previously collected survey data, NOAA will study the remote-sensing industry trends and activities in more than 20 Asian countries and Australia.

"With so much business activity now occurring in the entire Asian region, it is a wise decision for NOAA to expand the remote-
sensing survey to include Asia," says Kay Weston, chief, Satellite Activities Branch. The online survey, which can be completed in less than eight minutes, is posted at www.empoliant.com/NOAA-remote-sensing-research. The survey respondents should be individuals involved in the remote-sensing industry within Asia or specifically doing remote-sensing-related business in Asia. Additional research network partners are being sought to host the survey Web site link on their sites and to initiate e-mails to their Asian databases encouraging respondents to complete the surveys. Research network partners will be recognized in all the material relating to the study and will receive the first release of the study in January 2007.

Countries targeted by the survey include Australia, Bangladesh, Bhutan, Brunei, Cambodia, China, Hong Kong, India, Indonesia, Japan, Laos, Malaysia, Mongolia, Myanmar, Nepal, Philippines, Russia, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam.

ESRI Business Partner Global Marketing Insights, Inc. (the NOAA contractor responsible for the study), will collect online surveys through fall 2006 when data analysis will begin. The final report will be prepared and delivered to NOAA in late 2006. As with the current study, the results will be made publicly available.

More Information

The 74-page full NOAA-sponsored final report, "Survey Analysis of Remote Sensing Aerial and Spaceborne," from which this article has been extracted, is posted as a PDF for downloading by the public at www.licensing.NOAA.gov or www.globalinsights.com. Stop by the Global Marketing Insights booth #1614 at the 26th Annual ESRI International User Conference to receive a free CD of the report and to complete the current Asian remote-sensing survey.

Dr. Shawana P. Johnson, president, Global Marketing Insights, will be presenting a paper focused on additional study results on Tuesday, August 8 at 2:30 p.m. For more information about being a research network partner for the Asian study and for more information about custom analysis of the existing research data, contact Sherry Loy, Global Marketing Insights (tel.: 216-525-0600, e-mail: sherryloy@globalinsights.com).
Hello, Geotech

“Modeling our world,” geography returns to Harvard.

by CHRISTOPHER REED

Within a university curriculum. “That is the past,” said President Lawrence H. Summers on May 5. “Geography is a very different field today, and it is increasingly at the center of a very wide range of intellectual concerns.”

The new center is housed at the Institute for Quantitative Social Science in the north building of the spiffy terracotta-and-glass quarters of the Center for Government and International Studies on Cambridge Street (go to www.gis.harvard.edu/icb/ccb.do). Its affairs are overseen by an eight-person faculty steering committee composed of GIS pioneers in the Faculty of Arts and Sciences and the Division of Engineering and Applied Sci-
ences, the Graduate School of Design, and the Harvard School of Public Health. One of them, the first director of this hotspot of high-tech geospatial analysis, is Bol, an historian who has spent most of his intellectual time in medieval China.

"Things exist in time and space," Bol says. "Historians have been very good on temporal change. We haven't been good on spatial variation.

"Think of a chronology as the basic tool of historians. If you were to do a chronology of the past 20 years in the United States, you'd probably focus on presidential leadership and the Congress, longer-term economic trends, and things like that. But if you were to cut across the picture at any one moment, you would think of government as quite dispersed; it's not only what happens in Washington, it's the state governments and local governments. Economic activity is stronger in certain areas than in others. Incomes are distributed unequally by regions and within regions and among groups of people. Pollution, climate, water resources—all these things vary spatially."

So does the inside of the brain or the inside of the earth. An estimated 80 percent of all data has a spatial component, says Bol, and it is a component that has been largely neglected. Spatial analysis is a way of thinking—about how things are distributed and about the relationships among things.

A map is the basic tool of a geographer, and a map and a chronology have a peculiar similarity: both are false. "A chronol-

THE CHINA HISTORICAL GIS

The project maps aspects of Chinese history from 222 B.C.E. to 1911 C.E. This map concerns Liangzhe province in 1077. The background shows population density, the colored circles represent the tax quotas for commercial tax collection offices. "By 1077, in contrast to earlier periods," explains Peter Bol, Carswell professor of East Asian Languages and Civilizations, "the hierarchy of economic central places, as represented by the tax quotas, no longer corresponded to the hierarchy of administrative central places—the counties and, above them, the prefectures. This was a sign that a commercial revolution was taking place, because the economy was no longer being subordinated to the administrative system. Some non-administrative towns have more economic activity than their county seats, some county seats are more active than the seats of the prefectures to which they belong. If this can be extended to all of China—and it can be, since we have the figures—we will be on the way to showing how economic activity was distributed and where the important trade routes were."

1077 Liangzhe Market Town Tax Quota
- 1 - 249
- 250 - 499
- 500 - 999
- 1000 - 1999
- 2000 - 3999
- 4000 - 7999
- 8000 - 15999
- 16000 - 31999

1077 Liangzhe County Tax Quota
- 1 - 249
- 250 - 499
- 500 - 999
- 1000 - 1999
- 2000 - 3999
- 4000 - 7999
- 8000 - 15999

1077 Liangzhe Prefectural Seat Tax Quota
- 4000 - 7999
- 8000 - 15999
- 16000 - 31999
- 32000 - 63999
- 64000 - 127999

1077 Pref. seats without tax quotas:
1077 County seats without tax quotas:
- Lakes and Inlets
- Rivers
- Coastline

1102 Population Density
- 0
- 0 - 9.425
- 9.425 - 14.578
- 14.578 - 20.251
- 20.251 - 28.034

Harvard Magazine 45
ogy picks out what’s important in terms of what’s going to happen later, and misrepresents actual things by picking out certain things as worthy of attention. It’s a scaled representation where the scale is always false,” says Bol. “The map is also a representation, of the spatial arrangement of things, and any map, to be useful, also is false. On a gas-station road map, the roads are not represented to scale. If they were, you wouldn’t be able to see them.”

One problem with that gas-station map is that you have to take it on faith. You don’t know where the data that went into it came from or how accurate they are. A geographic information system lets you disaggregate all the kinds of data you might have on a map, ask what the precise sources of that information are, and then choose which data to represent. Making and using a map require judgment and interpretation.

“I happened to have some very large data sets for medieval China of persons who passed the civil-service examinations, entered government, and held higher office,” says Bol about his own use of GIS in research. “I can show on a GIS map that from the eleventh to the thirteenth century, the geographic distribution of high officials narrows. In the eleventh century, most areas have some representation in government. But by the thirteenth century, there are only three places producing most of the officials, and government is dominated—just as it is about to fall to the Mongols—by three regional elites. That is not something I knew before I made the map.”

There’s more to geotech than GIS—specifically, there are data gathered by remote sensing from satellites and aircraft and by global positioning systems (GPS), the devices some of us have in our automobiles to tell us exactly how lost we are. A team of researchers at the School of Public Health has used wearable GPS units attached to members of the public to measure to what extent community trails and paths contribute to the promotion and maintenance of physical activity. Professor of biology Brian Farrell, who heads a team from the Museum of Comparative Zoology that is mapping the insect biodiversity of Hispaniola, has his field researchers keep GPS units in their backpacks so that they can determine and record precisely where in the forest they met a particular beetle (see “Brian Farrell in Bugdom,” September-October 2003, page 56). Paul Cote, “geographic data wrangler” at the design school, has offered a course there in remote sensing. He has also demonstrated that there’s more to GIS than flat-looking maps. For instance, he has made three-dimensional topographic maps of downtown Boston (with video tours in which the viewer flies among and around the buildings) and shown in an animation that the Eiffel Tower could be moved to fit nicely into Government Center Plaza.

Users testify that GIS is not only a technology for displaying information, but an instrument of discovery. Here’s evidence from two other historians who have latched onto GIS.

Professor of history Jill Lepore writes in the appendix of her recent book, <i>New York Burning</i>: Liberty, Slavery, and Conspiracy in Eighteenth-Century Manhattan (see “Witness to Violence,” September-October 2005, page 42), that she began her research by constructing a three-part database that included a list of city residents, a detailed coding of events from a trial that was central to her story, and an inventory of buildings, streets, and meeting places in the city. “With these data in hand, I then reconstructed the city spatially, using GIS mapping. My initial aim was to detect patterns in the conspiracy, the fires, the confessions, and the trials that were otherwise unobservable. As it turned out, I did discover important patterns, many of which informed my argument. But reconstructing the city proved as much an end itself as a means to another end. The database took me to the streets; it introduced me to the people and places of eighteenth-century New York. When I set about to write, I found myself referring to my database constantly: how long did it take to walk from Hogg’s to Hughson’s; what kind of people lived on Broadway; how many cooperers worked in the West Ward? The database helped shape and refine my argument but also helped me to understand the city.”

Michael McCormick, Goelet professor of medieval history, speaks of a more distant era: “I was making a GIS map of communication networks to go with a paper I’d written, and I began by writing a legend describing what the map was about. I had to rewrite the legend three times because as I made the map of communications microzones and local ceramic distribution in
Geographers See Death, Birth, and Job Prospects

Moreover, and perhaps most important in the fight, Buck and Conant wanted to save money. One fallen soldier opined, “Conant thinks that he is captain of a sinking ship [financially] and he is prepared to jettison anything. Geography was the first good opportunity.”

Geography would rise from this wreckage. The quantitative method of geographical research began to gain ground after World War II, and increasingly capable computers let researchers manipulate and display burgeoning amounts of new data. In the Harvard Graduate School of Design’s Laboratory for Computer Graphics and Spatial Analysis, founded by Howard T. Fisher, geographers, cartographers, artists, mathematicians, and computer savants began in 1965 to invent a way to make map displays on a computer. Jack Dangermond, president of Environmental Systems Research Institute, worked there in his student days. “We made maps,” he recalls, “on very funny output devices like line printers, which would do alphanumeric overprinting of characters in order to create gray tones for thematic displays of such things as population density, soil composition, and vegetation.” Nicholas R. Chrisman, now professor of geomatics sciences at the Université Laval in Quebec City, worked in this frontier lab from 1972 to 1982. He believes that the place was key to the development of GIS and spatial analysis, as he writes in his new book, Charting the Unknown: How Computer Mapping at Harvard Became GIS (ESRI Press), which comes with a CD containing three short films, video interviews, and more.

Key, too, were the swelling power of computers and their shrinking price. “Ten years ago,” says Wendy Guan, director of GIS (geographic information system) research services at the Center for Geographic Analysis, “just about any GIS would require a much-heavier-than-average workstation to operate on. Today, just about any decent PC can run GIS software with reasonable speed. Some even runs on cell phones.”

“Today, as in the mid-20th century, the academic discipline of geography appears to be under threat” at locales as disparate as the United Kingdom and India, wrote Nigel Waters last year in “What Can GIS Do to Save Geography?” on geoplace.com. He sees the discipline still “hopelessly divided between its physical and human branches.” But he added that geography at the University of Calgary hears this gong of hope: “GIS is recognized as providing academic geography with an essential requirement for its survival; a marketable skill.”

“Geotech, nanotech, and biotech are the fastest growing fields in technology,” says historian Peter Bol, director of the Center for Geographic Analysis. “The U.S. government has undertaken massive hiring of people with GIS expertise. Central Intelligence Agency staff told me they had been ordered to double their geospatial-analysis capabilities within a year.”

Waters recounts that veteran Foreign Service officer Carleton S. Coon Jr., at the fiftieth reunion of his Harvard class of 1948, offered what he called “a single pearl of wisdom” at a symposium on foreign policy: “Reinstitute geography at Harvard”
Byzantine Galilee and Judaea, I kept discovering relationships among the data that I had not noticed before.

McCormick, who will teach "The Fall of the Roman Empire" next spring, is now making a series of 50 maps with an underlying GIS architecture for that course. One or two maps, for instance, will spotlight the fate of the city of Trier, in Germany: home of the Celtic Treveri tribe; conquered by the Romans in the first century B.C. and founded as a city by Augustus; attacked by barbarians and rebuilt in the third century; a capital of the Roman Empire in the fourth century; finally abandoned by the Romans in the early fifth century, to be sacked and captured by the Franks and possibly the Huns, before ending up as a medieval archbishop's town. The maps will show what's going on in Trier in this century or that, as well as abundant information about the empire's changing borders, trade routes, settlements, natural conditions, and so on. McCormick will build databases keyed to his 50 maps, so that a student can hit a button to see all the shipwrecks of the fourth century, for instance, or watch short videos made by their professor of monuments, excavations, and other sights in Rome, Constantinople, Milan. He hopes that the new maps will show his students how historians can use GIS as an analytical tool to help understand the avalanche of new information bearing on the Roman Empire coming in from written sources, archaeology, and the natural sciences. And he offers this pedagogical observation: "Our undergraduates today are certainly as smart as they used to be, but they are now more visually aware than students 20 years ago. They are quicker to get into visual material than texts."

McCormick is supported in this project by the staff of the Harvard Map Collection, housed in Pusey Library and repository of more than half a million maps (see http://hcl.harvard.edu/libraries/#hmc). David Cobb, its head, "has been very helpful digging out relevant historical maps, and he is a whiz at digitizing them," says McCormick. In preparation for his class, the role of the professional staff at the Center for Geographic Analysis will be to search for, evaluate, and obtain data layers, such as digital elevation models or satellite images, from both public and commercial sources; to manage data-conversion contracts with external service providers who will massage the data in various ways to make it suitable for GIS use; to design a database structure for organizing the spatial data; to prepare training materials and deliver the training to the research assistants who will enter data into the database and maintain the database in the long term; to design and build a dynamic data-viewing and -mapping tool that can be downloaded from the course website and run on personal computers without network or license constraints; and to provide instruction to students on how to use that tool. Thus equipped and instructed, McCormick's students will be able to do GIS work on their own, and make their own discoveries about that "great historical enigma, the fall of Rome."

But what about other undergraduates? "The fact of the matter is that in the Faculty of Arts and Sciences we have no formal GIS curriculum; zilch," said Bol last spring. "The problem is very serious." Wendy Guan, director of GIS research services at the center, says that five courses are needed to grasp the field fully: in GIS and computer cartography, in remote sensing, in both introductory and advanced GIS, and in spatial analysis.

The problem for students who just want to put a bit of GIS in their intellectual toolkit eased on September 1 when the government department appointed Harvard's first preceptor in GIS: Sumeeta Srinivasan. The center conducted the job search and found Srinivasan in the Division of Engineering and Applied Sciences, where as a postdoctoral research associate she taught a course on the spatial analysis of environmental and social systems.
a course with a good deal of quantitative content and some fairly stiff mathematical expectations. The first time she taught it, in the spring of 2005, she had only one undergraduate among her students, Lee Murray ’06, who won Harvard’s Howard T. Fisher Prize in Geographical Information Science for a class project, “Spatial Analysis of Redistricting of Congressional Districts in New York State Following the 2000 Census.” In 2006 Srinivasan had nine undergraduates in class and one of them, Frances C. Moore ’06, won the Fisher Prize for “A Spatial Analysis of the Causal Factors of Nepal’s Maoist Insurgency.”

This fall Srinivasan is teaching a less mathematically daunting introduction to GIS and its applications in both the social sciences and environmental sciences. It is one of the prerequisites for her spatial analysis and modeling course in the spring. In the spring she will also offer an advanced GIS workshop in which students can explore some aspect of GIS in depth and do a semester-long project. She plans a three-week intensive introduction-to-GIS workshop to be taught in January in the Longwood Medical Area; it will feed into spatial-statistics course offerings at the School of Public Health.

Guan has a staff of two GIS specialists full time and one GIS applications engineer, who splits his time between the center and the University Library. “Two types of projects come to us,” she says. “Those like Mike McCormick’s, in which a scholar understands the possibilities of GIS but lacks the equipment or time to do what’s wanted with it, and those in which a scholar says, ‘I’m doing this research. How can you help?’” “People in lots of disciplines are starting to recognize that there’s something going on with geospatial analysis that’s important,” says Bol. “If they have grant money available for a project, the center will charge for its services. If not, we won’t.”

“Getting the data is often the most challenging step in a project,” says Guan. “Collecting quality, precise data can be so hard that some researchers become discouraged.” But the center itself is collecting and disseminating spatial data sets from diverse sources inside and outside of Harvard. That is a critical part of its mission. Some are public goods and free, shared by government agencies through the Web. Some come from third-party vendors who repack raw data, add some value, and resell them. The University maintains a marvelous data source, the Harvard Geospatial Library. It keeps and catalogs data sets, so far numbering in the thousands (and many more will come to it, from the center and elsewhere). Go to “other libraries” on the University Libraries website (http://lib.harvard.edu) for a look. Bewildered newcomers to the site should head at once to the “general help” menu. “The volume of data in the world is increasing exponentially, its price dropping linearly,” says Guan. “Just think of the number of satellites circling the globe.”

Yes, think of those satellites, many equipped with cameras capturing plain or fancy images of the earth. Jason Jr., assistant professor of anthropology, has used declassified intelligence-satellite imagery, in a GIS framework, to reconstruct state-sponsored irrigation systems in the Assyrian heartland from 702 to 681 b.c.

