Integrated Science and Technology (M.S.)

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Professors

Associate Professors

Print Version of Catalog

Integrated Science and Technology

Admission Criteria

The program seeks a diverse student body with grounding in the natural or social sciences. Qualified applicants may have a background in such fields as engineering, mathematics, economics, environmental studies, natural science, political analysis, operations research, geography, sociology, international relations or selected areas of education, among others. Individuals with experience in industry, government or the non-profit sector are especially valued. Applicants should have demonstrable competence in both natural and social science by having completed a minimum of 15 semester credit hours in the natural sciences and mathematics and an equivalent amount in the social sciences or humanities. Work experience can be substituted for academic experience.

Admission decisions will be holistically based on the following considerations:

• A bachelor’s degree or its equivalent awarded by an accredited college or university.
Applications are being accepted for the M.S. ISAT international master's program in environmental management and sustainability, which is taught in Malta. Applicants to this program should follow the instructions detailed on The Graduate School's online application system. The master of science program in integrated science and technology is not currently accepting students for its program at the main JMU campus in Virginia.

Mission

The mission of the Department of Integrated Science and Technology's (ISAT) master's program is to provide diverse and experienced professionals with an educational program that facilitates in-depth knowledge and skills by integrating a variety of scientific and technological disciplines and by utilizing a systems approach to analysis and problem solving.

Unique characteristics of the program include:

- Curriculum and teaching methods that are in constant touch with the realities of professional careers related to science and technology.
- Graduates skilled in information technology and knowledge management tools applicable to a broad range of professional careers.
- A curriculum and graduates that are flexible, versatile and able to stay current with critical technologies and compelling social problems related to science and technology.
- Interdisciplinary and integrated applied problem solving that uses systems perspectives to analyze problems and the feasibility of their solutions, including the considerations of non-technological factors such as politics, economics and ethics.

Accreditation

James Madison University is accredited by the Southern Association of Colleges and Schools' Commission on Colleges to award baccalaureate, master's and doctorate degrees. University of Malta is not accredited by the Commission on Colleges and the accreditation of James Madison University does not extend to or include the University of Malta or its students. Although James Madison University accepts certain course work in transfer toward a credential from University of Malta, or collaborates in other ways for generation of course credits or program credentials, other colleges
and universities may or may not accept this work in transfer, even if it appears on a transcript from James Madison University. This decision is made by the institution subsequently considering the possibility of accepting such credits.

Continuation and Graduation Requirements

Prospective students should familiarize themselves with the ISAT program and the ISAT master’s curriculum. Graduation requires successful completion of core and elective program course work in a sequence approved by the student’s graduate adviser. To graduate, students must have a GPA of 3.0 or higher and may not have received a “C” grade in more than any two graduate courses; at least half of the credit hours in the student’s program of study must be at the 600-level or higher. A student will be dismissed from the program if the student receives an “F” or “U” in any graduate course or a total of three “C” grades in his/her graduate program. Time limitations for completion of the program, continuous registration requirements and thesis preparation guidelines must follow the regulations of The Graduate School.

Master of Science in Integrated Science and Technology

The master of science in integrated science and technology (ISAT) offers programs in Europe and at the JMU campus in Harrisonburg, Virginia. This M.S. in ISAT with a concentration in environmental management and sustainability is taught in Malta in collaboration with the University of Malta as a dual degree program; students who successfully complete the program of study are award a master of science degree from both universities.

The M.S. in ISAT requires a minimum of 30 hours of graduate course work; the concentration in environmental management and sustainability requires an additional 12 credit hours of graduate classes for a total of 42 credit hours.

The thematic core curriculum provides a solid foundation for the M.S. in ISAT. Students acquire quantitative tools for applied problem-solving as well as for the management of technological issues encountered in contemporary professional practice. The core stresses quantitative and qualitative data analysis, modeling and simulation, and the management of information and technology. It also stresses dynamic systems analysis as a key to problem solving and incorporates non-technical dimensions of science and technology including social, political, economic and ethical considerations. Students focus on selected areas of science and technology with practical, in-depth exposure to the size and complexity of contemporary problems.

