FY11-02: Graduate Committees: Co-Advisor as External Member

Issue of concern:
Some students have chosen a co-advisor from outside their administrative home department and that person has been the only external member on the committee. Question: Are all the roles of an external member well met by the co-advisor serving in that capacity? A subcommittee of GFC recommends that departments be given the flexibility to allow this but in recognition of the issue recommends the following additional statements (in bold) be added to the current policy language:

Changes are shown below for the Degree Requirements area of the web pages for the Doctor of Philosophy and Master of Science areas. Text equivalent to the text for the Master of Science area will appear in the MBA, Master of Forestry, and Master of Engineering areas.

Proposed Wording – for Degree Requirements - Doctor of Philosophy:

ADVISOR
…The primary advisor, or a co-advisor must hold a regular or adjunct appointment in the student's administrative home department or school. While one co-advisor may be from outside the student’s administrative home department, it is recommended but not required that this co-advisor not fill the role of sole external member on the student’s committee. Before recommending a sole advisor who holds an adjunct appointment in the student’s administrative home department, the appropriate graduate program director should ensure that this person is sufficiently familiar with the department/school standards for research and with applicable university policies/procedures and that this person can maintain adequate contact with the student.

…

ADVISORY COMMITTEE:
…This committee, with the addition of a fourth, external member, will often become the Examining Committee. If co-advisors are chosen and one co-advisor is from outside the student’s home department, it is recommended but not required that an additional external member must be chosen.

…

ORAL EXAMINATION
…The examining committee will be appointed by the Graduate School in consultation with the department chair. The committee will consist of at least four members of the graduate faculty. At least one of these will be from outside the student's administrative home department or school. The primary advisor, or a co-advisor who serves as chair of the committee, must be from the student's home department or school. While one co-advisor may be from outside the student’s administrative home department, it is recommended but not required that this co-advisor not fill the role of sole external member on the student’s committee.

…
Current Wording found in Degree Requirements - Doctor of Philosophy:

ADVISOR:
Initially the advisor may be the graduate program director, but as soon as possible, and no later than the end of the second semester in residence, a permanent advisor should be chosen. This Michigan Tech graduate faculty member advises the student on course selection and, if applicable, supervises the research experience. The primary advisor, or a co-advisor must hold a regular or adjunct appointment in the student's administrative home department or school. The advisor is an important factor in the graduate student's timely and successful completion of the program of study. All graduate students must have an advisor.

ADVISORY COMMITTEE:
The advisor and committee, consisting of at least two members of the graduate faculty in addition to the advisor, will be recommended by the advisor and the chair/graduate program director of the major department, school, or program and approved by the Graduate School and filed on the Advisor and Committee Recommendation form. This committee, with the addition of a fourth, external member, will often become the Examining Committee (see “Oral Examination” below).

ORAL EXAMINATION
…The examining committee will be appointed by the Graduate School in consultation with the department chair. The committee will consist of at least four members of the graduate faculty. At least one of these will be from outside the student's administrative home department or school. The primary advisor, or a co-advisor who serves as chair of the committee, must be from the student's home department or school. For interdisciplinary and non-departmental programs, the outside examiner may not be affiliated with the interdisciplinary or non-departmental program. A person external to Michigan Tech may be appointed as an ad hoc member of the Graduate Faculty to serve as the outside examiner. Persons who are not members of the Graduate Faculty may not serve as voting members of doctoral examination committees.
…
Proposed Wording – for Degree Requirements – Master of Science:

ADVISOR
…The primary advisor, or a co-advisor must hold a regular or adjunct appointment in the student's administrative home department or school. While one co-advisor may be from outside the student’s administrative home department, it is recommended but not required that this co-advisor not fill the role of sole external member on the student’s committee. Before recommending a sole advisor who holds an adjunct appointment in the student’s administrative home department, the appropriate graduate program director should ensure that this person is sufficiently familiar with the department/school standards for research and with applicable university policies/procedures and that this person can maintain adequate contact with the student.

Examination Committee—The examination committee will be appointed by the Graduate School in consultation with the department chair. The committee will consist of at least three members of the graduate faculty. At least one of these will be from outside the student's administrative home department or school. The primary advisor, or a co-advisor must hold a regular or adjunct appointment in the student's administrative home department or school. While one co-advisor may be from outside the student’s administrative home department, it is recommended but not required that this co-advisor not fill the role of sole external member on the student’s committee.

Current Wording found in Degree Requirements - Master of Science:

ADVISOR:
Initially the advisor may be the graduate program director, but as soon as possible, and no later than the end of the second semester in residence, a permanent advisor should be chosen. This Michigan Tech graduate faculty member advises the student on course selection and, if applicable, supervises the research experience. The primary advisor, or a co-advisor must hold a regular or adjunct appointment in the student's administrative home department or school. The advisor is an important factor in the graduate student’s timely and successful completion of the program of study. All graduate students must have an advisor.

Examination Committee—The examination committee will be appointed by the dean of the Graduate School in consultation with the department chair. The committee will consist of at least three members of the graduate faculty. At least one of these will be from outside the student's administrative home department or school. The primary advisor, or a co-advisor must hold a regular or adjunct appointment in the student's administrative home department or school.
Figure 1. Number of finishing fellowship applications per semester since spring 2009. The fall 2009 and 2010 applications have been accepted in the spring and summer of those years.