Joseph A. Greene, assistant director of the Semitic Museum, is considering deploying what he calls a “slightly theoretical” technology that uses low-level aerial scanning—from helicopters, say—in wavelengths other than visible light, to detect ancient
structures now covered by vegetation. "The data come back as numbers that are processed into pictures. The scans tell you where to look first. You spot something and go onto the ground and, yes, it's a road and it was built by the Romans."

So far, there's been more talk than action at Harvard about using remote-sensing data in research, but, says Guan, "there are many ideas." She is a seasoned user of remote-sensing and GPS data. Born in China, she became interested in the facts of geography as a child. But when she went to college—when the government, for the first time after the Cultural Revolution, allowed students to take an examination and, based on their scores, go on to college—she studied biology. "There were still remnants of political censorship, and geography was classified as a state-secret-related major," she says. "I wasn't trustworthy enough to study geography."

When China opened its door, Guan emigrated to Canada, where she studied the geography of recreational resources in Ontario at Trent University and got a master's degree. She went on to earn a Ph.D. at the University of Georgia in the late 1980s in an interdisciplinary program in forestry, economics, and geography. Her dissertation was on water-quality modeling with GIS. Her first job was at a government agency in Florida, using GIS applications in Everglades restoration, land and natural-resource management, and regulatory programs. Then she migrated to Seattle to work for the Weyerhaeuser Corporation, an international forest-products company. As part of the forestry technology team, she managed GIS, remote-sensing, and GPS technology to keep track of the company's trees—were they diseased? were they drought-stressed?—to regulate the fertilization plan, to plot helicopter routes, and much else. Black boxes containing GPS units mounted in the logging trucks promoted efficiency. (They also allowed headquarters to see whether a truck was speeding, which didn't sit well with all drivers, but there was a potential upside to the technology as far as they were concerned: if a truck shouldered up on a head-office monitor as motionless for two hours on a remote dirt road, trouble could be deduced and help dispatched.) Data from remote sensing and global positioning systems feed into GIS, the core technology. Harvard scholars mired on a dirt road with such data will often require the analytical help of trustworthy specialists.

Guan and colleagues, jointly with the Harvard University Center for the Environment, will host a public workshop later this fall to showcase research at Harvard that uses remote sensing and to provide a high level, up-to-date overview of the technology and its applications.

Alongside its other responsibilities, the center hopes to advance the field of GIS and spatial analysis intellectually. For

Reprinted from Harvard Magazine. For more information, contact Harvard Magazine, Inc. at 617-495-5746.
starters, Bol and his colleagues have proposed that the University raise the money for two professorships, one in the Faculty of Arts and Sciences and one at the design school, to bring to the University persons with a strong background in geographic information science, with broad vision, who are likely to see ways in which geographic information can be relevant in many disciplines and provide a platform for tying interdisciplinary knowledge together. Word is awaited on the realization of that initiative.

Jack Dangermond, M.I.A. '69, of Redlands, California, was on hand for the center's launch and spoke there. Trained as a landscape architect, he came to Harvard originally to earn his master's degree, but spent most of his time working in the design school's Laboratory for Computer Graphics and Spatial Analysis, founded by Howard T. Fisher, a geographer and mathematical cartographer. Dangermond's wife, Laura, worked there, too. The lab was in the process of inventing the very first computer map displays. He and Laura, full of youthful enthusiasm to do good, took what they had learned back to California and founded the Environmental Systems Research Institute (ESRI), an infant nonprofit firm that applied the new computer-mapping techniques learned at Harvard to the analysis of such things as air pollution. ESRI morphed into a booming business, the leading provider of GIS software to business, government, and education. Jack Dangermond remains its influential president. About 140,000 organizations use the company's tools as their foundation for building and applying geographic knowledge. The Dangermonds made a gift of all ESRI's software to the University, so that academics could get access to the technology easily. He also provided the initial endowment for the Fisher Prize.

"GIS is becoming pervasive as an information infrastructure for managing geography," he said in an interview. "As we increasingly affect the planet, the human footprint becomes bigger and more invasive, and we gradually are moving into a role of managing the world, instead of being participants in a natural world. We are going to have to take more responsibility for all the processes of geography—water, climate, the forests, those natural aspects of the landscape that persist. When we weave the various GIS systems together into a kind of nervous system for the planet, we will see and increasingly participate in its evolution. Now GIS brings geography back to Harvard. It left for unfortunate reasons, and that was a big loss to Harvard and to academic geography in general because it signaled that geography was a fading science. Now it returns, not as a traditional place-based geography—where is Nigeria—but as a science of the planet, modeling our world as a whole, its processes, and their relationships."

Christopher Reed is executive editor of this magazine.
Appendix E:
Evidence of business/industry support
Dr. Scott Olson, Provost  
Minnesota State University  
Mankato, MN 56001

Dear Dr. Olson,

On behalf of the Minnesota GIS/LIS Consortium, I would like to offer this letter of support for a certificate program in Geographic Information Science (GISc) at Minnesota State University (MSU) – Mankato. The GIS/LIS Consortium is a group of volunteer professionals dedicated to the education and expansion of GIS throughout Minnesota and the surrounding area. Each year, the Consortium hosts professionals from the Upper Midwest at its annual conference and workshops. Other events include offering cash scholarships to GIS students in Minnesota. Recently, GIS/LIS has awarded several scholarships to students from MSU.

As Chair of the 2007 GIS/LIS Board of Directors, I would like to submit this letter on behalf of the Board in supporting the GISc certificate program proposed by the Department of Geography. We feel this program would be a wonderful opportunity for students to expand their knowledge of GIS as they prepare for the workplace or advance in their current careers. Similar programs at St. Mary’s and St. Cloud State University have been very successful and popular with students. Professionals, who are currently practicing GIS, find certificate programs beneficial in gaining valuable knowledge and experience without the need to complete a full academic program. Many students from other disciplines and existing professionals can use a certificate in GIS to complement their existing studies and degrees.

MSU, Mankato has become known in the GIS community as an excellent institution to pursue education in GIS and a certificate program would only strengthen the Geography program in Mankato.

Sincerely yours,

Chad Martini,  
Board Chair, Minnesota GIS/LIS Consortium
February 8, 2007

FOR YOUR ACTION:

Richard Davenport, President
John Alessio, Dean, Social and Behavioral Sciences
Donald Friend, Chair, Geography Department
Susan Taylor, Director of Development, Social and Behavioral Sciences

FROM: Joann Jaqua, Manager
Gift Receipting, Administration and Stewardship

RE: Micro-Trak Systems, Inc.
c/o Dan Theobald
PO Box 99
Eagle Lake, MN 56024-0099

Details about the gift: We have received an in-kind gift valued at $29,286.50 from Micro-Trak Systems, Inc.; lifetime giving to the MSU Foundation is over $38,000. This gift designated for the geography department consists of eleven T100 digital GPS receivers; one T200 digital GPS receiver; and two antennas. Micro-Track will be honored at this fall’s gala as new members of the Purple and Gold Society’s Dean’s Circle. Thank you notes can be sent to Dan at the above address.

FOR YOUR INFORMATION:

Scott Olson, Vice President, Academic Affairs
Patricia Swatfager-Haney, Vice President, Student Affairs
David Williams, Vice President, University Advancement
Margot Zelenz, Associate Vice President, University Advancement
Cynthia Bemis-Abrams, Director, Alumni Relations and Special Events
Appendix F:
Letters of Support
Excerpts from the Minnesota State University, Mankato
Department of Geography
Program Review
External Evaluators' Report, April 2007

By: Dr. Gregory Chu, Professor of Geography, University of Wisconsin – La Crosse and
Dr. Darrell Napton, Professor of Geography, South Dakota State University

“A new departmental strength is in the area of Geographic Information Sciences which include GIS, remote sensing, cartography, spatial analysis and GPS. The department’s facilities in this area are excellent. New faculty members who were recently conducting their dissertation research at institutions such as the University of Minnesota and Ohio State University found the Geography Department equipment and software holdings current and excellent. We concur with their assessment.” p. 1

“Since the last program review in 1993, much has changed. Most noteworthy has been the Department’s successful incorporation of recent technologies and ideas related to Geographic Information Sciences. This was the result of the efforts of many individuals who were willing to change the way things had been done to better the Department... The efforts ... were clearly successful, and today the Department has one of the best equipped Geographic Information Sciences facilities in the nation. The faculty members who use those facilities are also among the best. The Department knows that success is a moving target. It just put a GIS certificate into place. This should make geography graduates more competitive, attract additional students, and raise the profile of the Department in the region.” p. 2

“Geography’s contribution by offering GIS classes is especially appreciated across the campus.” p. 2

“Faculty research and publication, collaborative projects with students, an emphasis on field classes and field work, and an outstanding Geographic Information Sciences ideas and technologies clearly contributes to the advancement of the field and helps produce highly qualified students who find good jobs within the region or pursue additional education.” p.3

“The advent of geo-spatial science and its related technologies have empowered geographers with added intellectual and analytical skills to enter into collaborative research with other disciplines. Geographers with advanced GIS, Remote Sensing, and GPS navigational skills are being sought after by researchers from various disciplines, spanning from the physical sciences to the social and behavioral sciences to collaborate on multi-disciplinary research.” p. 4

“Additionally, the numbers of majors is solid and the number and quality of graduate students has increased.” p. 15
Marty--
URSI is supports the proposed GIScience Certificate from Geography with enthusiasm. We see this as a growing field, and are grateful that Geography is prepared to offer it. We anticipate that some of our students (particularly in planning) will want to consider such a certificate. We see no conflict between the courses/certificate program and the courses/programs in URSI.

Tony Filipovitch, Chair
Urban & Regional Studies Institute
Minnesota State Colleges and Universities

NEW

PROGRAM APPLICATION

RELATED POLICY or STATUTE: MS 1996, Ch. 368, Sec. 33; MS 1995, Ch. 248, Article 11, Sec. 10; and MS 1996, Ch. 398, Sec. 38; Board Policy 3.14, 3.17

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SECTION I: DESCRIPTION OF THE PROPOSED PROGRAM

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<tr>
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<tr>
<td>45.0702</td>
<td>Graduate Certificate in Geographic Information Science (GISC)</td>
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Effective start date(s): Fall 2007 or Spring 2008

Affiliated educational institution that offers one or more credits in this program: n/a

Closure Date (when applicable): Is this award jointly offered? Yes ❌ No

Brief catalog description of the program: Students will receive a fundamental knowledge and understanding of Geographic Information Systems (GIS) and Remote Sensing technologies with the option to focus more intensively on advanced GIS, Remote Sensing or Global Positioning Systems (GPS) principles and applications.

Program Learning Outcomes (“Graduates will be able to ______”): See attached list of learning outcomes.

* NOTE THAT THE GRADUATE CERTIFICATE HAS ENHANCED RESEARCH AND MANAGEMENT OUTCOMES AS COMPARED TO THE UNDERGRADUATE CERTIFICATE OUTCOMES.

SECTION II: DOCUMENTED NEED FOR THE PROGRAM (See Section III, “Resources,” for assistance in documenting these items.) Also review the “New Program Rating Criteria” in this section.

Mission. The proposed program supports the following two Minnesota State University, Mankato Strategic Goals: (1) The University will strengthen its role as a major provider of graduate education, offering intensive, scholarly graduate programs including collaborative efforts with other institutions and professionals, culminating in student expertise at professional levels. (2) The University will invest in the professional development of all members of the University Community and in the appropriate technologies necessary to achieve excellence in learning through teaching, research, and service. (from: http://www.mnsu.edu/supersite/about/mission.html)

The proposed program also supports the College of Social and Behavioral Sciences Goal # 7:

The College of Social and Behavioral Sciences will use new technologies in support of teaching, learning,
Learning Outcomes: Geographic Information Systems (GIS)
Core GIS courses introduce main concepts and basic principles of geographic information systems and their use in spatial analysis and information management. Intermediate GIS course provides a background in GIS-based spatial analysis and network analysis approaches with their capabilities, uses, and limitations. The Issues in Geographic Techniques seminar (GEOG 670) emphasizes the development of students’ research design creation, management and project completion abilities that will parallel professional geospatial career demands. Management and research foci will also be included in all 500-level GIS courses as graduate students will be required to lead and manage undergraduate research teams on applied project assignments throughout each semester.

- I. Student will understand main concepts and basic principles of geographic information systems, including:
  1. Projection/coordinate systems
  2. GIS data types
  3. Vector and raster data structure
  4. Spatial data model
  5. Spatial analysis
  6. Topology in spatial data
  7. Spatial interaction
  8. Location analysis
  9. Errors in GIS data
  10. Spatial Decision Supporting System

- II. Students will develop the skills of GIS through lab exercises and projects that address "real-world" GIS application problems, including:
  1. Analysis of spatial data
  2. Geovisualization
  3. Network analysis
  4. Making 2D and 3D maps
  5. ArcIMS mapping
  6. US Census data
  7. Accessibility measurement

- III. Students will develop GIS research design skills required for professional management-level careers, including:
  1. Systems management
  2. Staffing prerequisites and tasking
  3. Project development from conception to completion
  4. Strategic planning
  5. Results reporting
Learning Outcomes: Remote Sensing (RS)
The core introductory remote sensing course introduces the main concepts and basic principles of remote sensing and how these are used in real world settings. Management and research foci will also be included in both 500-level RS courses as graduate students will be required to lead and manage undergraduate research teams on applied project assignments throughout each semester.

• I. Students will understand the core concepts of remote sensing (RS) including:
  1. Principles of electro-magnetic radiometry
  2. Principles of image interpretation and photogrametry
  3. Airborne remote sensing
  4. Multi-spectral remote sensing systems
  5. Thermal IR remote sensing
  6. LIDAR and microwave remote sensing
  7. Digital image processing

• II. Students will develop skills of using remote sensing with "real world" situations, including:
  1. Remote sensing image interpretation, processing and analysis
  2. How to design and implement projects
  3. How to conduct research and communicate findings

• III. Students will develop RS research design skills required for professional management-level careers, including:
  1. Systems management
  2. Staffing prerequisites and tasking
  3. Project development from conception to completion
  4. Strategic planning
  5. Results reporting

Learning Outcomes: Global Positioning Systems (GPS)
The optional Digital Field Mapping course introduces main concepts and basic principles of global positioning systems and their use in information management. Management and research foci will also be included in the 500-level GPS course as graduate students will be required to lead and manage undergraduate research teams on applied project assignments throughout each semester.

• I. Students will understand main concepts and basic principles of global positioning systems, including:
  1. GPS coordinate system
  2. Reference systems
3. Types of GPS observable data
4. Basic principles of GPS operations
5. GPS signal structure
6. GPS error structure
7. Differential GPS
8. Post-processing

- II. Students will develop the skills of digital field mapping with "real-world" GPS application problems, including:
  1. GPS data collection
  2. GPS error analysis
  3. Differential GPS receiver
  4. GPS data post-processing
  5. System integration with GIS
  6. Mobile GIS with ArcPad
  7. Auto navigation

- III. Students will develop GPS-based field-mapping research design skills required for professional management-level careers, including:
  1. Systems management
  2. Staffing prerequisites and tasking
  3. Project development from conception to completion
  4. Strategic planning
  5. Results reporting

**Learning Outcomes: Advanced GISc applications**
The elective 500-level courses will prepare students for careers in a variety of applied geo-spatial areas in private and public sector occupations in planning, resource management, environmental consulting and public safety applications. Management and research foci will also be included in the 500-level elective courses as graduate students will be required to lead and manage undergraduate research teams on applied project assignments throughout each semester.

I. Additional applications from GIS and remote sensing and/or global positioning systems will be applied to more advanced geo-spatial projects including:
   1. Transportation network analysis
   2. Natural resources applications
   3. Urban and regional planning
   4. Environmental hazards
   5. Crime analysis and social issues
be well prepared for the opportunities after graduation. (from: http://sbs.mnsu.edu/about/)

The proposed program also supports the MnSCU Board of Trustees' strategic action plan for 2006-2010, *Designing the Future*, especially specific to the following areas:

**Strategic Direction 2:** Promote and measure high-quality learning programs and services

**Goal 2.1:** Demonstrate high quality in all educational programs.

**KEY CONCEPT:** PROMOTE INCREASED PARTICIPATION IN SCIENCE, TECHNOLOGY, ENGINEERING AND MATH, KNOWN AS STEM, FIELDS.

Minnesota State Colleges and Universities must provide students with foundation skills in mathematics and science and prepare increasing numbers of graduates for careers in scientific and technical fields.

