# WPI

Systems

Engineering

Ph.D.

Guidelines

**Systems Engineering Program**

**Worcester Polytechnic Institute**

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# Contents

# 1. Welcome and Introduction

This booklet represents a compilation of material relevant to the Ph.D. program in **Systems Engineering** at Worcester Polytechnic Institute (WPI). We hope that you read this material and learn about our program, the requirements for the degree, and learn about the faculty involved in advising dissertation topics.

Please don't hesitate to contact and ask questions directly of the program faculty, or indirectly to us through our email alias SEphd@wpi.edu. The SE faculty are excited about our new Ph.D. program[1] and look forward to advising dissertation students and helping the program evolve as we gain experience working with our program students.

For now, please accept our warm Welcome! We hope that this booklet addresses the information you were looking for. If not do not hesitate to contact us.

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## 2. Program Overview

Most traditional Ph.D. programs are designed to support full-time, primarily on-campus students. The SE Ph.D. program is different. We expect the majority of our students to be part-time, off-campus candidates who have full time jobs and who have been or are involved in systems engineering related work. The implications of this expectation are that the SE program faculty and administrators will;

- Offer most program courses on-line.
- Offer the required research seminars in a virtual classroom setting where all participants can readily interact with each other.
- Support student research by strongly encouraging, and financially supporting the travel costs for presentations at national conferences.
- Expect regular, documented, Research Advisor(s) interactions.
- Explore unique, as well as best-practice ways to enhance student engagement and professional development.

> *Continuous, constructive and supportive student engagement is critical to the success of our students and program.*

### *Program Summary*

Although the Ph.D. program requirements are detailed later in this document, a summary of the Ph.D. program requirements is provided here.

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Course Requirements

There are *no specific course requirements* for the WPI SE Ph.D. program.

Minor Requirements

Minor 1 - A minimum of 12 credit hours of thematically related graduate courses selected from the areas of Science (including Computer Science), Mathematics and Engineering, and selected in consultation with the Research Advisor(s).

Minor 2 - A minimum of 9 credit hours of thematically related courses, in any area and selected in consultation with the Research Advisor(s).

Research Requirements

A *minimum* of 30 credits registered as SYS 699 - Dissertation Research.

Exam Requirements

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|---|---|
| Qualifying Exam | *Designed to evaluate a student's level of academic preparation and identify any shortcomings in the student's background.* Taken no later than 18 credits beyond the MS degree. |
| Area Examination | *Intended to evaluate the suitability, scope and novelty of a student's proposed research topic.* Taken after the Qualifying Exam and no later than 42 graduate credit hours after matriculation into the Ph.D. program. |
| Defense | *A public defense* of the final Ph.D. dissertation research. The defense can be scheduled any time after the end of the semester in which the Area Examination was completed. |

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## 3. Systems Engineering Ph.D. Program

All prospective and current SE Ph.D. students are strongly encouraged to read the pertinent sections of the WPI Graduate Catalog found here: http://www.wpi.edu/academics/catalogs/grad.html

### Preferred Program Applicant

The preferred program applicant will have an **MS in Systems Engineering**. However, applicants who have earned an engineering MS degree, but not in Systems Engineering, and who have demonstrated SE work experience, are also strongly encouraged to apply. All applicants will be considered for admission into the Ph.D. program based on a thorough review of their application material (see below).

Students who have not yet earned an MS degree will not be considered for the WPI Systems Engineering Ph.D. program until completion of the MS degree.

### Admission to the Ph.D.

Prospective graduate students submit their applications for the SE Ph.D. program online. Links to applications, including the SE Ph.D. program, can be found at http://grad.wpi.edu/+apply. Application and admission requirements include the following:

- There are three separate applications one can select through the on-line link. Applicants to the SE Ph.D. program should select the link for "(1) **engineering**, science, social sciences and interdisciplinary studies".
- A non-refundable $70 **application fee** (waived for WPI alumni and current WPI students).
- Official college **transcripts** in English from *all* accredited degree-granting institutions attended.
- Three **letters of recommendation** from individuals who can comment on the applicant's qualifications for pursuing graduate study in the chosen field. Applicants are required to invite their recommenders to submit letters of reference through the online application program.
- **A statement of purpose**. This is a brief essay discussing background, interests, academic intent, and the reasons the applicant feels s/he would benefit from the program. The statement of purpose must be submitted electronically with the online application.
- **A statement of relevant and related SE work experiences**. This statement of relevant and background experience and expertise is particularly important for students who do not have a MS degree in Systems Engineering, but all students are required to submit this document as well.
- Proof of **English language proficiency** must be submitted by all applicants for whom English is not the first language. In order to prove English language proficiency, applicants must submit an official score report from either the TOEFL (Test of English as a Foreign Language) or IELTS (International English Language Testing Service). The minimum scores for admission are: TOEFL: 84 (internet-based test) 563 (paper-based test) IELTS: 7.0 overall band score with no sub-score lower than 6.5.

