ISAT Senior Project Manual:

A Guide through the ISAT Senior Project Process

For ISAT 491, 492, & 493
And
ISAT 499 A, B, & C

Table of Contents

Introduction to the ISAT Senior Project

The Senior Project is designed to be the capstone of your ISAT experience. It provides you with the opportunity to use skills from a variety of your courses to tackle a substantial real-world problem. Most Senior Projects are done in small teams, but you may choose to pursue a project on your own if you prefer. ISAT graduates often point to their Senior Project experience as a central highlight of their time at JMU.

You will perform an independent research project to identify and analyze a technology based problem, develop alternative solutions, recommend the best solution, and provide a written and oral technical report. As part of your Senior Project experience, you will have the chance to demonstrate your ability to define and manage a project; identify goals, track and report progress; deliver results on time; and clearly report results. Specifically, you will

- Develop innovative solutions to significant, real world problems
- Work with others including your team, project Sponsors, and faculty members
- Situate your work in the relevant social context(s)
- Develop and deliver a clear, convincing oral presentation and
- Write an extensive professional report.

The Senior Project spans three semesters and three courses: ISAT 491, 492, & 493. Most of you have never worked on or completed a project of this magnitude, and it poses a different sort of challenge than traditional coursework. Although there is no substitute for your own initiative and hard work, the ISAT faculty and staff will help guide you through the process. This section of the ISAT Senior Project Manual provides an overview of the first part of the Senior Project: the Proposal, which you will complete in ISAT 491. Subsequent sections will help to guide you through the Project and the oral and written presentations, which are part of ISAT 492 & 493.[1] The material presented here is intended to articulate the minimum requirements for an acceptable Senior Project Proposal, not to provide an exhaustive list of what a good Proposal will include. Indeed, many Projects will go far beyond these basic requirements. Note also that this manual is meant to provide general guidance, not to establish hard-and-fast, inflexible rules. Your Senior Project Advisor must approve of the final format of your Proposal and your final Project write-up. Your Advisor is ultimately responsible for approving of your Project, ensuring that it meets ISAT's standards, and assigning you a grade in ISAT 492 & 493.

The ISAT Senior Project is one of the most unique offerings in your university education. Not only does it provide a platform for you to engage in a hands-on educational experience, it also sets you apart from the thousands of other college graduates that will be competing with you for employment. Every college student takes classes, but not every student has the opportunity to conceive and execute a project on a real-world topic that interests them. If you make the most of your Senior Project, it can demonstrate to employers (and yourself) that you can achieve tangible results when facing an actual issue or problem. ISAT Senior Projects allow students to showcase the breadth of their knowledge and skills, and their ability to tackle challenging problems.

---

[1] Students enrolled in the Honors Thesis option will enroll in ISAT 499 A, B, and C instead of ISAT 491, 492, and 493. The two sequences of courses are identical in all ways except their titles and course numbers.

To put it another way: imagine that you are an employer searching for qualified candidates and have to wade through hundreds of applicants or dozens of interviewees for a job. You likely wouldn't be very interested in hearing about an applicant's experience in chemistry or physics classes, but would you likely be much more interested in a real-world problem that an applicant helped to solve during the multi-semester project. If this project involved both social and technical components – as good ISAT Projects should – this makes for an almost uniquely powerful combination that few of your peers from other institutions can match. Since you will have ownership of this Project you will be able to speak intelligently and authoritatively about it during an interview, allowing you to demonstrate your abilities. It is in your best interest to make the most of this opportunity: start early and put maximal effort into your Senior Project!

This manual will guide you through the Senior Project process: from thinking up an idea to handing in your Final Report. It is organized in several sections, starting with the Proposal process, continuing with the Final Report guide, and ending with a guide on style and several appendices. Not all students will need to consult all of the appendices. Some portions of this manual should look vaguely familiar. Much of the style guide is fairly standard for academic and business writing. The structure suggested for both the Proposal and the Final Report are similar to the structure described in the ISAT Style Manual that you might have used in some of your ISAT classes.

Initially, you might want to read through this manual briefly to get a sense for the Senior Project as a whole and what to expect. As you proceed through the Senior Project process, the ISAT Senior Project Manual will serve as a handy and (hopefully) useful reference.

Getting Started with a Senior Project

Although each Senior Project is unique, what follows are some general guidelines that should help you develop ideas as your Project takes shape. Here are answers to some common questions from students who are beginning the process of defining their Senior Project.

Components of a Senior Project

Your Senior Project should address a problem of technical and/or social significance pertinent to your ISAT studies. You should analyze the technical and social dimensions of the problem, discuss the larger context to which the problem relates and include a literature review summarizing recent developments and discussions pertinent to the project.

Most importantly, you must identify a problem-solving deliverable. This deliverable might take the form of a report, web site, computer program, design prototype, or some other type of professional output. In some cases, the only deliverable will be a written report and an oral presentation, but there is still an expectation that there is some value-added component to the project and that the student reaches some type of conclusion. This deliverable must be acceptable to your Faculty Advisor. Regardless of other deliverables, each student or team must produce a written Senior Project Report and make an oral presentation of the project results.

Support and Guidance for the Senior Project

As you develop your Senior Project, you should identify people to serve in the following important roles and secure their commitment to work with you.

Senior Project Advisor

You **must** secure the agreement of one ISAT faculty member to serve as your primary Senior Project Advisor and document this agreement by completing and signing a Memorandum of Understanding (MOU). This individual will serve as your official instructor for 492 and 493, will guide you through the Senior Project process, and will grade your Proposal and Final Report. Any ISAT faculty member (and a few non-ISAT faculty members) can serve as an Advisor. *You do not need to choose an Advisor (or a project) from your concentration.*

Senior Project Readers

There are three other types of individuals who can serve as readers for Senior Projects. Although none are technically required, you are strongly encouraged to have at least one of the following types of readers involved in your Project.

>   **Co-advisors** – Given the breadth of many ISAT Senior Projects, it makes sense that some have more than one Faculty Advisor. Although one faculty member must serve as

the primary Advisor (students enroll in his or her section and he or she is ultimately responsible for final grades), co-advisors can be a very important part of a Senior Project team. They are typically involved throughout the project and take on a role roughly or nearly equal to the primary Advisor. Co-advisors should sign off on all materials requiring the signature of the Senior Project Advisor.

External Sponsors (if applicable) – Many students choose to pursue projects that involve businesses, civic organizations, or other groups. If your project is being completed for a business or other group outside of ISAT, you must identify the External Project Sponsor who will serve as your primary contact for the project. This individual should also serve as a Project Reader. Note that the deliverable(s) you agree on with your Sponsor will likely be different than the deliverables for your Faculty Advisor, though there is often some overlap between the two.

Faculty Readers – Especially if you don't have a co-advisors or external Sponsors, you should identify one or two individuals to read your final report. They review your Project and provide feedback to you and your Advisor. Readers will often have competence in some area that your project addresses, but they need not be subject-area experts. Indeed, it is often desirable to have Readers who isn't an expert, since they have a different perspective on your Project. They do not have to be JMU faculty; however, your Project Advisor must approve your Project Readers.

Getting Ideas for Senior Projects

Ideas for Senior Projects come from everywhere. Many students choose a Senior Project that is of particular interest to them. Someone who loves river kayaking might choose a project related to water quality issues or river bank erosion. A student who likes working with computers might choose to build a database for a community group. Many projects stem from ideas that students initially had during one of their ISAT classes. Many students choose projects in collaboration with a particular professor that they like and respect. A number of ISAT professors have ongoing research to which students can contribute. External companies or organizations often have an opportunity that they wish to develop or problem that they wish to solve, and your project could help them in these efforts. **But remember that your Senior Project is yours, not your Faculty Advisor's**. Don't choose a particular Project *only* because a faculty member told you to do so. Furthermore, **it is perfectly acceptable to devise a project for yourself that you are particularly interested in or feel passionate about** – in fact, the best Senior Projects are often student-created. You do not need to choose a Senior Project from a list of those that faculty members have proposed; you only need to find a faculty member who will agree to advise you through your project. If you are unsure about which faculty member would be best for your project idea, ask the 491 teaching team or a faculty member that you know well for advice.

As you think about ideas, make sure that they address a real problem of technical and/or social significance pertinent to your ISAT studies. Your Project **does not need to be directly related to your concentration**, however, and many students have chosen projects that are tangentially

related to their concentration or even completely unrelated to their concentration. This is fine as long as it builds upon what you have learned in your ISAT career. Remember that your project will have to be accepted by ISAT faculty who will make sure that it meets the learning goals for a Bachelor of Science in ISAT. But above all, make sure that you choose a project that interests you. You will likely be spending hundreds of hours working on your Senior Project, so make sure that you choose one that motivates you. If you can't get excited about your Senior Project, who will?

Also, some ISAT Senior Projects are part of a larger, longer-term project, often associated with a particular faculty member(s) or external Sponsors. Indeed, some projects such as building a BioTrike or researching Lacritin realistically can't be completed in a single year – they are only possible if multiple students work on parts of them over the course of several years. Students working on Projects that aim to secure funding and design or implement a complex technology might never see the final product, yet they are solving real-world problems just as much as the student who finally realizes and tests the completed system. If you choose such a Project, it is important for you to clearly delineate the scope of your project, noting clearly what has been done before, what your role is and what you hope to accomplish, and what work will remain for future students. It is important to remember that just because the Project might already be well defined for you, that does not mean that you should be passive and simply do what you are told. Part of being an ISAT student is taking an active part in projects and solving diverse problems. You should never simply be content with doing an adequate job on a well-defined project that someone else has handed to you.

Working on a team vs. working individually

Knowing whether to work as a team on a project or work on one individually is a difficult issue, and one that will depend on your situation. On the one hand, ISAT encourages teamwork and it is part of the ISAT philosophy. Working on a Senior Project team lets students continue to develop their teaming skills, which are very valuable in most professional settings and which are valued by most employers. Furthermore, some projects are sufficiently large and/or complicated that they could not be adequately tackled by a single individual.

