RIT | **Department of Cybersecurity**

CAPSTONE GUIDE
~ Master of Science in Cybersecurity~

~ A General Guide for the MS Capstone Experience ~

(Note that the MS Project option is available for students who started the MS program before Fall 2024. Students beginning their MS in Cybersecurity program during and after Fall 2024 can enroll in the 6-credit Thesis or take an additional Advanced Elective (3 credits) + Research Elective (3 credits). Please refer to the MS Student Handbook for the current list of electives.)

> The term "capstone" refers to a final culminating educational expectation for MS degree candidates. The capstone experience for a given MS program is defined by the faculty to match the educational goals of that program. It can be implemented as an open-ended experience, i.e. a project or thesis, or as a closed-ended development expectation, i.e. a course with specific creative and professional goals.

Introduction

The capstone experience is the final requirement of the Master of Science degree offered by your department. The topic chosen for a capstone experience should build upon the student's studies to demonstrate mastery and advanced technical ability. Although we expect students to demonstrate their capabilities as computing professionals and to push their investigations beyond their coursework, this is not a time to change direction and attempt to learn something entirely new. Rather, the purpose of this requirement is to allow the student to pull together the knowledge that has been gained during graduate study and to demonstrate, under the guidance of a faculty committee, creativity and professionalism. After the capstone work (project or thesis), the student writes a scholarly document and defends the work in a public forum to the satisfaction of the faculty committee members. The department faculty prefer that students plan for and complete this requirement immediately after finishing their coursework. Under special circumstances, the faculty committee may allow capstone work to be completed at a distance.

Thesis or Project: What's the Difference?

Thesis (6 credits): A thesis involves researching a topic of interest. This research is typically based upon a hypothesis or an assertion statement. The hypothesis may be verified using mathematical analysis, experiments, simulations or emulation. There may or may not be a development component. It must, however, add some "nugget of knowledge" to the body of literature on the chosen topic. In other words, a thesis is more than simply a large literature review or report on a given topic area. It requires investigation, analysis and creativity of high quality, suitable for external peer-reviewed publications. The investigation process and the results are documented in a published document, available to the public through the RIT Library and the Internet.

MS Project (3 credits) (for students who *started* their MS program before Fall 2024): A project involves some type of practical development with a deliverable. This may include development with computer equipment, software packages, and programming or scripting languages. Alternately, it may be the development and demonstration of an innovative process that addresses a current computing issue or problem. A well-written professional report is required that details current thinking on the topic in the professional literature, the design and implementation of development that was done, and a critical evaluation of the results.

Description of Capstone Options (Course Catalog)

CSEC 790 MS Thesis - This course is a capstone course in the MS in Cybersecurity program. It offers students the opportunity to investigate a selected topic and make an original contribution, which extends knowledge within the cybersecurity domain. As part of their original work students will write and submit for publication an article to a peer-reviewed journal or conference. Students must submit an acceptable proposal to a thesis committee (chair, reader, and observer) before they may be registered by the department for the MS Thesis. Students must defend their work in an open thesis defense and complete a written report of their work before a pass/fail grade is awarded. (6 Credits)

CSEC 791 MS Project (for students who *started* their MS program before Fall 2024): - This course is a capstone course in the MS in Cybersecurity program. It offers students the opportunity to investigate a selected topic within the cybersecurity domain. The student may complete a project for real-world application or in a laboratory environment. Students must submit an acceptable proposal to a project committee (chair, and reader) before they may be registered by the department for the MS Project. Students must defend their work in an open project defense and complete a written report of their work before a letter grade is awarded. (3 credits)

General Considerations

The capstone experiences for our MS program are student-directed work with the specific purpose of providing the student with an opportunity to apply the education that he/she has received to an independent creative endeavor. The major difference between a project in a course and a capstone experience is that you must individually move beyond your coursework to investigate a topic, manage the design and planning for this effort, and successfully complete the work with appropriate scholarly depth and professional expertise.

You should plan to spend at least six (6) months completing your capstone. Expect to begin the actual capstone work while you complete your MS coursework. Your capstone work should be interesting and exciting, and your faculty look forward to working with you as you complete it. However, please be aware that the faculty cannot be expected to respond to any deadline pressures that you may have due to relocation, termination of

financial support, employment requirements, promotion opportunities, I-20 or H1-B deadlines, etc. RIT expects quality effort.