Changes to future finishing fellowship competitions:
- Limit applications to two attempts per student.
- Eliminate competition in the spring for fall fellowships.
Dean’s Fellowship Guidelines

Overview
Beginning in January 2009, the Graduate School will offer up to ten Dean’s Fellowships to assist with the recruitment of highly talented applicants to Michigan Tech’s PhD programs. Dean’s Fellowships will provide partial support for the recipient’s first year in a PhD program. The support will include a stipend of $2,000 per academic-year semester (fall and spring) as well as full summer support (stipend plus minimum full-time tuition and fees). The primary goal of the Dean’s Fellowship program is to support Michigan Tech’s strategic plan goal of being an inclusive and welcoming campus for faculty, students, and staff who bring rich, diverse perspectives to our teaching, learning, and research. The Dean’s Fellowship is intended to contribute to the development of a diverse academic community, which includes future faculty and others who will be leaders throughout their professional careers.

Eligibility Criteria
Students are eligible to be nominated for the fellowship if the following conditions have been met at the time of nomination:

1. Student has applied to and been accepted into a PhD program at Michigan Tech.
2. Student is a US citizen or permanent resident.
3. Student has been offered at least four years of support by the accepting department or graduate degree program. Support can be from a combination of internal and external sources. Funding provided through the Dean’s Fellowship program will supplement funding from another source (including internal funds) for the fall and spring semesters of the student’s first year but will provide full support (at the minimum level) during the summer semester following the student’s first academic year of study. Support may be terminated at any time if the student fails to make satisfactory progress toward their degree.
4. Student has been assigned a faculty mentor who will provide guidance as soon as the student enters Michigan Tech. The faculty mentor need not necessarily be the student’s research advisor, but the mentor must be able to provide guidance that will assist the student in making good progress toward their degree from the time that the student matriculates at Michigan Tech.
5. The department or program has a formal peer-mentoring program in place. Peer mentors should provide new students with information about the graduate experience at Michigan Tech. Peer mentors should make new students feel “at home” in graduate school at Michigan Tech and in the local community.

Nomination Process
Students must be nominated for the Dean’s Fellowship by the chair of the department or the graduate program director of the unit that has accepted the student. Nominations are due by March 1 each year. The Dean of the Graduate School will announce the recipients of the Dean’s Fellowship by March 22 each year. Nomination files will consist of the following:

1. A copy of the student’s application file.
2. A copy of the student’s acceptance and offer of support letter.
3. A statement by the department chair or graduate program advisor identifying the name of the faculty mentor and peer mentor that will be assigned to the student once s/he matriculates at Michigan Tech.
4. A statement of how the student will contribute to the goals enumerated in Michigan Tech’s Strategic Plan (http://www.mtu.edu/stratplan/).
**Review Process**

The credentials of nominees will be reviewed by a faculty panel convened by the dean of the Graduate School using the criteria listed below. *Each nomination will be reviewed on an individual basis using a holistic approach.*

The goals of Michigan Tech’s strategic plan will guide the evaluation process. These goals are:

1. **Attract and support a world-class and diverse faculty, staff, and student population.**
   1.1. Provide an outstanding work environment and support opportunities for all members of the Michigan Tech community.
   1.2. Increase the diversity of our faculty, staff, and students.
   1.3. Provide exceptional facilities and an aesthetically pleasing environment.

2. **Deliver a distinctive and rigorous discovery-based learning experience grounded in science, engineering, technology, sustainability, and the business of innovation.**
   2.1. Provide dynamic experiential learning that integrates instruction, research, and innovation in undergraduate and graduate programs.
   2.2. Develop undergraduate and graduate programs in new and emerging areas.
   2.3. Provide exemplary student life activities.

3. **Establish world-class research, scholarship, and innovation in science, engineering, and technology that promotes sustainable economic development in Michigan and the nation.**
   3.1. Increase interdisciplinary initiatives to expand knowledge and address societal needs.
   3.2. Promote economic development and innovation in Michigan and the nation.
   3.3. Address societal needs through global partnerships.

Additional criteria will also be considered during the evaluation of nominees. These include:

1. Is the nominating department taking steps to encourage applications from and participation by members of groups that are currently underrepresented on the Michigan Tech campus?
2. Are PhD students in the nominee’s graduate program publishing in peer-reviewed journals and making presentations at national and international professional conferences?
3. Is it likely that the nominating department or graduate program will continue to supplement the student’s stipend and provide summer support using funds obtained from external sponsors, research incentive accounts, the Michigan Tech fund, or departmental funds?
4. Does the nominee have an outstanding academic record?
5. Does the nominee have an ethnic/cultural background that is underrepresented in their discipline and/or is the applicant a first-generation college student?
6. Has the nominee demonstrated a commitment to diversity in their professional, personal, or educational endeavors (for example, by participating in activities that address racial and gender disparities and/or race relations in the US).
7. Does the nominee have family or individual financial status that would make it difficult to continue in graduate school without financial support from the University?
8. Will the nominee’s background, life challenges, or life experiences bring a unique prospective to the academic program to which s/he is applying?

