Part I: Institutional and Program Information

Name of Institution:
University of Maine

Date:
February 24, 2015

Institution President's Name:
Dr. Susan Hunter, President

Mailing Address of Institution:
President's Office, Alumni Hall
University of Maine
Orono, ME 04469

Official Email Address:
hunter@maine.edu

Department Submitting Application:
Spatial Informatics Program, School of Computing and Information Science

Applying at which program level:
Undergraduate ( ) Graduate (x) Both ( )

Accreditations

Nationally accredited?
Yes ( ) No (x)

Regionally accredited?
Yes (x) No ( )

Name of National Accreditation Body:
[no appropriate graduate education accreditation body exists]

Name of Regional Accreditation Body:
New England Association of Schools and Colleges (NEASC)

Institution Points of Contact (POC)

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(Note: Supplemental documents under all criteria are indexed at https://spatial.umaine.edu/docs)

Criterion 1: Outreach and Collaboration

Demonstrate how Geospatial Science is extended beyond the normal boundaries of the Institution. See the NGA-USGS CAE in Geospatial Science Education Program Criteria for specific items to be addressed).

Note: If any links below under Criterion 1 are inactive, see https://spatial.umaine.edu/docs/criterion1/

a) Shared curriculum

Teaching materials are often freely distributed to the world by our geospatial science graduate faculty members. By example, see the detailed syllabus of SIE 525 Information Systems Law at http://umaine.edu/computingcoursesonline/sie525/ The course lectures often include examples drawn from the geospatial practice community and notice that detailed lecture videos, reading assignments, and homework assignments are available to the world for other graduate programs to access and/or emulate if they so desire without asking. Notice the Creative Commons License posted at the bottom of each page. Further, past mid-term and final exams are regularly shared with current students and are made available to professors at other universities upon request. Notice as well the explicit Outcomes Assessment Assignment at http://umaine.edu/computingcoursesonline/files/2015/02/ACM-IEEEComCurQuestions.pdf that other universities may use as well in specific areas to ensure they meet the explicit requirements of accrediting bodies and the curricula suggested by professional bodies and agencies. Depending on the UMaine academic unit and personal preferences of faculty members, some professors impose more restrictive policies concerning their course materials but reasonable requests for sharing from other universities are almost always honored.

We also support a facility available to the world that provides ready access to the proceedings of most leading geospatial science academic conferences within the last decade. See http://giscienceconferences.org

Numerous graduate students have worked on geospatial projects engaging K-12 students and/or teachers and/or students. By example, PhD candidate Stacy Doore has worked extensively with local school districts implementing spatial thinking curriculum and mentoring high school students to use geospatial technologies in K-12 classrooms. For details see https://spatial.umaine.edu/docs/criterion1/. PhD candidate Matthew Dube served as volunteer research mentor during the past three summers for eleven Upward Bound Students from Maine and Massachusetts who attended Portland High, Oxford Hills Comprehensive, Stearns, Mattanawcook Academy, Bangor High, Central High, Mount View High, Lowell High, Lawrence High, Nokomis High, and Penobscot Valley High. These students developed individual research projects, published in UMaine's A Journal of Explorations. For authors and titles of the mentored projects see http://www.spatial.maine.edu/~matthew.dube/index_files/cv.htm.

b) Reciprocity of credits

The official policy of the University of Maine Graduate School (http://gradcatalog.umaine.edu/) states: A maximum of 6 hours of credit in the case of a master's candidate, and 30 hours beyond the bachelor's degree in the case of a doctoral candidate, may be accepted in transfer (subject to the approval of the candidate's advisory committee) for appropriate courses completed in residence at other institutions prior to matriculation in the Graduate School at The University of Maine. Courses to be accepted must have been taken at a fully accredited college or university that offers a graduate program, and must be acceptable at that institution in partial fulfillment of its requirements for an advanced degree.

There exist numerous instances of graduate students transferring up to 6 graduate course credits from other universities to our Spatial Information Science and Engineering Master's program and similarly transferring up to 24 course credits to our PhD program. Example graduate student transcripts with identifying information removed showing such transfer courses may be found here and here for the MS and here for the PhD.

The University of Maine System provides an online system for quickly verifying the transferability of courses from hundreds of universities and community colleges to the University of Maine and specifies the UMaine courses for which the transfers are equivalent. See http://www.maine.edu/transfer-students/transfer-course-equivalencies/(Create an account to access.) Geospatial Science faculty from

across campus continually assess the course transcripts of transferring students against the database and add further courses to the graduate course transfer list as appropriate.

c) Sponsorship or participation in state, regional, or national geospatial events/activities

Our list of professional outreach activities is long and the details and totality of geospatial professional activities may be observed in the public service sections of the supplied curriculum vitas of faculty members. A small sample of conferences germane to graduate education for which our faculty led or are leading the organization of the conference or on which they served on the organizing committee include: (1) COSIT 2015—Spatial Information Theory: Twelth International Conference, Santa Fe, NM, September, 2015, (2) Third IEEE International Workshop on Human Mobility Computing (HuMoComp 2015), Pittsburgh, PA, June 2015, (3) GeoRich 2015: Second International ACM SIGMOD Workshop on Managing and Mining Enriched Geo-Spatial Data, Melbourne, Australia, May 2015, (4) The 5th International Workshop on Location and the Web—LocWeb 2015, Florence, Italy, May 2015, (5) Advancing Geographic Information Science: The Past and Next Twenty Years, Bar Harbor Maine, June 2015, (6) 9th International Workshop on Modular Ontologies (WoMo 2015) at IJCAI 2015, Buenos Aires, Argentina, (7) GeoVoCamp, Reston, VA, December 2014, (8) Early Career Symposium at FOIS 2014, (d) 8th International Workshop on Modular Ontologies (WoMo 2014) at FOIS 2014, Rio de Janeiro, Brazil, (9) Spatial Cognition Conference, Bremen, Germany, 2014, (10) GSDI 14 and Africa GIS, Addis Ababba, Ethiopia, November, 2013.

d) Local or State Government Outreach

Illustrative university geospatial outreach activities by Spatial Informatics faculty members germane to graduate education involving local and state government include:

(1) Developed an Emergency Response and Logistics Tracking approach using wireless sensor technologies for the Maine National Guard and the Maine Emergency Management Agency.
(2) Conducted a spatial-temporal analysis and developed new visualization approaches for the Maine Department of Marine Resources on the shellfish bed water quality monitoring data
(3) Member of oversight committee for Project Login (http://www.projectlogin.com/) supporting internships in government and business for our SCIS undergraduate and graduate students
(4) Current co-chair of the University of Maine System Credit Transfer General Education Workgroup which is a state-wide group enhancing the transferability of university courses among and to the University of Maine campuses
(5) Participation in the state-wide Maine University-Business Information Technology and Computer Science Partnership which involves government, private sector and university representatives in enhancing technological education in the state including support for geospatial technologies

e) Community Outreach

The UMaine VEMI Lab is but one example of a geospatial facility that engaged over 700 people in tours this past year with visitors that included members of the local community, high school students, K-12 and community college teachers, college students from across campus and many members of the State Legislature. In addition to many informal tours, newsworthy open houses and scheduled demonstrations by this geospatial lab in 2014 alone included: **(1)** VEMI Lab Showcases Updated Virtual & Touch Devices. News piece by WFVX tv FOX 22, Oct 2014, **(2)** Wind Farm Simulation By Tamara Field, The Senator George J. Mitchell Center: Sustainability Solutions Initiative <news story link>, April 2014, **(3)** UMaine VEMI Lab combines research, technology, and friendship. Tour reported on by The Maine Campus, March 2014, **(4)** UMaine Students Show Off "Virtual Reality". News piece by WABI TV5, Feb 2014, **(5)** VEMI Lab on UMaine Campus Holds Open House. News piece by WVII ABC tv 7, Feb 2014. See the faculty vitas for examples of further community outreach activities including work that tracks bird flights through wind farms and work with farmers and blueberry growers.

Criterion 2: Center for Geospatial Science Education

Describe how your institution has a formal organizational structure such as a department, program of study or "Center" for GS Education, which serves as a resource for faculty and students. The term "Center" is used in a general sense and includes "departments," "laboratories," etc. The formal organizational structure should provide guidance on GS curriculum and programs, general GS information, and promote collaboration and interaction among students, faculty and related programs of study. The "Center" must be operational, dynamic and current.

Note: If any links below under Criterion 2 are inactive, see https://spatial.umaine.edu/docs/criterion2/

Background – The University of Maine, located in Orono, is the State's land-grant and sea-grant institution of higher education and as such conducts research across many disciplines to benefit Maine citizens and the nation as a whole. The Carnegie Foundation for the Advancement of Teaching classifies it as a "Doctoral Extensive" university, which is the highest classification. It is Maine's largest university and Maine's most comprehensive liberal arts and science-based research university. It has 9,182 undergraduates, 2,065 graduate students, and 683 full- and part-time faculty.

a) Geospatial Sciences Center Description

The **School of Computing and Information Science** (SCIS) (http://www.umaine.edu/scis) is the academic organizational unit and primary center supporting geospatial sciences graduate education including Master's and PhD degrees in Spatial Information Science and Engineering, a Graduate Certificate in Geographic Information and the MS and Graduate Certificate in Information Systems (http://spatial.umaine.edu). A proposal for a new MS degree in Spatial Informatics will be considered by the Board of Trustees later this spring.

The Spatial Informatics Faculty with seven full-time Graduate Faculty (http://spatial.umaine.edu/faculty) is a formally recognized faculty group within SCIS supporting these graduate programs. All Spatial Informatics Faculty members are also affiliated with the **National Center for Geographic Information and Analysis (NCGIA)** (http://umaine.edu/ncgia). NCGIA is a research consortium of UC Santa Barbara, the University at Buffalo, and the University of Maine established through an NSF award in 1988. At UMaine, NCGIA is a formally recognized and administratively supported research center (http://umaine.edu/research/centers-and-institutes) and as such the organizational center for advanced research on geospatial science topics at UMaine.

b) Operational, Dynamic, and Current

A general resource and information page for SCIS students is at http://umaine.edu/scis/students. News and featured articles about spatial informatics activities and events are available through the SCIS homepage (see http://umaine.edu/scis/news/news-events and http://umaine.edu/scis/news/features). In addition, anything posted to these forums is automatically posted to SCIS and Spatial Informatics Facebook and Twitter Accounts. By example, over 200 current, potential and past graduate students are subscribers to the Spatial Informatics Facebook page (https://www.facebook.com/pages/Spatial-Informatics-CIS-University-of-Maine/194292035306) and receive regular updates of activities and upcoming events. We also have a YouTube playlist for the department for posting videos of spatial informatics student projects and faulty presentations (https://www.youtube.com/playlist?list=PL855D83B3E2407CC5). A search of the Spatial Informatics web pages will divulge additional links to numerous related resources. By example, https://spatial.umaine.edu/applied-gis-courses-and-projects provides a list of applied geospatial science courses offered across the campus as well as a list of recent illustrative student and faculty projects.

c) Geospatial Journal Availability

Fogler Library, the largest library in the state, is designated as the state's Science, Technology, and Business Library, and has developed an extensive Web portal of electronic resources. All enrolled students, whether sitting on campus or taking courses at a distance from across the country have remote access using their student ID to the full and comprehensive journal collections of the library as well as to its numerous research databases. To view the breath of geospatial journals available to UMaine students

and faculty through Fogler Library, see the results at https://spatial.umaine.edu/geospatialjournals/ of a few geospatial keyword searches on the library collections. Hundreds of geospatial journals are shown.