If you disappear for several years after completing your coursework, it will be much more difficult to satisfy your capstone requirement. In addition, faculty members have very busy professional schedules. If you wait to start your capstone, you will find it <u>much</u> more difficult to generate an acceptable topic and to recruit faculty or to return to campus. In addition, you risk losing your previously completed coursework. (Under RIT policy, you have up to seven (7) years from the time that you took your first course towards the MS degree requirements – excluding any prerequisite coursework; see the "Time Limits" section of this document for details.)

For your capstone, it may be possible to work on an appropriate, industry-sponsored topic. However, this can present problems. Issues such as proprietary concerns or conflicts between satisfying academic constraints versus organizational goals can arise. Students should discuss possible industry projects with the graduate director. If such a project is acceptable, your capstone committee may include an industry representative – either formally or informally. All capstone work is an <u>individual</u> effort, however. In addition, all capstone defenses and the final capstone documentation are public knowledge. Therefore, a letter from your employer confirming that the company approves the project as your capstone, that you will be the only employee working on the project, and that all information included in the final capstone document and defense is non-proprietary is required.

Outline of an Open-Ended Capstone Process (for both Thesis and Project)

Creating an Initial Idea Document

1. Think of a project area that you would like to explore. Write a couple of paragraphs outlining the idea. In particular, you should highlight why the project idea is worth exploring.

Identifying Committee Members

2. Based on your project idea, identify the *CSEC faculty member* who has the subject matter expertise to guide you on your project topic and serve as your committee chair. You may have to try with a few faculty members, depending on their availability and interest in the project work.
3. Once your committee chair is determined, work with them to form your committee (a 2-member committee for projects and a 3-member committee for the thesis). Capstone chairs must be CSEC faculty; committee members can be anyone with an MS degree. You need approval from the graduate program director for non-RIT committee members.

Creating a Proposal

4. Expand your initial document into a full proposal.
5. The proposal must include at least the following sections (these are the minimum requirements; The committee can have other specific requirements):
   a. Problem statement, including why this is a problem of interest
   b. Literature search describing prior work in this area
   c. Description of the work to be done
   d. A clear enumeration of deliverables
   e. A timeline for the proposed work
   f. List of references, consistently formatted
6. Although there is no page limit for Capstone proposals, typical project proposals are 8-10 pages long, while Thesis proposals are 15-20 pages.
7. You may ask for a sample proposal from your Capstone committee chair to help in planning out your proposal write-up.
8. This proposal should also incorporate any comments or suggestions from your committee members.

Finalizing Your Proposal

9. Be sure to use the appropriate cover page for the proposal, available on the department website (https://www.rit.edu/computing/cybersecurity-resources).

10. When all your committee members have signed off on the cover page, submit an electronic copy of the signed proposal to cybergrad@rit.edu.

11. Get access to the MyCourses Capstone Submissions page from department staff.

12. Access the MyCourses page and submit your proposal to the appropriate assignment submission area (there are separate proposal submission areas for project and thesis in the assignment submission shell). This will run a Turnitin check on your proposal to ensure original scholarship.

13. At this point, your proposal becomes an informal contract indicating the specific work to be done and the approval of the topic and tasks by the faculty.

14. You will be enrolled in CSEC 790 (MS Thesis) or CSEC 791 (MS Project) by the department staff after the approval process is complete.

15. We can register you for all your MS thesis credits at one time. However, you should consider the length of time that it will take you to complete your work. Since thesis work can take several semesters to complete, it is typically best to spread the credits over multiple semesters to maintain your active status and access to RIT resources. Talk with your graduate director or graduate academic advisor if you are not sure about the best registration plan to fit your situation.

16. All approved capstone proposals are valid for **one year** after approval. If you do not successfully complete your project within one year, you may need to start the process all over again.

17. For MS Projects, if your work is not completed by the end of the semester in which you register for the credits, you will automatically receive an incomplete (I) grade. You have the standard two (2) semesters (summer counts as a semester) to complete the work and replace the incomplete grade with the actual capstone grade. After two semesters, the incomplete automatically becomes a grade of 'F'. The grade can typically be changed to the grade earned when all capstone work has been completed. If an extensive period has elapsed, the student may have to re-register (and re-pay) for these credits.

18. For an MS thesis, you will receive a grade of 'R' at the end of the semester, which indicates that you worked on the thesis.