Following review of the nominees’ qualifications, the panel will recommend to the dean of the Graduate School that each student 1) receive a Fellowship, 2) receive a Fellowship if sufficient funds are available, or 3) not receive a Fellowship. The dean of the Graduate School will review the panel’s recommendations and make the final decision about each nominee. The number of Fellowships ultimately awarded will depend on the size and quality of the pool of nominees and on the funds available to support the Dean’s Fellowship program each academic year.
Current Situation:
Currently only the advisor and department chair/graduate program director need to sign page 2 of the “Report on Oral Examination” indicating that “The candidate addressed comments of the dissenting committee member and the final thesis/report/dissertation copy is accepted without further revision or correction.”

Issue of Concern:
Recently a dissenting examiner expressed concern when faced with the pressure of a short time line to review a revised document and noted that there is opportunity for an advisor to sign page 2 without the student fully addressing issues raised by the dissenting examiner. Would adding the requirement of the signature of the dissenting examiner better ensure that all concerns were addressed?

Proposed Change:
Page 2 of the “Report on Oral Examination” would include a signature line for the dissenting examiner.
1. General Description and Characteristics of Program

Sustainable development of a society depends greatly on the availability and reliability of geospatial data. Terabytes of multi-dimensional geospatial data and metadata are acquired using various sophisticated instruments such as global navigation satellite systems, aerial and satellite panchromatic hyper-spectral remote sensors, high-precision optical-electronic surveying instruments, laser scanning systems, radar, sonar, etc. Data are used by scientists from many different disciplines such as engineering, geology, forestry, agriculture, social sciences, history, and political science to study diverse aspects of the Earth and human activity. All these disciplines use geospatial data and technology as a supplementary tool in their research, but geospatial data acquisition and processing is a science in itself.

The roots of geospatial technology are geodetic science, photogrammetry, cartography, surveying, topographic mapping, and thematic mapping. Combined with new technological developments in optics, electronics, and computing, these roots have produced a new blend of applied science — Integrated Geospatial Technology. Examples of recent applications of these technologies include: terrestrial and airborne laser scanning systems that are widely used to obtain 3D models of objects; high-resolution satellite imaging sensors that provide multi- and hyper-spectral video data which allow users to investigate spatial-temporal and physical properties of objects; and Global Navigation Satellite Systems that provide real-time and accurate geo-positioning and navigation data to define precise locations of objects on land and water, including man-made structures or natural features.

There is a large and growing need for scientists and engineers with advanced training in the geospatial technologies. In particular, there is a recognized need among different disciplines for more effective systems to gather, analyze, and interpret geographically referenced spatial data. Powerful new research and technological tools for addressing these problems require graduate-level training in the geospatial sciences.
In many cases, the same geospatial product, such as a Digital Terrain Model, can be created by different techniques. To achieve a goal, professionals need to reason and predict the spatial and semantic accuracy of the final product, compare different techniques and approaches, and estimate technological, financial, and manpower requirements. Planning the data acquisition process, balancing errors and accuracies, and combining and optimizing different technologies for data acquisition and adjustment requires professional knowledge integrated with skills spanning different aspects of quantitative geospatial techniques and technologies.

The proposed Master’s Degree is designed for students from a variety of backgrounds for careers in surveying, photogrammetry, remote sensing, Light Detection and Ranging (LiDAR), terrestrial laser scanning industries, and for allied areas that require knowledge and understanding of the acquisition, processing, and analysis of spatially referenced data.

2. RATIONALE

Current trends in industry and government agencies indicate that a stable demand exists for geospatial technology within multiple disciplines. In academia, a growing number of faculty and graduate students are using geospatial data within a variety of fields. Active research programs, courses, and a growing number of graduate degrees incorporate the use of such data and information. The Master’s Degree proposed here will support ongoing activities by facilitating interdisciplinary collaboration in graduate education, and will add value to Michigan Tech’s current graduate offerings by providing a suite of courses in the area of Integrated Geospatial Technology.

The design of this proposed graduate program specifically addresses the following goals:

- Provide a flexible interdisciplinary structure to ensure the best positioning of its graduates in job markets.
- Allow for rapid response to the current demands of industry and foreseeable future trends.
- Incorporate state-of-the-art geospatial research and technology.
- Attract current students of Michigan Tech as well as students at other universities nationally and internationally.
- Promote flexibility in terms of staffing, research interests, practical expertise and modes of course delivery.
- Promote sustainable research infrastructure and staffing in the area of geospatial science and technology at Michigan Tech.

The proposed Master’s Degree is viewed as the initial stage in the strengthening of geospatial science and technology at Michigan Tech. As interest in graduate geospatial education grows and the campus becomes more familiar with the needs and interests of students in this program, the Master’s program could be scaled-up to an interdisciplinary PhD program.
3. Discussion of Related Programs Within the Institution and at Other Institutions

Very few higher education institutions offer baccalaureate degree programs focused specifically on geospatial technology and GIScience per se. Berdusco¹ identified about 425 higher education institutions worldwide (about 260 in the US) that offer formal certificate, diploma, or degree programs in GIS and GIScience.