For examples of courses that link students directly to their reading assignments see the syllabi for SIE 510 (password= polygon) (http://umaine.edu/computingcoursesonline/sie510/lectures-and-assignments-510/) and SIE 525 (http://umaine.edu/computingcoursesonline/sie525/lectures-and-assignments-525/).

d) Physical and/or virtual facilities

The general learning environment for the SCIS graduate programs is steeped in current technology. Students can easily access electronic mail, library resources, and course material over a campus-wide wireless network. SCIS students have access to state-of-the-art software in several laboratories. The University of Maine has educational site licenses for Oracle Spatial, a wide variety of state of the art GIS software including many Esri products, as well as a suite of open source web server and web application software. Compilers and software development environments for the common programming languages include C++, Java and the School promotes the use of open source software such as Linux and Eclipse, and mySQL. A robust research program ensures that the existing facilities remain up-to-date and that their capability is extended as new technology becomes available. SCIS facilities relevant to graduate courses include:

• *The Geosensor Networks Laboratory* (GSN) [https://geosensornetworks.wordpress.com/research/] has been funded through several projects supported by NGA, NASA and NSF. Its mission is to establish a test bed infrastructure for the development of information technology for sensor-rich environments. The laboratory includes a cluster of 8 state of the art PCs and is equipped 20 motes and extensive software packages. Syllabus links to classes requiring use of this lab in assignments: SIE 555, SIE 557, SIE 559

• *The Virtual Environment and Multimodal Laboratory* [http://www.vemilab.us/] is highly interdisciplinary, combining theories and principles from psychophysics, perception, cognitive neuroscience, and interface design to study multimodal spatial cognition and to develop human optimized spatial displays. The Lab supports extensive fully immersive virtual reality systems with multiple channels of sensory input/output. Syllabus links to classes requiring use of this lab in assignments: SIE 515, SIE516, SIE 598sln

• The *Robot Interaction Laboratory* focuses on human robot interaction research, aspects of mobile agent control, and people tracking. Equipped with two mobile robots and several laser range finders, projects in the lab investigate assistive technologies for sensor-based spatial descriptions for blind users, and natural-language based robot command interfaces. Syllabus links to classes requiring use of this lab in assignments: SIE 570, SIE 571

• SCIS State-of-the Art *Distance Education Equipment* - Three classrooms within SCIS include high-resolution web cameras, web-based Adobe Connect Pro software, microphone and audio system for interactive distance education and recording of class sessions. The majority of our graduate classes make use of these facilities.

• *General SCIS Computing Laboratory* - 25 Dell Optiplex 755 Minitower Systems with Intel Core2Quad Q6700 2.66 Ghz , 4GB of RAM, and 250GB SATA Hard Drives, Scanner, Esri ArcIMS (Internet Map Server), 2 Printers: 1 HP Laserjet 5000; 1 HP color jet 4450, Network connections: 100mps Ethernet. Syllabus links to classes requiring use of this lab in assignments: SIE 507, SIE 509

Further details on facilities may be found at each of the lab links and at http://spatial.umaine.edu/facilities-and-resources/

Student Projects - Numerous videos by grad students about their projects using our facilities are posted at http://umaine.edu/scis/graduate-student-project-videos/ Past graduate student thesis and dissertation topics are listed at http://umaine.edu/scis/graduate-student-theses/ with links to the full electronic text of many. Links to illustrative student research projects and papers produced using our lab facilities are reported under criterion 5.

Criterion 3: Robust and Active Geospatial Science Academic Program

Demonstrate how students successfully participate in the academic program requirements aligned to GS curriculum that map to the CAE KUs. Use up to one additional page for this criterion, if needed:

Note: If any links below under Criterion 3 are inactive, see https://spatial.umaine.edu/docs/criterion3/

a) Geospatial Science Curriculum

The requirements for the following geospatial science graduate programs are contained in the official 2014-2015 University of Maine Graduate Catalog as indicated through the following links:

- MS Spatial Information Science and Engineering (Thesis Option: 24 credits of graduate coursework and 6 thesis credits, Project Option: 27 credits of graduate coursework & 3 credit project course) - http://gradcatalog.umaine.edu/preview_program.php?catoid=29&poid=3496&returnto=489
- PhD Spatial Information Science and Engineering (42 credits of specified graduate coursework and 6 thesis credits) - http://gradcatalog.umaine.edu/preview_program.php?catoid=29&poid=3496&returnto=489
- Graduate Certificate in Geographic Information Systems (15 cr of specified graduate coursework) - http://gradcatalog.umaine.edu/preview_program.php?catoid=29&poid=3454&returnto=489

Please note in section II of this application that students in the MS and PhD programs are able to include within their programs of study all of the CAE core KUs and a minimum of five optional KUs.

A typical example of an appropriate set of courses for the **MS degree (Project Option)** meeting both the CAE and University requirements would be:

SIE 507	Information Systems Programming (3 cr)
SIE 510	GIS Applications (3 cr)*
SIE 512	Spatial Analysis (3 cr)*
SIE 525	Information Systems Law (3 cr)*
SIE 555	Spatial Database Systems (3 cr)*
SIE 571	Pattern Recognition & Robotics (3 cr)*
SIE 589	Graduate Project (3 cr)
SIE xxx	Electives (9 cr – typically three 3 cr courses)

The total shown equals 30 credits. The courses shown with an * cover all Center of Excellence Core Areas plus six Focus Areas as documented later in this application. The additional courses shown in the list above are required to meet the degree requirements and they provide additional coverage of KUs.

A typical example of an appropriate set of courses for the **MS degree (Thesis Option)** meeting both the CAE and University requirements would be:

SIE 501	Introduction to Graduate Research (1 cr)
SIE 502	Research Methods (1 cr)
SIE 503	Principles of Experimental Design (1 cr)
SIE 507	Information Systems Programming (3 cr)
SIE 510	GIS Applications (3 cr)*
SIE 512	Spatial Analysis (3 cr)*
SIE 525	Information Systems Law (3 cr)*
SIE 555	Spatial Database Systems (3 cr)*
SIE 571	Pattern Recognition & Robotics (3 cr)*
SIE 693	Graduate Seminar (1 cr)
INT 601	Responsible Conduct of Research (1 cr)
SIE 699	Thesis (5 cr)
SIE xxx	Elective (2 cr min)

The course requirements for the PhD in meeting the Center of Academic Excellence requirements as well as the program degree requirements are met by the same set of courses listed above in the MS (Thesis Option) except that additional breadth courses are required and the student must complete a total of seventeen additional course credits to meet the degree requirement. This comes to a minimum of 54 course and thesis credits. A minor degree needs to be pursued of at least nine credits within these parameters.

Notice that the MS (Project Option) and the PhD programs offer students greater leeway to concentrate in a Focus Area or add courses in pursuit of specific geospatial science interests.

Illustrative transcripts of students taking a geospatial science curriculum path that includes all Core and the six Focus Area Knowledge Units are here (SIE 510 is not shown due to similar course content coverage in undergrad program) and here (SIE 555 not shown due to similar content in background). We cannot show MS transcripts meeting all of the requirements because (a) most current students pursue a thesis option research path with a much more constrained research program and (b) recent course revisions and number changes as a result of bringing on new faculty make older transcripts difficult to assess against the KUs.

Students entering our graduate program come from wide ranging undergraduate programs and students already acquiring KUs at the undergraduate level are not required to meet those requirements again at the graduate level. Further, graduate education is not so much about training in certain skills as it is about advancing and expanding the knowledge base of geospatial science through research and exploratory analysis and discovery. Some students may be interested in a research specialization that might not encompass each and every NGA/USGS core and optional units but would cover a specialization in far greater depth than specified by wider ranging knowledge units.

b) Students Receive Certificate, Degree or Other Reference on Transcript in Focus Areas

The UMaine courses covering Knowledge Units within the CAE Focus Areas are documented later in this application and details are at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf

Information Science Focus Area - A graduate student that includes the following graduate courses in their program of study satisfies the knowledge unit requirements for meeting the NGA/USGS defined Focus Area of Information Science:

SIE 510 GIS Applications (3 cr) *
SIE 512 Spatial Analysis (3 cr)*
SIE 550 Design of Information Systems (3 cr)
SIE 558 Data Stream Management Systems (3 cr)
SIE 571 Pattern Recognition & Robotics (3 cr)*

Because three of these courses (with *) are already required to cover CORE KUs, SIE 550 and SIE 558 are the only additional courses required by a graduate student in the program to fulfill the requirements of the *Information Science Focus Area*.

Navigation and Location Focus Area - A graduate student that includes the following graduate courses in their program of study satisfies the knowledge unit requirements for meeting the CAE Focus Area of Navigation and Location:

SVT 437 Practical GPS
SVT 541 Geodesy

Because only two additional UMaine courses are required to fulfill the requirements of either of these Focus Areas, it should be obvious from Section a) that a student could take these courses as two out of the three elective courses in their MS (Project Option) program of study.

It should be obvious also that a PhD student with 17 additional course credits required beyond meeting the Core and Focus Area Knowledge Units and meeting all other mandatory courses imposed by the School could add at least one if not both of the above Focus Areas to their program of study.

Students pursuing the MS in Spatial Information Science and Engineering might need to go beyond the minimum credits required for the degree in order to fully complete all courses within the Information Science and Navigation and Location Focus Areas.

Comment: Just as it would be inappropriate to designate a specialty on a graduate degree in electrical engineering, business, law, or English, it would be inappropriate as well and against academic traditions and policies at the graduate level to designate a subspecialty on a MS or PhD degree in Spatial Information Science and Engineering. Most universities don't even have a mechanism for indicating such a specialty at the graduate level. Rather, all research focused graduate students specialize in topics germane to their thesis research and the specialty of their research thesis or dissertation speaks for itself. Further, the course work listed on a graduate transcript speaks for itself.

Criterion 4: Geospatial Science is Multidisciplinary within the Institution
Demonstrate that GS is not treated as a separate discipline at your institution, but as a multidisciplinary science with the body of GS knowledge incorporated into various disciplines, such as geography, engineering, environmental management, etc. See the NGA-USGS CAE in Geospatial Science Education Program Criteria for specific items to be addressed.

Note: If any links below under Criterion 4 are inactive, see https://spatial.umaine.edu/docs/criterion4/

a) Geospatial Science Teaching in Non-geospatial Science Courses for Non-geospatial Science Students

Non-geospatial science courses taught at the University of Maine which non-geospatial science students take that introduce them to geospatial science knowledge and methods include those listed in the following table. For all courses in the table, the official university catalog descriptions for undergraduate courses may be found through a search at http://catalog.umaine.edu/index.php?catoid=62# while the official catalog descriptions of graduate courses may be found through a search at http://gradcatalog.umaine.edu/. The following table also resides on the web at https://spatial.umaine.edu/applied-gis-courses-and-projects/.