That said, it is very important for you to be interested in, motivated by, and excited about your Senior Project, and it can be hard to find several students in your cohort who feel this way about the same project. In such a case, it makes much more sense to work individually on a project that you love rather than to join a project just to be part of a team.

If you do decide to work as a team, it is important to select the right team to successfully complete the Project. Consider your choice of teammates carefully. Don't just choose your friends – more than one friendship has ended because of a Senior Project gone awry. Instead you should think about who has the skills, temperament, and interest to help the team complete the Project successfully. You and your teammates must develop a framework to manage your team, decide on and clearly state who will be responsible for producing what, and create a set of criteria by which you can evaluate the performance of every member of your team.

Senior Projects and Summer Internships

It is possible to combine your Senior Project with your summer internship, and in some cases this will enhance your Senior Project experience. However, remember that you cannot simply double-count your internship as a Senior Project. The Senior Project must be in addition to your internship and you must submit a completed Senior Project Report for academic credit in addition to any deliverable required by your project Sponsor. An internship is a way to gain experience in a work setting, whereas the Senior Project is part of your academic experience. Internships can be (and usually are) totally separate from Senior Projects. If appropriate, you may arrange to receive academic credit for your internship, but this does not necessarily make it your Senior Project.

Many students that have worked with a company or agency during the summer have used that time to develop a Senior Project Proposal which they then completed during their senior year. In some cases, students want to develop Senior Projects based on summer internships but the organization that they will be working for cannot tell them specifically what they will be working on. In these cases – and **ONLY in these cases** – students can request to hand in their complete Senior Project Proposal by the end of the second week of classes in the following fall semester. **You are still required to complete a Senior Project Proposal as part of 491 and no exceptions will be made for any reason.** If you believe that the nature of your internship will not allow you to complete the Proposal on time, you must immediately inform your Advisor your 491 instructor. If they agree, then you must – in writing – provide them with clear documentation of your internship, explain reason for the delay, and agree upon a deadline (no later than the second week of classes during the following fall semester) for submitting the final Proposal to your Advisor and your 491 instructor, both of whom must sign off on this agreement.

Memorandum of Understanding (MOU)

Once you decide on a topic for your Senior Project, the next step is to produce a Memorandum of Understanding (MOU). The MOU serves as the initial agreement between you and your Senior Project Advisor. The MOU must be reviewed and approved by your Advisor. The MOU briefly describes your project idea, though you might not know all of the details right now, as some project ideas are quite clearly defined and others are still being developed at this stage. For example, if you plan to develop a Senior Project during your summer internship, you may have very little detail about your project (see above for details on handling this situation). The most important aspect of the MOU is that it establishes a commitment both from you and from your Senior Project Advisor to work together on a mutually agreed upon project. This agreement is documented and verified by the signatures of you (and your teammates) and your Advisor. A template for the MOU is posted on the ISAT 491 Blackboard site.

The MOU is a binding agreement, but there are certain conditions under which it can be terminated. Your Advisor can opt out of the agreement if he or she feels that you are not living up to your agreement. Generally this is accompanied by a poor grade by the Advisor for the student's work in ISAT 491 or 492. As a student, you can also terminate the MOU, but you

must follow a formal process. As a first step, you should talk to your Advisor to explain why you do not feel as though you can fulfill the conditions of your MOU. If you cannot resolve these issues with your Advisor, you should get your Advisor's approval to pursue another project with a different Advisor. In order to switch to a different Project with another Advisor you need to create and execute a new MOU, including signatures from you, your new Advisor, *and your previous Advisor*. If you believe that you are not being treated fairly by your faculty Advisor, you should take your concerns to the Department Head.

Senior Project Proposal

Each team (or student if you are pursuing an individual Senior Project) must write a Project Proposal and have it approved and graded by their Senior Project Advisor. This is an interactive process, so plan to meet often with your Senior Project Advisor and to submit a draft copy of your Proposal to him or her well before the end of the semester. Note that in order to have enough time to produce a substantive draft in this timeframe you will need to decide on a project early in the semester. **Expect your Advisor to suggest significant revisions to your first draft**, as this is a normal and expected when coming to an agreement on a project Proposal. In fact, you should get into the habit of drafting, editing, and re-drafting, as these are a critical part of the process of producing a Senior Project report or any other in-depth research document.

Your goal is to create a Proposal that will put you in a position to produce a successful Senior Project. In order to achieve this success, your project must be clearly defined, of manageable scope, and appropriate to ISAT. Therefore, as you develop your Proposal you will need to do the following (some of which were discussed above):

- Identify and clearly define your project
- Identify your project team (if applicable)
- Identify Readers and External Sponsor (if applicable)
- Secure the agreement of your Senior Project Faculty Advisor
- Consider, describe, and address relevant social context issues
- Search the literature for all relevant, published information
- Identify and important unpublished sources of information or guides for your project
- Write a Proposal and submit it to your Advisor and 491 instructor for approval

General Issues

Writing the Proposal
Start writing the Proposal early. Too many people wait until the last minute to begin to write. Overcoming inertia can be the hardest part of writing. You will generally be much better off if you start writing early and then edit, revise, and add to what you have written. That is, writing is an iterative process, not a one-off event. Writing is a process that aids and focuses your thinking. Getting an early start can help you realize what you do not know and thus help to guide your future work. Early drafts are often rough around the edges, as some sections will simply consist of notations to yourself that the work needs to be completed later. It is generally easier to attack a large problem by breaking into smaller, more manageable chunks. Start with the sections that you find easiest and are most comfortable with, and later move on to the more challenging sections. Word processors make working rearranging various sections easy and painless, so don't fret too much initially about what the final ordering will look like.

It is important to get feedback from your Advisor and ISAT 491 faculty early in the writing process. Don't make the mistake of producing a complete draft and only then showing it to your Advisor.

Example Senior Project Proposals
Models for how to construct a Proposal are included in the Examples appendix of this manual. Also, the ISAT 491 Blackboard site has examples of well executed Senior Project Proposals from former ISAT students. While not perfect, these Proposals can serve as useful models as you begin to construct your Proposal. Other Senior Project Proposals are on file in Fasha Strange's office (ISAT 122).

Proposal Outline

Your written Senior Project Proposal should clearly and concisely describe your project, explain why it is appropriate and compelling, and outline how you will complete it. Note that your completed Proposal effectively becomes your syllabus for ISAT 492 and493. Therefore, you need to take special care to ensure that your goals find the right balance between being substantial enough to constitute a compelling, important project, while also being modest enough to ensure that you can reasonably complete all that you set out to do. Striking this balance can be difficult, so be sure to solicit advice from your Advisor.

Senior Projects in ISAT come in many different forms and address highly diverse topic areas, so it is understandable that there is some variability in the structure of written Proposals. Most importantly, the content, organization and format of your Proposal must be accepted by your Senior Project Faculty Advisor. There are some good general guidelines for producing a strong Proposal, which are outlined below. Unless there are compelling reasons for straying from this structure, Proposals should include all of the following components, preferably in the order and manner described below.

Title Page

Your title page should include the project title, date, and the names and signatures of team members, your Faculty Advisor and any co-advisors or external Sponsors (if applicable). There is a formatted template for a Title Page on the ISAT 491 Blackboard site.

Executive Summary

The executive summary allows readers to quickly know what you are going to attempt without having to read your entire Proposal. The executive summary should be a complete description of the main parts of the Proposal without any details. It should be one paragraph at the most and a short one at that. Some students see the Executive Summary as something of an afterthought, but you should take it very seriously and work hard to make it one of the strongest sections of your paper. More people will see your Executive Summary than any other part of your paper, so make sure it that it is well written and gets across your central message.

Table of Contents

The Table of Contents lists the different sections of the Proposal, including on which page each section starts. It should be formatted in a way that is clear and easy to read. You should include all sections (including Appendices) in the Table of Contents except for the Title Page.

Introduction (Justification and Discussion of Significance)

The introduction explains to the reader the background of the Proposal and its purpose. This section must delineate and make very clear the problem you are investigating and why the project is worthwhile. In explaining this you might discuss what interested you in the project and, at even more importantly, why the reader should be interested in your project. As you will be devoting hundreds of hours to the project over the next year, you should have a very good idea about why you chose your particular project. Note that because this is a project Proposal, there will be little difference between the introduction and the justification and significance, and most students choose to combine them into introduction single section. In the final project report the justification and significance should be separate from the introduction.

It helps some students to think of the introduction in this way: How would you explain your project to a friend or relative who knows nothing about what you are doing? Your friend might ask these questions: Why are you doing this? Who cares? Would you explain the basic concepts to me so that I can understand what you are going to do? Who else would be interested in this?

The introduction should also briefly describe the method of the proposed investigation. How do you plan to complete your project or investigate the problem you chose? As there are always a number of different potential approaches to tackle a project, you should discuss why you chose your approach. Note that it is important to acknowledge the limitations as well as the advantages of your chosen approach. For example, if you are designing a website for an organization, you should have a plan for what information you will include, how you will design it, and in what form you will present the information. In this example, it would be particularly important to discuss why the website is being created and what it will accomplish, as well as noting the potential advantages and disadvantages of other projects such as a series of pamphlets or a video documentary.

Do not worry if there is some redundancy among the sections of your Proposal, as this is normal. Conveying similar information several times signifies to the reader that the point you are making is particularly important and it increases the likelihood that the reader will understand and retain the information.

For more help in writing a strong introduction you might want to consult a good writing manual. Robert A. Day's, *How to Write and Publish a Scientific Paper* (5th edition, Phoenix: Oryx Press, 1998) has a good discussion on writing an introduction.

<u>Literature Review</u>

All work, but particularly work in academia and business, builds upon previous research and the reported experience of others. In other words, nobody starts a project completely from scratch. The Literature Review is the section in which you orient the reader into your research world. Your work is part of a larger social effort in certain topic areas, and the Literature Review is where you describe how your project fits into this bigger picture. Often it will be valuable to briefly sketch the history of the technology with which you are working, as well as the latest scientific and technical developments that relate to and inform your project. Since at this stage you are still a novice, you will undoubtedly have a hazy and incomplete understanding of the relevant literature it your topic areas, but you should at least have a general understanding.