Of the 28 US universities listed as offering undergraduate degree programs in GIS, all but four in fact offer B.A. and B.S. degrees in Geography (nineteen programs.) Others offer baccalaureate degrees in Earth Science, Environmental Science, Natural Resources, or Forestry, with concentrations, specializations, tracks, or undergraduate certificates in GIS, GIScience, cartography, and related topics.

For the same reasons that the geospatial workforce is diffused among many industries in every employment sector, geospatial activities tend to be widely dispersed and poorly coordinated on four-year college campuses. Within academic programs, courses involving geospatial technologies are often positioned as intermediate or advanced technical specialties with prerequisites and class size limits that pose barriers to enrollment.

A small number of US universities offer graduate degrees in separate quantitative geospatial disciplines such as Surveying (Purdue, University of Texas at Corpus Christi, Florida), Photogrammetry (Ohio State) and Cartography (Penn State, Kansas), but there is no university in the US offering Integrated Geospatial Technology.

4. Projected Enrollment

The Michigan Tech Surveying Engineering program’s Advisory Board has expressed its support for establishing a graduate program in Integrated Geospatial Technology. The Board felt that there would be strong demand from industry for graduate students with the expertise that would be gained through participation in a certificate or Master’s program.

There are currently five students in the Surveying Engineering program who have expressed an interest in completing a Master’s degree. We expect 5-10 students a year will enroll in the proposed Master’s program.

We strongly believe that the unique structure of the proposed graduate program curriculum and the availability of online course delivery will attract additional non-degree seeking post-graduate students nationally and internationally.

5. Scheduling Plans

The classes will be taught on the Michigan Tech campus and most of them will have the option for online delivery.

¹ Berdusco, B., Results of a Survey of Known Higher Education Offerings in GIS and GIScience (2003), http://www.ucgis.org/priorities/education/GIS_Cert+Masters_Prog/Berdusco.htm
6. CURRICULUM DESIGN

MASTER OF SCIENCE PROGRAM:

Table 1 outlines options and requirements for the proposed Master of Science degree in Integrated Geospatial Technology.

Table 1: MS Degree Requirements

<table>
<thead>
<tr>
<th>Program</th>
<th>Option</th>
<th>Coursework</th>
<th>Thesis Research</th>
<th>Engineering Report or Practicum</th>
<th>Total Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS</td>
<td>Plan A</td>
<td>≥20</td>
<td>6-10</td>
<td></td>
<td>≥30</td>
</tr>
<tr>
<td>MS</td>
<td>Plan B</td>
<td>≥24</td>
<td>2-6</td>
<td></td>
<td>≥30</td>
</tr>
<tr>
<td>MS</td>
<td>Plan C</td>
<td>≥30</td>
<td></td>
<td></td>
<td>≥30</td>
</tr>
</tbody>
</table>

The Master’s program is designed to represent the diversity within the body of knowledge that comprises Integrated Geospatial Technology. The specific set of courses a student takes to meet the requirements of the degree is meant to be flexible to allow a customized program that will satisfy specific research or project interests. It is assumed that each student will take at least 2 courses from at least 2 different areas and specialize in one area in order to understand the essence of integrated approaches to solving real life problems.

7. COURSE DESCRIPTIONS

There are three groups of courses: A) required, B) professional electives, and C) supporting electives. The required group consists of three courses (6 credits), an introduction to the geospatial field, research methods and a research seminar.

The professional electives group provides the set of core courses for the degree. These courses are grouped into Geomatics, GIScience, Remote Sensing, and Geospatial Metadata and Cartography. The variety of courses provides flexibility for specific coursework selection depending on a student’s area of specialization. For example, a student interested in pursuing an emphasis in Geodetics would be advised to take the Fundamentals of Remote Sensing (GE4250) course and the introductory one credit course (SU5003) combined with Computational Geosciences to fulfill a GIS component. As another example, students interested in pursuing environmental geospatial applications might be advised to select FW5510, FW5540 and FW5560.

Supporting courses can be useful for tailored preparation of graduate students for specific career paths. This group includes courses in robotics and computer science, which could serve the needs of a student interested in the aerospace industry; and courses in environmental policy and decision making for students seeking employment with governmental agencies.

The actual program of study for each student will be developed in consultation with an advisor and will be based on individual educational goals.

A. REQUIRED COURSES

SU5010 Geospatial Concepts, Technologies and Data (3 credits), (course exists, delivery: Dr. Eugene Levin)

High-level review of geospatial data acquisition systems, sensors and associated processing technologies. Course considers geospatial metadata generation principles, interoperability, and major tools for manipulation with geospatial data. Course may help in transition of non-geospatial majors to geospatial field.
FW 5810 Research Methods in Natural Resources (2 credits) (course exists, delivery: SFRES faculty)
Overview of science and scientific research. The process of graduate education including choosing an advisor, selecting a research problem, writing a thesis proposal, scientific hypothesis testing, analyzing data, and communicating results through various media.

SU5800 Graduate Seminar (1 credit), (new course, delivery: participating faculty)
Student presentation of current geospatial research in a traditional seminar setting.

B. PROFESSIONAL ELECTIVE COURSES

I. GEOMATICS
Geomatics courses are designed to provide students with the knowledge required to collect geographic information, prepare it for use, and take into account the inherent measurement errors typically encountered.