(from: http://www.mnsu.edu/about/workplan/06-07_actionplan/2006systemactionplan.pdf)

**Occupational/Professional Demand.** The growth of the geospatial technologies career specialty has been well documented in a variety of occupational outlook publications. The US Bureau of Labor Statistics website (www.careervoyages.gov) refers to geospatial technologies as being an “emerging field where new ‘offshoot’ opportunities are occurring all the time.” The BLS “Table of In Demand Geospatial Technology Occupations” listed on its website clearly shows that multiple career fields that integrate GIScience are in growth modes and that hiring will continue for the foreseeable future. (See attached table from http://www.careervoyages.gov/geospatialtechnology-main.cfm)

The internationally renowned journal *Nature* described the demand for GIScience as follows: *From military planning to real estate, geospatial technologies have changed the face of geography and broadened job prospects across public and private sectors. Earlier this year [2004], the US Department of Labor identified geotechnology as one of the three most important emerging and evolving fields, along with nanotechnology and biotechnology. Job opportunities are growing and diversifying as geospatial technologies prove their value in ever more areas.* (See attached article in Appendix B). The article also highlights these additional perspectives on the future of geospatial technologies:

- NASA says that 26% of its most highly trained geotech staff are due to retire in the next decade.
- National Imagery and Mapping Agency (NIMA) [Now the National Geospatial-Intelligence Agency] is expected to need 7,000 people trained in GIS in the next three years.
- Of the 140,000 organizations globally that use GIS, most are government agencies.
- The U.S. military, the first industry to adopt GIS and remote sensing on a large scale, has spent more than $1 billion on commercial remote sensing and GIS in the past two years.

In 2006, the National Oceanic and Atmospheric Administration (NOAA) conducted an industry survey and found that the demand for GIScience professionals continued to grow. In an article published in ArcNews, the results of the study were summarized as follows: *"The future of geospatial technologies is looking better than ever. In a comprehensive review of the international remote-sensing market for aerial and spaceborne sensors and associated geospatial technologies, growth of the industry over the next decade looks strong, with the Satellite sector expecting large demand internationally and the Aerial Digital sector predicting the highest revenue growth of all the sectors worldwide."* (See attached article in Appendix B.)

In 2006, Harvard University responded to institutional demands for GIScience and created its own new Center for Geographic Analysis and has launched an undergraduate GIScience curriculum to support student demands for geospatial education. An article in Harvard Magazine cites the center’s director as saying, “*Geotech, nanotech, and biotech are the fastest growing fields in technology... The U.S. government has undertaken massive hiring of people with GIS expertise. Central Intelligence Agency staff told me they had been ordered to double their geospatial-analysis capabilities within a year.*” (See attached article in Appendix B.)
**Student Interest:** The demand for GIScience courses at Minnesota State University, Mankato increased significantly in the late 1990s and early 2000s and has been holding steady in the mid 2000s. (See attached three-year enrollment statistics in Appendix C.) There is also strong evidence to suggest that significant proportions of our students who are graduating with B.S. and M.S. degrees in Geography are getting jobs in geospatial career fields or they are enrolling in subsequent degree programs at MSU and other institutions and will desire further GISc credentials; these types of students will be prime candidates to enroll in the new certificate programs because these awards will further enhance professional development opportunities in the growing field of GISc. (See attached Graduate Classification, Job Title & Employer or Continuing Education reports for AY 2003 and 2004 in Appendix C.)

**Unnecessary Program Duplication:** There are only two existing graduate-level GISc certificate programs in the state of Minnesota at present:

1. St. Mary’s University: Professional Certificate in GeoSpatial Technology (post-baccalaureate and continuing education programs)

2. St. Cloud State University: Graduate Certificate—Geographic Information Science

(Note: The University of Minnesota has a professional masters degree in GIS, but offers no certificate program)

The proposed MSU,M GISc certificate program will be the only one of its kind in southern Minnesota and thus can serve a broad audience throughout the southern half of the state and much of northern Iowa.

Additionally, this program will be the only one in MnSCU that will offer advanced Remote Sensing (RS) content (two semester-length courses - the SCSU program only offers one course in RS). The MSU,M program will offer sequential courses in both GIS and RS for students who wish to obtain in-depth expertise in one or both specialty areas. Furthermore, this program will be the only one in MnSCU to offer Digital Field Mapping with GPS techniques (see section below concerning recent digital GPS equipment donations).

**Resources.** Describe the faculty, equipment, and library resources available for implementation of the program:

In April 2007, the Minnesota State University, Mankato Department of Geography Program Review External Evaluators’ Report noted that “today the Department has one of the best equipped Geographic Information Sciences facilities in the nation. The faculty members who use those facilities are also among the best.” The evaluators also stated that “…the Geography Department equipment and software holdings [are] current and excellent.” (See full list of Program Review excerpts in Appendix H.) Our department is clearly prepared and well-staffed to offer this new certificate award.

Because many of the same students who are enrolled in the department’s master’s program will opt to do the Graduate Certificate option as an elective program, we do not anticipate that any additional resources will be required to support this new program. If enrollment in the certificate program does rise at the rate anticipated below in Section III, these will generally be the same students we normally support in our GISc courses with our current level of resources (faculty FTE, lab seats, hardware, software licensure, etc.), so we anticipate no additional resource needs for the foreseeable future specifically for this program.

In terms of GPS hardware, in February 2007, the department received 12 new Digital GPS receivers as an in-kind gift from Micro-Trak Systems, Inc. valued at $29,286. This effectively doubled our current DGPS equipment inventory and significantly enhanced our ability to support the GEOG 571 Digital Field Mapping course, one of the certificate program optional courses. (See memo in Appendix E.)
**External Relations/Collaboration.** Since the early 1990s, both our faculty and alumni have served as members of the Board of Directors of the Minnesota GIS/LIS Consortium, an official 501c3 non-profit organization whose mission is communicating information to, and improving cooperation among, those interested in Geographic Information Systems (GIS) and Land Information Systems (LIS) in the State of Minnesota. Members include GIS users in local, state and federal government agencies, business and industry, and educational institutions. The Consortium hosts annual statewide conferences, and establishes committees that deal with specific GIS/LIS-related issues in Minnesota.

Professor Mitchell completed a three-year term as the higher education board member last year, and Professor Yuan was elected as his replacement this year, so MSUM continues to be recognized as a leader in this respected professional GISc organization. Likewise, our graduates also are influential members of the organization: an alumna served as the board chair several years ago and another is presently the “local government” board representative.

Our service with the Consortium has kept our faculty abreast of GISc industry needs in Minnesota and has enhanced the statewide visibility of our program and the good quality of our graduates. As a result, the Consortium enthusiastically supports the new certificate program as evidenced by an attached letter from the chair of the Board of Directors, Mr. Chad Martini in Appendix E.

We also have attached in Appendix H an email expressing support from Dr. Tony Filipovich, chair of the MSUM Urban and Regional Studies Institute. Our departments have had a long and successful cooperative affiliation, and he and his colleagues welcome the addition of the new certificate as a viable program for their graduate students.

**SECTION III: BUDGET, STAFF AND FINANCIAL INFORMATION** (The board office will assume that a college/university reallocation will be achieved to balance revenues and expenditures)

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<tr>
<td>Student FYE</td>
<td>5</td>
<td>10</td>
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</table>

<table>
<thead>
<tr>
<th><strong>B. Identify the anticipated revenues for the program.</strong></th>
<th></th>
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<td>Student Tuition*</td>
<td>$42,384</td>
<td>$84,768</td>
<td>$127,152</td>
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<td>$9,780</td>
<td>$14,670</td>
<td>$19,560</td>
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<td>Grants</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>Gifts</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
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<td><strong>TOTAL</strong></td>
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<td>$94,548</td>
<td>$141,822</td>
<td>$189,096</td>
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<td>n/a</td>
<td>n/a</td>
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<td>Salary and Fringe**</td>
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<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Supplies</td>
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<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Equipment</td>
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<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Other</td>
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<td>n/a</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
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<td>n/a</td>
<td>n/a</td>
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</table>

*current rate per credit x student FYE x 32 semester credits per year
**fringe benefits: 25 percent of salary

**D. NOTICE:** If this new program is for an AS degree, refer to Board procedure 3.32.1 College Faculty Credentialing, subpart D to review the expected minimum faculty qualifications for an AS degree.

Do you expect any of your current faculty to teach in the proposed AS degree program?

- **YES**: Complete Part C and
- **NO**: Complete Part B.
E. Identify new facility/major equipment requirements (if applicable).
N/A - As stated in the “Resources” section above, the department’s facilities and equipment are sufficient to support this program.

SECTION IV: PROGRAM CURRICULUM  (See “Program Design” section for a description of program components.)

A. Program Specific Admission Requirements (if different from institution admission requirements). N/A

B. Program Requirements

<table>
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<tr>
<th>PROGRAM COMPONENT/COURSES</th>
<th>COURSE TITLE/NUMBER</th>
<th>NUMBER OF CREDITS</th>
<th>EXISTING COURSES?</th>
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<td>Prerequisites (total credits) n/a</td>
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<td></td>
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<tr>
<td>Major Core (three courses – 12 cr.)</td>
<td>GEOG 573 Intermediate GIS</td>
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<tr>
<td></td>
<td>GEOG 574 Introductory Remote Sensing</td>
<td>4</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>GEOG 670 Issues in Geographic Techniques</td>
<td>4</td>
<td>Y</td>
</tr>
<tr>
<td>Electives (Select 2 of 7 courses for a total of 6 - 8 cr.)</td>
<td>GEOG 539 Transportation Geography</td>
<td>4</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>GEOG 571 Digital Field Mapping with GPS</td>
<td>4</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>GEOG 575 Advanced Remote Sensing</td>
<td>4</td>
<td>Y</td>
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<tr>
<td></td>
<td>GEOG 576 Spatial Statistics</td>
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<td>Y</td>
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<tr>
<td></td>
<td>GEOG 578 Spatial Analysis</td>
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<tr>
<td></td>
<td>GEOG 579 GIS Practicum</td>
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<td></td>
<td>GEOG 580 Environmental Hazards</td>
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</table>

6-digit CIP Code: 45.0702

TOTAL NUMBER OF CREDITS IN AWARD | 18 credits minimum |
SECTION V: APPROVAL VERIFICATION

Application Author: Donald A. Friend
Title: Professor and Chair, Department of Geography
Campus: Minnesota State University, Mankato
Phone and E-Mail: 507-389-2618 donald.friend@mnsu.edu

Approval Chief Academic Officer:

Approval of President:

Signature of cooperating institution's president for joint awards:

SECTION VI: APPENDICES/SUPPORTING DOCUMENTATION

A. Institution Curriculum Committee Membership and Minutes showing recommendations (required)
B. Occupational/Professional Demand Data (required)
C. Student Interest Data (required)
D. Faculty Vitae (required, if available)
E. Evidence of business/industry support (required for occupational programs, optional for others)
F. Copies of Agreements with Institutions (Joint and Articulated degrees) (required, if applicable)
G. Justification for Exceeding Program Credit Lengths set in Policy (required, if applicable)
H. Evidence of External Review (required for graduate programs only)
I. Letters of Support (optional)
Appendix A:
Institution Curriculum Committee Membership and Minutes showing recommendations
Excerpt from the minutes for the meeting of 09 February 2007, Agenda Item #4.

4. **GISci certificate**: F Wilkerson moved to approve the GISci certificate program as edited at the last faculty meeting (26 January 2007). C Miller seconded the motion. Discussion included clarifying that the certificates will include an 18 credit minimum, and that Geog 670 will be included as a 4 credit course. Vote: All in favor, no opposed, motion carried unanimously.
Appendix B:
Occupational/Professional Demand Data

Geospatial Technology - Industry Overview

Want a truly 21st century career that combines interests in the Earth, space, and high technology? How about an emerging field where new “offshoot” opportunities are occurring all the time?

The geospatial industry acquires, integrates, manages, analyzes, maps, distributes, and uses geographic, temporal and spatial information and knowledge. The industry includes basic and applied research, technology development, education, and applications to address the planning, decision-making, and operational needs of people and organizations of all types.

Within Geospatial Technology, Photogrammetrists and Remote Sensing Specialists use pictures and other information from satellites, planes, and ground sensors to plot and gather data about where things are on Earth. Geographic Information Systems Analysts then review and turn this data into maps and decision-making tools.

And where might Geospatial Technology professionals, technologists, and technicians actually work? In addition to local, state, and federal government agencies, these skilled individuals can be found employed in the private and non-profit sectors in a wide-range of related scientific and technical fields, such as agriculture and soils; archeology; biology; cartography; ecology; environmental sciences; forestry and range; geodesy; geography; geology; hydrology and water resources; land appraisal and real estate; medicine; transportation: urban planning and development; and more.


* The term "geospatial industry" is not all-inclusive. It may refer to mapmakers, academics, and others engaged in such activities.

Source: http://www.careervoyages.gov/geospatialtechnology-main.cfm
<table>
<thead>
<tr>
<th>TITLE</th>
<th>INDUSTRY</th>
<th>SOC CODE</th>
<th>PROJECTED NEED (1600's)</th>
<th>PROJECTED GROWTH PERCENT</th>
<th>BOTTOM WAGE</th>
<th>MEDIAN WAGE</th>
<th>TOP WAGE</th>
<th>HIGH SCHOOL OR LESS PERCENT</th>
<th>SOME COLLEGE PERCENT</th>
<th>COLLEGE OR HIGHER PERCENT</th>
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<td>93</td>
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<td>11</td>
<td>18</td>
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<td>93.0</td>
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<td>45</td>
<td>3.1</td>
<td>3.9</td>
<td>93.0</td>
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</table>

In Demand Geospatial Technology Occupations
U.S. Bureau of Labor Statistics
http://www.careervoyages.gov/geospatialtechnology-main.cfm
Mapping opportunities

Scientists who can combine geographic information systems with satellite data are in demand in a variety of disciplines. Virginia Gewin gets her bearings.

Forest fires ravaging southern California, foot-and-mouth disease devastating the British livestock industry, the recent outbreak of severe acute respiratory syndrome (SARS) — all of these disasters have at least one thing in common: the role played by geospatial analysts, mining satellite images for information to help authorities make crucial decisions. By combining layers of spatially referenced data called geographic information systems (GIS) with remotely sensed aerial or satellite images, these high-tech geographers have turned computer mapping into a powerful decision-making tool.

Natural-resource managers aren’t the only ones to take notice. From military planning to real estate, geospatial technologies have changed the face of geography and broadened job prospects across public and private sectors.

Earlier this year, the US Department of Labor identified geotechnology as one of the three most important emerging and evolving fields, along with nanotechnology and biotechnology. Job opportunities are growing and diversifying as geospatial technologies prove their value in ever more areas.

The demand for geospatial skills is growing worldwide, but the job prospects reflect a country’s geography, mapping history and even political agenda. In the United States, the focus on homeland security has been one of many factors driving the job market. Another is the vast, unmapped landscape. While European countries are integrating GIS into government decision-making, their well-charted lands give them little need for expensive satellite imagery.

An Expanding Market

All indications are that the US$5-billion worldwide geospatial market will grow to $30 billion by 2005 — a dramatic increase that is sure to create new jobs, according to Emily DeRocco, assistant secretary at the US Department of Labor’s employment and training division. NASA says that 26% of its most highly trained geotech staff are due to retire in the next decade, and the National Imagery and Mapping Agency is expected to need 7,000 people trained in GIS in the next three years. Of the 140,000 organizations globally that use GIS, most are government agencies — local, national and international. A ten-year industry forecast put together last year by the American Society for Photogrammetry & Remote Sensing (ASPRS) identified environmental, civil government, defence and security, and transportation as the most active market segments.

Business at the Earth-imagery provider Space Imaging, of Thornton, Colorado, increased by 70% last year, says Gene Colabatistto, executive vice-president of the company’s consulting service. To keep up momentum, the company plans to hire more recruits with a combination of technical and business skills. Colabatistto cites the increased adoption of GIS technologies by governments as a reason for the rise. He adds that the US military, the first industry to adopt GIS and remote sensing on a large scale, has spent more than $1 billion on commercial remote sensing and GIS in the past two years.

Looking Down Is Looking Up

The private sector hasn’t traditionally offered many jobs for geographers, but location-based services and mapping — or ‘geographic management systems’ — are changing the field. “The business of looking down is looking up,” says Thomas Lillesand, director of the University of Wisconsin’s Environmental Remote Sensing Center in Madison, Wisconsin.

Imagery providers such as Digital Globe of Longmont, Colorado, also need more GIS-trained workers as markets continue to emerge. Spokesman Chuck Herring says that the company has identified 54 markets in which spatial data are starting to play a role.

The Environmental Systems Research Institute (ESRI), in Redlands, California, sets the industry standards for geospatial software. Most of its 2,500 employees have undergraduate training in geography or information technology, although PhDs are sought after to fill the software-development positions. Many private companies, including the ESRI and Space Imaging, offer valuable work experience to both graduate and final-year undergraduate students.

Grades in natural-resource management note that GIS and remote-sensing skills are becoming as important as fieldwork. GIS platforms, which manipulate all forms of image data, are transforming
disciplines such as ecology, marine biology and forestry.

"Science has discovered geography," says Doug Richardson, executive director of the Association of American Geographers (AAG). Many of the National Science Foundation's multidisciplinary research programmes now include a geospatial component.

SKILLED LABOUR

Some universities are offering two-year non-thesis master's programmes in geospatial technologies, including communication and business courses — perfect for professionals who want to build on existing skills or move into a new field. The non-profit Sloan Foundation has funded several geospatially related professional master's programmes. In addition, numerous short courses are available to bring professionals up to speed. Indeed, the ESRI alone trains over 200,000 people a year. AAG and ASPRS conferences also offer training sessions.