  The TOEFL/IELTS exams will be waived for applicants who:

  - have completed two years of full-time study at a college or university in the U.S.
  - completed at least two years of study at a university within the past five years and where classes were predominantly taught in English, and/or
  - have been employed in the US for at least two years.

  Applicants who believe their English language skills are sufficient to waive the TOEFL/IELTS exam requirement are encouraged to contact the SE program Academic Coordinator to arrange a phone interview to evaluate their language skills.

- WPI's institutional code for the TOEFL is 3969. Scores are valid for two years from the test date. For more information, or to take the TOEFL, go to: www.toefl.org. For more information on the IELTS, or to take the exam, go to: www.ielts.org.
- The **Graduate Record Exam** (GRE) is not required for admission, but applicants are strongly encouraged to submit GRE scores if they are current (~ last 3 years).

Applicants will receive information explaining how they can check the status of their applications after they submit their forms online. It takes approximately one week for the forms to be entered into WPI's database. After this time, the applicant will have access to their information unless otherwise notified.

- The Graduate Admissions Office will retain incomplete applications for one year after the application was started. The Office reserves the right to cancel an incomplete application at any time, but it will generally continue to hold incomplete applications in its files for one year.
- All applications and all supporting material become the property of WPI once they have been received by the Office of Graduate Admissions.

## Admissions Criteria

The SE Program faculty at WPI are committed to the broadest definitions and applications of systems engineering and to supporting a wide range of Ph.D. dissertation research endeavors that advance the state-of-the-art of systems engineering. The implications of these declarations are that the program faculty are interested in both general SE research topics, as well as the application of SE methods to areas outside of what are considered traditional SE application areas.

### Statement of Purpose

The statement of purpose (SOP) submitted with the application is critical to the evaluation of a candidate for admissions to the WPI SE Ph.D. program. Topics that would be appropriate to cover in the SOP include past and future career objectives, a self-assessment of a candidate's commitment to what surely will be a multi-year process, research interests and rationale (especially as they relate to specific faculty research interests listed later in this document), and a self-assessment of a student's preparedness for doctoral studies.

> *SE work experience is important to document, but lack of SE work experience should not dissuade a candidate from applying for the SE Ph.D. program.*

### SE Experience Statement

The faculty in the SE program represent a mix of professionals who range from primarily academic to primarily corporate professionals. It is expected that students applying to the WPI SE Ph.D. program will have a similar range of backgrounds, from those who have significant career interests and experience with systems engineering methods and challenges, to those who have limited industrial experience or shorter career experiences (or even no practical experience) in areas related to SE methods and challenges, and are perhaps purely academically motivated. The purpose of the SE Experience Statement is to provide all applicants an opportunity to describe their SE background, with an emphasis on unique and/or particularly interesting aspects of their background, their SE accomplishments, and to relate their SE background to their interests in the SE Ph.D. program.

### Admissions Assessment

Once all material has been received by the WPI Graduate Admissions office, the SE Program faculty involved in admissions decisions will review the submitted material and make a decision on the

suitability of the applicant to the SE Ph.D. program. Such an assessment will of course be based on the detailed submitted material, which includes the following;

- ☐ Formal application
- ☐ Resume/CV
- ☐ Statement of purpose
- ☐ Statement of SE experience
- ☐ Grades from all previous institutions
- ☐ GRE scores if applicable
- ☐ TOEFL scores if applicable
- ☐ Recommendations
- ☐ Any additional submitted material accompanying the application

The three possible outcomes from the application material assessment are accept, reject, or reject with encouragement. While the first two items are self-explanatory, the third (reject with encouragement) will be used in situations where the committee has questions regarding the applicant and their background, and either requests additional supporting application material or perhaps establishes a baseline for performance or expected experience before reconsidering the application. If rejected with encouragement, a candidate will be informed of the need for additional supporting documentation and/or experience and the application will be re-reviewed once the specified conditions have been met and supporting documentation has been received.