SU5020 Data Analysis and Adjustments (3 credits), prerequisite SU3250(C) or equivalent (course exists, delivery: Dr. Alfred Leick²)
Course explores fundamentals of mathematical error propagation theory including various observation equations, least squares adjustments, and Kalman filter methods. Blunder detection, decorrelation, and inversion of patterned and large matrices processes are considered. Involves analysis of position estimation deploying geospatial measurements.

SU5021 Geodetic Models (3 credits), prerequisite SU5020(C) (course exists, delivery: Dr. Alfred Leick)
Course provides solid geospatial background in geodetic reference frames: datums; geoids; and reference ellipsoids. 2D and 3D geodetic network adjustments are considered based on 3D spherical models.

SU5022 Positioning with GNSS (3 credits), prerequisite SU5020 or equivalent (course exists, delivery: Dr. Alfred Leick)
In depth study of GPS, GLONASS, Galileo, COMPASS satellite systems, theory, and processing of global positioning measurements. Strongly recommended for geospatial practitioners.

II. GEOGRAPHIC INFORMATION SCIENCE (GISc)
The courses in Geographic Information Science provide students with an introduction to the information science issues associated with processing and displaying geographical data.

SU5023 Geospatial Positioning (3 credits), (course exists, delivery: Colin Brooks³)
High-level summary of GPS-GAP courses. This course is intended for interdisciplinary graduate students who seek just ONE combination course in adjustments, geodesy and GPS (with emphasis on GPS/GNSS). Not available to students who have taken SU5020, SU5021, SU5022.

SU5041 Geospatial Data Processing (3 credits), (course exists, delivery: Dr. Yerach Doytsher⁴)
Advanced data collection techniques; raster to vector; data conversion and map projections; topology; principles and application via advanced spatial analysis; advanced database structure; geo-database; georelational data model versus object-component data model; advanced 3D applications – vector and raster data model application; network analysis; linear referencing and conflation; geo-coding, GIS-CAD integration; web-based GIS innovations.

SU5043 Topographic Analysis (3 credits), (course exists, delivery: Dr. Yerach Doytsher)
LiDAR measurements; DSM - data sources, accuracy analysis, quality control, vector data analysis; terrain representation and TIN; grid analysis - interpolation, visibility, filters (smoothing, edges, median); shading;

² Professor, Department of Spatial Information Science and Engineering, University of Maine; Adjunct Professor, Michigan Tech
³ Senior Research Scientist, Michigan Tech Research Institute (MTRI)
⁴ Professor, Civil and Environmental Engineering, Technion-Israel Institute of Technology
merging overlapping DSMs; spatial analysis - spectral analysis shape analysis; automatic feature extraction from DSM.

III. REMOTE SENSING

The courses in Remote Sensing provide a background in wireless or non-contact methods of obtaining information related to geospatial objects.

**SU5002 Infrared Technology, Sensors, and Applications (1 credit), (course exists, delivery: Dr. Robert Schuchman)**

Infrared remote sensing fundamentals, current and future technologies, and applications are considered. Remote sensing for both civilian applications such as environmental resource mapping and military applications will be included.

**SU5930 Synthetic Aperture Radar (SAR) Fundamentals and Applications (3 credits), (course exists, delivery: Dr. Robert Schuchman)**

Review of radar concepts, applications of SAR (InSAR) data, types of available satellite/airborne systems, and data processing methods. Applications for creating topographic data, recognizing targets, classifying ice and vegetation, and oceans/large lakes will be presented based on real-world examples.

**FW5560 Digital Image Processing: Remote Sensing Perspective (3 credits), (course exists)**

Presents the theory and quantitative procedures of digital image processing using remotely sensed data. Emphasizes image acquisition, preprocessing, enhancement, transformation classification techniques, accuracy assessment, and out-products. Discusses linkages to GIS. Also covers evaluating applications of the technology to current resource management problems via peer-reviewed literature.

IV. GEOSPATIAL METADATA AND CARTOGRAPHY

This group of courses provides the knowledge and background to understand the science of describing data and visualization in different types of maps.

**SU5042 Digital Cartography (3 credits), (course exists, delivery: Dr. Yerach Doytsher)**

Spatial relations - topology, relations and relationships, directions and distances; hierarchy; generalization - vector (linear, polygonal, fractals) and raster; labeling - automatic name placement, text arrangement and deletion text; computational geometric algorithms - line intersection, polygonal relationships, grid model, route analysis.

**SU3540 Geospatial Information Technology with Elements of Field Cartography (4 credits), prerequisite MA3710 (course exists, delivery: Dr. Eugene Levin)**

Application of GIS technology methods for processing surveying data obtained in the field. Concepts of interoperability and metadata organization are considered. Includes map projection review and 2D and 3D cartographic data visualization.

B. SUPPORTING ELECTIVE COURSES

**EE 5725 - Mobile Robotics & Multi-Robot Systems (3 credits)**

Introduction to mobile robotics and multi-robot systems. Introduce spatial description, mobile robot locomotion, kinematics, localization and mapping, motion planning and navigation. Topics in multi-robot systems include biological inspirations, control structure, inter-robot communication, learning in multi-robot systems, and modeling and analysis.