Although technical skills are important, Richardson stresses that employees need a deep understanding of underlying geographic concepts. "It's a mistake to think that these technologies require only technician-oriented functions," he says.

Throughout the European Union (EU), the many top-quality graduate geography programmes remain the primary training grounds. Recently, a few pan-European projects have also emerged, including a new international institute designed to train future geographers. Building on a collaboration between the European Space Agency and the US National Science Foundation, the Vespucci Initiative in 2002 began three-week summer workshops training students from around the world in spatial data infrastructure, spatial analysis and geodemographics. The EU even promotes distance learning: UNIGIS, a network of European universities, prides itself on being the only virtual, global, multilingual GIS programme in the world.

Although GIS is increasingly incorporated into UK government practices, there is little demand for remote-sensing expertise in this small and heavily mapped country. Mark Linehan, director of the London-based Association for Geographic Information, says that although the public-sector market is growing, it remains a struggle to find jobs for MScs at the appropriate pay scale and qualification level.

The European Commission (EC) is laying the groundwork to ease data-sharing across countries in anticipation of wider adoption of GIS among the member-state governments and to cut the costs of data gathering. That process alone will require at least a couple of thousand people trained in GIS, and many more proposals are expected.

Indeed, the EC and the European Space Agency have joined to propose a Global Monitoring for Environment and Security initiative, to provide permanent access to information on environmental management, risk surveillance and civil security. Given the scope of the mandate, this is likely to need people who understand how to interpret, integrate and manage satellite information — those who also have a background in natural-resource issues will be in highest demand.

Considering the role that GIS played in staving off the spread of foot-and-mouth disease, such a system will not only increase the prevalence of geospatial skills in Europe, it will better connect data with Europe's resource managers.

Virginia Gewin is a freelance science writer in Corvallis, Oregon.

Remote-Sensing Industry Strong and Growing over Next Decade

The future of geospatial technologies is looking better than ever. In a comprehensive review of the international remote-sensing market for aerial and spaceborne sensors and associated geospatial technologies, growth of the industry over the next decade looks strong, with the Satellite sector expecting large demand internationally and the Aerial Digital sector predicting the highest revenue growth of all the sectors worldwide.

Conducted by the National Oceanic and Atmospheric Administration (NOAA), the study includes more than 1,500 online surveys and 250 personal interviews. The surveys and interviews provide a sample from the following eight remote sensing project sectors: Academic End Users, Aerial Digital, Aerial Film, Aerial Sensor, Commercial End User, Government End User, Satellite, and Software/Hardware Providers. Although the survey was focused on Canada, Europe, and the United States, the survey results also represented global input, with respondents from Africa, Asia, Australia, Central America, and South America.

In addition to the remote-sensing technology data usage and budgetary data collected, this study also includes a 5- and 10-year analysis of the political, economic, and technical trends impacting the remote-sensing industry globally. These factors will shape the development of the industry by influencing end user demand for data, data availability, pricing, and applications.

Technical, Environmental, Economic, and Political Trends Impact Industry Development

All of the respondents were asked to identify the technical advances they see impacting their businesses in the years 2010 and 2015. In 2010, Technology Integration, Greater
Ground Resolution, and Greater Horizontal and Vertical Accuracy were the top three advances selected. In 2015, Greater Ground Resolution continued to be a primary concern; however, Greater Computer Processing Speed and Better Processing Software were the second and third most frequently selected trends.

There was more diversity in the top selections for the 2015 technical advances than in 2010. The Software/Hardware sector chose Greater Computer Processing Speed, and the Academic sector chose Continued Increased Channels and Bands. These selections reflect the specific interests of each sector. For example, the ability to collect more channels and bands in the imagery would provide new opportunities for research in the academic world, while the software/hardware industry is focused on the speed and efficiency of its products.

Based on the 1,547 survey responses, the Political, Economic, and Environmental trends that are likely to have the greatest impact over the next 10 years include National Defense/Homeland Security, Endangered Species/Natural Resources/Heritage Protection, and Global Warming. Some of these trends could have negative effects on certain sectors while having positive effects on others. It depends on whether the respondent is producing data and services or using data and services. For example, the increased interest in homeland security may result in restricted access data distribution, but the demand for data from the government will spur growth among data providers.

The geographic comparisons between sectors indicated more pronounced differences in the Political, Economic, and Environmental trends than in the Technical Advances. Canada and the United States were most concerned about National Defense/Homeland Security, while the other sectors were split geographically between Remote-Sensing Data Becoming a Commodity, Required Cadastral Mapping, Expansion of the European Union, and Licensing Issues.

Geospatial companies throughout the industry will need to take into consideration trends in all of the areas mentioned and assess for themselves how to best meet the needs of their domestic and international customers.

Government and Commercial Usage of Data and Software Continue Upward Trend
Since government agencies represent a significant revenue source for many geospatial companies (and were also the largest sector responding to the survey, globally), the Government sector was broken out by government units—Local, State/Provincial, Federal/National Civil, and Federal/National Defense—to provide added visibility into their needs. In 2010, Local, State/Provincial, and Federal/National Defense selected National Defense/Homeland Security as having the largest impact on the way in which they operate. In 2015, the emphasis changed somewhat for the State/Provincial respondents. They selected, along with the Federal/National Civil unit, Global Warming and Endangered Species/Natural Resources/Heritage Protection as the most important impacts.

In 2010, 32 percent of Federal/National Defense respondents, 20 percent of Federal/National Civil, 13 percent of State/Provincial, and 18 percent of Local predicted budgets of $50,000 or more. There was a slight increase in budgets projected by 2015, with the most significant change predicted by State/Provincial respondents, which could represent the Canadian and United States governments’ expectations for continued budget increases for Homeland Defense/National Security programs.

To indicate potential demand for geospatial data, sectors were asked to select which types of data they use from more than 25 choices. Among the Academic, Government, and Commercial sectors, the top three types of data selected as most used were GIS Data, Processed Imagery, and Digital Orthophotos. These types of data are commonly used in a variety of GIS applications, such as municipal planning, vegetation analysis, and transportation management.

The least-used types of data are Unprocessed Lidar and Unprocessed Hyperspectral, with usage percentages ranging from 11 percent to 22 percent in all the sectors. These findings are in line with the fact that these datasets are still somewhat new and
processing lidar and hyperspectral data requires different training and technology.

Raw imagery usage ranged from a high of 65 percent (Academic) to a low of 45 percent (Government). Unprocessed imagery is more appropriate for use by academics in research, while government employees are more likely to purchase processed data to use in their project applications.

In responses about software preferences, ESRI was clearly the software of choice, not only for the Government End User sector but also in all sectors and in all geographic areas. ESRI response rates averaged 87 percent across all sectors and 86 percent among government end users.

### Strong Growth Predictions in All Remote-Sensing Sectors

Overall, the aerial and spaceborne sectors indicate steady growth during the coming decade. The Aerial Digital, Aerial Film, Aerial Sensor, and Satellite sectors were asked to project their revenues in 2005, 2010, and 2015, broken out between United States and international sources and by department and company. The Aerial Digital respondents predicted particularly strong revenue growth, with 26 percent of the respondents selecting the United States company revenue category of "greater than $10 million" in 2005, increasing to 58 percent in 2015, and 25 percent selecting the international company revenue category of "greater than $10 million" in 2005, increasing to 44 percent in 2015.

The companies in the Aerial Digital and Aerial Sensor sectors overall selected larger revenue levels than Aerial Film and Satellite. By the year 2010, the Aerial Digital and Aerial Sensor sectors project an increase in market demand for their products and services, as indicated by increasing revenue and employee projections.

<table>
<thead>
<tr>
<th></th>
<th>% with Budgets of $50,000 or More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government Unit</td>
<td>2015</td>
</tr>
<tr>
<td>Federal/National</td>
<td>2010</td>
</tr>
<tr>
<td>Defense</td>
<td>20%</td>
</tr>
<tr>
<td>Federal/National</td>
<td>20%</td>
</tr>
<tr>
<td>Civil</td>
<td>20%</td>
</tr>
<tr>
<td>State/Provincial</td>
<td>13%</td>
</tr>
</tbody>
</table>

Federal/National Defense agencies have the largest budgets throughout the government sector; however, the number of State/Provincial budgets over $50,000 is predicted to grow by 5 percent in 2015.

The international market is a key market for the Satellite sector. In 2005, 22 percent of the Satellite sector respondents selected the international departmental category of "greater than $5 million" in revenue, and 30 percent of the respondents selected the international company revenue category of "greater than $5 million." However, the Aerial
Digital sector projects an increase in international activity, so by 2010, its percentages of high-earning departments and companies are similar to those of the Satellite sector.

**Future Technology Impacts and Developments**

The ongoing challenge in the remote-sensing industry is to make high-quality data accessible to more users—for an affordable price. The use of maps, aerial photos, and digital aerial and satellite imagery has already evolved dramatically during the past three decades—from primarily scientific and academic applications to commercial use in the media and on the Internet. Widespread consumer application of geospatial data has evaded the remote-sensing industry thus far, but there are several technology developments that have the potential to broaden the access and use of geospatial data. NOAA focused part of its analysis on the impact of related geospatial technologies on the remote-sensing industry over the next 10 years with 250 personal interview respondents selecting the following top three impacts.

One way of increasing the supply of remotely sensed data is through increased use of microsatellites. Until recently, remote-sensing satellite programs were thought to be too expensive for most developing countries (India being the major exception). However, advancements in microsatellite technology have made the cost more affordable, and a growing number of countries are acquiring their own satellites, many through technology transfers or collaborative agreements with academic research institutions in other countries. Developing countries benefit from the less expensive access to remote-sensing assets. It is a matter of national pride to have a space program and allows workers to be trained to establish a new high-tech industry while also providing some independence from foreign data sources.

<table>
<thead>
<tr>
<th>Geospatial Data Usage</th>
<th>Commercial</th>
<th>Government</th>
<th>Academic</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS Data</td>
<td>90%</td>
<td>95%</td>
<td>82%</td>
</tr>
<tr>
<td>Processed Imagery</td>
<td>80%</td>
<td>74%</td>
<td>79%</td>
</tr>
<tr>
<td>Digital Orthophotos</td>
<td>73%</td>
<td>75%</td>
<td>67%</td>
</tr>
</tbody>
</table>

Familiarity and easy accessibility makes use of the above types of geospatial data the most widespread. Advances in the development of microsatellite technology may begin to address the recurring concern of the survey respondents for greater revisit capability of satellites to ensure greater data availability at reduced prices.

Remote-sensing technology developers have also refined the use of the spectrum to expand detection limits in wavebands, spectral resolution, and spatial resolution. Spectral imaging involves dividing the electromagnetic spectrum into narrow spectral bands,
primarily in ultraviolet; visible; and shortwave, midwave, and longwave infrared. Multispectral imaging provides few bands, hyperspectral more bands, and ultraspectral many bands. Spectral imaging data allows extraction of features not detectable in conventional imagery.

As developments in hyperspectral and advanced imaging technologies continue, they are likely to yield a cross-fertilization of technologies that will also find their way back into the traditional remote-sensing arena. As part of the entire imaging science field, remote sensing can be expected to continue to grow and expand its overall customer base as these technologies are incorporated and new applications emerge from their use.

Just in the past few years, the value of remotely sensed data has been recognized by several heavy hitters in the Web services/search industry. Microsoft and Google, with combined annual revenue of more than $42 billion, have developed online mapping services called MSN Virtual Earth and Google Earth, respectively. The competition to capture the loyalty of consumers through fast, easy, up-to-date keyword searches linked to geographic data and maps has advanced awareness and demand more than any other trend recently. Others, such as Yahoo! Maps, have also recently entered the lineup to provide online mapping services.

Microsatellites, hyperspectral and advanced imaging, and online mapping services are just a few of the technological improvements focused on broadening the access to and use of geospatial data. Combining improved data capabilities and lower-cost data with mapping tools that are more user-friendly is essential for demand to grow outside of the traditional mapping market and will thereby help increase the size of the entire remote-sensing industry.

**Remote-Sensing Research to Focus on Asia**

In addition to continuing to work with the previously collected survey data, NOAA will study the remote-sensing industry trends and activities in more than 20 Asian countries and Australia.

"With so much business activity now occurring in the entire Asian region, it is a wise decision for NOAA to expand the remote-
sensing survey to include Asia," says Kay Weston, chief, Satellite Activities Branch. The online survey, which can be completed in less than eight minutes, is posted at www.empliant.com/NOAA-remote-sensing-research. The survey respondents should be individuals involved in the remote-sensing industry within Asia or specifically doing remote-sensing-related business in Asia. Additional research network partners are being sought to host the survey Web site link on their sites and to initiate e-mails to their Asian databases encouraging respondents to complete the surveys. Research network partners will be recognized in all the material relating to the study and will receive the first release of the study in January 2007.

Countries targeted by the survey include Australia, Bangladesh, Bhutan, Brunei, Cambodia, China, Hong Kong, India, Indonesia, Japan, Laos, Malaysia, Mongolia, Myanmar, Nepal, Philippines, Russia, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam.

ESRI Business Partner Global Marketing Insights, Inc. (the NOAA contractor responsible for the study), will collect online surveys through fall 2006 when data analysis will begin. The final report will be prepared and delivered to NOAA in late 2006. As with the current study, the results will be made publicly available.

More Information

The 74-page full NOAA-sponsored final report, "Survey Analysis of Remote Sensing Aerial and Spaceborne," from which this article has been extracted, is posted as a PDF for downloading by the public at www.licensing.NOAA.gov or www.globalinsights.com. Stop by the Global Marketing Insights booth #1614 at the 26th Annual ESRI International User Conference to receive a free CD of the report and to complete the current Asian remote-sensing survey.

Dr. Shawana P. Johnson, president, Global Marketing Insights, will be presenting a paper focused on additional study results on Tuesday, August 8 at 2:30 p.m. For more information about being a research network partner for the Asian study and for more information about custom analysis of the existing research data, contact Sherry Loy, Global Marketing Insights (tel.: 216-525-0600, e-mail: sherryley@globalinsights.com).
Hello, Geotech

"Modeling our world,"
geography returns
to Harvard.

by CHRISTOPHER REED

Take your geographic information system (GIS) for a spin around the block. It's easy. Sit at your computer, which you have loaded with GIS software, and call up on the monitor a street map of Greater Boston. Superimpose on it a second map showing the household incomes of the citizenry. Those with the best dental work are in the suburbs, struggling scholars in Cambridge, the poor in the inner city. Add a third layer of census ethnicity information. All these data are public and readily available. Top it off with lines and dots showing Massachusetts Bay Transportation Authority bus routes and subway stations. Almost everyone is near a stop except in one big chunk of the city south of downtown. Your multilayered map will reveal to you what you might not have otherwise perceived, that the poorest, blackest Bostonians, in Roxbury and Dorchester, the ones least able to afford cars, are the least well served by public transportation.

"That's an easy demonstration of GIS," says Peter K. Bol, Carswell professor of East Asian languages and civilizations. "Another is to look at high-voltage electricity lines and higher cancer rates and see that they don't go together. A college student could easily learn to do this in a course on GIS and figure out the answers to all sorts of questions, which may have to do with the distribution of populations in 1902 in China, something I'm working on at the moment, or very contemporary problems in the world we live in. If you wonder what happens when the polar ice caps melt and ocean levels rise, GIS can show you within minutes just how much of the coast will be inundated if you raise the water level by two feet.

"After we see the new coastline, we can look at population," Bol continues. "How many million people are going to have to move? How much infrastructure is going to disappear? Enabling people to use GIS, to have it as part of their intellectual toolkit for understanding the world around them, is a very important thing."

That is one of the goals of the University's new Center for Geographic Analysis, established with the support of the provost earlier this year and launched ceremoniously at a gathering on May 5. The occasion was heralded as a consequential reversal, the return of geography to a University that in 1948 had shocked academe by dumping its geography program (see page 47). President James B. Conant, a chemist, said then that the subject had no place within a university curriculum. "That is the past," said President Lawrence H. Summers on May 5. "Geography is a very different field today, and it is increasingly at the center of a very wide range of intellectual concerns."

The new center is housed at the Institute for Quantitative Social Science in the north building of the spiffy terracotta-and-glass quarters of the Center for Government and International Studies on Cambridge Street (go to www.gis.harvard.edu/_icb/ibc-dc). Its affairs are overseen by an eight-person faculty steering committee composed of GIS pioneers in the Faculty of Arts and Sciences and the Division of Engineering and Applied Sci-
ences, the Graduate School of Design, and the Harvard School of Public Health. One of them, the first director of this hotspot of high-tech geospatial analysis, is Bol, an historian who has spent most of his intellectual time in medieval China.

"THINGS EXIST IN TIME AND SPACE," Bol says. "Historians have been very good on temporal change. We haven't been good on spatial variation.