19. You may need a full-time equivalency for semesters in which you are registered for capstone credits to maintain your I-20 status or to work on campus, etc. The CSEC department allows a maximum of two (2) full-time equivalencies for capstone work.

20. Once you have paid for all your capstone credits, you may only be registered for zero (0) capstone credits <u>one (1) time</u> (other than in summer terms) to maintain your active academic status. After that, you will need to register for capstone continuation credit. The zero-credit or continuation-credit capstone registration options are not a way to postpone your capstone work (and any loan repayment) while you look for employment or engage in other unrelated activities.

Completing the Capstone Experience

21. Consider consulting the GCCIS subject librarian to help organize your research. A capstone consultation is also an opportunity to familiarize you with useful services provided by the RIT Library, such as interlibrary loan (acquiring documents from other academic libraries), citation management software[1], and electronic archiving of your capstone work through the RIT Digital Media Library.
To make a capstone consultation appointment, contact the RIT Library Liaison for GCCIS: Greyson Pasiak (gspwml@rit.edu).

22. Do the work. An MS capstone generally takes two (2) semesters of effort to complete. Typically, this means one semester to organize your effort (proposal, research, etc.), and another semester to complete the work. The longer you linger, the more likely it is that technology and the faculty will have changed from when you completed your coursework. Procrastination will only result in lengthy delays and more effort in completing the capstone experience.

23. As you work, keep in touch with your committee members. You should minimally be in contact with them one to two times per month. So, plan to submit frequent drafts of your document and to do periodic demonstrations. Your capstone faculty will tell you when you are ready to defend. Do not be tempted to push for an early defense or to announce a defense date without their approval. If you are allowed to defend before you are truly ready, you could fail the defense; be assigned additional work; and have to re-defend later when you are better prepared.

24. After you have completed your capstone work to the satisfaction of your committee, you will be ready to "defend" it in a public forum. The capstone defense is intended to allow you to demonstrate your expertise, skills, and professionalism within the context of your individual project or thesis. Your committee will set the requirements for the defense. However, it typically involves a formal presentation and, if applicable, a demonstration of your work. The defense may be done on campus or from a distance. You will need to make the arrangements (scheduling a time, getting a room, etc.) with the CSEC staff for your defense. Since your defense is open to the public, you will need to post an announcement for it <u>at least one week in advance</u> on the graduate bulletin board (see Appendix D for the posting format). The last day to defend is the last day of classes each term.

25. Occasionally, problems can occur during the completion of capstone work: research may not progress as anticipated, development problems can arise, anticipated resources may not become available, etc. If the problem(s) are significant, it may become necessary to revise your capstone proposal. This is the time to talk with your faculty. *Your capstone faculty must approve any change(s)*

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[1] Check out the Wallace Library page at http://library.rit.edu.

in advance. Changing the scope or direction of your project/thesis without your committee's prior approval, invalidates your previously approved proposal and you may be required to change your work, write a new proposal, repeat the approval process, and/or find a new committee. So please stay in close communication with your committee members.

26. Capstone committee members commit to work with you for up to one (1) year after they approve your proposal. If you delay starting or take longer than a year to complete your work and have not been in communication with them, the faculty may decline to continue on your committee. If this occurs, you will need to form a new committee and possibly develop a new proposal as well.

27. Occasionally, students propose an ambitious capstone topic to attract faculty interest and establish a committee quickly. Then, after a proposal is approved, they request that their faculty reduce the proposal requirements because they have insufficient time or knowledge to complete it. Faculty members do not appreciate this type of "bait and switch." They typically cancel the capstone and permanently withdraw from the student's committee.

28. You should also be aware that if you have been inactive for three (3) consecutive semesters or more, including summer, you will be dematriculated from RIT. If this has occurred, your department may be able to reinstate you. However, if it's been over two years and degree requirements have changed, you must reapply for admission through RIT Graduate Enrollment Services. If you need to be readmitted and the degree requirements have changed, you will be readmitted under the degree requirements that are currently in effect. This may mean that you need to do additional coursework in addition to completing your capstone. You should also be aware that you are subject to RIT's 7-year degree completion time limit (discussed under "Time Limits" below).

29. Your capstone document is <u>very</u> important. It represents your intellectual effort and professional capabilities. The faculty takes this document very seriously since they are required to sign off on it. Therefore, you can expect to receive extensive feedback on both your technical content and writing style. Please use the appropriate title page and approval form for the report, available on the department website (https://www.rit.edu/computing/cybersecurity-resources). Details on the capstone document format are included in Appendix A of this guide; however, please be aware that your capstone faculty may require a different format. Ideally, whenever possible, your final capstone document should be available at the defense.