Course Number	Course Title & Link to Official Catalog Description	Location technologies or software learned or used by students
I. Undergraduate Courses		
ERS 230	Geomatics for Earth Sciences	GNSS; GIS, remote sensing
ERS350	Freshwater Flows	Google Earth, Web Soil Survey
SFR 205	Forest Measurements	MapInfo
SFR208	Geomatics GPS and Coordinate Geometry	Trimble Pathfinder office, Trimble terrasync & MapInfo
SFR211	Introduction to Forest Operations Planning	Softree – Road EngGarmin GPS
SFR300	Field Practice in Forest Resources	Garmin GPS
SFR400	Applied Geographic Information Systems	ArcGis, MapInfo, Global Mapper, Trimble Pathfinder, Trimble terrasync, DNR Garmin
SFR 402	Advanced Forest Measurements	ArcGIS
SFR 406	Remote Sensing Image Interpretation & Forest Mapping	Nutting 254
SVT 331	Photogrammetry	GPS, remote sensing
SVT 352	Practical Field Operations	GIS, GPS, remote sensing
SVT 437	Practical GPS	GIS, GPS
SVT 490	Surveying Capstone	GIS, GPS
II. Graduate Courses		
ERS588	Freshwater Flows – graduate w/independent project	ArcGIS
INT 527	Integration of GIS and Remote Sensing in Natural Resources Applications	ERDAS Imagine, ArcMap
SFR 609	Remote Sensing Special Problems	Nutting 254
SMS 540	Satellite Oceanography	Terascan, MATLAB
SVT 501	Advanced Adjustment Computations	GPS, Remote Sensing
SVT 511	Geodetic Computations in the U.S. Public Land Survey System	GIS, GPS
SVT 531	Advanced Digital Photogrammetry	GIS, GPS, Remote Sensing
SVT 532	Survey Strategies in the Use of Lidar	GIS, GPS, Remote Sensing
SVT 541	Geodesy	GIS, GPS

b) Non-geospatial Science Courses Encourage Papers or Projects in Geospatial Science Topics

Recent illustrative projects affiliated with graduate courses or research in non-geospatial degree departments making substantial use of GIS, GPS or closely related location, tracking or mapping technologies are as follows:

Application of Spatial Modeling Tools to Predict Native Bee Abundance in Maine's Lowbush Blueberries, Shannon J. Chapin, 2014
http://digitalcommons.library.umaine.edu/etd/2112/

Evaluation of airborne LiDAR as a tool for obtaining sustainable forest management of Maine's forest. MS Thesis. University of Maine, School of Forest Resources, Hayashi, R. 2014
https://spatial.umaine.edu/files/2015/02/HayashiEvaluation.pdf

Maine Futures Community Mapper, University of Maine Research Team: Spencer Meyer, Christopher Cronan, Michelle Johnson, Rob Lilieholm, David Owen, Thomas Parr, 2015
http://www.MaineLandUseFutures.org

Development and Application of a Patch-Scale Bayesian Network – Cellular Automata Model for Exploratory Land Use Scenarios at a Regional Extent, Michelle Meyer, 2014,
http://www.nrel.colostate.edu/projects/gnu/

Development of a web-based tool for grower assessment of native bee abundance in the wild blueberry production landscape. Report from Brianne Du Clos (Ph.D Student); Dr. Sam Hanes, Department of Anthropology; Dr. Cyndy Loftin, USGS Coop Research Unit and Professor WLE; and Dr. Frank Drummond, 2014
https://spatial.umaine.edu/files/2015/02/DuClosDevelopment.pdf

Projected Future Fencing South of Nairobi National Park (Gnu Landscapes Policy Brief No 2), Effects of Unplanned Development in the Region South of Nairobi National Park (No 3), Projected 2035 Development and Fencing for the Region South of Nairobi National Park (No 4), Planning Tools for Managing Growth in the Region South of Nairobi (No 5), Rob Lilieholm, Univ of Maine, April 9, 2014
https://spatial.umaine.edu/files/2015/02/LilieholmBrief2.pdf,

Genetic diversity of *Vaccinium angustifolium* in managed and non-managed populations throughout its geographic range, Lee Beers, Frank Drummond and Jeannie Rowland, University of Maine, 2014
https://spatial.umaine.edu/files/2015/02/BeersDiversity.pdf

Using hydrologic measurements to investigate free phase gas in a Maine peatland, Christiaan Bon, 2013
http://digitalcommons.library.umaine.edu/etd/1923/

Biogeography and phenology of satellite-measured phytoplankton seasonality in the California current, Nicholas P. Foukal and Andrew C. Thomas, 2013
http://dx.doi.org/10.1016/j.dsr.2014.06.008

Effects of Water on Ice: A Remote Sensing Investigation, W.A. Sneed (PhD), 2013
http://digitalcommons.library.umaine.edu/etd/2053/

Wild Bee (Hymenoptera: Apoidea) Communities Associated with the Lowbush Blueberry Agroecosystem of Maine, Sara L. Bushmann, 2013
http://digitalcommons.library.umaine.edu/etd/2062/

Watershed Nitrogen and Mercury Geochemical Fluxes Integrate Landscape Factors in Long-term Research Watersheds at Acadia National Park, Maine, USA, J. S. Kahl et al, 2013
https://spatial.umaine.edu/files/2015/02/KahlWatershed.pdf

Reeve, A.S., P. H. Glaser and D. O. Rosenberry. 2013. Seasonal changes in peatland surface elevation recorded at GPS stations in the Red Lake Peatlands, northern Minnesota, USA. Journal of Geophysical Research: Biogeosciences 118:1616-1626.
http://onlinelibrary.wiley.com/doi/10.1002/2013JG002404/abstract

A longer list is accessible through the Supplemental Docs web page. Further, a table listing a different mix of projects accomplished by other campus programs that also lists geospatial location technologies and software used may be found at https://spatial.umaine.edu/applied-gis-courses-and-projects/.

Criterion 5: Student-based Geospatial Science Research

Describe how your institution encourages **student** research in GS. Research should relate back to one or more of the KUs. See the NGA-USGS CAE in Geospatial Science Education Program Criteria for specific items to be addressed.

Note: If any links below under Criterion 5 are inactive, see https://spatial.umaine.edu/docs/criterion5/

Pursuit of fundamental research is highly embedded within the courses and projects of the graduate program. As indicated earlier in this application, all students pursuing a thesis at the master's level or a dissertation at the PhD level are required to take the following additional research methods courses:

SIE 501 Introduction to Graduate Research (1 cr)
SIE 502 Research Methods (1 cr) (syllabus link)
SIE 503 Principles of Experimental Design (1 cr) (syllabus link)
SIE 693 Graduate Seminar (1 cr)
INT 601 Responsible Conduct of Research (1 cr) (syllabus link)

These one-credit courses are spread throughout two years or graduate study so that students are able to apply what they learn as they develop their thesis projects from inception through to completion.

Students pursuing the Masters (Project Option) are encouraged as well by their advisers to pursue applied geospatial science research particularly in support of advancing science in other disciplinary domains across the campus but as well in support of government and business.

a) Program with geospatial focus has thesis, dissertation, student paper or independent research project requirements.

An extensive list of Master's theses and PhD dissertations in Spatial Information Science and Engineering is available at http://umaine.edu/scis/graduate-student-theses/

Links to the full text of ten illustrative theses and/or required course research projects produced within the past three years are as follows:

1. Kesavan, Saranya, Indoor Scene Knowledge Acquisition Using Natural Language Descriptions
   https://spatial.umaine.edu/files/2015/02/1KesavanIndoor.pdf
2. Palani, Hari Prasath, Making Graphical Information Accessible Without Vision Using Touch-Based Devices
   https://spatial.umaine.edu/files/2015/02/2PalaniGraphicalInfo.pdf
3. O'Shaughnessy, Brendan Daniel, Depth Sensing Planar Structures: Detection Of Office Furniture Configurations
   https://spatial.umaine.edu/files/2015/02/3OShaughnessyDepth.pdf
4. Jain, Shreyans, Assessment of Audio Interfaces for Use in Smartphone Based Spatial Learning Systems
   https://spatial.umaine.edu/files/2015/02/4JainAssessment.pdf
5. Kaim, Luke, Feature Similarity Metrics for Integrating Volunteered Geographic Information (VGI)
   https://spatial.umaine.edu/files/2015/02/5KaimFeatureSim.pdf
6. Venkatesan, Balaji, Feasibility Study of Continuous Real-Time Spatial Interpolation Of Phenomena Using Built-In Functionlity of a Commercial Data Stream Management System
   https://spatial.umaine.edu/files/2015/02/6BalajiFeasibility.pdf
7. Doore, Stacy, Representing dynamic context dependencies in spatial prepositions as used in natural language indoor scene descriptions and object localizations
   https://spatial.umaine.edu/files/2015/02/7DooreContextDepend.pdf
8. Dube, Mathew, Qualitative Topological Determination from Metric Information
   https://spatial.umaine.edu/files/2015/02/8DubeMetricToTopololgy.pdf
9. Lewis, Joshua, iNotation
   https://spatial.umaine.edu/files/2015/02/9LewisiNotation.pdf
10. Mudannayake, Pathum, Semantic Topological Change
    https://spatial.umaine.edu/files/2015/02/10PathumSemanticTopology.pdf

b) Geospatial sciences courses that require research papers or projects.

Geospatial science graduate courses that require a research paper or project include:

SIE 510 - GIS Applications
Syllabus: http://spatial.umaine.edu/files/2015/02/SIE510Syllabus.pdf

SIE 512 – Spatial Analysis
Syllabus: http://spatial.umaine.edu/files/2015/02/SIE512Syllabus.pdf

SIE 515 - Human Computer Interaction
Syllabus: http://spatial.umaine.edu/files/2015/02/SIE515Syllabus.pdf

SIE 554 – Spatial Reasoning
Syllabus: http://spatial.umaine.edu/files/2015/02/SIE554Syllabus.pdf

SIE 693 - Graduate Seminar
Syllabus: http://spatial.umaine.edu/files/2015/02/SIE693Syllabus.pdf

Links to the full text of ten illustrative project papers produced within these courses within the past three years are as follows:

1. SIE510 - Bird, Kendra, Using Python to Calculate Spatial Locations of Cataloged Archaeological
   https://spatial.umaine.edu/files/2015/02/1-BirdUsing.pdf
2. SIE510 - Sims, Meagan, Watershed Analysis of York County
   https://spatial.umaine.edu/files/2015/02/2SimsWatershed.1.pdf
   https://spatial.umaine.edu/files/2015/02/2SimsWatershed.2.pdf
   https://spatial.umaine.edu/files/2015/02/2SimsWatershed.3.pdf
3. SIE510 - Sturtevant, Luke, FEMA Floodplain Mapping
   https://spatial.umaine.edu/files/2015/02/3SturtevantFEMA.pdf
4. SIE515 - Navneet Jain, Luke Kaim, Ben Maynard, Navigation Aids for the Elder Population: 'Never Lost'
   https://spatial.umaine.edu/files/2015/02/4JainEtAlNavigation.pdf
5. SIE515 - Berube, Eric, Luke Sturtevant, and Lydia Chang, Smart Homes for the Aging
   https://spatial.umaine.edu/files/2015/02/5BerubeEtAlSmart.pdf
6. SIE515 - Perry, Raymond, Using Mobile Devices for Indoor Spatial Awareness
   https://spatial.umaine.edu/files/2015/02/6PerryIndoor.pdf
7. SIE 693 - Jain, Navneet, The Physical Internet Routing Model
   https://spatial.umaine.edu/files/2015/02/7NavneetPhysical.pdf
8. SIE 693 - Palani, Hari Prasath, Assistive Technology for Visually-Impaired People in Accessing Graphical Material Using Touch-Based Devices
   https://spatial.umaine.edu/files/2015/02/8HariAssistive.pdf
9. SIE 693 - Plummer, Mark, Problems with Fields as Functions
   https://spatial.umaine.edu/files/2015/02/9PlummerProblems.pdf
10. SIE 693 - Xu, Fuyu (Frank), Convex Hull-Based Metric Refinements for Topological Spatial Relations
    https://spatial.umaine.edu/files/2015/02/10XuMetric.pdf

Criterion 6: Number of Geospatial Science Faculty and Course Load
Describe the composition of the Geospatial Science faculty at your institution. List all full-time Geospatial Science faculty members and additional faculty members (part-time, adjunct, visiting professor, etc.) teaching at least one Geospatial Science course. Provide a short (one page or less) synopsis of the CV or biography here and links to the full biographies or curriculum vita for each faculty member. See the NGA/USGS CAE in Geospatial Science Education Program Criteria for specific items to be addressed.