"Think of a chronology as the basic tool of historians. If you were to do a chronology of the past 20 years in the United States, you'd probably focus on presidential leadership and the Congress, longer-term economic trends, and things like that. But if you were to cut across the picture at any one moment, you would think of government as quite dispersed; it's not only what happens in Washington, it's the state governments and local governments. Economic activity is stronger in certain areas than in others. Incomes are distributed unequally by regions and within regions and among groups of people. Pollution, climate, water resources—all these things vary spatially."

So does the inside of the brain or the inside of the earth. An estimated 80 percent of all data has a spatial component, says Bol, and it is a component that has been largely neglected. Spatial analysis is a way of thinking—about how things are distributed and about the relationships among things.

A map is the basic tool of a geographer, and a map and a chronology have a peculiar similarity: both are false. "A chronol-

THE CHINA HISTORICAL GIS

The project maps aspects of Chinese history from 222 B.C.E. to 1911 C.E. This map concerns Liangzhe province in 1077. The background shows population density, the colored circles represent the tax quotas for commercial tax collection offices. "By 1077, in contrast to earlier periods," explains Peter Bol, Carswell professor of East Asian languages and civilizations, "the hierarchy of economic central places, as represented by the tax quotas, no longer corresponded to the hierarchy of administrative central places—the counties and, above them, the prefectures. This was a sign that a commercial revolution was taking place, because the economy was no longer being subordinated to the administrative system. Some non-administrative towns have more economic activity than their county seats, some county seats are more active than the seats of the prefectures to which they belong. If this can be extended to all of China—and it can be, since we have the figures—we will be on the way to showing how economic activity was distributed and where the important trade routes were."

1077 Liangzhe Market Town Tax Quota

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<th>Tax Quota</th>
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<tbody>
<tr>
<td>1 - 249</td>
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<tr>
<td>250 - 499</td>
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<td>500 - 999</td>
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<td>1000 - 1999</td>
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<td>2000 - 3999</td>
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<tr>
<td>4000 - 7999</td>
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<tr>
<td>8000 - 15999</td>
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<tr>
<td>16000 - 31999</td>
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</tbody>
</table>

1077 Liangzhe County Tax Quota

<table>
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<th>Tax Quota</th>
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<td>1 - 249</td>
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<td>2000 - 3999</td>
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<tr>
<td>4000 - 7999</td>
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<td>8000 - 15999</td>
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1077 Liangzhe Prefectural Seat Tax Quota

<table>
<thead>
<tr>
<th>Tax Quota</th>
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<tbody>
<tr>
<td>4000 - 7999</td>
</tr>
<tr>
<td>9000 - 15999</td>
</tr>
<tr>
<td>16000 - 31999</td>
</tr>
<tr>
<td>32000 - 63999</td>
</tr>
<tr>
<td>64000 - 127999</td>
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1077 Pref. seats without tax quotas

1077 County seats without tax quotas

Lakes and Inlets

Rivers

Coastline

1102 Population Density

<table>
<thead>
<tr>
<th>Density</th>
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<tbody>
<tr>
<td>0 - 9.425</td>
</tr>
<tr>
<td>9.425 - 14.578</td>
</tr>
<tr>
<td>14.578 - 20.251</td>
</tr>
<tr>
<td>20.251 - 28.034</td>
</tr>
</tbody>
</table>
ogy picks out what's important in terms of what's going to happen later, and misrepresents actual things by picking out certain things as worthy of attention. It's a scaled representation where the scale is always false,” says Bol. “The map is also a representation, of the spatial arrangement of things, and any map, to be useful, also is false. On a gas-station road map, the roads are not represented to scale. If they were, you wouldn't be able to see them.”

One problem with that gas-station map is that you have to take it on faith. You don't know where the data that went into it came from or how accurate they are. A geographic information system lets you disaggregate all the kinds of data you might have on a map, ask what the precise sources of that information are, and then choose which data to represent. Making and using a map require judgment and interpretation.

“I happened to have some very large data sets for medieval China of persons who passed the civil-service examinations, entered government, and held higher office,” says Bol about his own use of GIS in research. “I can show on a GIS map that from the eleventh to the thirteenth century, the geographic distribution of high officials narrows. In the eleventh century, most areas have some representation in government. But by the thirteenth century, there are only three places producing most of the officials, and government is dominated—just as it is about to fall to the Mongols—by three regional elites. That is not something I knew before I made the map.”

There's more to geotech than GIS—specifically, there are data gathered by remote sensing from satellites and aircraft and by global positioning systems (GPS), the devices some of us have in our automobiles to tell us exactly how lost we are. A team of researchers at the School of Public Health has used wearable GPS units attached to members of the public to measure to what extent community trails and paths contribute to the promotion and maintenance of physical activity. Professor of biology Brian Farrell, who heads a team from the Museum of Comparative Zoology that is mapping the insect biodiversity of Hispaniola, has his field researchers keep GPS units in their backpacks so that they can determine and record precisely where in the cloud forest they met a particular beetle (see "Brian Farrell in Bugdom," September-October 2003, page 60). Paul Cote, “geographic data wrangler” at the design school, has offered a course there in remote sensing. He has also demonstrated that there's more to GIS than flat-looking maps. For instance, he has made three-dimensional topographic maps of downtown Boston (with video tours in which the viewer flies among and around the buildings) and shown in an animation that the Eiffel Tower could be moved to fit nicely into Government Center Plaza.

Users testify that GIS is not only a technology for displaying information, but an instrument of discovery. Here's evidence from two other historians who have latched onto GIS.

Professor of history Jill Lepore writes in the appendix of her recent book, *New York Burning: Liberty, Slavery, and Conspiracy in Eighteenth-Century Manhattan* (see “Witness to Violence,” September-October 2005, page 42), that she began her research by constructing a three-part database that included a list of city residents, a detailed coding of events from a trial that was central to her story, and an inventory of buildings, streets, and meeting places in the city. “With [these] data in hand, I then reconstructed the city spatially, using GIS mapping. My initial aim was to detect patterns in the conspiracy, the fires, the confessions, and the trials that were otherwise unobservable...As it turned out, I did discover important patterns, many of which informed my argument...But reconstructing the city proved as much an end itself as a means to another end. The database took me to the streets; it introduced me to the people and places of eighteenth-century New York. When I set about to write, I found myself referring to my database constantly: how long did it take to walk from Hogg's to Hughson's; what kind of people lived on Broadway; how many cooperers worked in the West Ward? The database helped shape and refine my argument but also it helped me to understand the city.”

Michael McCormick, Goolet professor of medieval history, speaks of a more distant era. “I was making a GIS map of communications networks to go with a paper I'd written, and I began by writing a legend describing what the map was about. I had to rewrite the legend three times because as I made the map of communications microzones and local ceramic distribution in
Geographers See Death, Birth, and Job Prospects

Moreover, and perhaps most important in the fight, Buck and Conant wanted to save money. One fallen soldier opined, “Conant thinks that he is captain of a sinking ship [financially] and he is prepared to jettison anything. Geography was the first good opportunity.”

Geography would rise from this wreckage. The quantitative method of geographical research began to gain ground after World War II, and increasingly capable computers let researchers manipulate and display burgeoning amounts of new data.

In the Harvard Graduate School of Design's Laboratory for Computer Graphics and Spatial Analysis, founded by Howard T. Fisher, geographers, cartographers, artists, mathematicians, and computer savants began in 1965 to invent a way to make maps displays on a computer. Jack Dangermond, president of Environmental Systems Research Institute, worked there in his student days. “We made maps,” he recalls, “on very funny output devices like line printers, which would do alphanumeric overprinting of characters in order to create gray tones for thematic displays of such things as population density, soil composition, and vegetation.” Nicholas R. Chrisman, now professor of geomatics sciences at the Université Laval in Quebec City, worked in this frontier lab from 1971 to 1982. He believes that the place was key to the development of GIS and spatial analysis, as he writes in his new book, Charting the Unknown: How Computer Mapping at Harvard Began GIS (ESRI Press), which comes with a CD containing three short films, video interviews, and more.

Key, too, were the swelling power of computers and their shrinking price. “Ten years ago,” says Wendy Guan, director of GIS (geographic information system) research services at the Center for Geographic Analysis, “just about any GIS would require a much-heavier-than-average workstation to operate on. Today, just about any decent PC can run GIS software with reasonable speed. Some even runs on cell phones.”

“Today, as in the mid-20th century, the academic discipline of geography appears to be under threat” at locales as disparate as the United Kingdom and India, wrote Nigel Waters last year in “What Can GIS Do to Save Geography?” on geoplace.com. He sees the discipline still “hopelessly divided between its physical and human branches.” But the professor of geography at the University of Calgary hears this song of hope: “GIS is recognized as providing academic geography with an essential requirement for its survival: a marketable skill.”

“Geo-tech, nanotech, and biotech are the fastest growing fields in technology,” says historian Peter Bol, director of the Center for Geographic Analysis. “The U.S. government has undertaken massive hiring of people with GIS expertise. Central Intelligence Agency staff told me they had been ordered to double their geospatial-analysis capabilities within a year.”

Waters recounts that veteran Foreign Service officer Carleton S. Coon Jr., at the fiftieth reunion of his Harvard class of 1948, offered what he called a “single pearl of wisdom” at a symposium on foreign policy: “Reinstitute geography at Harvard!”

Three days before Harvard’s launch of the Center for Geographic Analysis, National Geographic News released the results of a survey of geographic literacy in young adults in the United States. Its findings were not startling. “Take Iraq, for example,” read the report. “Despite nearly constant news coverage since the war there began in 2003, 63 percent of Americans aged 18 to 24 failed to correctly locate the country on a map of the Middle East. Seventy percent could not find Iran or Israel. Nine in ten couldn’t find Afghanistan on a map of Asia.” (How about you, reader?) David Rutherford, a specialist in geography education at the National Geographic Society in Washington, was quoted as saying “Young Americans just don’t seem to have much interest in the world outside of the United States.” That may change, for an economic reason if none other.

In 1947, when Marland P. Billings, professor of geology at Harvard, launched an attack on its geography program, he touched off what the Crimson called “an academic war.” The decisive battle came a year later, when Provost Paul Buck and President James B. Conant axed geography, with the president declaring that “geography is not a university subject.” The late urban geographer Jean Gottmann (who coined the term megapolis) in 1982 characterized the defeat as “a terrible blow to American geography” and one from which “it has never completely recovered.”

Geographer Neil Smith wrote an exhaustive analysis of the war for the Annuals of the Association of American Geographers in 1987, when he was teaching at Rutgers University. “Oral accounts of the Harvard affair have centered almost exclusively on the character and actions of several key individuals. It has been widely asserted that Derwent Whittlesey, who led geography at Harvard in the 1930s and 1940s, was gay and that this was the pivotal issue in the elimination of the geography department,” wrote Smith. “Alexander Hamilton Rice, a scoundrel by various accounts, who funded and headed the university’s Institute for Geographical Exploration, has also been widely implicated in its demise. Smith wrote to lift a heavy surrounding fog of mythology from the matter and to suggest the true reasons why the war was lost.

Geography had been weak at Harvard particularly, although perhaps one prominent critic went too far when he called the program an intellectual kindergarden and the Ph.D.s it granted worthless. More importantly, Smith concluded, the field generally had weakened itself through the “ambiguity of its own self-conception.” At Harvard, as elsewhere, geography was taught at first as a part of geology, with the emphasis on hard science topics such as geomorphology. But the human side of geography emerged, and parts of the discipline began to be seen as soft—as social science. A Harvard committee appointed in 1949 to reconsider whether dropping geography had been a good thing “was perplexed,” wrote Smith. “by its inability to extract a clear definition of the subject, to grasp the substance of geography, or to determine its boundaries with other disciplines. To the end the committee saw the field as hopelessly amorphous.”
Byzantine Galilee and Judaea, I kept discovering relationships among the
data that I had not noticed before.

McCormick, who will teach "The Fall of the Roman Empire" next spring,
is now making a series of 50 maps with
an underlying GIS architecture for that
course. One or two maps, for instance,
will spotlight the fate of the city of
Trier, in Germany: home of the Celtic
Treveri tribe; conquered by the Romans
in the first century a.d. and founded as a
city by Augustus; attacked by barbarians
and rebuilt in the third century; a
capital of the Roman Empire in the
fourth century; finally abandoned by
the Romans in the early fifth century, to
be sacked and captured by the Franks
and possibly the Huns, before ending
up as a medieval archbishop's town.
The maps will show what's going on in
Trier in this century or that, as well as
abundant information about the empire's changing borders, trade routes,
settlements, natural conditions, and so
on. McCormick will build databases
keyed to his 50 maps, so that a student
can hit a button to see all the shipwrecks of the fourth century for in-
stance, or watch short videos made by
their professor of monuments, excavations, and other sights in
Rome, Constantinople, Milan. He hopes that the new maps will
show his students how historians can use GIS as an analytical tool
to help understand the avalanche of new information bearing on
the Roman Empire coming in from written sources, archaeology,
and the natural sciences. And he offers this pedagogical observa-
tion: "Our undergraduates today are certainly as smart as they used to be, but they are now more visually aware than students
20 years ago. They are quicker to get into visual material than texts."

McCormick is supported in this project by the
staff of the Harvard
Map Collection, housed
in Pusey Library and
repository of more than
half a million maps (see
http://hcl.harvard.edu/libraries/hmc). David Cobb, its head, "has been
very helpful digging out
relevant historical maps,
and he is a whiz at digi-
tizing them," says Mc-
Cormick. In preparation
for his class, the role of
the professional staff at
the Center for Geograph-
ic Analysis will be to search for, evaluate, and obtain data layers,
such as digital elevation models or satellite images, from both pub-
lic and commercial sources; to manage data-conversion contracts
with external service providers who will massage the data in vari-
ous ways to make it suitable for GIS use; to design a database
structure for organizing the spatial data; to prepare training mate-
rials and deliver the training to the research assistants who will
enter data into the database and maintain the database in the long
term; to design and build a dynamic data-viewing and -mapping
tool that can be downloaded from the course website and run on
personal computers without network or license constraints; and
to provide instruction to students on how to use that tool. Thus
equipped and instructed, McCormick's students will be able to do
GIS work on their own, and make their own discoveries about
that "great historical enigma, the fall of Rome."

But what about other undergraduates? "The fact of the matter is
that in the Faculty of Arts and Sciences we have no formal GIS
curriculum, zilch," said Bol last spring. "The problem is very seri-
ous." Wendy Guan, director of GIS research services at the center,
says that five courses are needed to grasp the field fully: in GIS
and computer cartography, in remote sensing, in both introdutory
and advanced GIS, and in spatial analysis.

The problem for students who just want to put a bit of GIS in
their intellectual toolkit eased on September 1 when the govern-
ment department appointed Harvard's first preceptor in GIS: Suneeta Srinivasan. The center conducted the job search and
found Srinivasan in the Division of Engineering and Applied Sci-
ences, where as a postdoctoral research associate she taught a
course on the spatial analysis of environmental and social systems.
Simulated Mean Unemployment Rate
Preliminary Data by Kreis

Driving Time to Former Border

Estimated Drive Time by Kreis
- Less than 1 hour
- 1 to 2 hours
- 2 to 3 hours
- 3 to 4 hours
- Over 4 hours

UNEMPLOYMENT RATES IN GERMANY

Nicola Fuchs-Schündeln, assistant professor of economics, joined forces with Rima Izem, assistant professor of statistics, and with the help of the Center for Geographic Analysis undertook a spatial analysis of unemployment rates in Germany. Their goal is to explain the stubbornly low labor productivity in the former East Germany, and their findings could have public-policy implications. The project is a work in progress. The map at far left shows the sharp break in unemployment rates at the former East-West border; the unemployment rate in the West is about half that in the East, even after reunification. The simulated unemployment rates are based on a model developed by Fuchs-Schündeln and Izem that explains the gap in unemployment rates by differences in job characteristics and workers’ skills in East and West. The model shows the effects of individuals’ commuting behavior between counties.

a course with a good deal of quantitative content and some fairly stiff mathematical expectations. The first time she taught it, in the spring of 2005, she had only one undergraduate among her students, Lee Murray ’06, who won Harvard’s Howard T. Fisher Prize in Geographical Information Science for a class project, “Spatial Analysis of Redistricting of Congressional Districts in New York State Following the 2000 Census.” In 2006 Srinivasan had nine undergraduates in class and one of them, Frances C. Moore ’06, won the Fisher Prize for “A Spatial Analysis of the Causal Factors of Nepal’s Maoist Insurgency.”

This fall Srinivasan is teaching a less mathematically daunting introduction to GIS and its applications in both the social sciences and environmental sciences. It is one of the prerequisites for her spatial analysis and modeling course in the spring. In the spring she will also offer an advanced GIS workshop in which students can explore some aspect of GIS in depth and do a semester-long project. She plans a three-week intensive introduction-to-GIS workshop to be taught in January in the Longwood Medical Area; it will feed into spatial-statistics course offerings at the School of Public Health.