The Literature Review should also address the broader social, economic, cultural, and ethical issues that influence or affect your project. ISAT projects deal with actual problems, and human problems always have important social issues that must be addressed. Every project has social or economic constraints that serve as limiting factors for what is feasible, what is acceptable, and what is desirable. Thoughtful and competent consideration of appropriate social context issues is one of the skills that sets ISAT students apart from most other technical students.

For your proposal, the Literature Review should also identify what information or skills you will need in order to complete your project. This might include reading and mastering published laboratory procedures, learning a new programming language, or seeking out and contacting an expert on a particularly technique that you will be using. This might also include the names of people who will need to provide input for your project (such as Sponsors or other interested parties), a broad summary of the scientific research data needed (if any), and any other required information that is not already printed in the accessible literature.

In-text Citations
A prominent feature of any literature review is the inclusion of citations to the material that you believe will be most helpful to you in your project, with which your work engages, or upon which your work builds. Citations tell the reader where each idea or fact in your Proposal came from (if they were not your own). This serves two different purposes.   First, properly credits the author of the material. Second, it provides interested readers the opportunity to follow up with your source either to verify that it says what you claim that it does or because they want to know more about the item for which the citation was provided.

Crediting your sources is an essential part of any academic work and is required throughout your Proposal, not just in the Literature Review (though this is the section that will likely contain the most citations). If you take an idea or directly quote from another person's or group's work, you must cite that source in your paper. This includes not only written work, but also websites, films, audio recordings, personal conversations, or any other form of evidence. When in doubt, it is always better to cite your source; including an unnecessary citation is overkill, omitting a necessary citation is intellectual theft. Taking someone else's ideas and research and putting it in your paper as your own without proper citation is **PLAGIARISM**. Plagiarism violates JMU's Honor Code, which is a very serious matter. Keep in mind that if your faculty Advisor provides information, either in written or oral form, you may need to credit him or her as well – ask your Advisor if you are unsure about whether it is necessary for any particular case. Make sure to communicate with your Advisor and clarify what needs to be credited and what is simply part of normal advisory duties.

There are a variety of acceptable ways to cite material within a document, including parenthetical in-text cites, footnotes, and endnotes – you should consult with your Advisor and your 491 instructor about which is most appropriate for your Proposal. Note that for in-text citations if there are more than two authors, you should only list the first author, followed by the phrase "*et al.*" which means "and others.") There are also a variety of acceptable citation styles; **ISAT does not require the use of any particular citation style.** You should consult with your Advisor about whether he or she has a strong preference concerning citation style. Whatever style you choose, make sure that it is an established, standard style and that your citations are complete. For more on citations, see the Style & Formatting section below. (See also the entry on citations in the Writing Style section below).

Methodology

The Methodology section describes in greater detail what you plan to do, how you plan to do it, and what form your final output will take. Since this is a Proposal, not a final Report, you might not have your methods completely planned out yet. At a minimum, however, you should have a framework in mind of what you will need to do and you should clearly indicate which parts still need to be worked out. The more detail you can provide in this section, the easier it will be to complete this work during ISAT 492 and 493, and the less likely you are to have a less-than-fully-successful Senior Project.

This section should also describe the resources that will be required for the project and estimate how much they will cost. Resources may include equipment, software, instrumentation, lab supplies, travel, expert help (consultants). Most Senior Projects receive little, if any, funding. If your project requires expensive equipment or other resources, you need to think very carefully at the outset about whether the project is realistic for you to accomplish. Don't abandon an ambitious project just because it requires significant resources, but you want to avoid pledging to complete a project that simply isn't feasible.

Discuss the project management plan, which involves addressing a variety of questions. What will you do and when will you do it? How will you report progress?   What intermediate milestones will you establish and how will you determine if you have successfully met them?

How will you address any trouble or delays that you might encounter? This part of the report should refer to an appendix that will contain a Gantt Chart or other project schedule and activity list.

Be sure to define your deliverables in as much detail as possible, since producing the deliverables will be a major portion of your overall Senior Project grade. Brainstorming sessions with your teammates and Advisor can be helpful for fully thinking through and describing your deliverables. Remember that your project will officially span three semesters, so it is easy for "project creep" to set in; that's when your Advisor or Sponsor keeps changing the deliverable as the project takes shape. Some amount of uncertainty and change is to be expected with many projects, as the parameters and resources are often not well known at the outset. But since it is obviously much harder to hit a moving target, a clear and complete definition of your deliverables, in additions to guiding you through the process, also protects you from shifting expectations.

Appendices

Appendices serve to support your main document but are either too large or are sufficiently tangential that they would hurt the flow and/or readability of the body of your Proposal. You should have at least two appendices (Project Schedule, and Works Cited) and possibly more.

Project Schedule
A one page schedule should be attached and referenced in the Methodology section of your Proposal. ISAT has a site license for Microsoft Project® for use in the ISAT computer labs to help you to create a Gantt Chart, which shows the major deliverables for the project and the timelines associated with them. A number of other software packages are available (including some freeware programs) that you might also choose to use instead. It is crucial, however, that you produce a clear timeline with deliverables, including important project milestones, a communication schedule, and (if applicable) team member responsibilities.

Team Management Plan (if applicable)
If you are working on your project in a team, you must develop and describe a management plan for your team. This should follow the general concept of a "self-directed work team." Identify how the team will make decisions, who will be responsible for various aspects of team administration (such as calling meetings, taking notes, etc.), and how the project work will be divided among the team members. Also, decide upon and document how your team will handle conflict between team members, evaluate the performance of individual members of the team, and provide feedback to team members. Each team member should have a good idea of his or her role, what other team members will be expecting, and how the team with function as a unit. Careful planning and well-documented assignments created now will save your team from potentially serious trouble later on. A well-functioning team makes for an extremely satisfying experience for everyone involve. A poorly functioning team can not only make everyone involved miserable, it can also ruin friendships and alienate classmates.

Works Cited

Any source that you directly utilize – including quoting or taking a fact or idea from – in your Proposal must be included in an appendix as part of a list of Works Cited.   The Works Cited section includes a complete list of the sources that you have cited in your Proposal.

That does not mean that these are the only sources that you should consult for your project. On the contrary, throughout the span of your project you should continue to build on the literature search that you do as part of ISAT 491. Often, an annotated bibliography containing citations and associated notes can be a valuable tool to facilitate your knowledge of related fields and can make writing your Literature Review much easier. It is **NOT** acceptable to simply take some references provided by your Advisor and assume that it includes all of the literature that you need to know to do well on your Project. Whatever sources (if any) your Advisor provides you with should be a starting point for exploring the literature on your own. This is primarily YOUR project, not your Advisor's, and you need to gain as deep an understanding of the relevant fields and topics as you can. The discoveries that most significantly impact your project deliverable often come from the student's own literature search. The JMU Library has many useful resources that to assist you in searching for and collecting relevant information. The library's website has a variety of powerful search engines and a great many publications are now available online in full-text format. For sources that the JMU library does not own, we have an excellent Interlibrary Loan (ILL) program that allows you to request whatever information resource you need free of charge.

Securing Approval of Your Proposal

In order for your Proposal to be complete, you need a number of signatures, which indicate approval of the Proposal as written. First, the Proposal needs to be signed by all of the team members. Second, your Advisor must sign (and therefore approve) your final Proposal. Third, if you are working with a Sponsor, you need to secure your Sponsor's approval as well. Ideally this would include the Sponsor's signature, but we recognize that this might always be possible given the distances that can be involved and the busy nature of many Sponsors' schedules. What **must be documented** is the specifics of the agreement, the nature of the deliverables, and the agreed upon timeframe for completion. This documentation should be included as an Appendix to your completed Proposal.

Senior Project Final Report Manual

Your Final Report is the culmination of your Senior Project experience. As the final tangible expression of what you have achieved, you should put significant thought and effort into this document. While your Oral Presentation might be the most nerve-wracking part of the project, the Final Report is the most durable one. Years from now, when you look back on your academic work at JMU, this document is likely to be the single most important piece of evidence of your achievement. More importantly, it is an excellent way to showcase your skills for potential employers. A well presented Senior Project Final Report demonstrates that you can conceive of and execute an extended self-directed project. Seize the opportunity to make your Final Report outstanding!

Final Report Structure

The layout presented here is a suggested as a good general template, but not all project reports need to strictly follow the template. The following structural guide is most appropriate for technical reports. This structure should work well for most Senior Projects involving scientific experimentation, technological prototype development, or optimization studies. Some Senior Projects, of course, are quite different and do not comfortably fit into such a structure. A very brief guide to developing a structure for a good literature-based Final Report is included as an appendix below. Your Advisor (and faculty readers, if you have any) can suggest a format structure that best suits your particular project.

Title Page

Your title page should include all of the following:

> ***Project Title*** This should include the full title, including any subtitle. Subtitles are generally listed after the title, which is followed by a colon (*Title: subtitle*).

> ***List of Team Members*** This should include the signatures of team members as well. These are usually listed in alphabetical order.

> ***Senior Thesis Faculty Advisor(s)*** This should include signature(s).

> ***Senior Thesis Reader(s)*** This should include signature(s). Include this only if you have one or more faculty readers in addition to your Advisor.

> ***External Sponsor*** Include this only if you have an external Sponsor. Often an external Sponsor is a company or government agency, but it can be an individual as well. Make sure to know precisely how your Sponsor would like to be listed and double check the spelling.

> ***Date of Submission***

The title page is not numbered, nor is it included in the numbering; that is, begin your numbering *after* the title page. An example Report title page is included as an appendix below.

Abstract

An abstract is a very brief overview of your project, its significance, methodology, and results. A good abstract provides the reader with enough information to decide whether to spend the time and energy to read through the entire report. The abstract should be no more than 150 or 200 words. The abstract is arguably the most important part of the entire report since it is almost certain to be read more often than any section. While it is often the last section to be written, it is crucial that you leave yourself enough time to draft and re-draft a strong abstract. Furthermore, a good abstract encapsulates the entire project, meaning that you can give your abstract to potential employers or other interested parties.