**EE 5522 - Digital Image Processing (3 credits) (course exists)**

Image formation, enhancement, and reconstruction. Applications in medical imaging, computer vision, and pattern recognition.

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5 Co-Director, Michigan Tech Research Institute (MTRI)
**CS 5611 - Computer Graphics: Advanced Rendering and Animation (3 credits) (course exists)**
Topics include polygonal objects, parametric curves and surfaces, lighting models, shadows and textures, ray-tracing techniques, radiosity methods, volume rendering, and animation.

**CS 5811 - Advanced Artificial Intelligence (3 credits) (course exists)**
Course topics include current topics in artificial intelligence including agent-based systems, learning, planning, use of uncertainty in problem solving, reasoning, and belief systems.

**FW 5540 - Advanced Terrestrial Remote Sensing (4 credits) (course exists)**
Remote sensing principles and concepts at the graduate level. Topics include camera and digital sensor arrays, types of imagery, digital data structures, spectral reflectance curves, applications and introductory digital image processing.

**FW 5550 - Geographic Information Systems (4 credits) (course exists)**
Use of geographic information systems (GIS) in resource management. Studies various components of GIS in detail, as well as costs and benefits. Laboratory exercises use ArcGIS software package to solve resource management problems.

**FW5560 - Digital Image Processing: Remote Sensing Perspective**
Presents the theory and quantitative procedures of digital image processing using remotely sensed data. Emphasizes image acquisition, preprocessing, enhancement, transformation classification techniques, accuracy assessment, and out-products. Discusses linkages to GIS. Also covers evaluating applications of the technology to current resource management problems via peer-reviewed literature.

**GE 4100 - Geomorphology and Glacial Geology (4 credits) (course exists)**
The study of the processes, including fluviol, glacial, wind, mass movement, and wave action, shaping the earth's surface by erosion and deposition of geologic materials. Emphasizes the role of past and present climate. Field trips are a major component.

**GE 4250 - Fundamentals of Remote Sensing (3 credits), (course exists)**
This course focuses on the basic physics behind above-surface remote sensing and remote sensing systems. Topics covered include: properties of the atmosphere, absorption and scattering of electromagnetic radiation, instrument design, data acquisition and processing, validation, and basic applications.

**SS 5300 - Environmental Policy and Politics (3 credits), (course exists)**
An overview of environmental policymaking and politics in the U.S. Emphasizes policies regarding air and water pollution, toxics and hazardous waste. Discussion of rulemaking, enforcement, and administration of laws by EPA. Investigation of environmental politics on national and community levels, with focus on social movements and citizen participation.

**SS 5350 - Environmental Policy Analysis (3 credits), (course exists)**
The role of economic analysis in environmental policy, including a detailed review of the major tools that are used at the federal, state, regional, and local levels. Special emphasis on benefit-cost analysis and comparative risk analysis.

**SU 4140 - Photogrammetry (3 credits) (course exists)**
Basic principles of photogrammetry and its role as a technology for spatial data collection. Use of photogrammetry in the fields of surveying, engineering, and geographic information management will be discussed.

**SU3540 Geospatial Information Technology with Elements of Field Cartography (4 credits), (course exists)**
Application of GIS technology methods for processing surveying data obtained in the field. Concepts of interoperability and metadata organization are considered. Includes map projection review and 2D and 3D cartographic data visualization.

**SU 4100 - Geodetic Positioning (3 credits) (course exists)**
Introduces the instruments and procedures used in surveying projects that require a high order of accuracy. Discusses some conventional instruments and techniques but the greater emphasis is on GPS techniques.
8. Library and Other Learning Resources

The library has basic literature in the area of geospatial technologies but the following additional books and journals would be required.

List of Books (Approximate Cost: $2,000)


List of Journals (Approximate Annual Cost: $12,345)

1. *GPS Solutions*, Springer, ISSN: 1080-5370 (Available through SpringerLink)
9. **Computing Access Fee**

A computer access fee of $210 (2010-11) per semester will be required for students enrolled in this program and additional university Distance Learning fees may be required for on-line courses.

10. **Faculty Resumes**

   Colin Brooks (http://expertise.cos.com/cgi-bin/exp.cgi?id=1265087)
   Yerach Doytsher, PhD (http://www.technion.ac.il/~doytsher/13.htm)
   Michael Falkowski, Ph.D (http://forest.mtu.edu/faculty/falkowski/)
   Alfred Leick, PhD (www.gnss.umaine.edu)
   Eugene Levin, PhD, CP (http://www.tech.mtu.edu/Faculty_Pages/Eugene_Levin.html)
   Ann MacLean, Ph.D http://forest.mtu.edu/faculty/maclean/index.html
   Robert Schuchman, PhD (http://expertise.cos.com/cgi-bin/exp.cgi?id=1289668)
   Aleksey Smirnov, Ph.D http://www.geo.mtu.edu/profile/AVSmirnov.htm
   Igor Ternovskiy, PhD (www.intopsys.com)

11. **Description of Available/Needed Equipment**

   The School of Technology has been teaching surveying engineering and photogrammetry for over 20 years. In terms of equipment, the School of Technology already has the following capital assets to support the new program.