Depth is provided through elective course work and thesis or capstone project study. Thematic areas of science and technology around which students may build a program of study are distilled from national critical technologies and include the environment, energy, biotechnology, information technology and manufacturing.

Students are required to complete a six-credit hour capstone project or thesis as a core requirement. The project/thesis can be theoretical or practical, and it can
involve research, social analysis, evaluation of potential solutions and/or design implementation. The effort requires students to demonstrate their mastery of an integrated approach to scientific and technological issues.

Core Curriculum

Requirements

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tr>
<td>Foundational Concepts of Integrated Science and Technology</td>
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<tr>
<td>ISAT 502. Earth Systems and the Sustainability of Natural Resources</td>
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<tr>
<td>ISAT 510. Foundations in Integrated Science and Technology</td>
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<tr>
<td>ISAT 620. Introduction to System Dynamics</td>
<td>4</td>
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<tr>
<td>Science, Technology and Society</td>
<td>3</td>
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<tr>
<td>ISAT 610. Social Context of Science and Technology</td>
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<tr>
<td>ISAT 612. Sustainability, Society and Change</td>
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<tr>
<td>Analytical Methods and Techniques</td>
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<td>ISAT 630. Computer Modeling and Simulation</td>
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<td>ISAT 632. Analytical Methods and Techniques</td>
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<td>Information and Technology Management</td>
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<tr>
<td>ISAT 640. Information and Technology Management</td>
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<td>ISAT 642. Applications of GIS for Resource Management</td>
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<tr>
<td>Capstone Project or Thesis</td>
<td>6</td>
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<tr>
<td>Capstone Option (all courses below are required)</td>
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<tr>
<td>ISAT 504. Project Management in a Cross-Cultural Environment (1 credit)</td>
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<tr>
<td>ISAT 564. Integrated Case Study Seminar (1 credit)</td>
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<tr>
<td>ISAT 690. Capstone Project (4 credits)</td>
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<td>Thesis Option</td>
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<td>ISAT 700. Thesis</td>
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M.S. in Integrated Science and Technology (Harrisonburg)

The M.S. in ISAT taught at the main JMU campus is a 30-credit hour master of science curriculum that consists of 21 credit hours of required core courses followed by nine credit hours of elective course work tailored to the student’s needs and goals. The core curriculum reinforces the student’s foundation in science, explores methods of research and analysis in a multidisciplinary environment and imparts sensitivity to the social context of applying science and technology. The nine graduate elective credits must be approved by the student’s adviser.

M.S. in Integrated Science and Technology Requirements

Requirements

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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>Core curriculum</td>
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<tr>
<td>Approved electives</td>
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<td>30</td>
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Concentration in Sustainable Environmental Resources Management

A version of the ISAT master’s degree is offered as a dual degree, international master’s program jointly with the University of Malta and is supported by JMU’s Office of International Programs. This 42-credit hour program offers a specialized course of study in environmental management and sustainability and is taught entirely in Malta as an accelerated 12-month degree program. Both JMU and University of Malta faculty contribute equally to instruction and project or thesis supervision. Students who successfully complete the degree requirements are awarded a master of science degree from each university.

The M.S. in ISAT with a concentration in environmental management and sustainability is designed to build holistic thinking and problem solving using systems perspectives on environmental and sustainability challenges. The curriculum explores principles of sustainability science from Earth systems, natural resource and societal perspectives. It also builds a suite of analytical methods and competencies including GIS, cross-cultural project management, field techniques and statistics. Elective course work builds depth through specialized classes in additional analytical methods, policy analysis, and resource conservation and management. Students broadly focus on either natural resource conservation (such as biodiversity, water resources or agricultural resources) or on sustainable technology management (such as energy conservation or industrial processes). Electives are selected in consultation with, and approved by, the student’s graduate adviser to help students build a coherent and meaningful program of study.