Table of Contents

A Table of Contents should include all sections of your report, complete with page numbers. Each page of your report should also be numbered. Usually, pages preceding the main body (everything before the Introduction) are numbered using small Roman numerals (i, ii, iii, etc.) whereas the main body is numbered with Arabic numerals (1, 2, 3, etc.). The first page usually is not numbered.

List of Figures and/or List of Tables (if applicable)

If you have more than one figure or table in your report, you need to list them in this section. For each figure or table you should provide the title and the page on which it is located. All figures or tables must be numbered; Arabic numerals are preferable.

Acknowledgments (optional)

It is a thoughtful gesture to thank individuals and organizations that have assisted you in some aspect of your project. Keep your acknowledgments brief and professional – think of it like a good acceptance speech at the Academy Awards. This section is *especially* encouraged if you received any funding or special assistance from a person, organization, or institution.

Introduction

Your introduction should explain to the reader how your work fits into the broader scientific, technical, and social context. It is a statement of what your project is and why you are pursued it. A strong introduction should convince the reader that your project is well-conceived and purposeful. It must explain why your project is important enough to justify the time and energy that you expended. The introduction should also provide the necessary background or contextual information needed to clarify the purpose or implementation of your project. For example, the

introduction for a project on possible viral causes of the Shenandoah River fish kill should discuss the general problem of fish kills, the extent of the Shenandoah River fish kill and its impact, previous research on its causes, and relevant research on viruses in fish. Introductions usually conclude with an overview of the entire project.

Literature Review

The literature review locates your project within a larger intellectual conversation. It describes how your work draws upon, interacts with, and potentially even extends upon the work done by other people in the relevant field or fields in which you are working.
A good literature review demonstrates to a knowledgeable reader that you understand the most important scholarship in any relevant fields and how that scholarship relates to your project. Note that this does not mean that you need to survey entire disciplines, but rather the scholarship that is relevant to your project within relevant disciplines. This usually requires referencing and discussing journal articles, government documents, and/or articles in trade publications, as well as popular magazine and newspaper articles. Depending on your project, you might need to discuss information from other types of material such as patents, working papers, dissertations or websites.

In your discussion of these materials you must demonstrate a mastery of them at a basic level. In other words, an expert in a relevant field should come away with the impression that you have a basic grasp on the most important work in the field. You do not need to demonstrate an in-depth mastery of these fields, however, since that is not a reasonable expectation for undergraduate research. Your literature review should be written in a way that is straightforward and as uncomplicated as possible. An educated reader who knows nothing about your topic should be able to read and understand your discussion as a whole, even if certain parts of it are beyond his or her technical competence. For example, if you discuss a technique for gene expression, many readers won't be able to understand the technical jargon, but they should be able to grasp the basics of the technique and how it differs from other approaches.

Objectives

This section should clearly state the main objectives and significant sub-objectives of the project. That is, you must make explicit what you aimed to accomplish. This section should also identify the deliverables of your project. If your project is investigative in nature, you may not have predictable, quantifiable deliverables at the beginning of your project. Indicate your hypothesis and the specific purpose of your investigation. Deliverables might include items such as completed lab reports, an operational technology, or an implemented technical system (e.g. a functioning website). Some projects will have no physical deliverable outside of a written final report; this is perfectly acceptable in many cases. Even if your project does not include a tangible deliverable other than your Final Report, this section should clearly detail the goal(s) of your project. It should also include any quantitative goals that are appropriate to the project. Finally, if your work was done in accordance with a particular standard (e.g., a highway bridge design standard or building code) you should note this here.

Methodology

The senior project document is not only a record of your successful work in ISAT, it is also a reference document for future work in the field(s) that your project addresses. Therefore, you should treat your written Report as a publication that details your procedures so that other scholars can learn from (and possibly extend) your work. In essence, your report becomes part of the scholarship on your topic. For experimental or other hands-on projects, keep in mind that other scholars may need to *replicate* your work – and they most certainly will need to understand how you arrived at your conclusions – so provide specific details about your methodology. Focus on your procedures and methods in this section; the analysis of your results belongs in a later section.

This section details the specific steps employed in your project and answers the follow questions: What are the major tasks and in what sequence did you do them (or are doing them)? It should provide details on how you produced your deliverable, collected your data, and accomplished your goals. It should also convey a clear sense of why you made the methodological and procedural choices that you did, so that readers can understand your decision-making process. For example, this section may include any number of the following:
- Equipment or instruments required
- Details of experimental design and materials used
- Experimental protocol utilized
- Testing completed to verify your design or decide on the nature of the final product
- How specific data were obtained and how observations were made
- The calculations that resulted in the final form of the design.
- The mechanics that were used to make design decisions.
- Detailed drawings and specifications that would be used to construct your design.
- Cost estimates

It is important for this section to be as specific as possible, as this will make it easier for others to learn from and/or replicate your work. You can assume that the reader will have a basic familiarity and competence with scientific techniques in general, but not in your particular techniques. When in doubt, think back to what you knew before you began the project – the procedures should be clear enough that someone with that level of knowledge should be able to follow what you did.

Results

This is where you present the results of your work. This might take any number of different forms, depending on your project. This section usually includes the output of the experiment, model, or computation. Although results are often quantitative, qualitative results are also perfectly acceptable. For example, you might observe no result from your experiment…which in itself is a result!

In presenting your results, use a concise, economical style. Whatever form you use to present your results should be comprehensible to and usable by others. Ideally, your results should be

organized in some combination of tables, graphs, and charts. Such visual depictions can be very effective, but be sure that the format you use to display your data does not present a distorted or misleading impression.

Provide as much information as possible, as long as it is relevant and important. Be sure to include any formulas that you used or calculations that you performed. If you employed repetitive calculations, only a small sample is required. When deciding what is needed, use your best judgment, and don't be afraid to ask your Advisor for guidance. If you used software to perform computations (e.g. a spreadsheet) then you need to include relevant printouts. Any statistics that you generate and reproduce here should be meaningful – don't just spew out data if it doesn't have any real meaning.

Resist the temptation to discuss the meaning or importance of your results! There is a proper place for you to interpret your results: in the Discussion section. For the Results section, just stick to the facts.

Discussion

The purpose of the Discussion section is to communicate what you think was learned, how the results informed your conclusions, and how significant you believe that your results are. This section is often the one where your professional views and judgment are most clearly on display. It allows you to demonstrate your analytical ability and knowledge of the topic by making sense of and interpreting your results. This requires judgment, such as determining whether your results seem reasonable and what to do about it if they do not seem reasonable. If you had to make assumptions, you should discuss how realistic these assumptions are. If you changed these assumptions would that dramatically influence your results and conclusions? That said, having a realistic view of the limits on your confidence in your conclusions is not the same thing as an invitation to waffle or equivocate. Be clear and bold about the lessons you believe we have learned from your project, but don't oversell it either.

It is crucial not **just** to make conclusions here, but to describe how you arrived at those conclusions and meticulously articulate why they are justified by your results. If any part of this process is weak, an astute reader will likely be led to doubt your analysis and perhaps your credibility. If the experiment failed, you should discuss why it failed. If the results are not what was predicted by theory, do they suggest that the theory is wrong or was the experiment flawed in some way? If your results include abnormal values, trends, or relationships, note this and attempt to explain them. When possible, *extract* principles, relationships, or generalizations from the data.

Your discussion must be rooted in evidence and reason. It is not appropriate simply to state whatever you personally think, but you have to persuade the reader that your analysis is legitimate and justified. Sometimes simplicity is the best approach: if the results largely speak for themselves, then don't interject a lot of unnecessary and ultimately pointless analysis. In making your case, carefully reference other researchers' work to establish how your results fit into the broader literature.

Conclusions

This section is often brief and straightforward: simply state the most important findings from your research. Be sure to elucidate the most significant conclusion(s) first, then develop subsidiary conclusions. If there are key limitations of or uncertainties arising from your work, state them clearly and directly. Do not over-elaborate here – this section should be distinct from your Discussion section.

Future Work (may be combined with conclusion)

Even the most comprehensive and complete ISAT Senior Projects will leave some work to be done. Over the course of you project you have developed a limited expertise in your topic area(s). In this section you should apply this expertise and understanding to develop a plan that outlines the next steps that would need to be taken to move the project forward. If you had more time and resources, what would you do next?

More often than not, scientific inquiry raises new questions or uncertainties. For many scientific studies, the future work section will identify new unknowns that were discovered and suggest experiments to explore them. These experiments are outside the scope of the initial study, but part of the intellectual work that you are doing is pointing out areas that need attention for future scholars. Just as you relied on the existing literature to help guide your initial work, so should you provide guidance to those following in your footsteps. Understanding what to do next is often as important as understanding what you just did.

Unintended Consequences (if appropriate)

Our actions often have unintended consequences. These unintended consequences can have positive effects, but sometimes they have detrimental ones. Any project that might potentially result in unintended consequences must include a section on this topic. Note that virtually any hands-on project – from building a vehicle to performing a lab-based experiment – has the potential for unintended consequences, so most projects should include this section.

Unintended consequences can take many forms, such as environmental, social, ethical, or economic impacts. Some are relatively minor, such as the increased use of cell phones deteriorating people's ability to plan ahead. Other can be quite major, as with the introduction of the Cane Toad into Australia, which, although intended to help control the population of cane beetles (which eat sugarcane), ended up multiplying rapidly and helping to make several native species go extinct.

You should approach this subject with a broad in scope in mind and should address the potential impact (whether good or bad) that *could* occur on any significant scale. Contemplating these side effects is an exercise in risk management.