   - Trimble GNSS RTK system $60,000
   - Trimble S6 total stations (4 pcs) $96,000
   - TSC2 wireless data collectors (4 pcs) $10,000
   - Leica DN Digital Levels (10 pcs) $30,000
   - Trimble Geomatics Office (90 licenses) $400,000
   - Arc GIS licenses (unlimited) (available via Michigan Tech)
   - Carlson Civil Suite software (90 licences) $927,000
   - SimWright StereoGIS softcopy photogrammetric workstation (5 licenses) $50,000
   - Cardinal Systems VrMapping photogrammetric software suite (12 licenses) $120,000
   - Chrysler PT Cruiser vehicle $6,700
   - Small aerial UAV (in production with ME-EM aerospace student enterprise) $13,000
   - RIEGL 3D Imaging Sensor LMS-Z210ii terrestrial LiDAR scanner $50,000

   Total current assets are valued at $1,762,700.

   The School of Technology and MTRI have all the necessary equipment and software licenses to start the proposed graduate degree program.
12. **Program Costs**

The Graduate program may be started without additional costs since a portion of the distance learning tuition revenue will be used to support the external instructors. The plan is to have an agreement that pays the instructors a fixed amount per student with a cap on the maximum compensation per class. This means that classes with very low enrollment might not be offered if the instructor does not feel there is adequate compensation. Tuition revenue from classes with enrollment beyond the break-even point could possibly be used to subsidize low enrollment classes.

13. **Space**

Several shared graduate student offices will be required for full-time students (one room for each 5 students). In the event that a geospatial faculty member is hired as part the SFHI, an office in the School of Technology (EERC) might be needed in the future.

14. **Accreditation Requirements**

None

15. **Planned Implementation Date - Fall Semester 2010**

16. **Internal Status of the Proposal**

Approved by:

Date:
PROPOSAL FOR A
GRADUATE CERTIFICATE IN
INTEGRATED GEOSPATIAL TECHNOLOGY

SUBMITTED BY THE
SURVEYING ENGINEERING PROGRAM, SCHOOL OF TECHNOLOGY
SCHOOL OF FOREST RESOURCES & ENVIRONMENTAL SCIENCE
MICHIGAN TECH RESEARCH INSTITUTE (MTRI)

1. GENERAL DESCRIPTION AND CHARACTERISTICS OF PROGRAM

Sustainable development of a society depends greatly on the availability and reliability of geospatial data. Terabytes of multi-dimensional geospatial data and metadata are acquired using various sophisticated instruments such as global navigation satellite systems, aerial and satellite panchromatic hyper-spectral remote sensors, high-precision optical-electronic surveying instruments, laser scanning systems, radar, sonar, etc. Data are used by scientists from many different disciplines such as engineering, geology, forestry, agriculture, social sciences, history, and political science to study diverse aspects of the Earth and human activity. All these disciplines use geospatial data and technology as a supplementary tool in their research, but geospatial data acquisition and processing is a science in itself.

The roots of geospatial technology are geodetic science, photogrammetry, cartography, surveying, topographic mapping, and thematic mapping. Combined with new technological developments in optics, electronics, and computing, these roots have produced a new blend of applied science – Integrated Geospatial Technology. Examples of recent applications of these technologies include: terrestrial and airborne laser scanning systems that are widely used to obtain 3D models of objects; high-resolution satellite imaging sensors that provide multi- and hyper-spectral video data which allow users to investigate spatial-temporal and physical properties of objects; and Global Navigation Satellite Systems that provide real-time and accurate geo-positioning and navigation data to define precise locations of objects on land and water, including man-made structures or natural features.

There is a large and growing need for scientists and engineers with advanced training in the geospatial technologies. In particular, there is a recognized need among different disciplines for more effective systems to gather, analyze, and interpret geographically referenced spatial data. Powerful new research and technological tools for addressing these problems require graduate-level training in the geospatial sciences.

In many cases, the same geospatial product, such as a Digital Terrain Model, can be created by different techniques. To achieve a goal, professionals need to reason and predict the spatial and semantic accuracy of the
final product, compare different techniques and approaches, and estimate technological, financial, and manpower requirements. Planning the data acquisition process, balancing errors and accuracies, and combining and optimizing different technologies for data acquisition and adjustment requires professional knowledge integrated with skills spanning different aspects of quantitative geospatial techniques and technologies.

The proposed graduate certificate is designed for students from a variety of backgrounds for careers in surveying, photogrammetry, remote sensing, Light Detection and Ranging (LiDAR), terrestrial laser scanning industries, and for allied areas that require knowledge and understanding of the acquisition, processing, and analysis of spatially referenced data.

2. RATIONALE

Current trends in industry and government agencies indicate that a stable demand exists for geospatial technology within multiple disciplines. In academia, a growing number of faculty and graduate students are using geospatial data within a variety of fields. Active research programs, courses, and a growing number of graduate degrees incorporate the use of such data and information. The graduate certificate proposed here will support ongoing activities by facilitating interdisciplinary collaboration in graduate education, and will add value to Michigan Tech’s current graduate offerings by providing a suite of courses in the area of Integrated Geospatial Technology.