Students complete a four credit hour capstone project; exceptional students may opt to complete a master’s research thesis, which requires approval from the program’s Board of Studies. Students completing the thesis option should expect that their program of study will be 16 months instead of 12. Details on the curriculum structure, required course work, available electives and a program calendar may be found on the program website.

Environmental Management and Sustainability Requirements

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<th>Minimum Requirements</th>
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<tr>
<td>Core curriculum</td>
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<tr>
<td>ISAT 568. Freshwater Resources Management</td>
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<td>ISAT 614. Sustainability Policy and Law</td>
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<td>ISAT 656. Mediterranean Field Study</td>
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Course Offerings

Integrated Science and Technology

ISAT 502. Earth Systems and the Sustainability of Natural Resources. 2 credits.
A conceptual and descriptive scientific understanding of critical Earth systems and natural resources as they pertain to applied environmental and sustainability management. The course is intended to provide an integrative introductory foundation
of knowledge, terminology, models, and concepts with respect to the physical, biological, and ecological processes that govern life on Earth; to explore the limits that these processes pose for human natural resource use and recovery; and to illustrate the power of humans to disturb the dynamics that support a living planet. Course is taught online.

**ISAT 504. Project Management in a Cross-Cultural Environment. 1 credit.**

An introduction to the basic principles of project management and key processes including initiating, planning, and scheduling a project. The course also explores work collaboration in cross-cultural environments and international settings, where interpersonal communication, organizational cultures, and societal norms can affect productive and collegial project collaboration. Important cultural competencies are explained and practiced. The class is conducted in a blended learning environment that incorporates online tutorials, group work, seminar discussions, and guided learning exercises. Taught in Malta.

**ISAT 510. Foundations in Integrated Science and Technology. 2 credits.**

This course introduces the student to the fundamental concepts of applied interdisciplinary science and technology and the methodologies required for using an integrated problem-solving approach in the technical area.

**ISAT 511. Quantitative Methods for Systems Analysis. 1-3 credits.**

This course is intended to improve the quantitative skills of certain graduate students. Basic mathematical functions and techniques are reviewed, and linear systems topics and numerical analysis techniques introduced. The course meets in tutorial sessions for lectures, discussion and recitation. Does not satisfy graduation requirements for MS ISAT students.

**ISAT 515. Energy Systems. 3 credits.**

This course will present an overview of energy generation and distribution technologies that are in use or under development. Selected technologies will be covered in detail including the underlying scientific principles. In addition, students will study tools and techniques used to measure, control and analyze energy consumption.

**ISAT 525. Environmental Systems. 3 credits.**

This course covers the basics of environmental pollution, processes, and control technologies. Three major areas of environmental concern (air, water and waste) are addressed. Environmental risk and decision making are discussed. Topics are presented in an integrated manner in the context of the regulatory programs. Participation in environmental projects such as impact assessment, site remediation, water quality management, air quality monitoring are required.

**ISAT 528. Industrial Ecology. 3-4 credits.**

Industrial ecology, the science of sustainability, seeks to encourage the development of a sustainable industrial society. This course introduces and examines this relatively new field of inquiry and practice. The course addresses various practical topics which are associated with industrial ecology, including life cycle assessment, design for environment and environmentally conscious manufacturing. There are additional requirements for graduate students beyond those for undergraduate students enrolled in this dual-level course.

**ISAT 530. Manufacturing Systems. 3 credits.**

This course covers systematic and analytical treatment of manufacturing systems to identify opportunities for improving existing systems, to design more effective
systems and to improve decision-making processes in manufacturing. Topics include manufacturing systems; tools for automation and integration in manufacturing; automated process planning; technology change and strategies for implementing new technologies; and others.

**ISAT 540. Information and Technology Management Systems. 3 credits.**
This course focuses on the representation, manipulation, storage, and retrieval of data, information and knowledge from both a historical and contemporary perspective. Students will be introduced both to programming skills and also to introductory concepts in database design and development. The course will stress aspects of data quality, privacy, and security.