Works Cited

In this section you should list any materials (books, articles, reports, etc.) that you cited in your report. There are many different styles for citing sources. Some faculty members prefer a specific style for references, so be sure to check with your Advisor to see if he or she has strong preferences. In general, you should choose a citation style that is appropriate to the field(s) that your project spans. No matter what, be consistent and make sure that your citations are complete. Note that for any websites this includes the dates that you accessed the material on the site.

Appendix or Appendices (if applicable)

An appendix is used as a place to put *relevant* materials that would (for any of a number of reasons) distract or detract from the flow of the body of your Report. Common reasons for not including material in the main body of the Report is that it is too long, too technical for the typical reader, or sufficiently tangential that many readers would not be interested in it.

Especially lengthy items are usually placed in an appendix rather than in the main body. As a rule of thumb, if including it in the main body would unnecessarily interrupt or detract from the flow of the text. Examples of such items include original data sheets, computer programs, lists of symbols or acronyms used in the report, and statistical tables.

An appendix should not be a hodgepodge of assorted, out-of-place information, however. Do not include any material that is not relevant or would not be helpful for at least some readers. Figures, graphs, and charts generated from your work should be included in the body of the report (oft in the results and discussion section).

Style and Formatting Guide

Technical students are sometimes tempted to think that writing style doesn't matter – if their work is technically sound, others will recognize its value. This is not the case. How you present your work critically affects how others will receive it. You will often be judged by first impressions and appearances. This is especially true in industry where competition is stiff and decision-makers have little time for poorly communicated ideas. Professionalism in a written report suggests a well-executed and professional project. That said, the particular style and tone of your written components is, to a certain extent, up to you. Your style and tone should be consistent, however, and should not be excessively informal. The following section provides some suggestions.

General Writing Issues

We all have a process by which we write, and many factors can be part of this process: when we write, where we write, our revision and editing practices, the stimulation or lack of stimulation we require, the rituals we use to get down to the task of starting to write, and our state of mind all might help to determine the quality of our written work. There is no single formula for writing well; you must develop your own writing process. Having a writing process means knowing which practices and habits help you write as clearly and efficiently as possible. For example, many individuals write best early in the morning, before their minds are cluttered with thoughts of the day's activities. Some people write best with no outside stimulation, such as music or television. Other individuals use rituals, like cleaning the house, making a cup of coffee, or exercising in order to get started writing. Try to identify the practices you use to start writing; eliminate the ones that slow you down and enhance the ones that foster good writing habits. Knowing and developing a writing process that works for you is an important step in developing your writing skills.

A document as significant as a Senior Project Proposal or Final Report cannot be thrown together at the last moment. These documents represent a depth of research and hands-on effort that takes time to develop. Though some students prefer a less structured approach to the writing process, this is very difficult to do for a project this significant. Outline your work before you begin writing. An outline does for a technical report what framing does for a house: provides the structure needed to support the rest of the work. Outlines can (and often do) change as your project develops, but they can also facilitate organizational changes. Revision is also necessary. Good writing does not spring forth fully formed and perfected; it requires constant revising, editing, and proofreading.

Good writing is an art that takes a lifetime to develop and master. Even the best writers continue to develop their skills. Regardless of your personal style, if your writing is clear, concise, complete, and easy to understand then you have been successful. Since the purpose of writing of this sort is convey your purpose, results, and conclusion, your style must be clear and concise. Your project idea and execution might be fantastic, but if you cannot clearly communicate this to your reader then the excellence of your work means little. Rather than concern yourself with clever expressions or pleasing sentence formations, you should focus on writing and designing

your documents to be easily accessible to your readers. If you are effective in your writing, there should be no ambiguity in what you are saying. You are not writing poetry; every reader should interpret your work in precisely the same way.
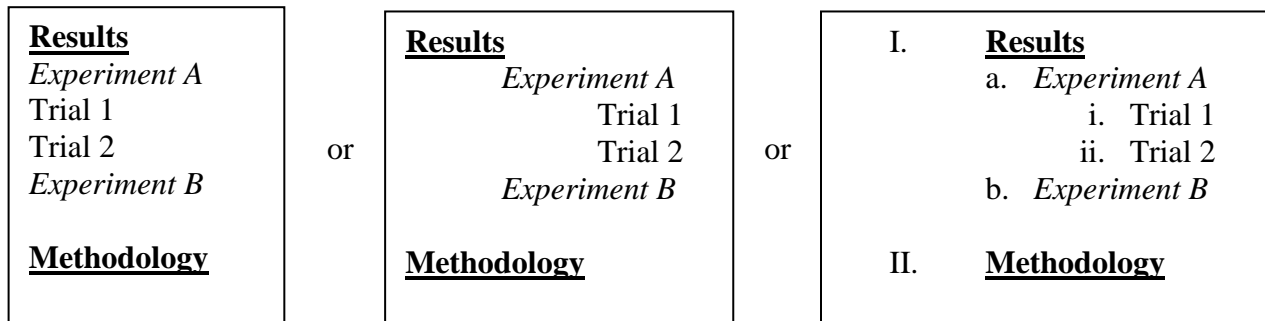
Technical, scientific, business writing is intended to meet the needs of your audience, not yourself. Although you do not know who will be reading your Project Report, you should generally write for an audience that is fairly knowledgeable but not expert in the area. You should not assume that the reader is necessarily interested in your topic. Indeed, it is your job to interest your reader in what you have done. Make the case for why your work is important, compelling, and worth spending time on. Most importantly, make sure you know and clearly convey the central purpose of your work. Make this purpose explicit up front – don't wait until your conclusion to let your reader know why your work is worthwhile.

Clarity should be a hallmark of your written work. Organize your document so that your structure and purpose are apparent. Be consistent in your structure, formatting, and style. Your work should flow in a logical way.

Organization & Formatting

Organizing Sections

Your Proposal and Final Report must have a clear and rational structure, as described above. Within each section, it may be useful to make subdivisions to make them easier to read. This should be done whenever a section is relatively long. If you do subdivide sections, it is important to follow a consistent formatting pattern. This means that headings at the same level should be formatted in the same way. For example, if your Results section has two major subdivisions, Experiment A and Experiment B, then they should be formatted in the same way, and that should be different from the formatting of the Results section title. Any additional subdivisions (under Experiment A, for example) should have a different formatting style, but should be consistent within that level. This may be indicated using indentation, though this is not strictly necessary. You also may choose to number sections. If so, use a consistent and standard technique, such as the one depicted in third box below.

Results		
Experiment A		
Trial 1		
Trial 2	or	
Experiment B		
Methodology		

Results		
	Experiment A	
	Trial 1	
	Trial 2	or
	Experiment B	
Methodology		

I.	**Results**	
	a. *Experiment A*	
	i. Trial 1	
	ii. Trial 2	
	b. *Experiment B*	
II.	**Methodology**	

As with most issues of style and format, above all you should ensure that what you produce is clearly and professionally presented. If the reader has to think about your structure or is confused in any way, then you haven't been effective.

Font

The type on the title page and throughout should be plain and easily readable. Use a serious font to convey the message that you have done serious work. Make sure that your font is large enough that everyone can easily read it; avoid fonts smaller than 11 point. A good, safe font is Times New Roman 12 point. A formal report is a serious document; avoid ornamentation.

Length

There is no set minimum or maximum number of pages for either the Proposal or the Final Report. The appropriate length depends upon the level of detail required to clearly explain your project and its purpose, what you did, and your conclusions. Too short of a write-up makes your Project seem trivial, while too long of a write-up will put off potential readers. **Do not add "fluff" material** just to make your work seem more substantial. All but the most naïve readers will recognize unnecessary material for what it is and including it reduces your credibility.

Spacing and Pagination

The text of your report should be spaced so that it is easy to read. Use your own judgment, but make sure the text does not look crowded or unattractive.

Because your Proposal and Final Report are serious, significant documents, you **must** number your pages. Use Roman numerals (i,ii,iii,iv…) on all material that prefaces your report (title page, executive summary, table of contents, list of figures, acknowledgements). No number appears on the title page. Start Arabic numbering (1,2,3,…) from the first page of the report (Introduction page), *not* the title page or executive summary. By custom, many people do not include a page number on the first substantive page (page one of the Introduction).

Graphics

All tables, figures, and other graphical presentations should be computer-generated, numbered, titled, and *discussed in the text* before (or on the same page as) they actually appear. Once you have introduced a table or figure, you may refer to it again later without additional commentary. Table titles are normally placed above the table, whereas figure titles should be placed below the figure. Whenever possible, integrate graphics into the body of the text rather than on separate pages or in the appendix. This allows graphics to appear at the same time they are being discussed in the text (and your reader will not have to flip pages to see your figure or table). Although some complicated graphics may require a half-page to be easily readable, most graphics require less space. When necessary, reduce the size of your graphics to fix comfortably into the text, or reduce and cut and paste graphics, if necessary. No graphics should be glued or taped into a report; always photocopy and cut and paste work.

Whenever possible, use a consistent design and presentation style for your graphics. If you use a color graphic, remember that many document copying and printing is usually done with black-

and-white machines. Therefore, design your graphics so that they can be easily and accurately reproduced in black and white (e.g., use hash marks to denote differences in a table, rather than color).

Writing Style

As you develop your own writing style for technical documents, be mindful of your central purpose: to communicate effectively with your audience. Keeping your audience in mind as you write will influence such stylistic concerns as vocabulary, amount of detail and specificity, document length, and amount and type of background information. Writing for a busy manager in industry is quite different from writing for the average American, which is also very different from writing for an academician. For example, a busy manager is more likely to want fewer details, as their domain is the big picture, the bottom line. In contrast, an engineer would expect a very detailed and thorough laboratory report, and the average American would need much more background than either of the former. Your audience might well be some combination of these three, though which one takes precedence will vary according to the project. Finding the proper level of detail can be tricky, as you must balance economy of language with sufficient detail, emphasis, and authoritativeness. When in doubt, be complete. What seems obvious to you may not be at all obvious to the reader.