The design of this proposed graduate certificate specifically addresses the following goals:

• Provide a flexible interdisciplinary structure to ensure the best positioning of its graduates in job markets.
• Allow for rapid response to the current demands of industry and foreseeable future trends.
• Incorporate state-of-the-art geospatial research and technology.
• Attract current students of Michigan Tech as well as students at other universities nationally and internationally.
• Promote flexibility in terms of staffing, research interests, practical expertise and modes of course delivery.
• Promote sustainable research infrastructure and staffing in the area of geospatial science and technology at Michigan Tech.

The proposed graduate certificate is part of an effort to strengthen geospatial science and technology at Michigan Tech.

3. DISCUSSION OF RELATED PROGRAMS WITHIN THE INSTITUTION AND AT OTHER UNIVERSITIES

Refer to the proposal for the Master’s Degree Program in Integrated Geospatial Technology.

4. PROJECTED ENROLLMENT

The Michigan Tech Surveying Engineering program’s Advisory Board has expressed its support for establishing a graduate program in Integrated Geospatial Technology. The Board felt that there would be strong demand from industry for graduate students with the expertise that would be gained through participation in a certificate or Master’s program.
Currently, there are five industry professionals who have expressed interest in a graduate certificate and we anticipate approximately ten students participating in the program at any point in time.

We strongly believe that the unique structure of the proposed graduate certificate and the availability of online course delivery will attract additional non-degree seeking post-graduate students nationally and internationally.

5. SCHEDULING PLANS

The classes will be taught on the Michigan Tech campus and most of them will have the option for online delivery.

6. CURRICULUM DESIGN

Certificate:

All of the courses in the proposed Master’s program, except Graduate Research, will be available to students seeking the graduate certificate. Any combination of fifteen credits may be selected depending on the technical emphasis area of the student. Example groups of courses oriented towards particular areas of emphasis are provided below. This allows each student to create a personalized program of study.

- **Surveying Engineering and GPS**: SU5010, SU5020, SU5021, SU5022, SU5042
- **GIS and 3D Visualizations**: FW5560, SU5010, SU5041, SU5042, SU5043
- **Remote Sensing and GIS**: FW5550, SU5001, SU5002, FW5560, SU5010, SU5023, SU5930
- **Automated Cartography and GIS**: FW5550, SU5001, SU5002, FW5560, SU5041, SU5043
- **Manned & Unmanned Robotic Platforms (UAV/UGV) Guidance, Navigation and Control (Geospatial Background)**: FW5560, SU5010, SU5022, SU5041, SU5042
- **Interdisciplinary**: SU5021, SU5022, SU5041, SU5042, SU5930

7. COURSE DESCRIPTIONS

Refer to the proposal for the Masters Degree Program in Integrated Geospatial Technology.

8. LIBRARY AND OTHER LEARNING RESOURCES

Refer to the proposal for the Master’s Degree Program in Integrated Geospatial Technology.

9. COMPUTING ACCESS FEE

A computer access fee of $210 (2010-11) per semester will be required for students enrolled in this program and additional university Distance Learning fees may be required for on-line courses.

10. FACULTY RESUMES

Colin Brooks (http://expertise.cos.com/cgi-bin/exp.cgi?id=1265087)

Yerach Doytsher, PhD (http://www.technion.ac.il/~doytsher/13.htm)

Michael Falkowski,Ph.D (http://forest.mtu.edu/faculty/falkowski/)

Alfred Leick, PhD (www.gnss.umaine.edu)
11. DESCRIPTION OF AVAILABLE/NEEDED EQUIPMENT
The School of Technology has been teaching surveying engineering and photogrammetry for over 20 years. In terms of equipment, the school has the capital assets to support the new program.

12. PROGRAM COSTS
The graduate certificate program may be started without additional costs since a portion of the distance learning tuition revenue will be used to support the external instructors. The plan is to have an agreement that pays the instructors a fixed amount per student with a cap on the maximum compensation per class. This means that classes with very low enrollment might not be offered if the instructor does not feel there is adequate compensation. Tuition revenue from classes with enrollment beyond the break-even point could possibly be used to subsidize low enrollment classes.

13. SPACE
No additional space is required.

14. ACCREDITATION REQUIREMENTS
There are no accreditation requirements for the proposed graduate certificate.

15. PLANNED IMPLEMENTATION DATE
Spring Semester 2011.

16. INTERNAL STATUS OF THE PROPOSAL
Approved by:

Date:
Points to address from November 2, 2010 GFC meeting

1. Will this program be housed in the School of Technology?

The MS in Integrated Geospatial Technology is interdisciplinary in nature and will have participating faculty members from several academic units within the university. We believe it is important for the success of the program that it be administered from within the School of Technology. The program proposal originated from within the school and there is a commitment from the dean to provide the necessary administrative and financial support so the program can be a success.

In addition, the surveying program has approximately $1.8 million in equipment and software in place to support the proposed graduate program.

2. Entry requirements.

Of course, the proposed MS program must adhere to all requirements imposed by the graduate school at the time a student applies for admission, and the applicant must follow the specified admissions procedures.

It is anticipated that applicants will come from various technical disciplines and will most likely have taken the appropriate foundation courses.

To be specific all applicants should have:

- three college-level calculus courses,
- an object-oriented programming course,
- and college level physics.

In addition, a course in linear algebra is recommended.

Conditional acceptance might be useful in order to give certain students the opportunity to complete any missing requirements.