Note: If any links below under Criterion 6 are inactive, see https://spatial.umaine.edu/docs/criterion6/

a) Full-time employees with overall responsibility for the geospatial sciences programs
Dr. Max Egenhofer, Director, School of Computing and Information Science and Professor of Spatial Informatics is responsible for the overall supervision of the academic graduate degrees in Spatial Information Science and Engineering as well as the overall management of the School.

Short Biography: Dr. Egenhofer has made numerous, highly significant research contributions to geographic information science. Many of his research results on spatial relations and the spatial query languages are commonplace in commercial geographic information systems and have been embedded as key ingredients in international standards. In these standards, the topological relations that derive from his 9-intersection model are often referred to as the "Egenhofer relations." Dr. Egenhofer is a Fellow of UCGIS, the 2003 UCGIS Researcher of the Year, and the 2002 recipient of the University of Maine's Presidential Research and Creative Achievement Award.

Background and Numbers: Dr. Egenhofer has authored or co-authored 53 articles in refereed journals, 81 papers in fully refereed conference proceedings, 13 book chapters, 56 papers in non-refereed journals or conference proceedings, and edited 12 books. He chaired or co-chaired 23 conferences and workshops, and served on the program committees of over 130 conferences. As first advisor he has supervised to completion 17 PhDs and 29 Masters, and has mentored 13 post-doctoral advisees. According to citation counts by Google Scholar, Dr. Egenhofer has published the most frequently cited papers in the *International Journal of Geographical Information Science*, in *Transactions in GIS*, in *Geomatica*, in the *COSIT* conference series, and in the *Spatial Data Handling* conference series. His research was funded by 49 grants from NSF, NGA (and its predecessor NIMA), CIA, NASA, NIH, NATO, the Advanced Research Project Agency, the Air Force Research Laboratory, Digital Equipment Corporation, ESRI, GE Corporate R&D Center, Intergraph Corporation, Lockheed-Martin Management and Data Systems, Space Imaging Inc., Bangor Hydro-Electric Co., and the Maine Mathematics and Science Alliance, totaling over $17Mio.

Full CV at http://spatial.maine.edu/files/2015/02/EgenhoferCV.pdf
Dr. Kate Beard-Tisdale, Director of NCGIA and Professor of Spatial Informatics is responsible for the direction of the National Center for Geographic Information and Analysis at the University of Maine which is a formally recognized research center on the campus.

Short Biography: Dr. Beard has an extraordinary record of accomplishment in advancing geographic information science, expanding and strengthening geographic information science education, and in building communities and networks to foster multi-disciplinary geographic information science research and education. Among the awards she has received at the University of Maine recognizing her research and teaching accomplishments have included the 2014 Presidential Research and Creative Achievement Award (highest research award on the campus), the 2014 Outstanding Faculty in Research/Creative Achievement Award (highest research award by that College), the 2014 ADVANCE Career Recognition Award from the University of Maine's Rising Tide Center (in recognition of her leadership among women faculty, the 1999 Ashley Campbell Award of the College of Engineering (highest academic and research award by that College). She has also been nationally and internationally recognized with the 2002 Earle J. Fennel Award for Outstanding Contribution to Surveying and Mapping Education and the 2002 Land Victoria Fellowship of the University of Melbourne, Australia.

Background and Numbers: Dr. Beard has authored or co-authored 37 articles in refereed journals and fully refereed conference proceedings, 12 book chapters, and 26 papers in non-refereed conference proceedings. She has served as principal investigator, co-principal investigator, or senior personnel on 36 research and training grants as PI, co-PI, or Senior Personnel totaling over $5 million awarded during the past 5 years, and with a career total of over $10 million funded by NSF, the Department of Defense, the NGA, and USGS. As first advisor, she has advised to completion 7 Ph.D. students and 27 master's degree students. As a testament to the breadth of her expertise and interdisciplinary scope, she has also served on the committee of 21 Ph.D. students in Spatial Information Science and Engineering and on 19 Ph.D. committees and 9 MS committees outside of her core disciplinary unit. These impressive numbers are complemented by the breadth and quality of her research work, her insightful achievements, and her ability to mobilize and lead teams of researchers and students in achieving the advancement of geographic information science.

Full CV at http://spatial.maine.edu/files/2015/02/BeardCV.pdf

b) Additional full-time geospatial science faculty members

The following listed persons are additional full-time members of the Spatial Informatics Faculty within the School of Computing and Information Science at the University of Maine. All faculty members are fully engaged in research and each carries a typical course load of two courses one semester and one course the other semester.

Dr. Nicholas Giudice, Associate Professor of Spatial Informatics – Full CV at http://spatial.maine.edu/files/2015/02/GiudiceCV.pdf

Dr. Torsten Hahmann, Assistant Professor of Spatial Informatics – Full CV at http://spatial.maine.edu/files/2015/02/HahmannCV.pdf

Dr. Reinhard Moratz, Associate Professor of Spatial Informatics – Full CV at http://spatial.maine.edu/files/2015/02/MoratzCV.pdf

Dr. Silvia Nittel, Associate Professor of Spatial Informatics – Full CV at http://spatial.maine.edu/files/2015/02/NittelCV.pdf

Dr. Harlan Onsrud, Professor of Spatial Informatics and Graduate Coordinator – Full CV at http://spatial.maine.edu/files/2015/02/OnsrudCV.pdf

c) Inter-departmental faculty teaching GS courses

The following University of Maine faculty members teach courses with primarily geospatial content or substantial geospatial content that are acceptable for inclusion on graduate programs of study for graduate students pursuing graduate degrees in Spatial Information Science and Engineering.

Dr. Raymond Hintz, Professor of Surveying Engineering Technology - CV at http://spatial.maine.edu/files/2015/02/HintzCV.pdf

Dr. Connie Holden, Professor of Developmental Math and Science, University of Maine at Augusta, Bangor Campus and Lecturer in UMaince SCIS - CV at http://spatial.maine.edu/files/2015/02/HoldenCV.pdf

Dr. Brian McGill, Assoc. Professor of Biology and Ecology – CV at http://spatial.maine.edu/files/2015/02/McGillCV.pdf

Dr. Steven Sader, Professor of Forest Resources – CV at http://spatial.maine.edu/files/2015/02/SaderCV.pdf

Dr. Andrew Thomas, Professor of Marine Sciences – CV at http://spatial.maine.edu/files/2015/02/ThomasCV.pdf

Dr. Yifeng Zhu, Assoc. Professor, Electrical and Computer Engineering – CV at http://spatial.maine.edu/files/2015/02/YifengCV.pdf

These professors support additional graduate degrees within their own domains that contain substantial geospatial science knowledge content such as graduate degrees in Forestry (with emphasis on Remote Sensing and GIS Applications), Marine Sciences and Engineering/Business (with emphasis on Photogrammetry and Geodetic Computations). Some of the additional geospatial technology courses supporting students in a variety of branches of science found in these other programs are listed at https://spatial.umaine.edu/applied-gis-courses-and-projects

Criterion 7: Active Faculty in Current GS Practice and Research

Describe how your institutions geospatial science faculty members are active in current GS practice and research, contribute to GS literature, are members in GS professional societies, are subject matter experts or attend/present at professional GS conferences.

Note: If any links below under Criterion 7 are inactive, see https://spatial.umaine.edu/docs/criterion7/ Due to the page limit, **a more extensive listing in each category** below is provided at this url. Consult also the full CVs of Spatial Informatics faculty for even more numerous entries in each of the categories.

a) Peer reviewed publications on geospatial topics in refereed journals or conference proceedings

In the past 3 years. each of our faculty members has typically published multiple peer-reviewed articles.

Beard K. and Neville M., 2014, A Place and Event Based Context Model for Environmental Monitoring. In: H. Huang, J. Hahn, C. Claramunt, and T. Reichenbacher (Eds.) Proceedings of the 1st International Workshop on Context-Awareness in Geographic Information Services (in conjunction with GIScience 2014). pp. 3-16. <Full Text>

G. Camara, M. Egenhofer, K. Ferreira, P. Andrade, G. Queiroz, A. Sanchez, J. Jones, and L. Vinhas, Fields as a Generic Data Type for Big Spatial Data, in: M. Duckham, E. Pebesma, K. Stewart, and A. Frank (eds.), Geographic Information Science-Eighth International Conference, GIScience 2014, Vienna, Lecture Notes in Computer Science, Vol. 8728, pp. 159-172, September 2014. <Full Text>

Giudice, N.A., Klatzky, R.L., Bennett, C.R., & Loomis, J.M. (2013). Combining locations from working memory and long-term memory into a common spatial image. Spatial Cognition and Computation. 13(2), 103-128 <Full Text>

T. Hahmann and M. Gruninger: Complementation in representable theories of region-based space. Notre Dame Journal of Formal Logic 54(2), 38 pages, 2013. <Full Text>

Mossakowski, Moratz, R., Luecke, D.: Relations Between Spatial Calculi About Directions and Orientations, *Journal of Artificial Intelligence Research*, [status: in press, 2015. <Full Text>

Whittier, J.C., Liang, Q., and Nittel, S., "Evaluating Streaming Predicates over Dynamic Fields", Proceedings of 5th International Workshop on "Geostreaming" in conjunction with ACM SIGSPATIAL International Conference on Advances in GIS, Dallas, TX, 2014. <Full Text>

Campbell, James and Harlan Onsrud, 2014, Desirable Characteristics of an Online Data Commons for Locally Generated Spatial Data from Disparate Contributors, *URISA Journal 26(1), 35-43* <Text>

b) Published books or chapters of books on geospatial topics within the last 5 years

(i) Book Chapters

Beard K., 2014, Visualization of Uncertainty. In: D. Richardson (Ed.) International Encyclopedia of Geography: People, the Earth, Environment, and Technology. Wiley-AAG, in press.