Make your documents easy to read and understand by writing clearly and concisely. Be specific whenever possible. In a technical report or essay, vagueness results in mediocrity. Do not write in generalities or in broad, sweeping language. Use unambiguous, concrete words rather than fuzzy ones. Plain language is preferable to either conversational or extremely technical language. Avoid clichés, the passive voice (say "x caused y" not "y was done by x"), exaggerations of any kind, and unnecessary verbiage. Use direct, forceful sentences and declarative statements when you can. Be bold but not arrogant.

What follows is a brief introduction to some stylistic issues that often arise with undergraduate writing. It is by no means exhaustive, and you should invest a few dollars in a good style manual. William Strunk & E.B. White's *The Elements of Style* is a classic that is widely available at little expense.

Economy of Language

One problem that plagues many writers is verbosity. Make every word count. Wordy sentences and paragraphs detract from your message. This is not to say that you can never restate a key message; targeted and selected repetition emphasizes a salient point. Excessive repetition is annoying and distracting, however, as is the tendency to include unnecessary word, phrase, sentences, paragraphs, and section. Below are a few tips to tighten up and strengthen your writing.

➢ Eliminate phrases such as there are, there is, there were, it is, and it seems.
  ✗ There are three committees reviewing this proposal.
  ✓ Three committees are reviewing this proposal.

- ✖ It seems clear that additional funding is needed.
- ✓ Clearly, additional funding is needed.

➢ Avoid obvious opening statements of intent.
- ✖ I am writing this letter because I would like to apply for the position advertised in the *New York Times*.
- ✓ I would like to apply for the position advertised in the *New York Times.*

➢ Cut redundancies of time and quantity.
- ✖ A total of ten members attended the meeting.
- ✓ Ten members attended the meeting.
- ✖ We can eliminate the problem in the span of two weeks.
- ✓ We can eliminate the problem in two weeks.

➢ Avoid wordy phrases when one word will suffice.
- at this point in time = presently
- at a rapid rate = rapidly
- due to the fact that = because
- the majority of = most
- is in conflict with = conflicts
- give a summary of = summarize
- came to the conclusion that = concluded

➢ Fix wordy passages by eliminating needless words.
- ✖ *The purpose of the laboratory experiment was to explore* the effect of time and temperature on a sample of aluminum alloy.
- ✓ In this lab experiment, the effect of time and temperature on a sample of aluminum alloy *was explored*.
- ✖ Through e-mail, the company *has the capability* to quickly address customers' questions
- ✓ Through e-mail, the company *can* quickly address customers' questions.

➢ Avoid short, choppy sentences that reduce the effectiveness of your writing by separating your ideas and creating redundancies.
- ✖ For many years, the company has *attempted to increase employee productivity*. This has been done by offering extra incentives
- ✓ For many years the company has attempted to increase employee productivity by offering extra incentives.

➢ If you end a sentence with the same word or phrase that begins the following sentence, they can usually be combined.
- ✖ The companies have been rivals since *the market sales decreased*. The market sales decreased because of lack of customer support.
- ✓ The companies have been rivals since the market sales decreased due to lack of customer support.

Grammar and Mechanics

Your execution of the basic fundamentals of writing, such as spelling and grammar, indicates your seriousness as a scholar and writer. Errors detract from your message and can reflect negatively on your ability not only to write, but also to think. Some errors result from sloppiness. This indicates a lack of attention to detail; an employer might (understandably) associate sloppiness in writing execution with sloppiness in job performance. Sloppy errors often send a message that you simply don't care very much. Some errors result from systematic misconceptions or ignorance of proper techniques, resulting in error patterns that repeated manifest themselves in your writing. Errors of this sort can be addressed through a conscious effort to identify and fix the error patterns you have developed. Your goal as a writer is to compel the reader to interpret your work exactly as you intend; mechanical errors can thwart this goal. Errors of this sort often fall into one of the following categories.

Pronoun Reference
Unclear pronoun references can cause your reader to wonder to whom or what you are referring. Good writers ensure that each pronoun refers unmistakably to the noun it stands for.

> **Ambiguity**
> A pronoun could refer to more than one noun. Restructure to clarify.
> - ✘ When the students met with representatives of the university, they presented their concerns.
>   - *(Who presented concerns? The students or the representatives?)*
> - ✔ The students presented their concerns when they met with representatives of the university.
> - ✘ In this laboratory experiment, we tested samples of aluminum, titanium, and copper. They resisted breaking for the longest time.
>   - *(Which material resisted breaking for the longest time?)*
> - ✔ In this laboratory experiment, we tested samples of aluminum, titanium, and copper. The sample of titanium resisted breaking for the longest time.

> **Vagueness**
> A sentence lacks an easily identifiable antecedent. Problems of this sort can often be avoided by using "that".
> - ✘ The laboratory supervisor canceled the class because they had not arrived.
>   - *(What does 'they' refer to?)*
> - ✔ The laboratory supervisor canceled the class because the material samples had not arrived.
> - ✘ Two days after our presentation and demonstration, we received our evaluation. We were all relieved that our supervisor was pleased with it.
>   - *(What is 'it,' the presentation, the demonstration, or both?)*
> - ✔ Two days after our presentation and demonstration, we received our evaluation. The group was relieved to find that our supervisor was pleased with the presentation.

Hints: Avoid using *it*, *which*, *this*, or *that* to refer to a clause or sentence. Also, vague pronoun references frequently occur at the beginning of a sentence because using these pronouns seem to make starting a sentence easier; however, the result is lack of clarity. A small addition can clear

up much confusion. Rather than writing, "This supports our first hypothesis," (*what* supports our first hypothesis?) use, "This finding supports our first hypothesis."

Parallel Structure
Sentences should exhibit the same grammatical form throughout; this is known as parallel construction. Reading aloud is a helpful way of identifying sentences that are not parallel.

- ✘ The step involved mixing sand, water, and stirring them together. *(not parallel)*
- ✓ The step involved mixing sand and water, and stirring them together. (*parallel*)
- ✓ The step involved taking sand, adding water, and stirring them together. (*parallel*)
- A. Lee prefers working in groups rather than to work alone. (*not parallel*)
- ✓ Lee prefers working in groups rather than working alone. (*parallel*)
- ✓ Lee prefers to work in groups rather than to work alone. (*parallel*)

Agreement
Make sure that your nouns, verbs, and adjectives agree, both in tense and number.
- B. Manuel and Aaron erects a wind turbine. (*noun and verb don't agree*)
- ✓ Manuel and Aaron erect a wind turbine. (*noun and verb agree*)
- C. Last year as a junior, Amy's project appears nearly complete. (*noun and verb don't agree*)
- ✓ Last year as a junior, Amy's project appeared nearly complete. (*noun and verb agree*)

Comma Usage
Improper use of commas – including omitted, extraneous, or misplaced commas – can confuse readers. For example, these two sentences have *very* different meanings:
- Don't stop!
- Don't, stop!

➢ Use a comma after an introductory phrase.
- Following the presentation, we all stood to applaud the group.
- After years of research, the new material was unveiled to the company.

➢ Use a comma after a subordinate clause that begins a sentence. Subordinate clauses begin with conjunctions such as when, if, because, after, although, as, while, since, even though, before, and whenever. You do not usually use a comma when the dependent clause comes at the end of the sentence.
- While I wrote our presentation, she finished the lab work.
- She finished the lab work while I wrote our presentation.

➢ Use a comma before a coordinating conjunction (and, but, yet, for, so, or, and nor) that joins two independent clauses.
- Today was warm, but it was cloudy.
- The wire was put under tension until it broke, and then we spliced it.

➢ Do not use a comma before a coordinating conjunction that joins two words or phrases.
- ISAT and geography are programs in the same department. *(two nouns)*

- We were celebrating because our team won and was awarded a large prize. *(two verb phrases)*

➢ Use commas to separate items in a series. For clarity, you **should** use a comma before the conjunction that attaches the last item to the others.
- Students have completed projects in wind, solar, and geothermal energy.
- We cold rolled the sample, prepared the solution, and completed the experiment.

➢ With a list of adjectives, use a comma only if the comma could be replaced with the word "and".
- She is a lean, mean engineering machine.
- He is a good old boy.

➢ Use commas to set off an adjectival clause if the clause is not essential to the meaning of the sentence. This error occurs most frequently when people misuse the words *which* and *that*. Use *which* when the omission of the clause does not change the meaning of the sentence (and requires a preceding comma); use *that* when the clause is essential to understanding the sentence (and should not have a preceding comma).
- The book, which was heavy, was delivered to my office by a student.
- The book that I requested was delivered to my office by a student.

➢ Use commas at your careful discretion to intentionally break the flow of the sentence. In general, if it would be appropriate to pause when you spoke the sentence, it is a good idea to use a comma. There are not hard-and-fast rules for all comma usage, and some writers make more extensive use of commas than others. Be sure to use commas correctly and consistently, even if others might have made different choices about whether and when to use commas.

Hyphenation
Note that a hyphen (-) is **not** the same as a dash (–) and the two are **not** interchangeable.

➢ Two or more words compounded to form an adjective modifier are hyphenated, unless one is an adverb ending in -ly.
- ✘ state of the art technology *(incorrect)*
- ✓ state-of-the-art technology *(correct)*
- ✓ technically accurate manual *(correct)*

➢ Two adjacent nouns are hyphenated if they express a single idea, and if, without the hyphen, this idea is not immediately clear. (e.g., light-year)

➢ Place a hyphen between the number and the unit of measure when they modify a noun. (6-inch diameter sample, 100-lb weight)

Sentence Construction

➢ Avoid dangling participles.
   - ✖ Turning over our papers, the exam began. *(incorrect)*
   - ✓ Turning over our papers, we began taking the exam. *(correct)*

➢ Avoid run-on sentences (two or more independent clauses with a comma or no punctuation between them). Join two independent clauses with a semi-colon or make two sentences.
   - ✖ The computer is down, you must fix it soon. *(incorrect)*
   - ✓ The computer is down; you must fix it soon. *(correct)*

➢ Avoid sentence fragments. A complete sentence must contain a subject and a verb.
   - ✖ Maxwell's remarkable discovery that the speed of propagation of electromagnetic effects is precisely the same as the speed of light in the same medium. *(incorrect)*
   - ✓ Maxwell discovered that the speed of propagation of electromagnetic effects is precisely the same as the speed of light in the same medium. *(correct)*

Abbreviation

➢ Avoid using too many abbreviations in writing. The first time you use an abbreviation, write it out, and follow it with the abbreviation in parentheses.
   - ✓ I am a student in the Integrated Science and Technology Department (ISAT) at James Madison University (JMU).