If a Research Advisor(s) is not selected or indicated at the time of matriculation, a Ph.D. student will be assigned an academic advisor until such time as a formal Research Advisor(s) is selected. Once a formal Research Advisor(s) is selected, the Research Advisor(s) will also act as the academic advisor.

## Plan of Study

Each admitted student must file a formal Plan of Study (POS) with the SE program within the first semester if full-time, and within the first year of graduate study if part time. Plan of Study changes are common and initiated by a student in consultation with their Research Advisor(s). Copies of a student's Plan of Study will be maintained in the SE Program office.

## Acceptability of Credit Applicable to the SE Ph.D.

Graduate level credit may include:

> *Candidates should remember that their program of study can include pre-approved courses intended to be taken at other universities and then transferred to WPI.*

- Coursework included in the approved Plan of Study.
- Coursework completed or planned for at the graduate level, not applied toward another degree, and successfully transferred to WPI from other accredited, degree-granting institutions.
- Coursework completed at the graduate level at WPI and not applied toward another degree.

Departments and programs may limit the use of credit depending upon their specific requirements.

## Ph.D. Credit Hour Requirements

Students must complete 60 or more credits of graduate work beyond the Master of Science degree. Of the 60 credits, at least 30 credits must be registered under the designation SYS 699 PH.D. DISSERTATION which is reserved solely for Ph.D. research activities.

The doctoral student must establish two minors in areas outside of Systems Engineering. The specific courses used to meet the minor requirements are selected in consultation with a student's Research Advisor(s). One of the minors must be comprised of courses from a Science (including Computer Science), Mathematics, or Engineering program and must total a minimum of 12 credit hours of approved, thematically-related graduate level courses. The second minor is selected in consultation with the Research Advisor(s) and must consist of a minimum of 9 credit hours of approved, thematically-related graduate level courses. Courses which are cross-listed between the Systems Engineering program and the course offerings of another department or program *cannot* be used to fulfill the requirements of a minor area.

All SE Ph.D. students are encouraged to continue to take SE graduate level courses. The SE program at WPI continues to evolve and courses are being developed and newly offered nearly all the time. As a result, most SE Ph.D. students will find that over time there are SE courses they have not taken that will be of benefit to their development as an SE professional.

All doctoral students are required to attend and pass two offerings of the SE graduate seminar courses[2], SYS 596A (fall semester) and SYS 596B (spring semester). Students may enroll in the graduate seminar course in any combination (e.g. two different semesters, or same semester over multiple years). Enrollment in the graduate seminars is required even if a student has already enrolled and counted seminar credit as part of an M.S. degree program.

> *As a clear indicator of scholarly activities, Ph.D. students should endeavor to publish two peer reviewed articles, and present 2-3 papers/posters at professional conferences prior to completing their degree.*

## Publications and Presentations

A student's Research Advisor(s) will be the primary point of contact to determine and discuss what should be considered for conference presentation and/or peer reviewed publication. All SE Ph.D. students are encouraged to submit and present their research results at appropriate academic and/or professional conferences. Funding for conference participation can be requested from the WPI Graduate Student Organization (https://orgsync.com/43823/forms) and the SE Program office. Students should of course also seek conference travel support from their employer.

## Research Advisor(s) and Dissertation Committee Selection

The doctoral student is required to select a Research Advisor or Co-Advisors. In consultation with the Systems Engineering Academic Program Chair, the Research Advisor(s) form a Dissertation Committee for the student prior to scheduling the Ph.D. Qualifying Examination (described below). The following rules apply to the committee membership.

- The committee must consist of at least three faculty members if there is a single Research Advisor, or four faculty members if there are two Research Co-Advisors.
- At least one of the committee members must be a full-time, WPI tenured/tenure-track faculty member.

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[2] Although students must register for and "attend" a seminar course, no credit is awarded and, consequently, no tuition is charged. Grades for seminar courses are pass/fail.

- At least one of the committee members and the Research Advisor (or one of the Research co-Advisors) must hold an earned doctoral degree.
- At least half of the committee members must be Systems Engineering full-time or Adjunct faculty members.
- At least one committee member must be a faculty member not affiliated with the WPI SE Program, or a recognized subject matter expert from government or industry *(with the approval of the Academic Program Director)*.