M. Egenhofer, Qualitative Spatial-Relation Reasoning for Design, in: J. Gero (ed.), Studying Visual and Spatial Reasoning for Design Creativity, Springer Science+Business Media, pp. 153-175, 2015.

Loomis, J.M., Klatzky, R.L., & Giudice, N.A. (2013). Representing 3D space in working memory: Spatial images from vision, touch, hearing, and language. In S. Lacey & R. Lawson (Eds). *Multisensory Imagery: Theory & Applications* (pp. 131-156). New York: Springer.

T. Hahmann and M. Gruninger: Region-based Theories of Space: Mereotopology and Beyond. In: Qualitative Spatio-Temporal Representation and Reasoning: Trends and Future Directions, ed. by S. M. Hazarika, IGI Publishing. 62 pages, 2012.

Winterboer, A., Tenbrink, T., Moratz, R.: Spatial Directionals for Robot Navigation. In: Dimitrova-Vulchanova , M., van der Zee, E. (Eds.), *Motion Encoding in Language and Space*, pages 84-100, Oxford University Press, Oxford, 2012.

S. Nittel, "Geosensor Networks", in Handbook of Geographic Information , Ed: W. Kresse, Springer, Wolfgang Kresse, 2012.

(ii) Books

K. Baclawski, T. Groza, T. Hahmann , I. Varzinczak (Eds.): Proceedings of the 8th Int. Workshop on Modular Ontologies (WoMO 2014). CEUR Workshop Proceedings Vol. 1248 (ceur-ws.org), 2014.

C. Del Vescovo, T. Hahmann , D. Pearce, D. Walther (Eds.): Proceedings of the 7th Int. Workshop on Modular Ontologies (WoMO 2013). CEUR Workshop Proceedings Vol. 1081 (ceur-ws.org), N 2013.

Onsrud, Harlan and Abbas Rajabifard, Eds, *Spatial Enablement in Support of Economic Development and Poverty Reduction* (GSDI Association Press) 2013, http://www.gsdi.org/openaccessbooks

c) Faculty involved in Writing Grants on Geospatial Topics

The Spatial Informatics faculty members have been consistently successful in acquiring grants on wide ranging fundamental geospatial topic. They generated and were engaged on ten funded grants during the past three years. Three among them included: **(1)** Strengthening the scientific basis for decision-making: Advancing sustainability science and knowledge-action capacities in coupled coastal systems. (Senior Researcher: Beard). NSF- EPSCoR Track II. 9/1/13-8/31/16, **(2)** 2015-2018 NIH grant R01-EY019924-07, "Audio-Haptic Virtual Environments for Large-Scale Navigation in the Blind", researching behavioral and neuroimaging effects of multimodal interfaces on spatial learning without vision (N.A. Giudice, UMaine PI; with L. Merabet , Harvard (PI); and K. Sathian, Emory) and **(3)** CDI-Type II: Collaborative Research: Perception of Scene Layout by Machines and Visually Impaired Users CDI-1028895, Kate Beard, Nicholas Giudice, Reinhard Moratz, $700,937, 10/2010-9/2014

d) Subject Matter Experts in Geospatial Forums

As indicated by the full CVs of the Spatial Informatics faculty members, one or more of them has been called upon to serve as a subject matter expert in over 50 forums during the past three years. Among them have included: **(i)** serving as experts on organizing/review committees for over 20 major academic conferences (e.g. Beard, GIScience 2014, Egenhofer, COSIT 2015, Hahmann GeoVoCamp 2014 and Onsrud, GSDI 14 and Africa GIS 2013), **(ii)** serving as experts on editorial boards of ten academic journals (e.g. Journal of Spatial Information Science, Journal of Spatial Cognition and Computation, and URISA Journal)**,** (iii) serving as experts in reviewing scholarly articles (too many to mention), (iv) serving as experts on Board of Directors for five societies or a scientific study panels (e.g. Board Member, University Consortium for Geographic Information Science, Member of Strategic Orientation Committee, Centre for Research in Geomatics, Université Laval, Canada, and Advisory Board Centre for Spatial Data Infrastructures and Land Administration (CSDI&LA), University of Melbourne, Australia, (v) serving as experts in five symposia, on panels or in agency sessions (e.g. Egenhofer, Max, Keynote Address, A Future History of Geographic Information Science, GeoInfo 2014, Campos do Jordão, Brazil, 2014, Giudice, N.A. (2014). Invited talk at the symposium on Merging Neuroplasticity, Education, and Rehabilitation in the Blind. Radcliffe Institute, Harvard University, Cambridge MA, USA. and Onsrud, Harlan, Advisory Board SHRP 2 Safety Technical Expert Task Group (T-ETG) on Data Access for the Naturalistic Driving Study, FA009, TRB, Washington, D.C., 2010-2015

e) Membership in Geospatial Science Professional Societies

One or more faculty members has been an active member in the more ten professional societies within or over the past three years including 1. URISA, 2. ACSM, 3 AAG, 4. GITA, 5. International Geospatial Society (IGS), and 6. UCGIS and GSDI (faculty unit membership).

f) Presentations at Major Regional/National/International Conferences and Events

In addition to the conference presentation affiliated with refereed conference proceedings articles, Spatial Informatics faculty members report an additional twelve conferences at national and international conferences. See the CVs. A small sampling includes:

1. Beard K., A Place and Event Based Context Model for Environmental Monitoring. 1st International Workshop on Context-Awareness in Geographic Information Services (in conjunction with GIScience 2014). Vienna, Austria, Sept 24-26, 2014.
2. Li, H. & Giudice, N.A. (2014). Multi-level cognitive maps for supporting indoor wayfinding. Talk at the 5th Annual Mainely Data Conference. May, University of Maine, Orono, ME.
3. Hahmann, H., B. Brodaric: Kinds of full physical containment, Conf. on Spatial Inf. Theory (COSIT-2013), Scarborough, UK, Sept. 2013
4. Onsrud, Harlan, Tracking Everyone Everywhere All the Time: Protecting Individual Privacy within a Ubiquitous Observation Society, University Consortium for Geographic Information Science (UCGIS) Annual Symposium, Pasadena California, 21 May 2014

Part II: Curriculum Mapping to Knowledge Units and Focus Areas

Note: Detailed reporting of the knowledge units in each course in the following tables may be viewed by clicking the last two url links on the page at https://spatial.umaine.edu/docs/

Summary — Fill in Optional KU #

Course #	Course Title	Geo- Referencing Systems	Spatial Data Fundamentals	Remote Sensing Fundamentals	Spatial Data Management	Geospatial Data Standards	Effective Visual Comms of Spatio-temporal info	Professional Ethics in GIS&T	Geospatial Analysis	Errors in Geospatial Information	Geospatial analytic reasoning and problem ...	Foundations of Spatial Thinking	Geometric Measures	Analysis of workflow in project management	Analysis of topographic or field-based data	Geostatistics and Spatial Econometrics	Network Analysis	Spatial Data Integration	Foundations of Cartography
SIE 502	Research Methods													P					
SIE 503	Principles of Experimental Design						P												
SIE 505	Formal Foundations for Information Science		P		P								P				P		
SIE 507	Information Systems Programming																		
SIE 509	Principles of GIS	P	C	P	P	P			P	P		P	P		P		P		P
SIE 510	GIS Applications	C	C		C	P	C		P	C	P	P	P	P	P		C	C	C
SIE 512	Spatial Analysis						P		P	P	P	P	P	P	P	C			P
SIE 515	Human Computer Interaction						P				P								
SIE 516	Virtual Reality Research and Applications	P					P												
SIE 525	Information Systems Law							C											
SIE 550	Design of Information Systems		P		P						P							P	
SIE 554	Spatial Reasoning		P		P		P		P	P	P	P	P				P		
SIE 555	Spatial Database Systems		C		C	C					P	P							
SIE 557	Database System Applications																		
SIE 558	Data Stream Management Systems				P							P						P	
SIE 559	GeoSensor Networks										P	P	P		P			P	
SIE 565	Reasoning with Uncertainty in																		

	Spatial Information Systems																		
SIE 570	Spatial Cognition and Computing	P	C		P	P	P			P	C	P	C				P	C	
SIE 571	Pattern Recognition & Robotics	P	C	C	P		P		P	P			P					P	
SIE 598 fo	Formal Ontologies		P			P												P	
SIE 598 sln	Spatial Learning and Navigation											P							P
Bio 597	Advanced Biometry for the Environmental Sciences												P			P			
Ece 574	Cluster Computing																P		
Int 527	Integration of GIS and Remote Sensing Data Analysis in Natural Resource Applications	P	P	C	P				P	P			P		P	P			
Sfr 406	Remote Sensing, Image Interpretation, and Forest Mapping			C					P						P				
Sms 540	Satellite Oceanography																		
Svt 437	Practical GPS																		
Svt 531	Advanced Digital Photogrammetry																		
Svt 541	Geodesy																		

Part II: Continued

Summary

Course #	Course Title	Remote Sensing Collection Platforms	Digital Image Processing	Photogrammetric Application	Close Range Photogrammetry	Mathematics, Statistics, and Optimization	Spatial Applications of Big Data	Advanced Spatial Analysis Through Programming	Spatial Query Operations and Query Language	Geodesy	Fundamentals of GPS and the Global Naviga…
SIE 502	Research Methods										
SIE 503	Principles of Experimental Design										
SIE 505	Formal Foundations for Information Science								P		
SIE 507	Information Systems Programming										
SIE 509	Principles of GIS	P								P	P
SIE 510	GIS Applications							P	C	P	
SIE 512	Spatial Analysis						P	P	P		
SIE 515	Human Computer Interaction										
SIE 516	Virtual Reality Research and Applications						P				
SIE 525	Information Systems Law										
SIE 550	Design of Information Systems						P		C		
SIE 554	Spatial Reasoning								P		
SIE 555	Spatial Database Systems								C		
SIE 557	Database System Applications										
SIE 558	Data Stream Management Systems						P	P	C		
SIE 559	GeoSensor Networks						P		P		

SIE 565	Reasoning with Uncertainty in Spatial Information Systems										
SIE 570	Spatial Cognition and Computing										
SIE 571	Pattern Recognition & Robotics	P	C					P			
SIE 598 fo	Formal Ontologies										
SIE 598 sln	Spatial Learning and Navigation										
Bio 597	Advanced Biometry for the Environmental Sciences							P			
Ece 574	Cluster Computing										
Int 527	Integration of GIS and Remote Sensing Data Analysis in Natural Resource Applications	P	P								
Sfr 406	Remote Sensing, Image Interpretation, and Forest Mapping	P	P								
Sms 540	Satellite Oceanography	P	P								
Svt 437	Practical GPS										C
Svt 531	Advanced Digital Photogrammetry			C	C	C					
Svt 541	Geodesy									C	

In the table above, list your institution's Geospatial Science courses (as described in the following pages) and, for each core knowledge unit, indicate whether the course completely satisfies ("**C**") or partially satisfies ("**P**") the core KU. List the numbers for the optional knowledge units (up to 12) that your curriculum satisfies at the top of the "Optional KU" columns and indicate whether the course completely satisfies ("**C**") or partially satisfies ("**P**") the optional KU. See the example above. Use up to one additional sheet, if needed.