➢ The abbreviation for a specific word or phrase takes the same case (upper or lower) as the word or phrase. An abbreviation that is an acronym is usually written in capital letters, except when the acronym stands for a unit of measure. (e.g. Prof. Jones, VHF, mph)

➢ Typically units of measure that are abbreviated do not require the use of a period except for "in." and "tan." and other abbreviations that form words.

Capitalization

➢ Capitalize trade names. Often, familiar trademarked names fall into general use, such as Kleenex, Xerox, Frisbee, AstroTurf, and Scotch tape.

➢ Do not capitalize words to emphasize their importance. This practice was perfectly acceptable in the 17th century, but is not acceptable today.
   - ✖ Certain kinds of fuels can cause Fuel Starvation as cells age. *(incorrect)*

➢ Capitalize the full names of government agencies, departments, divisions, organizations, and companies, but not words such as department or administration when they stand alone.
   - ✓ Sally works in the Office of Personnel Management. Her department is in charge of hiring all governmental employees. *(correct)*
   - • Note that terms like Literature Review and Senior Project are capitalized in this manual because they are referencing particular sections and titles. This is an instance where the rules are not fixed, and a different author might well have chosen not to capitalize these terms. As always, consistency is critical, however.

30

➢ Capitalize all proper nouns and adjectives unless usage has made them so familiar that they are no longer associated with the original name.
  • ampere (Andre-Marie Ampere)

Numbers and Units

➢ Write out numbers ten and under, except for when numbers are used with units of measure, time, etc. (e.g., nine tractors, 2 yards)

➢ Decimals and fractions are written as numerals. (e.g., 0.34, 4/10, or 0.4)

➢ If a number is an approximation, write it out. (e.g., half a glass of water vs. ½ cup of water)

➢ When many numbers are presented in the same section of writing, write them all out as numerals.
  ✗ I had two good students, four puppies, thee hamsters, six large oxen….
  ✓ We used 4 lemons, 2 cherries, 14 ounces of orange juice, 2 apples….

➢ Do not begin a sentence with numerals.
  ✗ $250,000 went into the development of this process. *(incorrect)*
  ✓ This process cost $250,000 to develop. *(correct)*
  ✗ 2,000 test subjects participated in the experiment. *(incorrect)*
  ✓ Two thousand test subjects participated in the experiment. *(correct)*

➢ When one number appears immediately after another as part of the same phrase, one of the numbers (preferably the shortest) is spelled out.
  ✗ 6 5-person teams *(incorrect)*
  ✓ six 5-person teams *(correct)*

➢ Keep all units consistent.

➢ For units formed by multiplying or dividing other units, write as symbols. (e.g., 32 ft/s^2)

➢ Multiplication of units is indicated by a raised dot (·), and a division by a slash (/).
  • .3 J/(mol·K)

➢ If the number is one or a fraction of one, the unit is written in the singular.
  ✗ 0.8 tons *(incorrect)*
  ✓ 0.8 ton *(correct)*

➢ Write secondary units in parentheses next to the primary units.
  • 10-meter (32.8-foot) diameter)

Equations and Symbols

➢ Center and number equations on a separate line in the text.

➢ Keep all division lines (or fractions) and plus or minus signs on the same level.

➢ Punctuate words used to introduce equations just as you would words forming part of any sentence (e.g., don't use a colon or comma unless required).

➢ Avoid duplicating symbols.
  - ✘ The R in the test wire was 60 ohms; ambient temperature was 520°R *(incorrect).*
  - ✓ The resistance in the test wire was 60 ohms; the ambient temperature was 520°R *(correct).*

➢ Since symbols substitute for words, they must fit grammatically into the structure of the sentence.

➢ To make it easier on your reader, do not overuse symbols.

➢ Define the symbols you use as they are introduced into the text.
  - to convert Celsius to Fahrenheit, use
$$°F = 1.8 \ (°C) + 32°$$
    where *F* is degrees Fahrenheit and *C* is degrees Celsius.

Citations

You must properly format all citations. There are a wide range of common citation styles, use of which often varies by discipline. ISAT is a multi-disciplinary department, so individual professors may strongly prefer that you use or another citation style. Since there is no correct style to use, be sure to check with your Advisor to see if he or she has a strong preference; if so, you should use your Advisor's preferred style.

The JMU Library website has an online citation tool called CheckCite that can help you with formatting citations. Perhaps the most commonly used style is Turabian, also known as *Chicago Manual of Style* (sometimes shortened to simply Chicago). Two other widely used styles are American Psychological Society (APA) and Modern Language Association (MLA), which are especially popular in the social sciences and humanities, respectively. Some scientific disciplines use Council of Science Editors (CSE) style. Whatever citation style you choose **be sure to be consistent** throughout the document!

Oral Presentation Guide

The fear of public speaking is more common among Americans than the fear of anything else, even death.[2] Being in a professional position, as most ISAT students hope to be, will almost certainly require at least some form of public speaking before an audience that you do not know well. Like it or not, you may very well be judged by your oral presentation skills. Having technical knowledge is important to making an effective presentation, but having effective public speaking skills is even more important. Excellent work that is poorly communicated may be of little or no value to others. As with your written work, a key goal of your presentations should be to ensure that the information you are presenting allows for no other interpretation than the one you intend.

Knowing your audience and your material is an important first step to a having a strong presentation. Think about who your target audience is. This means more than just who is likely to be listening, although that is very important. Target audience focuses on those that you are most trying to reach. For example, your parents might be in the room when you deliver your presentation, but it might be more important to you to impress your Sponsor and your ISAT 311 instructor, both of whom will also be in attendance. Think about how you can make an impression on your audience, and what techniques are likely to make your message stand out. You don't want to completely confuse the less technically adept members of the audience, however. It is fine to utilize technical jargon when it is useful or necessary to do so. Do not namedrop or use jargon to show off how smart you are – if you can't demonstrate your ability and knowledge without a bunch of jargon, adding technical language isn't likely to help you. In any case, every person in the audience should be able to understand what you did, why you did it, and what you learned. That is, everyone should be able to understand the introductory and concluding parts of the presentation even if you lose some members during the central part of the talk. Remember also that ISAT is a broad technical degree program, not a narrow specialty. All of our graduates, including you, should be able to communicate with diverse audiences, including those without extensive technical knowledge.

Having proper evidentiary support for your claims is also important. Just because your presentation likely won't have detailed footnotes doesn't mean that you don't need evidence to support your views. Often presenters will show a slide at the end of their presentation documenting sources used to support the presentation, though this is usually much shorter than a Works Cited section for a Final Report.

A strong presentation is almost impossible without adequate preparation. Know your constraints, including your time limit, available technology, and lighting. Novice speakers often dramatically underestimate, for example, how long a presentation will take to deliver. Many people are not comfortable extemporizing and so should prepare some notes. Do not simply read a paper, however, and this generally does not lend itself well to a presentation and certainly is not part of the ISAT culture. The presentation should also have a clear and logical structure, just as with your written work.

---

[2] DeNoon, Daniel J. "Fear of Public Speaking Hardwired." http://www.webmd.com/anxiety-panic/guide/20061101/fear-public-speaking. Accessed 3-4-09.

Similarly, make sure to practice your presentation. Although most of you have given oral presentations in class before, few of you will have given a talk as significant as the one you will deliver at the ISAT Senior Symposium. Ideally, you should give your practice talk in the same room as your official one. That way you can familiarize yourself with the computer, projector, and screen in the room (some of them work differently). If you have any props or physical demonstration devices, make sure that you have practiced with them. Make sure that any visuals or demonstration pieces support and reinforce your presentation – don't just hand out cool stuff that you ran across while doing your project.

You may emphasize certain aspects of your project more than others; this is perfectly fine. You might have spent three weeks trying to make a particularly difficult experiment to come out correctly, for example. Your audience does not need to know about the details of this, and it may be appropriate to mention this only briefly. In a sense it's like making a good movie: some scenes often take up a disproportionate amount of screen time because they are particularly interesting or compelling. Having a catchy introduction is desirable, as it immediately grabs the audience's attention and puts them in a receptive mindset. Don't get too cute, however, as your overall tone should be fairly serious since your work is serious.

In terms of mechanics, make sure to speak sufficiently slowly, clearly, and loudly that everyone in the audience can hear and understand you. If you feel pressed for time, cut down on the information that you cover, don't speak faster in an attempt to squeeze everything in. Rushed presentations feel rushed, and members of the audience are less likely to come away impressed and enlightened. Don't stare at your notes – make eye contact with your audience. Ideally, you want every member of the audience to feel as though you are speaking to *them*. If you make a mistake or get tripped up, don't dwell on it. Correct your error or pause and re-focus, then continue with your presentation.

In a presentation, visual effects matter. Dress nicely for your presentation. This signals that you recognize the importance of the occasion and that you take your own project seriously. Managing your non-verbal message is also important. Try to be aware of your body movements. It can be distracting if speakers are constantly moving around. On the other hand, standing completely still can be off-putting; people want to listen to a person, not a statue. The same can be said of gesturing and hand movement – a little bit is valuable, but excessive amounts are distracting. Too much or too little movement can create a sense that you are nervous or jittery. Relax and try to feel comfortable. If you are comfortable, it will make your audience feel more comfortable and you will come across as more confident and self-assured.

If you are part of a team, you will need to think and plan carefully about which team members will do which parts of your presentation. You should try to balance the presentation load so that no speaker has a disproportionately large or small role. There are many different ways to split up a group presentation; no one single approach is correct. Be specific when identifying roles, however, since any confusion during your presentation gives the impression that your group is disorganized and unprofessional. The key to a good group presentation is to rehearse it so that everyone is familiar and comfortable with how it will develop. Whereas an individual speaker

can extemporize more easily, this can create redundancies, omissions, or poor timing in group presentations.