Guan has a staff of two GIS specialists full time and one GIS applications engineer, who splits his time between the center and the University Library. “Two types of projects come to us,” she says. “Those like Mike McCormick’s, in which a scholar understands the possibilities of GIS but lacks the equipment or time to do what’s wanted with it, and those in which a scholar says, ‘I’m doing this research. How can you help?’” “People in lots of disciplines are starting to recognize that there’s something going on with geospatial analysis that’s important,” says Bol. “If they have grant money available for a project, the center will charge for its services. If not, we won’t.”

“Getting the data is often the most challenging step in a project,” says Guan. “Collecting quality, precise data can be so hard that some researchers become discouraged.” But the center itself is collecting and disseminating spatial data sets from diverse sources inside and outside of Harvard. That is a critical part of its mission. Some are public goods and free, shared by government agencies through the Web. Some come from third-party vendors who repackage raw data, add some value, and resell them. The University maintains a marvelous data source, the Harvard Geospatial Library. It keeps and catalogs data sets, so far numbering in the thousands (and many more will come to it, from the center and elsewhere). Go to “other libraries” on the University Libraries website (http://lib.harvard.edu/) for a look. Bewildered newcomers to the site should head at once to the “general help” menu. “The volume of data in the world is increasing exponentially, its price dropping linearly,” says Guan. “Just think of the number of satellites circling the globe.”

Yes, think of those satellites, many equipped with cameras capturing plain or fancy images of the earth. Jason Ur, assistant professor of anthropology, has used declassified intelligence-satellite imagery, in a GIS framework, to reconstruct state-sponsored irrigation systems in the Assyrian heartland from 702 to 681 B.C.

Joseph A. Greene, assistant director of the Semitic Museum, is considering deploying what he calls a “slightly theoretical” technology that uses low-level aerial scanning—from helicopters, say—in wavelengths other than visible light, to detect ancient
Intake fraction per road segment

<table>
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<tr>
<th>TFE(200 m)</th>
<th>0% - 31%</th>
<th>32% - 44%</th>
<th>45% - 51%</th>
<th>52% - 58%</th>
<th>59% - 93%</th>
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<td>61</td>
<td>72</td>
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</table>

Bus routes considered for retrofits

Fraction of total exposure within 200 meters of the midpoint of each road

IP (per million)

| 0.81 - 5.1 | 5.2 - 7.8 | 7.9 - 10 | 11 - 13 | 14 - 23 |

MAXIMIZING THE BENEFITS OF URBAN BUS RETROFITS

Urban buses belch unhealthy fine particulate matter, and installing diesel particulate filters is a common retrofit considered by transit authorities. Susan L. Greco, a doctoral student in environmental health at the Harvard School of Public Health, and colleagues did a case study of 25 Massachusetts Bay Transportation Authority bus routes and determined the "intake fraction"—an expression of the emissions-to-public exposure relationship—for all road segments in the Boston area. They imagined that funds were available to retrofit only half the buses and compared the public-health benefits of retrofitting half the buses on each route to the benefits of retrofitting the same number of buses but exclusively those on the high-intake-fraction routes. The latter course of action increased net benefits by 77 percent.

When China opened its door, Guan emigrated to Canada, where she studied the geography of recreational resources in Ontario at Trent University and get a master’s degree. She went on to earn a Ph.D. at the University of Georgia in the late 1980s in an interdisciplinary program in forestry, economics, and geography. Her dissertation was on water-quality modeling with GIS. Her first job was at a government agency in Florida, using GIS applications in Everglades restoration, land and natural-resource management, and regulatory programs. Then she migrated to Seattle to work for the Weyerhaeuser Corporation, an international forest-products company. As part of the forestry technology team, she managed GIS, remote-sensing, and GPS technology to keep track of the company’s trees—were they diseased? were they drought-stressed?—to regulate the fertilization plan, to plot helicopter routes, and much else. Black boxes containing GPS units mounted in the logging trucks promoted efficiency. (They also allowed headquarters to see whether a truck was speeding, which didn’t sit well with all drivers, but there was a potential upside to the technology as far as they were concerned: if a truck showed up on a head-office monitor as motionless for two hours on a remote dirt road, trouble could be deduced and help dispatched.) Data from remote sensing and global positioning systems feed into GIS, the core technology. Harvard scholars mired on a dirt road with such data will often require the analytical help of trustworthy specialists.

Guan and colleagues, jointly with the Harvard University Center for the Environment, will host a public workshop later this fall to showcase research at Harvard that uses remote sensing and to provide a high level, up-to-date overview of the technology and its applications.

ALONGSIDE ITS OTHER RESPONSIBILITIES, the center hopes to advance the field of GIS and spatial analysis intellectually. For
starters, Bol and his colleagues have proposed that the University raise the money for two professorships, one in the Faculty of Arts and Sciences and one at the design school, to bring to the University persons with a strong background in geographic information science, with broad vision, who are likely to see ways in which geographic information can be relevant in many disciplines and provide a platform for tying interdisciplinary knowledge together. Word is awaited on the realization of that initiative.

Jack Dangermond, M.I.A. '69, of Redlands, California, was on hand for the center’s launch and spoke there. Trained as a landscape architect, he came to Harvard originally to earn his master’s degree, but spent most of his time working in the design school’s Laboratory for Computer Graphics and Spatial Analysis, founded by Howard T. Fisher, a geographer and mathematical cartographer. Dangermond’s wife, Laura, worked there, too. The lab was in the process of inventing the very first computer map displays. He and Laura, full of youthful enthusiasm to do good, took what they had learned back to California and founded the Environmental Systems Research Institute (ESRI), an infant nonprofit firm that applied the new computer-mapping techniques learned at Harvard to the analysis of such things as air pollution. ESRI morphed into a booming business, the leading provider of GIS software to business, government, and education. Jack Dangermond remains its influential president. About 140,000 organizations use the company’s tools as their foundation for building and applying geographic knowledge. The Dangermonds made a gift of all ESRI’s software to the University, so that academics could get access to the technology easily. He also provided the initial endowment for the Fisher Prize.

“GIS is becoming pervasive as an information infrastructure for managing geography,” he said in an interview. “As we increasingly affect the planet, the human footprint becomes bigger and more invasive, and we gradually are moving into a role of managing the world, instead of being participants in a natural world. We are going to have to take more responsibility for all the processes of geography—water, climate, the forests, those natural aspects of the landscape that persist. When we weave the various GIS systems together into a kind of nervous system for the planet, we will see and increasingly participate in its evolution. Now GIS brings geography back to Harvard. It left for unfortunate reasons, and that was a big loss to Harvard and to academic geography in general because it signaled that geography was a fading science. Now it returns, not as a traditional place-based geography—but is Nigeria?—but as a science of the planet, modeling our world as a whole, its processes, and their relationships.”

Christopher Reed is executive editor of this magazine.
Appendix C:
Student Interest Data
# Undergraduate Enrollment Numbers

**AY 2005-2007**

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<th>Course #</th>
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(Note: n/a indicates course did not exist)
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(Note: n/a indicates course did not exist)
Graduate Classification, Job Title, & Employer
or Continuing Education & Institution
by Program/Major
Class of 2003-04

Minnesota State University, Mankato, College of Soc & Beh Science Campus

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<th>Classification</th>
<th>Job Title / Degree Pursued</th>
<th>Employer Name / Higher Ed Inst</th>
<th>Employer City / Higher Ed City</th>
<th>Employer State / Higher Ed State</th>
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<td>Carlson Craft</td>
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<td>MN</td>
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NOTES:
1) Caution about the use of data for a program is advisable when the number of graduates is low or the number of "Status Unknown" exceeds 15% of the total graduates.
2) Graduates or individuals who know the graduates provided this information, including relatedness of employment to program of study.
Graduate Classification, Job Title, & Employer
or Continuing Education & Institution
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Class of 2003-04

Minnesota State University, Mankato, College of Soc & Beh Science Campus

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<thead>
<tr>
<th>Classification</th>
<th>Job Title / Degree Pursued</th>
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<th>Employer City / Higher Ed City</th>
<th>Employer State / Higher Ed State</th>
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2) Graduates or individuals who know the graduates provided this information, including relatedness of employment to program of study.

Report 6.1 -- Sort: Institution/Campus/Program Name/Award Type/CIP Code
## Graduate Classification, Job Title, & Employer 

or Continuing Education & Institution 

by Program/Major 

Class of 2002-03 

### Minnesota State University, Mankato, College of Soc & Beh Sciences Campus 

<table>
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<tr>
<th>Classification</th>
<th>Job Title / Degree Pursued</th>
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<th>Employer State / Higher Ed State</th>
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<td>2096</td>
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<td><strong>NO DATA</strong>*</td>
<td><em><strong>NO DATA</strong></em></td>
<td><em><strong>NO DATA</strong></em></td>
</tr>
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<td>2097</td>
<td>Status Unknown</td>
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</tr>
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<td>2099</td>
<td>Status Unknown</td>
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<td><em><strong>NO DATA</strong></em></td>
<td><em><strong>NO DATA</strong></em></td>
</tr>
</tbody>
</table>

### NOTES:

1) Caution about the use of data for a program is advisable when the number of graduates is low or the number of "Status Unknown" exceeds 15% of the total graduates.

2) Graduates or individuals who know the graduates provided this information, including relatedness of employment to program of study.
Appendix D:
Faculty Vitae
CURRICULUM VITAE

CHANGJOO KIM

CONTACT INFORMATION

Department of Geography
Minnesota State University, Mankato
7 Armstrong Hall
Mankato, MN 56001, USA
Office: 507-389-1324
Fax: 507-389-2989
E-mail: changjoo.kim@mnsu.edu

EDUCATION

<table>
<thead>
<tr>
<th>Date</th>
<th>Degree</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2004</td>
<td>Ph.D. in Geography</td>
<td>The Ohio State University Columbus, OH, USA</td>
</tr>
<tr>
<td>1997-1999</td>
<td>M.A. in Geography</td>
<td>The Ohio State University Columbus, OH, USA</td>
</tr>
<tr>
<td>1989-1996</td>
<td>B.S. in Geography</td>
<td>Kyunghee University Seoul, Korea</td>
</tr>
</tbody>
</table>

AREAS OF SPECIALIZATION

- Geographic Information Systems and Science
- Global Positioning Systems
- Spatial Optimizations in Network Models, Location Models
- Spatial Analysis in Quantitative Methods, Retail Models, Spatial Interaction Models
- Transportation and Planning
- Spatial Statistics
- Remote Sensing
- Environmental Modeling
- Urban Geography
- Regional Studies
PUBLICATIONS

JOURNALS


TECHNICAL REPORTS


PROCEEDINGS


AWARDS AND HONORS
Kim

- Recipient of the CSISSL SPACE Workshop scholarship, June 18-23, 2006, Columbus, OH
- Recipient (Best Paper) of the Student Paper Competition from the "Spatial Analysis and Modeling" specialty group, March 3-8, 2003, 99th Annual Meeting, The Association of American Geographers (AAG), New Orleans, LA, USA
- Recipient of the Summer Research Fund, 2003-2004, Department of Geography, The Ohio State University, Columbus, OH

PROFESSIONAL CONFERENCES AND MEETINGS

- Changjoo Kim, and Suhee Sang, "Disaggregated Travel Forecasting", August 7-11, 2006, 25th Annual ESRI International User Conference, San Diego, CA, USA.
- Changjoo Kim, "Disaggregated Travel Forecasting", March 7-11, 2006, 102 Annual Meeting of The Association of American Geographers (AAG), Chicago, IL, USA.
- Changjoo Kim, "Travel Demand Forecasting in a GIS-T Context", October 3-5, 2005, 15th Annual MN GIS/LIS Consortium, St. Cloud, MN, USA.


• Changjoo Kim, “Examination of Trade Areas in Competitive Choice-based Samples: Study of Pharmacy Stores in Columbus, OH”, October 18-19, 2002, East Lake Division Association of American Geographers (ELDAAG) Regional Meeting, Mt. Pleasant, MI, USA.

• Changjoo Kim et al., “Development of Greenland GIS Database System (GGDS)”, October 5-6, 1998, Greenland Science and Planning Meeting, Program for Regional Climate Assessment (PARCA), Virginia, VA, USA.

PROFESSIONAL WORKSHOP

• 6/18/2006-6/23/2006, SPACE Workshop, GIS & Spatial Modeling For Undergraduate Socical Science Curriculum, The Ohio State University, Columbus, OH

INVITED LECTURES

• 2004 Department of Geography, Minnesota State University, “Location Modeling in GIS”

GRANTS

• 2005 Faculty Improvement Grant, Minnesota State University
• 2006 Faculty Research Grant, Minnesota State University

PROFESSIONAL ACTIVITIES & EMPLOYMENT HISTORY

• 2004-current Assistant Professor Department of Geography, Minnesota State University
• 2003-2004 Research Assistant SBC Ameritech Project, Internet Survivability and Reliability, The Ohio State University
• 2001-2004 Instructor Department of Geography, The Ohio State University
• 2000-2001 Research Assistant
NSF Project (BCS 96745), CURA (Center for Urban and Regional Analysis), The Ohio State University

- 1999-2000 Teaching Assistant
  Department of Geography, The Ohio State University
- 1997-2001 Research Assistant
  NASA Project (TM-1999-209205), Geomatics Laboratory for Ice Dynamics, Byrd Polar Research Center, The Ohio State University

RESEARCH EXPERIENCE

- GIS databases
- Spatial data mining
- Geovisualization
- Processing and interpretation of remote sensed data
- Computer programming
- Optimization in linear programming packages
- Statistical packages

COURSES TAUGHT

- Geography 200 (The Ohio State University), World Regional Geography
- Geography 373 (Minnesota State University, Mankato), Introduction to GIS
- Geography 439/539 (Minnesota State University, Mankato), Transportation Geography
- Geography 471/571 (Minnesota State University, Mankato), Digital Field Mapping with GPS
- Geography 473/573 (Minnesota State University, Mankato), Advanced GIS
- Geography 670 (Minnesota State University, Mankato), Issues in Geographic Techniques
- Geography 673 (Minnesota State University, Mankato), GIS for Planners

STUDENTS ADVISED

MASTER ADVISOR
- Andrew Moore, current, “Site Selection and Location Analysis”
- Hamid Yunus, current, ESRI
- Yong-seuk Park, current, “Spatial Zoning”
- Joel Nyhus, current, “Housing Market Analysis”
- Sajan Dhakal, current, “Site Location Analysis”
- Piush Dahal, current, “Spatial Decision Supporting System”
- Woo Jang, graduate, “Jobs and Housing Balance”
MASTER COMMITTEE MEMBER
- Tonya Rogers, 2005
- Rie Yamada, current
- Ellen Pillsbury, 2006
- John Nugent, current

MEMBERSHIP PROFESSIONAL SOCIETIES
- 1996-present  The Association of American Geographers (AAG)
- 2001-present  Regional Science Association International (RSAI)
- 2002-present  Sigma Xi, The Scientific Research Society
- 2003-present  Institute for Operations Research and the Management Sciences (INFORMS)
- 2006-present  Gamma Theta Upsilon, The International Geographical Honor Society

UNIVERSITY COMMITTEES SERVICE
- 2006-current  Space Committee in Social Behaviors and Studies, Minnesota State University
- 2004-current  Technique Representative in Social Behaviors and Studies, Minnesota State University
- 2004-current  Department web master, Department of Geography, Minnesota State University
- 2002-2003  Graduate Student Representative on the departmental committees, Homepage, WWW, and Infrastructure, The Ohio State University
- 2001-2003  Visiting Scholar Representative, The Ohio State University

JOURNAL REVIEW SERVICE
- Applied Geography
- European Journal of Operational Research
- Geographical Analysis
- Tourism Management
Jose Javier Lopez, Ph.D.

Geography Department

Minnesota State University, Mankato MN 56001

507-389-1890 (work) 507-625-6269 (home) 507-382-0497 (cell phone)

EDUCATION:

Ph.D. Indiana State University, 1998.

M.S. The University of Akron, 1993.


CURRENT RESEARCH INTERESTS:

Social and Economic Geography

Spatial Analysis and Statistics in Geography

Criminology

Latin America

PUBLICATIONS:


MISCELLANEA GEOGRAPHICA (Other publications):


HONORS AND AWARDS:


Highlights of Teaching - Recognized by departmental peers as representative of the outstanding teaching. Minnesota State University, College of Social & Behavioral Sciences, 2001.

The Benjamin Moulton Award - Indiana State University Honor Convocation, Office of the Provost, 1997.

Golden Key National Honor Society, University of Puerto Rico, 1990.

The Presidential Academic Fitness Award, Our Lady of Pilar High School, 1987.

BIOGRAPHICAL LISTINGS:


OTHER BIOGRAPHICAL LISTINGS:


SERVICE TO MY UNIVERSITY AND PROFESSIONAL COMMUNITIES:

Instructor of basic research methods to McNair Scholars, Summer 2004.

Faculty and Mentor for MSU's Learning Communities and First Year Experience Program, 2003-2004.


Member of the Minnesota State University, Mankato, Graduate Education Sub-Meet and Confer Unit, 2002-2004.

Coordinator of the Geography Graduate Program, Minnesota State University, 1999–2004.


Member of the Chicano, Mexicano, and Latino Education/Career Fair Committee (Southern Minnesota), 2001-2002.