Course Synopsis 1

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 502	Research Methods	Spring 2014	Annual	2014

Course Description (provide URL link to syllabus)

Covers process of successful graduate research, including the written and verbal presentation of plans and results. Students formulate hypotheses, perform a literature search, write abstracts and introductions of research papers, learn about presentation styles and techniques, make two presentations (3-minutes and 10-minutes) about research proposals. Lec 1.
http://spatial.umaine.edu/files/2015/02/SIE502Syllabus.pdf

Course Objectives

Introduce students to disseminating their research in orally and in writing. By the end of the course students will:

- Understand how to make quality scientific presentations
- Understand how to write abstracts and introductions
- Understand how to write scholarly reviews

Course Satisfaction of Knowledge Units

Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU of: Network Analysis

Course Synopsis 2

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 503	Principles of Experimental Design	Fall 2012	Biennial	2012

Course Description (provide URL link to syllabus)

This is an interdisciplinary course designed primarily for first year graduate students and advanced standing undergraduates who plan to engage in scientific research. The course covers topics in: (1) design of experiments, (2) modern experimental techniques and instrumentation, and (3) data collection, organization, and statistical analysis techniques.
http://spatial.umaine.edu/files/2015/02/SIE503Syllabus.pdf

Course Objectives

1. Gain an understanding of how to perform rigorous scientific research, and the issues that are important to consider in the research process.
2. Become better able to evaluate the quality of others' research and think critically about what scientific evidence means in a variety of contexts.
3. Develop an appropriate research question/problem.
4. Design and conduct your own research project.
5. Generate an appropriate statistical plan to support a proposition.
6. Build your experience with scientific communication by writing and speaking about your research and reading about others' research.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this

course partially satisfies Core KU of: Effective Visual Communications of Spatio-temporal Information

Course Synopsis 3

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 505	Formal Foundations for Information Science	Fall 2014	Annual	2014

Course Description (provide URL link to syllabus)

Increases student's understanding of the approach to information systems and science by formalisms. Draws on mathematics to increase familiarity with formal syntax and language, develops understanding and technical ability in handling structures relevant to information systems and science. Includes a review of fundamental material on set theory, functions and relations, graph theory, and logic; examines a variety of algebraic structures; discusses formal languages and the bases of computation. http://spatial.umaine.edu/files/2015/02/SIE505Syllabus.pdf

Course Objectives

• Introduce students to a variety of mathematical formalism (formal languages, mathematical structures and logical systems) to represent information; • Equip students with the basic toolset to study more advanced formalism from mathematics and theoretical computer science on their own; • Enable students to formally write up their ideas in a clear and well-structured manner; • Associate mathematical formalisms to problems encountered in the student's own work or research.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course partially satisfies the Core KU's of: Spatial Data Fundamentals and Spatial Data Management **Focus Area KU's:** As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU's of: Geometric Measures, Network Analysis and Spatial Query Operations and Query Language

Course Synopsis 4

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 507	Information Systems Programming	Fall 2014	Annual	2014

Course Description (provide URL link to syllabus)

Programming for those envisioning careers focused on developing and managing information systems and databases as opposed to software design. Data structures, algorithms, and their analysis. http://spatial.umaine.edu/files/2015/02/SIE507Syllabus.pdf

Course Objectives

• Introduce students to central concepts of information processing systems • Develop an understanding of software development environments • Acquire essential computer programming skills

Course Satisfaction of Knowledge Units

This course satisfies no knowledge units but appears in the proposal for other illustrative purposes.

Course Synopsis 5

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 509	Principles of GIS	Fall 2014	Annual	2014

Course Description (provide URL link to syllabus)

Covers foundation principles of geographic information systems, including traditional representations of spatial data and techniques for analyzing spatial data in digital form. Combines an overview of general principles associated with implementation of geographic information systems and practical experience in the analysis of geographic information. http://spatial.umaine.edu/files/2015/02/SIE509Syllabus.pdf

Course Objectives

• An overview of the development and basic principles of geographic information systems. • Practical experience in the use of ArcGIS 10.x (one of the most popular commercial GIS packages). • An understanding of the development of a GIS project.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course completely satisfies the Core KU of: Spatial Data Fundamentals. Further it partially satisfies the Core KU's of: Geo- Referencing Systems, Remote Sensing Fundamentals, Spatial Data Management, Geospatial Data Standards, Geospatial Analysis, Errors in Geospatial Information. **Focus Area KU's:** As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU's of: Foundations of Spatial Thinking, Geometric Measures, Analysis of topographic or field-based data, Network Analysis, Foundations of Cartography, Remote Sensing Collection Platforms, Geodesy, Fundamentals of GPS and the Global Navigation

Course Synopsis 6

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 510	GIS Applications	Spring 2015	Annual	2015

Course Description (provide URL link to syllabus)

Introduces both conceptual and practical aspects of developing GIS applications. Covers application areas from natural resource planning through transportation, cadastral and land information systems and their spatial modeling requirements, and application development from requirement analysis to database design and implementation. http://spatial.umaine.edu/files/2015/02/SIE510Syllabus.pdf

Course Objectives

The purpose of this course is to investigate theoretical and practical aspects of GIS applications and application development using the Python programming language. The course will review GIS models and operations, various application areas, and dependencies between models and applications. The course will cover the process of application development from requirements analysis to conceptual data

modeling, database development, analytical steps and customization. The basics of Python programming will be covered along with specifics of using Python for GIS scripting. Course grades will be based on completion of several lab and programming exercises, presentations and class participation, a midterm exam, and development and completion of an application project.
The application project involves working with a client(s), some level of requirements analysis to determine the client's needs, specification of requirements, and development of application prototypes to serve the client's needs.
Projects require a final presentation to the class and clients and submission of a final project report at the end of the semester.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course completely satisfies the Core KU's of: Geo- Referencing Systems, Spatial Data Fundamentals, Spatial Data Management, Effective Visual Communications of Spatio-temporal Information, and Errors in Geospatial Information. Further it partially satisfies the Core KU's of: Geospatial Data Standards and Geospatial Analysis.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course completely satisfies the Focus Area KU's of: Network Analysis, Spatial Data Integration, Foundations of Cartography and Spatial Query Operations and Query Language. Further, it partially satisfies the Focus Area KU's of: Geospatial analytic reasoning and problem solving fundamentals, Foundations of Spatial Thinking, Geometric Measures, Analysis of workflow in project management, Analysis of topographic or field-based data, Advanced Spatial Analysis Through Programming and Geodesy.

Course Synopsis 7

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 512	Spatial Analysis	Fall 2014	Annual	2014

Course Description (provide URL link to syllabus)

Introduces students to techniques for spatial analysis. Covers methods and problems in spatial data sampling, issues in preliminary or exploratory analysis, problems in providing numerical summaries and characterizing spatial properties of map data and analysis techniques for univariate and multivariate data. Students will be responsible for completing several hands-on exercises.
http://spatial.umaine.edu/files/2015/02/SIE512Syllabus.pdf

Course Objectives

This course introduces techniques for the statistical analysis of spatial data. Topics include characterization of spatial data, and techniques for visualizing, exploring and modeling spatial data distributed as point patterns, continuous data, and area data, and methods and problems in spatial data sampling. Students will become familiar with methods for identifying, describing, modeling and testing patterns in observed data. Students will be responsible for completing several lab exercises, one paper, a midterm exam and a final project. General course topics include: Issues in analyzing spatial data, General concepts in spatial data analysis, Methods for point pattern analysis, Methods for spatially continuous data analysis, Methods for area data analysis, Sampling spatial populations.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course partially satisfies the Core KU's of: Effective Visual Communications of Spatio-temporal

Information, Geospatial Analysis and Errors in Geospatial Information.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course completely satisfies the Focus Area KU of: Geostatistics and Spatial Econometrics. Further, it partially satisfies the Focus Area KU's of: Geospatial analytic reasoning and problem solving fundamentals, Foundations of Spatial Thinking, Geometric Measures, Analysis of workflow in project management, Analysis of topographic or field-based data, Foundations of Cartography, Spatial Applications of Big Data, Advanced Spatial Analysis Through Programming and Spatial Query Operations and Query Language.

Course Synopsis 8

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 515	Human Computer Interaction	Spring 2015	Annual	2015

Course Description (provide URL link to syllabus)

Students are introduced to the fundamental theories and concepts of human-computer interaction (HCI). Topics covered include: interface design and evaluation, usability and universal design, multimodal interfaces (touch, gesture, natural language), virtual reality, and spatial displays. http://spatial.umaine.edu/files/2015/02/SIE515Syllabus.pdf

Course Objectives

• Students will learn the basic physiological, perceptual, and cognitive components of human learning and memory.
• Students will gain theoretical knowledge of and practical experience in the fundamental aspects of designing and implementing user interfaces.
• Students will learn to analyze interaction problems from a technical, cognitive, and functional perspective.
• Students will develop an awareness of the range of general human-computer interaction issues that must be considered when designing information systems.
• Students will learn about multimodal displays for conveying and presenting information.
• Students will know and have practiced a variety of simple methods for designing and evaluating the quality of user interfaces and spatial displays.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course partially satisfies the Core KU of: Effective Visual Communications of Spatio-temporal
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU of: Geospatial analytic reasoning and problem solving fundamentals

Course Synopsis 9

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 516	Virtual Reality Research and Applications	Fall 2013	Annual	Within 2 years

Course Description (provide URL link to syllabus)

This course is designed to provide students with an overview of the basic principles of virtual reality

(VR) and virtual environment technology (VET). The goal is to learn enough about the strengths and limitations of VR technology in order to be able to construct simple immersive environments as well as to understand the human factors and cognitive issues that should be considered when using this medium.
http://spatial.umaine.edu/files/2015/02/SIE516Syllabus.pdf

Course Objectives

By the end of this course, students will:
• Understand how the design of VR technology relates to human perception and cognition
• Understand how VR and AR can improve industrial design, fast-prototyping, information visualization, and interface design.
• Discuss applications of VR to the conduct of scientific research, training, and industrial design.
• Gain first-hand experience with using virtual environment technology, including 3D rendering software, tracking hardware, and input/output functions for capturing user data.
• Learn the fundamental aspects of designing and implementing rigorous empirical experiments using VR.
• Learn about multimodal virtual displays for conveying and presenting information and techniques for evaluating good and bad virtual interfaces.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course partially satisfies the Core KU's of: Geo- Referencing Systems and Effective Visual Communications of Spatio-temporal Information.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU of: Spatial Applications of Big Data

Course Synopsis 10

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 525	Information Systems Law	Spring 2015	Annual	2015

Course Description (provide URL link to syllabus)

Current and emerging status of computer law in electronic environments: rights of privacy, freedom of information, confidentiality, work product protection, copyright, security, legal liability; impact of law on use of databases and spatial datasets; legal options for dealing with conflicts and adaptations of law over time.
http://spatial.umaine.edu/files/2015/02/SIE525Syllabus.pdf