**ISAT 550. Biotechnology Systems. 3 credits.**
This course is an intensive survey of the scientific foundations of biotechnology. Specific topics include the history, theory, and applications of recombinant DNA technology, genetic engineering, transgenic organisms, and the role of biotechnology in society.

**ISAT 551. Bioinformatics. 3 credits.**
The amount of DNA sequence data being collected today is increasing rapidly. The student will learn, through lectures and hands-on laboratory exercises, a compendium of algorithms that can search for sequence similarities, create alignments for finding consensus sequences, model three-dimensional structures and more. Prerequisites: ISAT 340, ISAT 351, and ISAT 454 (or their equivalents), or permission of the instructor (requires knowledge of molecular biology and database technology).

**ISAT 560. Complex Systems and How They Fail. 3 credits.**
This course provides an interdisciplinary study of complex system operation and failure focusing on real-world critical infrastructure (e.g., energy, telecommunications, health) systems functionality and problems. Based on known threats and hazards, cascading failures that can result in unexpected catastrophes are analyzed. Risk concepts and management strategies are examined.

**ISAT 564. Integrated Case Study Seminar. 1 credit.**
An in-depth exploration of a complex, existing real-world problem using formal case study analysis. Designed to illustrate the interdisciplinary nature of difficult problems and to foster integrated problem-solving through the application of systems thinking and structured problem analysis techniques. Course is taught in a discussion and seminar format.

**ISAT 565. Energy Sustainability. 4 credits.**
This course focuses on the exploration and analysis of case studies in the development of sustainable energy policies and practices around the world, including renewable and non-renewable energy sources and conservation practices. Connections of energy sustainability to other key areas, such as water, air and waste, agriculture and food and coastal resources will be emphasized. Offered in Malta.

**ISAT 566. Case Studies in Sustainability: Air and Water. 2 credits.**
This course focuses on the exploration and analysis of case studies in the development of sustainable air and water policies and practices around the world, including air pollution abatement, waste disposal and the interconnection of air and waste. Connections of air and water sustainability to other key areas, such as water,
energy, agriculture and food and coastal resources will be emphasized. Offered in Malta.

ISAT 567. Food Resources and Security. 4 credits.
This course focuses on the exploration and analysis of case studies in the development of sustainable agriculture and food security policies and practices around the world, including food safety and land use. Connections of agricultural sustainability to other key areas, such as water, energy, air and waste and coastal resources will be emphasized. Offered in Malta.

ISAT 568. Freshwater Resources Management. 4 credits.
This course focuses on the exploration and analysis of case studies in the development of sustainable water policies and practices around the world, including potable water supply and production and water pollution. Connections of water sustainability to other key areas, such as agriculture and food, energy, air and waste and coastal resources will be emphasized. Offered in Malta.

ISAT 569. Conservation Planning. 4 credits.
An exploration of biodiversity conservation as an essential element of sustainability. Reviews current state of biodiversity worldwide, highlighting patterns and trends in relation to genetic, species, and ecosystem diversity. Options for mitigating the driving forces of biodiversity loss are critically discussed in terms of their feasibility, including the fundamental conservation biology principles that underpin conservation initiatives. In situ and ex situ conservation options, as well as planning strategies for terrestrial and aquatic/marine ecosystems, are addressed. Offered in Malta.

ISAT 570. Telecommunication Systems. 3 credits.
This course covers the science, technologies and regulation of established as well as emerging telecommunications systems. Included are network design and planning, as well as information and infrastructure security. Student course work will include laboratory experience.

ISAT 571. Interaction Design. 3 credits.
Processes, principles, tools, models, and techniques for designing interactions between humans and digital products and systems. Students will learn through directed reading, design exercises, heuristic design evaluations and empirical studies of designs.

ISAT 580. Readings and Research. 1-3 credits.
This course will allow graduate and advanced undergraduate students to undertake intensive study of selected topics that are of special interest. May be repeated when content changes. Prerequisite: Permission of instructor.