30. Your final capstone document <u>must</u> be of professional quality and written well, in terms of language usage, your expression of ideas, visual presentation, and references. Presenting your committee with a well-written document will speed up completion of the capstone requirement. Your committee members have many demands upon their time, so please do not expect them to provide extensive editing support.

31. Appropriate references are critical to a well-written capstone document. Ideally, you should have a wide range of information sources: books, journals, etc. The Internet is not a dependable source of reference material. If you do cite a reputable website, use an appropriate referencing format (see the APA, MLA and IEEE references in Appendix B) and print the opening page and all directly referenced pages for inclusion in an appendix to your document. The Internet changes constantly, but your references <u>must</u> be "locatable."

32. If you receive feedback from your faculty that you should "clarify," "explain," or add "depth" to a section of your document, do so. If you're unsure what is meant by a comment or how to proceed, talk with them. Do not be tempted to just drop that section from your document. Removing important content weakens your document, can aggravate your faculty and delay completion, and ultimately may negatively affect the evaluation of your work.

33. Your defense may result in further suggestions or changes that will need to be incorporated into your capstone work and/or documentation. You may also be required to defend more than once.

34. When your capstone is successfully defended and your faculty members are satisfied with the capstone document, they will sign the official capstone signature page that must be attached to the front of your capstone document.

Capstone Grade

35. The MS capstone requirement is successfully completed when all work, the defense, and the capstone document have been completed to the satisfaction of your committee; it has been approved and signed off on by *all* of your capstone committee members; and the required copies of the capstone document have been appropriately submitted per RIT and your department requirements.

36. After a MS project capstone is successfully completed, the members of the faculty committee award a letter grade based upon the student's demonstrated performance.

37. The MS thesis capstone is pass/fail and a grade of 'R' is assigned. When your faculty committee members accept the thesis, the name of the thesis is entered into the student's permanent academic record, and it is considered "completed" at that point.

38. Satisfactory completion of the capstone requirement and the final grade is determined by agreement between all of your capstone committee members. This decision is based upon the quality of both your capstone work and your defense.

Final Submission of your report

39. The final step in completing your capstone is to submit your capstone document for permanent retention by RIT. Note that RIT no longer requires hard copies of the final thesis. Thesis capstone reports are maintained by both RIT's Wallace Library and your department. Please submit an electronic copy of the document to the department once you are done with the defense. For submission details on the electronic copy to the library, please refer to https://infoguides.rit.edu/thesis-services

40. Project capstone reports are permanently maintained by your department. Please submit an **electronic** copy (with the signed signature page) to cybergrad@rit.edu.

Important! The capstone document (electronic copy) must be submitted before you can be certified for degree completion and graduation. For an MS project capstone, this means an electronic copy of the final project document must be submitted to cybergrad@rit.edu by the deadline set by the department each semester. For an MS thesis capstone, along with the electronic copy of your thesis, the receipt from your ProQuest/UMI submission must be returned to your department before you can be certified.

Sharing Your Efforts

41. You may want to share your scholarly efforts on the Internet through an electronic theses and dissertation (ETD) site, through publication, or at a conference. Talk with your capstone faculty about this. RIT's Digital Media Library (https://ritdml.rit.edu/) is one option. The Digital Media Library provides electronic documentation of graduate student projects, theses, and doctoral dissertations for the RIT community. The library will post your scholarship efforts or you can post it on your own. For more information, please see the website or contact the RIT Wallace Library.

Alternatively, you can find a relevant conference by talking with your committee faculty.

Time Limits

All requirements for the master's degree, including your capstone, must be completed within seven (7) years of the semester in which the first course that is used towards the MS degree was completed. This includes any credit for courses transferred from other

universities. For example, if the oldest course on your MS worksheet was taken in the Fall of 2018 (2181), your 7-year deadline would be before the start of Fall 2025 (2251).

Additionally, we strongly encourage students to finish their capstone work within one (1) year of the time that your graduate coursework is completed. Remember, your faculty committee is committed to your capstone topic for *one year only*; beyond that time frame it will be up to your committee members to decide whether or not they will continue with you. If they do agree to continue on your committee beyond the one-year time frame, your capstone proposal will have to be reviewed, and possible revisions to the original proposal or a new proposal may be required. Significant revisions may require finding a new committee since the revisions may alter the original proposal in such a way that the topic is no longer within the areas of expertise or interest of your faculty.