Course Objectives

This course reviews the current status of information systems law in regard to rights of privacy, freedom of information, confidentiality, work product protection, copyright, security, legal liability, and a range of additional legal and information policy topics. We will investigate the legal difficulties that technological innovations are causing in all of these areas. We will focus particularly on these issues in regard to their impact on the use of digital data work products and databases. Legal options for dealing with the conflicts caused by technological change and likely adaptations of the law over time in response to societal changes will be explored.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course completely satisfies the Core KU of: Professional Ethics in GIS&T

Course Synopsis 11

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 550	Design of Information Systems	Fall 2014	Annual	2014

Course Description (provide URL link to syllabus)

Cognitive and theoretical foundation for representation of knowledge in information systems and fundamental concepts necessary to design and implement information systems. Logic programming as a tool for fast design and prototyping of data models. Formal languages and formal models, conceptual modeling techniques, methods for data abstraction, object-oriented modeling and database schema design. Relational data model and database query languages, including SQL. http://spatial.umaine.edu/files/2015/02/SIE550Syllabus.pdf

Course Objectives

• To introduce students to formal languages and formal modeling approaches that underlie information systems, that is, theoretical foundation for representing knowledge in information systems, • To use logic-based programming as a tool for fast prototyping and design of data structures, • To understand conceptual modeling techniques and methods for data abstraction, • To introduce major database models including relational and object-oriented models, • To explore extensions of these data models for temporal and spatial data • Introduce students to concepts of modern database systems • Develop an understanding of using, designing, and programming database systems • Expose students to practical work with database systems through a series of labs

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course partially satisfies the Core KU's of: Spatial Data Fundamentals and Spatial Data Management. **Focus Area KU's:** As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course completely satisfies the Focus Area KU of: Spatial Query Operations and Query Language. Further, this course partially satisfies the Focus Area KU's of: Geospatial analytic reasoning and problem solving fundamentals, Network Analysis and Spatial Applications of Big Data.

Course Synopsis 12

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 554	Spatial Reasoning	Spring 2014	Biennial	Within year

Course Description (provide URL link to syllabus)

Qualitative representations of geographic space. Formalisms for topological, directional and metric relations; inference mechanisms to derive composition tables; geometric representations of natural language-like spatial predicates; formalizations of advanced cognitively motivated spatial concepts, such as image schemata; construction of relation algebras. http://spatial.umaine.edu/files/2015/02/SIE554Syllabus.pdf

Course Objectives

• To acquire an in-depth knowledge of qualitative spatial reasoning • To learn the methods associated with qualitative reasoning • To become fluent in the most popular models for topological relations • To understand the deficiencies and shortcomings of current approaches

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course partially satisfies the Core KU's of: Spatial Data Fundamentals, Spatial Data Management, Effective Visual Communications of Spatio-temporal Information, Geospatial Analysis and Errors in Geospatial Information **Focus Area KU's:** As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU's of: Geospatial analytic reasoning and problem solving fundamentals, Foundations of Spatial Thinking, Geometric Measures, Network Analysis, and Spatial Query Operations and Query Language

Course Synopsis 13

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 555	Spatial Database Systems	Spring 2013	Annual	Within 2 years

Course Description (provide URL link to syllabus)

Covers internal system aspects of spatial database systems. Layered database architecture. Physical data independence. Spatial data models. Storage hierarchy. File organization. Spatial index structures. Spatial query processing and optimization. Transaction management and crash recovery. Commercial spatial database systems. http://spatial.umaine.edu/files/2015/02/SIE555Syllabus.pdf

Course Objectives

• Introduce students to principles of spatial database systems • Develop an understanding of spatial data storage, management and efficient processing in database systems • Expose students to spatial database systems as efficient software tools for management, retrieval and sharing of massive spatial data

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course completely satisfies the Core KU's of: Spatial Data Fundamentals, Spatial Data Management, and Geospatial Data Standards. **Focus Area KU's:** As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course completely satisfies the Focus Area KU of: Spatial Query Operations and Query Language. Further, it partially satisfies the Focus Area KU's of: Geospatial analytic reasoning and problem solving fundamentals and Foundations of Spatial Thinking.

Course Synopsis 14

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 557	Database System Applications		Biennial	Current

Course Description (provide URL link to syllabus)

Study, design and implementation of object-relational database system applications. Introduction to database systems. Integrating database systems with programs. Web applications using database systems. Final database project.
http://spatial.umaine.edu/files/2015/02/SIE557Syllabus.pdf

Course Objectives

· Introduce students to concepts of modern database systems
· Develop an understanding of using, designing, and programming database systems
· Expose students to practical work with database systems through a series of labs

Course Satisfaction of Knowledge Units

This course satisfies no knowledge units but appears in the proposal for other illustrative purposes.

Course Synopsis 15

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 558	Data Stream Management Systems	Fall 2012	Biennial	Fall 2012

Course Description (provide URL link to syllabus)

This course is an introduction into the technology of sensor data stream management. This data management technology is driven by computing through sensors and other smart devices that are embedded in the environment and attached to the internet, constantly streaming sensed information. With streams everywhere, Data Stream Engines (DSE) have emerged aiming to provide generic software technology similar to that of database systems for analyzing streaming data with simple queries. Sensor streams are ultimately stored in databases and are analyzed using scalable cloud technologies.
http://spatial.umaine.edu/files/2015/02/SIE558Syllabus.pdf

Course Objectives

General topics to be covered include:
• Introduction to sensor data stream management systems
• Data stream engine software
• Data model and query language concepts
• Stream query processing
• Stream query optimization techniques
• Adaptive stream query processing techniques
• Real-time sensor data stream management
• Historic sensor stream management in the cloud

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course partially satisfies the Core KU of: Spatial Data Management.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course completely satisfies

the Focus Area KU of: Spatial Query Operations and Query Language. Further, it partially satisfies the Focus Area KU's of: Foundations of Spatial Thinking, Spatial Data Integration, Spatial Applications of Big Data, and Advanced Spatial Analysis Through Programming.

Course Synopsis 16

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 559	GeoSensor Networks	Fall 2014	Biennial	2014

Course Description (provide URL link to syllabus)

In the last 15 years, several technology trends have influenced the field of geosciences in significant ways. The first trend is the more readily available technology of ubiquitous wireless communication networks and progress in the development of low-power, shortrange radio-based communication networks, the miniaturization of computing and storage platforms as well as the development of novel microsensors and sensor materials. All three trends have changed the type of dynamic environmental phenomena that can be detected, monitored and reacted to. Another important aspect is the realtime data delivery by novel platforms today. In this course, we will survey the field of geosensor networks, and mainly focus on the technology of small-scale geosensor networks, decentralized adhoc computing and collaboration, example applications and their feasibility and lessons learnt as well as the current research questions posed by using this technology today. http://spatial.umaine.edu/files/2015/02/SIE559Syllabus.pdf

Course Objectives

Topics to be covered will include: • Motivation, history and vision • Platforms • Data centric routing in wireless sensor networks • Spatial database management interfaces for wireless sensor networks • Decentralized, in-network, adhoc collaboration in geographic space • Geosensor networks applications • Testbed project

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course satisfies no Core KUs. **Focus Area KU's:** As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU's of: Geospatial analytic reasoning and problem solving fundamentals, Foundations of Spatial Thinking, Geometric Measures, Analysis of topographic or field-based data, Spatial Data Integration, Spatial Applications of Big Data, and Spatial Query Operations and Query Language.

Course Synopsis 17

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 570	Spatial Cognition and Computing	Spring 2014	Annual	Within year

Course Description (provide URL link to syllabus)

Study of cognitive aspects for understanding spatial representations and reasoning processes. Cognitive models are studied and related to Artificial Intelligence Systems.
http://spatial.umaine.edu/files/2015/02/SIE570Syllabus.pdf

Course Objectives

• Introduce students to spatial cognition foundations
• Develop an understanding of the research methods of cognitive science
• Expose students to recent findings of spatial cognition research

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course completely satisfies the Core KU of: Spatial Data Fundamentals. Further it partially satisfies the Core KU's of: Geo- Referencing Systems, Spatial Data Management, Geospatial Data Standards, Effective Visual Communications of Spatio-temporal Information, and Errors in Geospatial Information.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course completely satisfies the Focus Area KU's of: Geospatial analytic reasoning and problem solving fundamentals, Geometric Measures, and Spatial Data Integration. Further, it partially satisfies the Focus Area KU's of: Foundations of Spatial Thinking and Network Analysis.

Course Synopsis 18

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 571	Pattern Recognition & Robotics	Spring 2015	Annual	Within year

Course Description (provide URL link to syllabus)

Pattern recognition algorithms classify input data based on statistical information. A mobile robot needs pattern recognition algorithms to make sense of its spatial environment based on sensor input. The course will introduce the mathematical framework of pattern recognition and present practical applications in robotics. The course will also cover supervised neural network learning algorithms.
http://spatial.umaine.edu/files/2015/02/SIE571Syllabus.pdf

Course Objectives

• Introduce students to pattern recognition and image processing foundations
• Develop an understanding of the software design methods of image processing and mobile robotics
• Expose students to practical work with computer vision and mobile robots

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course completely satisfies the Core KU of: Spatial Data Fundamentals and Remote Sensing Fundamentals. Further it partially satisfies the Core KU's of: Geo- Referencing Systems, Spatial Data Management, Effective Visual Communications of Spatio-temporal Information, Geospatial Analysis, and Errors in Geospatial Information.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course completely satisfies the Focus Area KU of: Digital Image Processing. Further, it partially satisfies the Focus Area KU's of: Geometric Measures, Spatial Data Integration, Remote Sensing Collection Platforms, and Advanced

Spatial Analysis Through Programming.

Course Synopsis 19

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 598 fo	Formal Ontologies	Spring 2015	Biennial	Current

Course Description (provide URL link to syllabus)

This course provides an introduction and a hands-on experience covering a broad range of formalisms, languages, and approaches to capture the semantics of a domain or application of interest in an ontology. The course consists of a mix of lectures and a project related to a domain/application of each student's interest (such as geology, hydrology, building information, genomics, anatomy, e-commerce, health informatics, etc.), preferably related to their research. Students work on their project throughout the entire term, with several intermediate milestones they each present class.
http://spatial.umaine.edu/files/2015/02/SIE598foSyllabus.pdf

Course Objectives

• Introduce students to a variety of informal methods and logic-based formalisms to capture the semantics of knowledge;
• Equip students with the basic toolset to develop ontologies using a range formalisms and choosing a formalism suitable for the scope and application of the ontology;
• Enable students to evaluate their own ontologies and ontologies from the literature.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course partially satisfies the Core KU's of: Spatial Data Fundamentals and Geospatial Data Standards.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU of: Spatial Data Integration.

Course Synopsis 20

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SIE 598 sln	Spatial Learning and Navigation	Spring 2015	Annual	Current

Course Description (provide URL link to syllabus)

This is an interdisciplinary course covering fundamental concepts, core issues, and current topics in spatial cognition. The course will involve reading both seminal readings in the field as well as cutting edge papers and discussing the material in class. Some of the topics discussed include: spatial learning, navigation and wayfinding, maps and multimodal interfaces, and spatial problem solving.
http://spatial.umaine.edu/files/2015/02/SIE598slnSyllabus.pdf

Course Objectives

1. Gain a broad-based understanding of the core issues in the field of spatial cognition and navigation.
2. Learn about the behavioral aspects and neural underpinnings of spatial learning and navigation.
3. Identify the pros and cons of maps and technology supporting spatial learning and navigation
4. Consider the individual differences and variability of spatial abilities and how these influence the development of technologies and learning strategies.