One area that can trip up students is the question-and-answer (Q & A) period. You should always leave time for Q & A, as audience members will often have questions about some aspect of your presentation. Nothing is more frustrating for an audience member than to have a question sparked by a presentation and then not having a chance to ask the question. Q & A sessions also provide you an opportunity to demonstrate your knowledge of your subject area. It's one this to deliver a prepared presentation, but it's another to answer questions well. Answering tough questions can be challenging, but it is also a tremendous opportunity.

Be brief and clear when answering questions. Don't ramble on to show off how much you know, but make sure that you answer the question as thoroughly as you can given the time constraints. If you can't answer a question, just say so. Pretending to know or making up an answer is **much** worse than admitting that you don't know. Everybody's knowledge is limited, but good scholars and good employees acknowledge their limitations. Some questions are unfair or completely tangential to your topic. It is best to deal with such questions quickly and politely, but don't spend too much time fretting over them.

Appendices

A. Formatting for Literature-Based Senior Projects

Not all Senior Projects involve experimentation or hands-on implementation of a technological solution. Some project review the literature in a given area, explore a contentious topic, examine an emerging technology or scientific field, or otherwise adopt an approach that is based more in scholarship than in practice. ISAT has a strong hands-on culture, but these more traditional types of academic reports are certainly acceptable. If you do such a project, you are strongly urged to have some active component to your work, whether it is speaking with experts or officials, conducting a survey, or producing an informational packet.

These literature-based Senior Projects do not comfortably fit into the Final Report structure outlined above. Typically there are no results, since there is no experiment. The Introduction and Literature Review might comprise 90% of the Final Report. Clearly, a different structure is more appropriate. For some, the best approach will be a modified version of standard structure, simply omitting some sections while splitting or expanding others. For others, even that might not be appropriate. In such cases, developing more a chapter-like approach might be best. This usually means having an introduction and a conclusion, but the main body of the work is organized into topically structured sections. These sections might be organized chronologically if Project is more historical in nature, it could be broken up by topic area for more traditional surveys of a given field or technology. Note, however, that the Proposal structure should be appropriate for *all* ISAT Senior Projects, since *every* project in its formative stages needs an introduction, must identify important works in the existing literature, needs to establish a methodology, and requires a sound project management plan.

As with all aspects of the Senior Project, your Advisor is the ultimate arbiter of what is most appropriate. This is also an area where Faculty Readers can be extremely helpful, as some faculty have more experience than others with this type of write-up. There are a few general guidelines that should be followed. First, make sure that your organizational structure is logical and easy to understand. Upon looking at your Table of Contents, a reader should find your structure to be self-evident and sensible. Second, try to make your sections to be roughly comparable in terms of length and range of content, if possible. This is not a firm rule, but it does make reading your Report easier. Third, follow any widely established practices for organizing your work. In other words, if scholars and the public categorize works in a given area as being in category X, don't structure your paper to include them in category Y without a good reason for doing so. Going against the grain can be very effective if it is well thought out, but conventions are established for a reason and should be followed unless there is a compelling case for divergence.

It may be appropriate for literature-based Senior Projects to follow different conventions than more experimental projects in any of a number of ways. For example, most disciplines in the humanities and social sciences require complete bibliographies (which include all sources that the researcher consulted with and found useful), rather than the more limited works cited

conventions (which only include sources directly cited in the text) in most of the sciences and engineering. If you are doing a literature-based Project, be sure consult your Advisor about his or her expectations and how they might differ from the guidelines laid out in this manual.

B. Honors Theses

If you want to pursue a Senior Honors Project, JMU has particular rules that you must adhere to; these are described in the University's Senior Project Handbook. The key difference is that ISAT Senior Project is very often a group project, and the entire team collaborates to produce one written report. The Senior Honors Project, by contrast, requires that each Honors student individually write up a report, which must include a description of what that student has done for the project. This does not mean that an Honors student cannot work as part of a team, it only means that he or she must individually write up a Final Report. If you are interested in this option, you should consult the Honors Program's website on Senior Honors Projects and consult their Senior Project Handbook. You may also want to contact one of the ISAT Faculty Liaisons to Honors Program.

C. Intellectual Property

Intellectual property can be an important consideration in your Senior Project in two ways: you need to respect the intellectual property of others that you may use in the conduct of your project, and you need to be aware of any intellectual property that you create.

What is Intellectual Property?
Simply put, intellectual property is an idea or collection of ideas that have been put in some tangible form, such as software, an image, a recording, or a device (to name a few). Intellectual property is usually recognized and classified with either a copyright or a patent. Copyright is straightforward and simple – it is the tangible expression of an idea in a fixed medium, such as a paper or an audio recording. Technically, copyright requires no action on your part – once it is fixed in a tangible medium, you own the copyright – it requires no governmental review and provides you a certain set of protections under state and federal law. Patents, by contrast, require federal review and are typically pursued for an invention. Patent filings require documentation that the invention functions and is substantially different from any existing technology used for the same purpose. Typically, patent filers require legal advice and take considerable time to file. Patents provide protection in the market for a period of time, usually 20 years.

Using Intellectual Property
As a student, you have the ability to use other people's intellectual property in the pursuit of your education through a concept called Fair Use. However, you **must** credit the creator of any intellectual property that you use. This is typically done through a reference or citation in your project paper. You do not need permission to use the intellectual property unless you are proposing an extension or modification of it (called a derivative work), in which case you must get permission if you want to copyright or patent the extension/modification.

If your project involves work with a company or other entity, you should discuss intellectual property at the outset and understand what constraints, if any, the company is putting on any intellectual property that you are using. It is always best to have a written agreement to make sure all parties understand and agree with the conditions under which the work is being done.

Creating Intellectual Property
In your senior project, you will create intellectual property. In most cases this will simply be your project report, which is protected by copyright, or it may be something more – the creation of a new process, technology or idea. Intellectual property creation at JMU is governed by Policy 1107. Intellectual Property created by students typically belong to the student, unless the work was done "for hire," involved a substantial investment of university resources, or the student has agreed to grant the rights of the intellectual property to another person or group. "For hire" means that you were employed and paid to do something (such as being paid to work in a lab) – in that case, the intellectual property belongs to the employer. If JMU has invested more than $10,000 in a project, then the work belongs to JMU (this is very rare for Senior Projects). You can also assign your rights to someone else, for example, a company that is financially supporting your project. Your Faculty Advisor may also have you work on an ongoing project. In that case, you should discuss intellectual property with your Advisor to be clear about what happens if you discover anything novel. If you believe that the agreement that your Advisor is proposing concerning intellectual property is not fair to you, you should immediately consult the Department Head about the matter. If you think you have created something original and potentially valuable, you should consult JMU Policy 1107 for a more detailed description. Note that when you move to a job in business or industry, any intellectual property you create while working will belong to your employer. If you have any additional questions, ask your Faculty Advisor or another ISAT faculty member.

D. Working with Sponsors

Having an External Sponsor for your Senior Project can be a strong addition to your experience. Sponsors can provide funding and/or expertise, working with them gives you a chance to interact with people from the "real world," and the contacts you make can lead to future job opportunities. Working with a Sponsor is not without its concerns, however. The interest of your Sponsor might be at odds with your interests as a student. For example, if a Sponsor asks you to help their company find a safe disposal option for their wastewater, you might conclude after consulting the available literature that the company would be better off using a completely different process that produces very little wastewater. This might be a good solution to the problem, but it isn't what the company is interested in. Similarly, you might find it difficult to be critical of a Sponsor, even if your work suggests that your criticism is valid, since your Sponsor was nice enough to help you with your research.

These potential difficulties with Sponsors can be valuable learning experiences, since you might find yourself in a similar situation once you leave university and enter the workforce. Your Senior Project, however, may be your last chance to enjoy the academic freedom that you have enjoyed during your undergraduate years. You will likely have many more years to work on

problems that other people define, but this is a project that you have chosen to work on and spend months of your life learning about. In the end, your Senior Project is yours, not your Sponsors. In fact, your Sponsor's approval is not required for successful completion of the Senior Project (though it is preferable to have this approval) – your Advisor is the only person who gives you a grade. Try not to antagonize your Sponsor, but you don't have to compromise your interests or principles in trying to satisfy your Sponsor's interests.

E. Project Management Guide

Working collaboratively requires individuals to work as a team, and to establish a "group process" all members develop, agree to, and follow. Sometimes this requires re-evaluating personal goals, being cooperative instead of competitive, and putting the needs of the project before your own. Most importantly, group members need to "agree to disagree," that is, to be open, honest, and direct (yet kind and tactful) in discussions without allowing differences in opinion or approach to affect professional working relationships. Disagreeing with an individual's ideas is not a condemnation of his or her personality or style. Teams that learn how to work well collaboratively are unusually strong and productive.

All members of an effective work group should

- Know clearly the material or issues being discussed;
- Feel free and not professionally or personally threatened to contribute new ideas;
- Actively listen to each other;
- Support and accept new ideas, and explore their possibilities, even if the ideas do not seem productive initially;
- Know how to brainstorm effectively;
- Take turns talking, speak in normal conversational tones, and use names;
- Encourage all members to participate, and ask questions for clarity or more information;
- Relieve tension through humor;
- Give direction to the group;
- Keep personal issues (disagreements with others, romance, personal problems) outside the work setting;
- Develop methods, if necessary, for solving the group's collaborative problems, and
- Develop personal collaborative skills.

F. Multi-Year Projects

Most Senior Projects are conceived of and completed in a single 3-semester period. Some projects, however, simply could not be accomplished in such a timeframe. Several ISAT faculty members also have ongoing funded research projects that can benefit from contributions from undergraduate participation. Working on a multi-year project is acceptable and can be very rewarding. You must take special care, however, to specify what parts of the overall project were given to you and what were your unique contributions.