ISAT 610. Social Context of Science and Technology. 3 credits.
Critical perspectives on the economic and political systems as they affect scientific research and technological activity in the U.S. and the world. Case studies of major public policy debates involving science and technology. Identifying institutional players and their value commitments, describing political relationships among players, and designing dynamic solutions to social context dilemmas.

ISAT 612. Sustainability, Society, and Change. 3 credits.
An introduction to defining principles of environmental management and sustainability in the context of complex coupled social-ecological systems (SES) and the interdependence of people and nature at a variety of nested scales. Through examples, students analyze interactions between humans and their landscapes over time using different SES frameworks and related concepts, including planetary boundaries,
resilience, robustness, ecosystem services, and panarchy. The crucial role of personal ethical decision-making frameworks will be further analyzed, exploring the moral dimensions of a number of sustainability-related decision-making situations. Offered in Malta.

**ISAT 614. Sustainability Policy and Law.** 3 credits.
This course introduces students to the basic principles of international and national environmental law, policy, and regulation as it pertains to sustainability. Critical distinctions in environmental policy and sustainability policy are made, and the issues of governance for each are explored. Common problem domains of law and policy are explored, including externalities and pollution, common pool resources and resource overharvest, and biodiversity loss and landscape functioning. Transboundary environmental problems are addressed in depth. Offered in Malta.

**ISAT 620. Introduction to System Dynamics.** 4 credits.
An introduction of applied systems analysis approach to problem solving in a multidisciplinary context. Applications taken from biotechnology, energy, environment, health, information management and manufacturing. Topics include introduction to systems analysis and its application to social systems, technological systems, and systems in nature; systems characterization and optimization; advanced project management.

**ISAT 630. Computer Modeling and Simulation.** 3 credits.
Use of simulation tools to understand and optimize commonly occurring systems in the concentration areas. Development of simulation models, validation of models, and use of models to aid decision making. Topics include: applicability and limitations of simulation models; the model-building process; discrete-event models; dynamic models; deterministic and stochastic models; system optimization and validation.

**ISAT 632. Analytical Methods and Techniques.** 1-3 credits.
This course enables students to focus in-depth on specialized analytical methods, techniques, and instruments involving quantitative and qualitative data analysis, simulation, and modeling relevant to scientific, technical, and environmental analysis. Students select and complete structured instructional modules from a menu of topics offered by faculty in the degree program; each module is equivalent to 1 credit hour of graduate coursework. Examples of topics include data visualization, environmental impact assessment, survey design principles, advanced applications in GIS, water quality measurement techniques, thermal infrared imaging, and so on. Course may be repeated for additional module topics.

**ISAT 640. Information and Technology Management.** 3 credits.
This course focuses on the acquisition, representation, storage, retrieval, and distribution of data, information and knowledge from both a historical and contemporary perspective. It places special emphasis on IKM technology in science and technology and the information economy, the management of data, information, and knowledge as critical enterprise assets. Students will study computer systems as tools for information and knowledge management and examine ethical, legal, and social issues in the management of data, information, and knowledge, including intellectual property, privacy, and security.

**ISAT 642. Applications of GIS for Resource Management.** 3 credits.
This course focuses of the use of GIS as a decision support tool in managing natural resources and promoting sustainable development practices. Applications and spatial
problem-solving in the areas of energy, air and water, waste management, agriculture and coastal resources are emphasized.

ISAT 650. Advanced Integrated Science and Technology. 3 credits.
This course focuses on applied science and technology applications for K-12 teachers and industry trainers. Students will develop and assess sources of information on applied science and technology and develop inquiry-based activities to incorporate new issues in applied science and technology into existing curricula.

ISAT 652. Regulatory Issues. 3 credits.
The course will introduce the policy process affecting regulation and deregulation of various industries. Study of the theory behind and the institutional forms of regulation will be supplemented by case studies of specific industries. The course will also look at international politics and trade as they affect regulatory regimes globally. Prerequisite: ISAT 610.