5. Become comfortable in finding, reading, extracting and synthesizing relevant information from journal articles and source material.
6. Build your experience with scientific communication by writing and speaking about class topics.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course satisfies no Core KU's.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU's of: Foundations of Spatial Thinking and Foundations of Cartography.

Course Synopsis 21

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
BIO 597	Advanced Biometry for the Environmental Sciences	Fall 2014	Biennial	Within year

Course Description (provide URL link to syllabus)

A graduate course in advanced statistics oriented towards the environmental sciences. This course is intended as a breadth-oriented survey course that will expose the student to most of the types of statistics one might encounter in environmental research. It will review and place into a more general context ANOVA and regression, cover philosophy of science/modes of statistics (Bayesian and Monte Carlo), random/mixed/hierachical models, generalized linear models (including logistic and Poisson regression), modern regression (robust, non-linear, machine-learning), multivariate statistics, and spatial/temporal statistics. A previous course (undergrad or grad), not necessarily at this university, in statistics is a prerequisite. http://spatial.umaine.edu/files/2015/02/BIO597Syllabus.pdf

Course Objectives

Course objectives are 3-fold:
1.To take the last step from "cookbook" statistics to scientific inference
2.To survey most of the statistical techniques you may need for research-level statistics in the environmental sciences
3.To familiarize you with the basic tools of the trade (specifically using R)

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course satisfies no Core KU's.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU's of: Geometric Measures, Geostatistics and Spatial Econometrics, and Advanced Spatial Analysis through Programming.

Course Synopsis 22

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
ECE 574	Cluster Computing	Spring 2014	Biennial	Within year

Course Description (provide URL link to syllabus)

Advances in high-end computational technology continue to bring the digital revolution into academic, industrial and commercial areas. A popular approach for achieving high performance for these application domains is to use parallel computers. Introduces the primary parallel computer architectures, as well as the programming techniques applicable to concurrent, parallel and distributed computations. Students will gain experience in developing parallel computing solutions for challenging problems. Lec 3. http://spatial.umaine.edu/files/2015/02/ECE574Syllabus.pdf

Course Objectives

Topics to be covered include:
1. Principals of Parallel Algorithm Design
2. Analytical Modeling of Parallel Programs
3. Example parallel algorithms
4. Fundamental of GPU Accelerations
5. Advanced topics on GPU Accelerations
6. Fundamental of Parallel I/Os
7. Emerging Techniques of Storage and Memory
8. Literature Study and Discussion

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course satisfies no Core KU's.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU of: Network Analysis.

Course Synopsis 23

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
INT 527	Integration of GIS and Remote Sensing Data Analysis in Natural Resource Applications	Fall 2014	Annual	Within year

Course Description (provide URL link to syllabus)

Analysis of satellite imagery and GIS data bases including applications of raster and vector models, land cover analysis and forest change detection, wildlife habitat analysis, hydrological assessment, and landscape characterization. http://spatial.umaine.edu/files/2015/02/INT527Syllabus.pdf

Course Objectives

Progressing toward the completion of the course, students will be expected to:
1. Understand the theory, methods and techniques of spatial analysis using remotely sensed and GIS data.
2. Understand basic techniques of satellite image processing and how the data are interpreted and integrated into spatial analysis of forest landscapes.
3. Translate research questions in natural resource fields into RS and GIS analysis techniques.
4. Become proficient in using ERDAS IMAGINE raster and ArcGIS vector modeling as they apply to addressing natural resource data analysis problems.
5. Understand the advantages and limitations of RS/GIS based analysis approaches.
6. Plan and conduct spatially explicit research or applications using RS and GIS techniques.
7. Write brief but concise laboratory reports in appropriate technical style demonstrating the student's

understanding and interpretation of results.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course completely satisfies the Core KU of: Remote Sensing Fundamentals. Further it partially satisfies the Core KU's of: Geo- Referencing Systems, Spatial Data Fundamentals, Spatial Data Management, Geospatial Analysis, and Errors in Geospatial Information.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU's of: Geometric Measures, Analysis of topographic or field-based data, Geostatistics and Spatial Econometrics, Remote Sensing Collection Platforms, and Digital Image Processing.

Course Synopsis 24

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SFR 406	Remote Sensing, Image Interpretation, and Forest Mapping	Spring 2014	Annual	Within year

Course Description (provide URL link to syllabus)

Vertical and horizontal measurements from aerial photos, orthophotos, and topographical maps. Fundamentals of image interpretation, forest stand mapping, and forest disturbance monitoring from aerial and satellite-derived imagery. Laboratory training includes both manual and digital image interpretation and mapping methods.
http://spatial.umaine.edu/files/2015/02/SFR406Syllabus.pdf

Course Objectives

The principal focus is on the fundamentals of forest photogrammetry, image interpretation, forest stand mapping and forest disturbance monitoring from aerial and satellite derived imagery. Laboratory training includes both manual and digital image interpretation and mapping methods. The primary goal is to provide students with working knowledge of how to handle, acquire, interpret, and derive measurements and forest type information from aerial photos and prepare stand maps from processing of digital images. A major objective is to present practical information about aerial and satellite remote sensing systems and applications in mapping and monitoring of forests.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course completely satisfies the Core KU of: Remote Sensing Fundamentals. Further it partially satisfies the Core KU of: Geospatial Analysis.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU's of: Analysis of topographic or field-based data, Remote Sensing Collection Platforms, and Digital Image Processing.

Course Synopsis 25

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SMS 540	Satellite Oceanography		Biennial	

Course Description (provide URL link to syllabus)

An overview of the use of remote sensing technologies for making measurements of the marine environment. Introduces the various sensors used by oceanographers, their background, the principles behind their operation and measurement retrieval. Emphasis will be placed on readings from the prime oceanography literature and biogeophysical applications of the data, their analysis, advantages and limitations rather than physical/optical theory.
http://spatial.umaine.edu/files/2015/02/SMS540Syllabus.pdf

Course Objectives

The course relies heavily on readings from the prime oceanography literature to showcase satellite data analysis and applications. Included in the course are 1) a series of student-led presentations and discussions of assigned class readings 2) a series of computer laboratories to illustrate various data sets, data processing issues and analysis approaches and 3) an opportunity to explore a marine remote sensing topic of your choice in a term paper.

Course Satisfaction of Knowledge Units

Core KU's: As detailed at https://spatial.umaine.edu/files/2015/02/CoreAreaSurveyResults.pdf, this course satisfies no Core KUs.
Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course partially satisfies the Focus Area KU's of: Remote Sensing Collection Platforms and Digital Image Processing.

Course Synopsis 26

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SVT 437	Practical GPS	Fall 2014	Annual	Within year

Course Description (provide URL link to syllabus)

Presentation of all types of GPS equipment with their uses and limitations, GPS observation planning based on satellite geometry and obstructions, review of geodetic coordinate systems and datums, the geoid and how it relates to the production of elevations from GPS, execution of all components (planning, field collection, downloading, processing, and adjustment) of a GPS survey where raw data is collected, real time kinematic (RTK) GPS field execution and adjustment for control work, use of RTK GPS in collection of a topographic survey.
http://spatial.umaine.edu/files/2015/02/SVT437Syllabus.pdf

Course Objectives

Students are expected to learn basic GPS field survey instrumentation, operation, office processing, and how it relates to survey office products. Be able to apply design skills sufficient to meet employer and client expectations in the areas of land development and survey operations planning - control work and stakeout for land development are covered along with mission planning of GPS surveys.

Course Satisfaction of Knowledge Units

Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course completely satisfies the Focus Area KU of: Fundamentals of GPS and the Global Navigation.

Course Synopsis 27

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SVT 531	Advanced Digital Photogrammetry		Annual	New

Course Description (provide URL link to syllabus)

Airborne GPS-IMU processing techniques; conversion between local cartesian and conventional mapping coordinate systems; techniques in automated pixel matching; digital cameras and their calibration; optimization of automated photocoordinate measurement for aerotriangulation; recursive partitioning techniques for aerotriangulation solution optimization; techniques for automated feature extraction; synthesis of digital imagery and Lidar; image enhancements issues in orthophotos and mosaics; multi-ray considerations
http://spatial.umaine.edu/files/2015/02/SVT531Syllabus.pdf

Course Objectives

At the end of the course students will be able to:
(1) analyze GPS-IMU.
(2) perform geodetic coordinate transformations.
(3) apply various aspects of pixel matching to 3-D model creation.
(4) analyze system requirements of metric digital cameras.
(5) calibration metric digital cameras.
(6) optimize aerotriangulation solutions.
(7) optimize feature extraction.
(8) synthesize various geospatial data types.
(9) optimize imagery in georectified products.
(10) apply multi-ray photogrammetry successfully.

Course Satisfaction of Knowledge Units

Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course completely satisfies the Focus Area KU's of: Photogrammetric Application, Close Range Photogrammetry, and Mathematics, Statistics, and Optimization.

Course Synopsis 28

Course #	Course Title	Date Last Taught	Frequency Offered	Date Last updated
SVT 541	Geodesy	Spring 2015	Annual	Within year

Course Description (provide URL link to syllabus)

Types of coordinate systems and mathematical models; defining datums; defining transformation parameters between datums; Building of gravity models; Modeling continental drift; Conventional celestial and terrestrial references frames, precession, nutation, and polar motion; spherical trigonometry and spherical harmonic expansions; Geodesic line, geodesic curvature, differential equations of the geodesic, direct and inverse solutions; Conformal mapping of the ellipsoidal surface
http://spatial.umaine.edu/files/2015/02/SIE541Syllabus.pdf

Course Objectives

At the end of the course students can
(1) apply datum transformations.

(2) convert between geodetic coordinate systems.
(3) estimate error in datum products.
(4) model coordinate change over time.
(5) convert between astronomic and geodetic orientation.
(6) apply spherical trigonometry to geodesy.
(7) compute various types of geodetic distances.
(8) apply geodetic coordinate computations in all geometry types.
(9) convert between plane and geodetic coordinates.
(10) develop local projection systems.

Course Satisfaction of Knowledge Units

Focus Area KU's: As detailed at https://spatial.umaine.edu/files/2015/02/FocusAreaSurveyResults1.pdf, this course completely satisfies the Focus Area KU of: Geodesy.

Certification:
Our Institution understands and believes that our program meets the criteria defined for designation as an NGA/USGS Centers of Academic Excellence in Geospatial Science Education. Our program has active courses that cover the mandatory core knowledge units and at least five of the optional units to meet the academic content requirements. Our Institution agrees, as part of the application process, that we may be asked to participate in an in-person or remote curriculum review of our courses to verify satisfaction of the mandatory and optional knowledge units.

Optional:
We additionally certify that we believe our program satisfies the additional requirements for designation as an NGA/USGS CAE in Geospatial Sciences in the following focus area(s):
INFORMATION SCIENCE,
NAVIGATION AND LOCATION

Max Egenhofer
_____
Signature

02/25/2015
_____
Date