Associate to the GEO Education Center, Indiana State University, 1993-1996.


TEACHING EXPERIENCE:


Visiting Professor (University of Puerto Rico), Elements of Geography and Human Geography, 2005.

Assistant Professor (Minnesota State University), Cultural Geography, Economic Geography, Latin America, Rural Development, and Quantitative Methods, 1998-2003.

Instructor (St. Mary-of-the-Woods College), Geography of World Affairs, 1997.

Graduate Teaching Assistant/Instructor (Indiana State University), World Geography, 1996-1997.

Graduate Assistant to Prof. Dorothy Drummond (Indiana State University), World Geography, 1994-1996.

SCHOLARSHIPS AND ASSISTANTSHIPS:

Graduate Fellow, Indiana State University, Fall 1996.


Ph.D. DISSERTATION TITLE:


OTHER RESEARCH:

Geographic Patterns of Law Enforcement and Military Malpractice

Assault in the United States

Regional Analysis of Violent Crime and Drug Abuse in Puerto Rico

The Geography of Rural Minnesota

Testing Geographic Proficiency in Schools of West Central Indiana (Project under the direction of Dorothy Drummond)

FIELD EXPERIENCE:

Southern Minnesota, Summer 1999.

Western Indiana, Spring-Summer 1995.


Akron, Ohio, 1992.


TRAVEL EXPERIENCE:

Mexico, Venezuela, Dominican Republic, Canada, Federation of Saint Kitts and Nevis, Netherlands Antilles, Martinique, Grenada, Saint Vincent, and U.S. Virgin Islands.
CONFERENCE PRESENTATIONS:


PROFESSIONAL SOCIETIES:

Association of American Geographers

Gamma Theta Upsilon (International Geographical Honor Society)

National Council for Geographic Education

Sociedad Geógrafos de Puerto Rico (Association of Puerto Rican Geographers)

SEMINARS (Evidence of Continuing Preparation):


Minnesota GIS/LIS Consortium 1999 Spring Workshops (Spatial Analysis and GIS), April 22, 1999.


Introduction to Arc View Geographic Information System (Training offered by Schneider Engineering Corp.), 1995.


Seminar in the Geography of Asia, 1992.


CYNTHIA A. MILLER

Address: Department of Geography, AH 7
          Minnesota State University, Mankato
          Mankato, MN 56001

Phone: (507) 389-2617

Education:

Doctor of Philosophy, Geography (Passed With Distinction), Syracuse University, 1991
  Donald W. Meinig, Advisor

  Dissertation: “The United States Army Logistics Complex, 1818-1845: A Case Study of the Northern Frontier”

  Seminars included: Historical Geography, Cultural Geography, American History, Archaeology, Architectural History

Master of Arts, Geography, University of Georgia, 1986, Louis De Vorsey, Advisor

  Thesis: “Images of an Island: The Development of Tybee Island, Georgia, 1733-1895”

  Coursework included: Historical Geography, Field Methods, Bioclimatology

Bachelor of Arts, Geography (Summa Cum Laude), University of Georgia, 1984

  Coursework included: Historical Geography, Geography of the South, Native Americans of the Southeastern U.S., North American Archaeology, U. S. Civil War and Maritime History

Professional Experience in Higher Education:

May 2002 – Present  Associate Professor of Geography, Minnesota State University, Mankato

  Teaching and Research Interests: Historical Geography of North America; nineteenth century American settlement, urbanization, and transportation systems; Southeastern United States; Canada; cultural geography; historical land use and landscape reconstruction; landscape interpretation; historical environmental hazards location; applied archival, GIS and cartographic research techniques

April 2001 – Visiting Professor, Department of Geography, Macalester College, St. Paul, MN (On sabbatical From MSU Fall 2000 – Spring 2001) Team Teaching Applied GIS Case Studies with Carol Gersmehl

January 1991 – May 2002  Assistant Professor of Geography, Minnesota State University, Mankato
  Tenure granted in May 1995

1986-1988  Graduate Teaching Assistant, Department of Geography, Syracuse University

Research Experience in Geography:

1987-1989  Research Assistant to Donald W. Meinig, Department of Geography, Syracuse University

1984-1986  Research Assistant to Louis De Vorsey, Department of Geography, University of Georgia

1985-1986  Historical Geographer, Southeastern Archaeological Services, Inc., Athens, Georgia

1985  Illustrations Text Writer and Historical Researcher, The Atlas of Georgia, University of Georgia

1984  Archival Research Intern, The Atlas Project of Georgia, University of Georgia.

1982  Research Assistant, U.S. Department of State / University of Georgia Gulf of Maine Boundary Project
Research Awards and Grants:

2004  Indian Creek Watershed Land Cover Mapping Project, Blue Earth County Environmental Services ($3,941)
1994  Mankato State University College of Social and Behavioral Sciences Frontier Forum Lecture Award
1991-92 Mankato State University, College of Graduate Studies Faculty Research Grant ($1,200)
1989-1990 J. B. Snow Foundation Dissertation Fellowship
1989  Syracuse University Graduate Student Research Grant
1989  Syracuse University Roscoe Martin Fund Research Grant
1988  Second Place, Young Historical Geographers’ Paper Competition, Association of American Geographers Annual Meeting, Phoenix, AZ
1985  First Place, Master’s Student Paper Competition, Southeastern Division, Association of American Geographers Annual Meeting, Chapel Hill, NC

Academic Scholarships:

1986-1989  Syracuse University Graduate School Scholarship
1984-1986  University of Georgia Foundation Scholarship for Graduate Students
1982-1984  U.S. Army Scholarship, 81st Army Reserve Command

National Teaching Awards and Scholarships:

May 2004  Who’s Who Among America’s Teachers Award (3rd Award)
July 2001  National Science Foundation GIS Access Award to Attend and Present at ESRI EdUsers’ Workshop and Conference, San Diego, CA
July 2000  National Science Foundation GIS Access Summer Institute for Educators 2nd Year Learning Team Member, Macalester College, St. Paul, MN
May 2000  Who’s Who Among America’s Teachers Award (2nd Award)
July 1999  National Science Foundation GIS Access Summer Institute for Educators Learning Team Member, Macalester College, St. Paul, MN
May 1997  Who’s Who Among America’s Teachers Award

Local Teaching Awards, Grants and Service:

February 2003  MSU Faculty Improvement Grant to attend ERDAS Imagine “Advancing with ERDAS Imagine” course ($860)
October 2002  MSU College of Social and Behavioral Sciences Advisor of the Year Award
April 2002  Co-wrote MSU ITS Wireless Initiative grant proposal with Martin Mitchell and Jiyeong Lee to acquire 18 Compaq iPAQ Pocket PCs for departmental GIS / GPS fieldwork – Accepted and funded ($11,600)
March 2000  Faculty Mentor/Sponsor for Jonathan D. Johnson, Steven C. Berberich and Steven A. Silbermann, “An Environmental History of the Good Counsel Complex, 1912-1999,” Minnesota State University, Mankato, 2nd Annual Undergraduate Research Conference

1999  Departmental Nominee for College of Social and Behavioral Sciences “Teaching Highlights” Recognition

1997  Departmental Nominee for College of Social and Behavioral Sciences “Teaching Highlights” Recognition

1994  MSU Cultural Diversity Program Grant -- Field Studies of the American South ($1,495)

1992  MSU Faculty Improvement Grant -- British Columbia Field Studies at the International Historical Geography Conference, Vancouver, BC., Canada ($200)

1990 and 1991  Field Trip Lecturer, Syracuse University Graduate School Teaching Assistant Program Summer Orientation

1989  Outstanding Teaching Assistant Award, Syracuse University Graduate School

1989  Field Trip Coordinator, Syracuse University Graduate School Teaching Assistant Program

1988-1989  Teaching Fellow, Syracuse University Graduate School Teaching Assistant Orientation Program

National and Local Professional Service:

June 2003  Reviewed North American text manuscript (untitled) by Susan Hardwick, Fred Shelley and Andrew Marcus for Prentice Hall Publishers, Inc.


July 2001  Invited Demonstration of GPS and Tracking Analyst software for participants at ESRI EdUsers’ Conference, San Diego, CA

April 2001  Served as a judge at State Geography Bee, Minnesota Alliance for Geographic Education, Macalester College, St. Paul, MN

May 2000  Invited Manuscript Reviewer for The Geographical Review, Paul Starrs, University of Nevada, Reno, editor

July 1997  Invited Discussant, U.S. National Park Service Planning Team Conference, coordinated by the USNPS Southeast Archaeological Center, Fort Pulaski National Monument, Savannah, GA

1994-1997  Secretary/Treasurer, Historical Geography Specialty Group, Association of American Geographers (Elected to 3 yr. term)

March 1995  Served as Judge, Association of American Geographers Historical Specialty Group Student Paper Competition, Association of American Geographers Annual Meeting, Chicago, IL


February 1993  Named “Rising Star in Historical Geography” and interviewed by Graduate Historical Geography Seminar taught by Dr. Anne Mosher, Louisiana State University.

February 1993  Reviewed Geography of the United States and Canada manuscript text for William C. Brown Co.

April 1992  Served as Judge, Association of American Geographers Historical Specialty Group Student Paper Competition, Association of American Geographers Annual Meeting, San Diego, CA
College and University Service:

October 2003 "New Technologies in Geography: Student Projects Using GIS and GPS” presented to the MSU Foundation Board of Directors

February 2003 “GIS and GPS Technologies: 2002-2003 Student Field Projects” presented to the MSU Kiwanis Club

February 2003 Faculty Interviewer for MSU Presidential Scholarship Awards

October 2002 Coordinated and participated in CSBS College Conversation on “How to Organize and Work with Student Research Teams,” (With Perry Wood, Winnie Mitchell and Fred Slocum)

September 2002 Presented technology session titled “The World in Their Hands: Student Mapmaking with Pocket PCs” at the MSU Student Teaching Technology Excellence Seminar, MSU College of Education

October 2001 Invited article manuscript on GIS and GPS Technology submitted to CSBS In Touch Newsletter

September 2001 “Hazardous Risk Assessment and Landscape Reconstruction,” CSBS College Conversations

March 2000 “Making Group Projects Work,” CSBS College Conversations, with Joe Kunkel and Carol Perkins

October 1999 “Technology in Geography,” CSBS Advisory Board Presentation


1999-2000 CSBS Teaching and Learning Committee

1998-2003 CSBS Representative on MSU Undergraduate Research Committee

1999-2000 College of Education Elementary and Early Childhood Education Advisory Council

1996-2000 Departmental representative on CSBS Curriculum Committee

1996-2000 CSBS Inter-Faculty Organization Representative for the University Budget Sub-Meet and Confer Committee (elected for two three-year terms)

1998-1999 CSBS Representative on College of Education Curriculum Redesign Advisory Team

April 1998 Invited Panelist for President’s Initiative on Race / MSU Discussion on Race Relations in the U.S.

April 1998 CSBS Delegate for Inter-Faculty Organization Biennial Delegate Assembly

February 1998 MSU Leadership Talent Grant Selection Committee

February 1998 Faculty Interviewer for MSU Presidential Scholarship Awards

January 1997 Georgia and South Carolina Sea Islands Gullah Workshop, Team-taught with Maria Baxter-Nuamah, MSU Assistant Director of African American Affairs

October 1996 “Discovering the Past: Teaching Local History Using Historical Geography,” Mankato State University Social Studies Educator’s Annual Workshop

1995-1999 MSU Army ROTC Faculty Advisory Committee

1994-1995 CSBS Mission Statement Committee
May 1994 Co-Author of Q-7 Worlds of Thought Proposal (With Donald Strasser, Department of History and Linda Duckett, Chair, Department of Music) to bring Dr. John Vlach (African-American Folklore and 'Landscape specialist') to MSU for a two week residency in April 1995.


1993-1998 MSU Cultural Diversity Funding Sub-Committee

1992-1993 CSBS Research Committee

May 1991 Presented Invited Lecture "Using the U.S. Congressional Serial Set" to MSU Memorial Library Reference Librarians

1986 Co-Chair, University of Georgia/University of Florida Graduate Student Geography Conference

1985-1986 Graduate Student/Faculty Liaison Representative, Department of Geography, University of Georgia

Departmental Service:

2005 – Present Departmental Assessment Coordinator

2003-2004 Chaired Departmental Search Committee which led to hiring of Dr. Forrest Wilkerson

April 2003 Attended (as Departmental Representative) MnSCU Center for Teaching and Learning Discipline-specific Transfer Curriculum and Articulation Agreement Workshop, Eden Prairie, MN

2001-2004 Departmental Curriculum, Assessment and Personnel Coordinator

Fall Semester 2002 Acting Chair, Department of Geography (during Professor Martin Mitchell’s sabbatical)

November 2001 “The Location and Mis-Location of Hazardous Waste Sites in Southern Minnesota” with Jody Runke, MSU master’s student, Department of Geography Colloquium

1998-2000 Departmental Curriculum and Personnel Coordinator

1999-2000 Chaired Departmental Search Committee (no hire made)

November 1999 “Graduate School and/or Getting That First Job; The Nuts and Bolts of Applying,” with Martin Mitchell, Don Friend and Catherine Hansen, Department of Geography Colloquium

September 1999 “Using GIS For Phase I Environmental Site Assessments,” Department of Geography Colloquium

September 1998 “Advise-In: Semester Conversion and Graduation Issues,” Department of Geography Colloquium

1997-1998 Chaired Departmental Search Committee which led to hiring of Dr. Jose Lopez

1996-1997 Chaired Departmental Search Committee which led to hiring of Dr. Donald Friend

1994-1995 Graduate Studies Coordinator, Department of Geography

1994-1998 Faculty Advisor to Department of Geography RANGE Student Organization.

1994-1995 Faculty Advisor to the MSU Gamma Theta Upsilon National Geographic Honor Society Chapter

February-July 1993 Interim Chair, Department of Geography, (Appointed by Dean Bill Webster, College of Social and Behavioral Sciences)
1992-1993  Chaired Departmental Search Committee which led to hiring of Dr. Martin Mitchell
1991-1992  Service on Departmental Curriculum, Screening, and Personnel Committees

Community Service:

Spring 2003  Invited Lecturer for St. Peter High School, Andy Welti’s 9th Grade Geography Class
Fall 2002   Invited Lecturer for Mankato West High School, Dan Ondich’s 11th Grade Geography Class
November 2001  Interviewed on KMSU Morning Show about “The Location and Mis-Location of Hazardous Waste Sites in Southern Minnesota” colloquium

November 2001  Invited Lecturer, MSU Chapter of Delta Phi Epsilon (national business education organization), “Historical Geography and GIS”

September 2001  Invited Lecturer, MSU Emeriti Faculty, “What’s New In The World of Geography?”
March 1998   Invited Lecturer, Leadership Mankato Area, “The Geography of Mankato Neighborhoods”

1994-1996  Blue Earth County Historical Society Board of Trustees Member

May 1995   Invited Lecturer for Senior Geography Seminar taught by Dr. Bob Douglas, Department of Geography, Gustavus Adolphus College, St. Peter, MN


June 1994   Interviewed on Minnesota Public Radio Morning News Program concerning Field Studies of the American South Course


1992  Designed Illustration map and wrote text for City of Mankato 1993 Calendar (March -- “Churches in Mankato, 1855-1900”

1992  Served on 125th Anniversary History Committee, St. John’s Episcopal Church, Mankato, MN

May 1991   Invited Lecturer for Senior Geography Seminar taught by Dr. Bob Moline, Department of Geography, Gustavus Adolphus College, St. Peter, MN

1991-1992  Habitat for Humanity Committee member

Honorary and Professional Memberships:

Phi Beta Kappa
Gamma Theta Upsilon Geographic Honor Society
Omicron Delta Kappa National Leadership Honor Society
Scholarly Works, Research Reports and Publications:


Phase 1 Environmental Site Assessment (Historical Land Use) Report prepared for Micro-Trak Systems, Inc. Eagle Lake, MN (GEOG 480 / 580 seminar project) November 2001

RCRA Regulated Facility locational data accuracy report, corrected data spreadsheet and maps prepared for the Taylor Corporation, North Mankato, MN, (GEOG 480 / 580 seminar project) November 2001

Blue Earth County Leaking Underground Storage Tank Site locational accuracy report, corrected data spreadsheet and maps of 141 LUST sites submitted to the Minnesota Pollution Control Agency, (GEOG 480 / 580 seminar project) June 2001


Designed Geography Module for Student Advantage, Inc., Educational Resources Website, June 2000

Historical land use report, aerial photographs and maps prepared for the Minnesota Pollution Control Agency’s Open Dump Inventory project -- North Mankato and Lake Crystal Sites, May 2000

Atlas of Rural Minnesota, associate editor with Jose Lopez and Martin Mitchell (Mankato: Center for Rural Policy and Development, Minnesota State University, Mankato) 2000

Location report, aerial photographs and maps prepared for the Minnesota Pollution Control Agency’s Open Dump Inventory project -- Nicollet and Blue Earth County Sites, December 1999

Locations, Pattern and Regions: An Introduction to Geography, co-authored with Miriam Lo, Carol Gersmehl and Martin Mitchell. (Dubuque:WCB/McGraw Hill Custom Publishing) 1999; US Department of Education FIPSE Grant #P116B40440-95 and National Science Foundation DUE Grant #9555091 and 9751308.