ISAT 653. Quantitative Systems Analysis. 3 credits.
Focuses on the life-cycle model of systems design and development. Includes concepts related to data modeling, economic evaluation, optimization methods, human factors, queuing theory, system test and evaluation, and design validation techniques. Object-oriented analysis and design considerations emphasized. Prerequisite: ISAT 630.

ISAT 654. Advanced Technology Management. 3 credits.
This course will introduce students to methods, tools, and techniques for effective management of technology development and application including management of technology within a company; R&D management; Test and Evaluation procedures and metrics; investment strategies; intellectual property issues; fostering entrepreneurialism; managing innovation; and technology transfer. The course will also address managing technology as a tool, e.g., equipment modernization. Prerequisite: ISAT 640.

ISAT 655. Technology Assessment. 3 credits.
This course will introduce students to the theory and methods of technology assessment and transfer. Students will apply techniques such as risk analysis, cost-benefit analysis, forecasting, trend impact analysis, and technology sequence analysis to assess the impacts of new technologies on society. In addition, students will study the process of technology innovation, diffusion, and transfer in the context of both developed and developing nations. Prerequisite: ISAT 640.

ISAT 656. Mediterranean Field Study. 3 credits.
This course comprises a field trip to one or more sites within the Mediterranean Basin. Selected study areas combine a variety of natural, semi-natural and anthropogenic dimensions, and face several urgent management issues, many of which are also characteristic of the region. Site work combines lectures, hands-on projects, and analytical presentations. The experience reinforces techniques for evidence-based policy formation, environmental appraisal and impact assessment techniques, and protected area management, among others.

ISAT 657. Management Information Systems. 3 credits.
This course examines the organizational and technological foundations of information systems in a production operations setting. Topics include selecting and implementing tools and systems, database management, information integration, production planning and execution systems, supply chain integration and management, and managing system security. Prerequisite: ISAT 640 or permission of instructor.
ISAT 658. International Contexts of Science and Technology. 3 credits.
This course will make students aware of the global nature of scientific and technological decision-making and sensitive to the impact of culture on science and technology issues. Research and development system of the United States is placed in a global context. A comparative study of the R&D systems around the world is done. International technical issues, where solutions transcend political boundaries, are covered.

ISAT 680. Reading and Research. 1-3 credits.
Opportunity for supervised reading and research in areas of special interest to the student. Reading and research may be done only in the major field of study.

ISAT 690. Capstone Project. 4-6 credits.
The required capstone project for all non-thesis graduate students. The project involves an integrated, interdisciplinary approach to an applied problem in the student’s area of interest and specialization. Students are expected to demonstrate project management skills, produce a written technical report or analysis, and provide a presentation summarizing the scope and results of their work. The project can be an investigation or development undertaken by the student individually or as part of a larger effort conducted by a project team.

The course prepares students for planning and completing their master's thesis. Topics include problem definition, research question, literature review, research methods, and thesis planning process. All students draft a thesis proposal. The course must be completed within the first 12 credit hours of the student's program of study. Prerequisite: ISAT 620 or instructor approval.

ISAT 698. Comprehensive Continuance. 1 credit.
Continued preparation in anticipation of the comprehensive examination. Course may be repeated as necessary.

ISAT 699. Thesis or Capstone Project Continuance. 1-2 credits.
Continued study, research and writing effort on the thesis or capstone project. Continuance credits carry no credit hour production and do not count toward graduate program requirements. Students who have registered for six hours of thesis/project credit but have not finished must be enrolled in this course each semester until the completed thesis/project has been approved by the student’s committee. May be repeated as needed.

ISAT 700. Thesis Research. 6 credits.
A research thesis with an emphasis in the student's designated strategic area, but integrated with at least one other area. The thesis will report the results of original research undertaken individually by the student. This course is graded on a satisfactory/unsatisfactory/incomplete (S/U/I) basis.