Once the Dissertation Committee has been established, any changes to that committee must be approved by the Research Advisor(s). Changes to the student's Research Advisor(s) must be approved by the Systems Engineering Academic Program Chair. A completed *Research Advisor(s) and Committee Selection* form must be filed with the Systems Engineering Program prior to taking the Qualifying Examination and each time there is a change to the Research Advisor(s) or Dissertation Committee.

## Project, Thesis, and Dissertation Advising
*(excerpted from the WPI Graduate Catalog)*

The only faculty members who may, by virtue of their appointment, *automatically* be the formal advisors-of-record for graduate projects or independent study activities (ISGs, theses, dissertations, etc.) are:

1. Tenure/tenure track faculty,
2. Professors of practice, or
3. Others who have at least a half-time, full-year faculty appointment, with advising of independent work as part of their contractual load.

Individuals holding other faculty appointments, such as part-time adjuncts or non-instructional research professors, may co-advise and indeed are encouraged to do so, where appropriate.

Department heads wishing to authorize anyone with appointments other than these three categories as an advisor of record for projects, theses, or independent studies must first obtain agreement from the Dean of Graduate Studies.

## Ph.D. Qualifying Examination

> *The Qualifying Examination is used to evaluate a student's level of academic preparation and identify any shortcomings in the student's background upon entrance to the Ph.D. program.*

The doctoral student is required to successfully complete the Qualifying Examination no later than 18 credits beyond the M.S. degree. The Qualifying Examination is administered by the SE Academic Program Chair and the student's Dissertation Committee. At the discretion of the SE Academic Program Chair, additional faculty outside of the student's Dissertation Committee may also be invited to participate in the examination.

The format and duration of the examination is at the discretion of the SE Academic Program Chair and Dissertation Committee. The examination may be written and/or oral and may include questions to test the general background of the student as well as questions specific to the student's intended area of research. Other formats for this examination will be acceptable if approved by the SE Academic Program Chair in consultation with the Dissertation Committee and the Research Advisor(s).

The SE Academic Program Chair and Dissertation Committee determine the outcome of the Qualifying Examination (Pass, Repeat, or Fail) and any required remediation intended to address shortcomings identified in the student's background, as described as follows:

- A grade of Fail will result in dismissal from the SE graduate program.
- A grade of Repeat requires the student to retake the examination within one year of the date of the initial Qualifying Examination.
- A grade of Pass is expected to also include a summary of any required remediation including, but not limited to, coursework, reading assignments, and/or independent study, and a schedule for completing any required remediation.
- The only permissible grades if a student takes the Qualifying Examination a second time are Pass and Fail.

Irrespective of the outcome of the examination, a *Qualifying Examination Completion* form, signed by the SE Academic Program Chair and Dissertation Committee members, must be filed with the Systems Engineering Program upon completion of the examination.

Upon successful completion of the Qualifying Examination, each doctoral student must submit a new *Ph.D. Program of Study (POS)* form with the Systems Engineering Program. The program of study should be completed in consultation with, and signed by, the student's Research Advisor(s) and *should include specific course work designed to address any shortcomings identified in the student's background during the Examination.*

Upon successful completion of the Ph.D. Qualifying Examination, the student becomes a SE Ph.D. Candidate.

## Area Examination

*The Area Examination is intended to be an opportunity for the student's Research Advisor(s) and Dissertation Committee members to evaluate the suitability, scope, and novelty of the student's proposed dissertation topic.*

The doctoral student is required to pass an Area Examination prior to writing a dissertation. The format of the Area Examination is at the discretion of the student's Dissertation Committee but will typically include a presentation by the student describing the current state of their research field, their planned research activities, and the expected contributions of their work.

Students are eligible to take the Area Examination after they have successfully completed the Ph.D. Qualifying Examination and at least two semesters of coursework (18 graduate credit hours if part-time) in the graduate program. Failure to successfully complete the Area Examination prior to the end of the student's seventh semester (42 graduate credit hours if part-time) after Ph.D. program matriculation will be considered a failure to make satisfactory academic progress and may result in removal from the program.