“(Re)Reading the Meeting: Historical Geography at the 89th Annual Meeting of the Association of American Geographers -- Atlanta, Georgia, April 1993,” Historical Geography (September 1994)


“St. John’s Church and the Community: The Geography of the Parish, 1866-1900,” chapter in St. John’s Episcopa Church, 1866-1991, (Waseca, MN: Mastergraphics) 1991

“Archaeological Investigations at 9 Sw 113, St. James, Georgia,” co-authored with Chad O. Braley and R. Gerald Ledbetter, Southeastern Archaeological Services, Inc., Athens, Georgia. Prepared for the Oglethorpe Power Company, 1985

"Archaeological Investigations at Sullivan's Plantation, Mistletoe State Park, Columbia County, Georgia," co-authored with Thomas H. Gresham and R. Gerald Ledbetter, Southeastern Archaeological Services, Inc., Athens, Georgia. Prepared for the Georgia Department of Natural Resources, 1985

Professional Papers / Posters Presented:


"The MnSCU GIS Site License," poster presentation, Co-authored and co-presented with Mark Thomas, MnSCU Chancellor's Office, at the MNSCU ITeach: Best Practices in Teaching with Technology Annual Conference on “Designing The Future” at the Minneapolis Community & Technical College April 2003

"The Perils and Pleasures of Hazardous Risk Assessment Using GIS,” Invited plenary session paper at the 33rd Annual South Dakota State Geography Convention, Brookings, SD, April 2002


"Assessing the Quality of Environmental Hazards Data: A Minnesota Case Study” poster presentation, Association of American Geographers Annual Meeting, New York, NY, March 2001

"The Future of Historical Geography in North America," Invited panelist, Eastern Historical Geography Association Annual Meeting, Mississauga, Ontario, Canada, October 1996


"Leisure Landscapes: The Rise of the Resort Industry on Tybee Island, Georgia" colloquium presented at the Department of Geography and Anthropology, Louisiana State University, Baton Rouge, LA, April 1994


"The Historical Geography Imperative Revisited: Mediating Theory, Gender, and Empirical Research," Association of American Geographers Annual Meeting, Atlanta, GA, April 1993

Chair, editor, and organizer of session entitled “Female Perspectives on Past Geographies,” jointly sponsored by the Historical Geography Specialty Group and the Geographic Perspectives on Women Specialty Group, Association of American Geographers Annual Meeting, Atlanta, GA, April 1993

"The Umbilicus of Empire: The Early Nineteenth Century American Proto-Military Industrial Complex, 1815-1845," the International Historical Geographers Association Triennial Meeting, Vancouver, British Columbia, Canada, August 1992
"The Umbilicus of Empire: The Early Nineteenth Century American Proto-Military Industrial Complex, 1815-1845," co-located at the University of Minnesota Department of Geography, Minneapolis, MN, February 1992


"The Umbilicus of Empire: The American Proto-Military Industrial Complex, 1815-1845." Missouri Valley History Conference, Omaha, NE, March 1992

"The Umbilicus of Empire: The Early Nineteenth Century American Proto-Military Industrial Complex, 1815-1845," colloquium presented at the University of Kentucky Department of Geography, Lexington, KY, December 1991


"From 'Le Desert ce la Georige' to the 'Long Branch of the South': The Resort Development of Tybee Island, Georgia," Tybee Island Historical Association, Tybee Island, GA, October 1986


Professional Conferences / Workshops Attended: (At which no paper was presented)

November 2005 Environmental Data Resources, Inc. “AAI & Liability: Prepare, Preserve and Protect,” 12th Annual “Due Diligence at Dawn Series” Environmental Site Assessment Phase 1 Workshop, Atlanta, GA

April 2005 Edward Tufte’s “Presenting Data and Information Workshop,” Minneapolis, MN

November 2003 Environmental Data Resources, Inc. “Property Due Diligence: Tools of the Trade,” 10th Annual “Due Diligence at Dawn Series” Environmental Site Assessment Phase 1 Workshop, Denver, CO

July 2003 “Using Imagery to Update Your GIS” Leica Geosystems Software Workshop, Atlanta, GA

February 2003 NSF Grants Workshop, University of Minnesota, St. Paul Campus

February 2003 “Advancing with ERDAS Imagine” Leica Geosystems Software Workshop, Atlanta, GA

September 2003 “Imagine Virtual GIS” Leica Geosystems Software Workshop, Atlanta, GA

July 2002 “Migrating to ArcGIS” ESRI GIS Users' Workshop, Atlanta, GA

July 2002 “Fundamentals of ERDAS Imagine” Leica Geosystems Software Workshop, Atlanta, GA

June 2001 Minnesota Land Management and Information Center Metadata Workshop, MSU Water Resources Center

May 2001 Roweckamp GIS Geocoding Workshop, Coon Rapids, MN


January 2000 CSBS Grading and Assessment Workshop, North Mankato, MN

November 1999 National Council for Geographic Education Annual Meeting, Boston, MA

October 1998 Association of American Geographers West Lakes Division Annual Meeting, Madison, WI

October 1998 GIS/EPPL-7 Conference, St. Paul, MN

September 1998 Conference on Undergraduate Research, University of Wisconsin-LaCrosse, LaCrosse, WI

April 1998 Minnesota State Colleges and Universities Teaching & Learning Conference, Brooklyn Park, MN

April 1997 Association of American Geographers Annual Meeting, Ft. Worth, TX

November 1996 Association of American Geographers Southeastern Division Annual Meeting, Athens, GA

April 1996 Association of American Geographers Annual Meeting, Charlotte, NC

April 1995 Association of American Geographers Annual Meeting, Chicago, IL

November 1994 National Council for Geographic Education Annual Meeting, Lexington, KY
April 1994  Association of American Geographers Annual Meeting, San Francisco, CA
August 1993 National Council for Geographic Education Annual Meeting, Halifax, Nova Scotia, Canada
October 1991 National Council for Geographic Education Annual Meeting, St. Paul, MN

Military Experience:

February 2000  Honorable Discharge from U.S. Army Reserve
July 1991  Promoted to Captain, Quartermaster Corps, U.S. Army Reserve
December 1990 Completion of six-year mandatory commissioned service obligation in U.S. Army Ready Reserve; transferred to inactive member status in the Individual Ready Reserve
1988-1990  Clothing Sales and Warehouse Officer, 1209th U.S. Army Garrison, U.S. Army Reserve, Mattydale, NY
July-December 1987  U.S. Army Quartermaster Officer Basic Course Class 87-9, Fort Lee, VA; selected as “First Honor Graduate” upon completion
July 1987  Promoted to First Lieutenant, Quartermaster Corps, U.S. Army Reserve
February 1986  Detachment Commander / Laundry & Bath Officer, COSTA ABEJO 86, Republic of Panama
January-February 1985  Operations and Training Officer, REFORGER 85, Federal Republic of Germany
1984-1986  Operations and Training Officer, 1014th Supply & Service Company (Direct Support), U.S. Army Reserve, Athens, GA
May 1984  Commissioned Second Lieutenant, Quartermaster Corps, U.S. Army Reserve
May 1984  Selected as “Distinguished Military Graduate,” U.S. Army ROTC, University of Georgia
June-July 1983  U.S. Army ROTC Advanced Camp, Fort Bragg, NC
1982-1984  Assistant Platoon Leader, 1014th Supply & Service Company (Direct Support), U.S. Army Reserve, Athens, GA
1981-1984  U.S. Army ROTC, University of Georgia, Athens, GA
FEI YUAN

Department of Geography
Minnesota State University, Mankato
7F Armstrong Hall, Mankato, MN 56001

507-389-2376 (O)
507-389-2980 (Fax)
Fei.yuan@mnsu.edu

TEACHING COURSES

• Introduction to Remote Sensing
• Advanced Remote Sensing
• Introduction to GIS
• Geography of East Asia
• Seminar: Critical Issues in Contemporary China (scheduled on Spring, 2008)
• Element of Geography (scheduled on Fall, 2007)

RESEARCH INTERESTS

• Remote sensing of environment
• GIS, spatial analysis, spatial modeling, and spatial data visualization
• Environmental monitoring, assessment, and management
• East Asia issues

EDUCATION

• Ph.D., Remote Sensing, University of Minnesota, Twin Cities, 2004
• Master of Geographic Information System, University of Minnesota, Twin Cities, 2003
• B.S. in Geography, East China Normal University, Shanghai, China, 1994

EXPERIENCE

2005/08–current: Assistant Professor
Department of Geography, Minnesota State University, Mankato, Minnesota

2004/08–2005/05: GIS Coordinator
Department of Geography, Miami University, Oxford, Ohio

2000/01–2004/07: Graduate Research Assistant
Remote Sensing and Geospatial Analysis Lab, University of Minnesota, Twin Cities, Minnesota

1999/08–1999/12: Graduate Research Assistant
Department of Geography and Regional Development, University of Arizona, Tucson, Arizona

1994/07–1999/07: Remote Sensing and GIS Specialist
National Satellite Meteorological Center (NSMC), Beijing, China
REFERRED PUBLICATIONS


OTHER PUBLICATIONS


CONFERENCE PRESENTATIONS

Yuan, F. and Roy, S. S., Analysis of phenological change patterns and growing season trends in response to climatic variables and urbanization, AAG Annual Conference, San Francisco, April 17-20, 2007

Yuan, F. Automatic land use extraction from high resolution imagery using machine-learning feature analysis. 15th MNGIS Annual Conference, St. Cloud, Minnesota, October 4-6, 2006.


Yuan, F., Bauer, M.E., and Sawaya, K.E. (Poster) Monitoring landscape change with Landsat classification. 10th MNGIS Annual Conference, Duluth, Minnesota, October 4-6, 2000.

GRANTS AND AWARDS

2007: (Pending) MSU Research Reassignment Grant, “Preliminary monitoring and assessment of the Blue Earth River using airborne hyperspectral remote sensing”, one course release

2007: (Pending) MSU Technology Fee Grant – “Using new remote sensing technologies to enhance student learning in a multi-curricular context”, $18,268 (with Martin Mitchell)

2007: Legislative-citizen commission on Minnesota resources (LCCMR), “Improved river quality monitoring using airborne remote sensing”, Principle Investigator, $159,000 (Co-PIs: Forrest Wilkerson, Ginger Schmid, Donald Friend, and Bryce Hoppie)
2006: MSU Faculty Improvement Grant, “Hyperspectral remote sensing training”, $900

2006: MSU Research Reallocation Grant, “Follow-up research of environmental impacts analysis in the Greater Mankato”, one course release

2005: MSU Faculty Research Grant, “Landscape change and effects analysis in the Greater Mankato Area using remote sensing and GIS”, $4,115

2004: First Place Award, GIS Day Poster Competition, University of Minnesota (UMN)

SERVICE

2006 – Present: Minnesota GIS/LIS Consortium Board, Higher Education
2006-2007: College of Social and Behavioral Sciences Technology & Equipment Committee, MSU
2005-2006: College of Social and Behavioral Sciences Teaching & Learning Committee, MSU

MANUSCRIPTS REVIEWING

2006: Remote Sensing of Environment,
2006: Photogrammetric Engineering & Remote Sensing
2006: Remote Sensing of Impervious, Weng, Q.H. (Eds.)

ADVISEES

John Nugent
Christopher Kaczmarek
Tomas Morton

COMMITTEE MEMBERSHIPS

Melanie George
James Worm
Sajan Dhakal
Piush Dahal
AmberBeth VanNinger

PROFESSIONAL AFFILIATIONS

American Society for Photogrammetry & Remote Sensing
Association of American Geographers
Appendix E:
Evidence of business/industry support
Minnesota GIS/LIS Consortium
1000 Westgate Drive
Suite 252
Saint Paul, MN 55114
www.mngislis.org

Dr. Scott Olson, Provost
Minnesota State University
Mankato, MN 56001

Dear Dr. Olson,

On behalf of the Minnesota GIS/LIS Consortium, I would like to offer this letter of support for a certificate program in Geographic Information Science (GISc) at Minnesota State University (MSU) - Mankato. The GIS/LIS Consortium is a group of volunteer professionals dedicated to the education and expansion of GIS throughout Minnesota and the surrounding area. Each year, the Consortium hosts professionals from the Upper Midwest at its annual conference and workshops. Other events include offering cash scholarships to GIS students in Minnesota. Recently, GIS/LIS has awarded several scholarships to students from MSU.

As Chair of the 2007 GIS/LIS Board of Directors, I would like to submit this letter on behalf of the Board in supporting the GISc certificate program proposed by the Department of Geography. We feel this program would be a wonderful opportunity for students to expand their knowledge of GIS as they prepare for the workplace or advance in their current careers. Similar programs at St. Mary’s and St. Cloud State University have been very successful and popular with students. Professionals, who are currently practicing GIS, find certificate programs beneficial in gaining valuable knowledge and experience without the need to complete a full academic program. Many students from other disciplines and existing professionals can use a certificate in GIS to complement their existing studies and degrees.

MSU, Mankato has become known in the GIS community as an excellent institution to pursue education in GIS and a certificate program would only strengthen the Geography program in Mankato.

Sincerely yours,

Chad Martini,
Board Chair, Minnesota GIS/LIS Consortium
February 8, 2007

FOR YOUR ACTION:

Richard Davenport, President
John Alessio, Dean, Social and Behavioral Sciences
Donald Friend, Chair, Geography Department
Susan Taylor, Director of Development, Social and Behavioral Sciences

FROM: Joann Jaqua, Manager
Gift Receipting, Administration and Stewardship

RE: Micro-Trak Systems, Inc.
c/o Dan Theobald
PO Box 99
Eagle Lake, MN 56024-0099

Details about the gift: We have received an in-kind gift valued at $29,286.50 from Micro-Trak Systems, Inc.; lifetime giving to the MSU Foundation is over $38,000. This gift designated for the geography department consists of eleven T100 digital GPS receivers; one T200 digital GPS receiver; and two antennas. Micro-Track will be honored at this fall’s gala as new members of the Purple and Gold Society’s Dean’s Circle. Thank you notes can be sent to Dan at the above address.

FOR YOUR INFORMATION:

Scott Olson, Vice President, Academic Affairs
Patricia Swatfager-Haney, Vice President, Student Affairs
David Williams, Vice President, University Advancement
Margot Zelenz, Associate Vice President, University Advancement
Cynthia Bemis-Abrams, Director, Alumni Relations and Special Events
Appendix H:
Evidence of External Review
Excerpts from the Minnesota State University, Mankato
Department of Geography
Program Review
External Evaluators’ Report, April 2007

By: Dr. Gregory Chu, Professor of Geography, University of Wisconsin – La Crosse and
Dr. Darrell Napton, Professor of Geography, South Dakota State University

“A new departmental strength is in the area of Geographic Information Sciences which include
GIS, remote sensing, cartography, spatial analysis and GPS. The department’s facilities in this
area are excellent. New faculty members who were recently conducting their dissertation
research at institutions such as the University of Minnesota and Ohio State University found
the Geography Department equipment and software holdings current and excellent. We concur
with their assessment.” p. 1

“Since the last program review in 1993, much has changed. Most noteworthy has been the
Department’s successful incorporation of recent technologies and ideas related to Geographic
Information Sciences. This was the result of the efforts of many individuals who were willing
to change the way things had been done to better the Department... The efforts ... were clearly
successful, and today the Department has one of the best equipped Geographic Information
Sciences facilities in the nation. The faculty members who use those facilities are also among
the best. The Department knows that success is a moving target. It just put a GIS certificate
into place. This should make geography graduates more competitive, attract additional
students, and raise the profile of the Department in the region.” p. 2

“Geography’s contribution by offering GIS classes is especially appreciated across the
campus.” p. 2

“Faculty research and publication, collaborative projects with students, an emphasis on field
classes and field work, and an outstanding Geographic Information Sciences ideas and
technologies clearly contributes to the advancement of the field and helps produce highly
qualified students who find good jobs within the region or pursue additional education.” p. 3

“The advent of geo-spatial science and its related technologies have empowered geographers
with added intellectual and analytical skills to enter into collaborative research with other
disciplines. Geographers with advanced GIS, Remote Sensing, and GPS navigational skills are
being sought after by researchers from various disciplines, spanning from the physical sciences
to the social and behavioral sciences to collaborate on multi-disciplinary research.” p. 4

“Additionally, the numbers of majors is solid and the number and quality of graduate students
has increased.” p. 15
Appendix I:
Letters of Support
Marty--
URSI is supports the proposed GIScience Certificate from Geography with enthusiasm. We see this as a growing field, and are grateful that Geography is prepared to offer it. We anticipate that some of our students (particularly in planning) will want to consider such a certificate. We see no conflict between the courses/certificate program and the courses/programs in URSI.

Tony Filipovitch, Chair
Urban & Regional Studies Institute