Collaborative Work

All capstone work for an MS degree at RIT is an <u>individual</u> effort, even if contributing towards a collaborative project. The standard RIT and department academic honesty expectations and policies apply (https://www.rit.edu/academicaffairs/policiesmanual/d080).

The capstone is your opportunity to display your professionalism. Plagiarism and other acts of academic dishonesty have no place in this process and can have very serious consequences including dismissal from the institute sans degree. Be sure to do your own work and to appropriately and exhaustively reference all material obtained from outside sources.

Re-Use of Previous Course Work

A capstone may be an extension of work that you yourself started in one of your MS courses or that extends the capstone work of a previous student. However, your capstone proposal must clearly document your idea as such, so that your faculty committee is aware of and approves of the origin of the idea and any previously completed work. Capstones that extend the work of your classmates, such as team or group course projects, are generally not acceptable unless specifically approved by your capstone committee.

Since the capstone experience is an expectation beyond your MS coursework, projects or papers completed to satisfy assignments in courses taken during your studies either at RIT or at other academic institutions do not satisfy the capstone requirement, although as mentioned above, they may become the basis of it.

Appendix A
Sample Outlines

Below are sample format outlines for capstone proposals and final documents. While the requirements of the final documentation are agreed upon between the student and his/her committee members, the following formats are a general standard. For both the project and thesis capstone options, the proposal and final document <u>must</u> follow the APA, MLA or IEEE style guidelines (see Appendix B).

Project Proposal Outline (recommended)
- Topic Statement (state the problem you will investigate, including history and/or context)
- Significance (the importance of the topic and your interest in it; list, in detail, the concentration coursework and other experiences that will support your proposal)
- Proposed Solution and Deliverable(s) (list exactly what will be done; clearly and specifically describe exactly what the completed work will entail)
- Methodology (list the approach, techniques, and resources needed for implementation)
- Project Timeline or Schedule (anticipated, typically one-two semesters of effort)
- Supporting Research and References (relevant citations in appropriate format)

Thesis Proposal Outline (recommended)
- Hypothesis (hypothesis or assertion statements that clearly define the question to be investigated, the research that will be done, and the scope of your investigations)
- Significance (the importance of the topic and your interest in it; list, in detail, the concentration coursework and other experiences that will support your proposal)
- Literature Review (summarize the background literature that relates to your topic)
- Proposed Research and Deliverable(s) (list exactly what will be done; clearly and specifically describe exactly what the completed work will entail)
- Methodology (list the approach, techniques, and resources needed for implementation)
- Research (and development, if applicable) Timeline (anticipated; typically two semesters)
- Supporting Research and References (relevant citations in appropriate format)

Final Project or Thesis Documentation Format (recommended)
- Title Page
- Signed Project/Thesis Approval Form (https://www.rit.edu/computing/cybersecurity-resources)
- Abstract
- Table of Contents
- List of Tables, Charts, Illustrations, etc.
- Introduction
- Document Body (methods, results, discussion)
- Project/Thesis Conclusions (should reflect your personal thoughts on your work; minimally include results, all lessons learned, recommendations, and future tasks or suggestions for follow-up work)
- Appendices (charts, graphs, supplementary material, documentation of Web references)
- Supplemental Storage Media (with all development artifacts, if applicable)
- Bibliography

Appendix B
Writing Links & Other Helpful References

- **RIT Library:** http://library.rit.edu (Wallace; Building 05)

- **Citations**:

  Various tools, guides and services are available through the Library at
  https://infoguides.rit.edu/citation. Some of the more popular citation format guides
  are:

  IEEE Format: http://www.citethisforme.com/citation-generator/ieee
  APA Format: http://www.citethisforme.com/citation-generator/apa
  MLA Format: http://www.citethisforme.com/citation-generator/mla

- **Language Resources:**
  Guide to Grammar & Writing (includes structure and organization under Essay &
  Research Paper Level topic)
  https://www.guidetogrammar.org/grammar/

- **RIT Academic Support Center - Writing Center** (SAU-1180)
  https://www.rit.edu/academicaffairs/writing/

- **Official Copies of Capstone Forms:**
  https://www.rit.edu/computing/cybersecurity-resources#ms-student-resources

- **Google Scholar:** http://scholar.google.com