The Research Advisor(s) and Dissertation Committee determine the Pass/Conditional-Pass/Fail outcome of the Area Examination. A grade of Fail will result in dismissal from the SE Ph.D. graduate program. A grade of Pass may include recommendations for study or remediation (a "conditional-pass"). An *Area Examination Completion* form must be signed by the student's Research Advisor(s) and Dissertation Committee Members and filed with the Systems Engineering program Graduate Secretary upon

completion of the Area examination. If the results of the area exam were "Conditional-Pass", the remediation recommendations must be described on the *Area Examination Completion* form. Subsequently, an annual review of all Ph.D. students by the SE program will reference these recommendations to track compliance.

## Dissertation and Defense

> *The doctoral student must complete and publically orally defend a dissertation prepared under the general supervision of the Research Advisor(s).*

The dissertation defense can be scheduled any time after the end of the semester in which the Area Examination was completed. The Graduate Secretary must be notified of a student's defense at least seven days prior to the date of the defense, without exception.

The Research Advisor(s) and Dissertation Committee shall certify the quality and originality of the dissertation research, the satisfactory execution of the dissertation, and the preparedness of the student for the defense of the dissertation.

## Residency Requirements

The student must establish residency by being a full-time graduate student for at least one continuous academic year[3]. The SE program faculty and staff will work with all dissertation students to insure that this requirement is met.

## Definition of Full-Time and Part-Time Status

If a student is registered for 9 or more credits, the student is deemed to be a full-time student for that semester. If a student needs fewer than 9 academic credits to complete the degree requirements, registration for the number of credits required for completion of the degree establishes full-time status. A student *officially enrolled* in a full-time graduate internship program has full-time status during the internship period. If a Ph.D. student has completed the minimum number of credits required for the degree, enrollment in 1 *(or more)* credit of dissertation research establishes full time status.

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[3] An academic year is considered two continuous graduate semesters - *summer enrollment/residency is not usually considered part of the "academic year"*

## 4. Beyond the Rules and Regulations

### Mentors and Advisors

Faculty who are involved directly or indirectly with the SE Ph.D. program are listed in **APPENDIX II**. Students who are interested in the Ph.D. in Systems Engineering are strongly encouraged to review the research interests of these faculty, along with considering the program partnerships that are or could be established with other programs and departments at WPI, and to discuss their research interests in their application *Statement of Purpose.* Accepted and matriculated students are further encouraged to establish a connection with a few (2-3) faculty who have research and advising interests that parallel their own interests.

At this point, it is important to remember the credit hour requirements for the Ph.D. program;

- 60 or more credits of graduate work beyond the credits required for the Master of Science degree
- At least 30 credits must be registered under the designation SYS 699 (Dissertation Research).
- A minimum of 12 credit hours of approved, thematically related courses from Science (including Computer Science), Mathematics, or Engineering
- A minimum of 9 credit hours of approved, thematically-related graduate level courses

If all requirements are met with course or dissertation work (30+12+9), there are still 9 credits of pure electives remaining. Students are encouraged to remember that;

- The minors are credit specific, not course specific - and thus can be fulfilled to some extent by performing directed research in an appropriate area/department.
- Registering for research or directed study activities early in the program can help students develop both the background for, as well as the specific subject matter that will become the dissertation topic.
- Typically, about 1/3 of the courses taken to meet the minor requirements can be transferred in from other universities, *with prior program and dissertation/advisor approval*.

> *All matriculated graduate students are strongly encouraged to maintain excellent communications with their Research Advisor(s) and Dissertation Committee members so that they can explore all mechanisms for meeting program requirements.*

### SE Research

In most programs, research topics are related to funding opportunities or the specific research interests of the advisor(s), and more-often-than-not are mono-disciplinary within the context of topics supported by the home program (e.g. Mechanical Engineering, Computer Science, Biomedical Engineering, etc.). The WPI SE Ph.D. program is different because we intend to partner with colleagues across campus and in different departments on SE topics of national and/or wide spread importance and relevance. A few *hypothetical* examples will illustrate what we mean by this.

Consider the internationally recognized WPI Metal  Processing Institute (MPI)[4] Center for Resource Recovery and Recycling (CR³)*also FN.2*. A review of current CR³ research projects would indicate that there are opportunities for the development of standards, technical performance levels, architecture

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[4] http://wp.wpi.edu/mpi/ and http://wp.wpi.edu/cr3/

frameworks and other fundamental concepts of the SE process that would be of significant benefit to the establishment of national standards for SE processes relevant to recycling optimization[5]. Similarly, as part of the ECE Power Systems Engineering program[6], there are opportunities for SE research applied to smart grid, distributed and sustainable power generation, and even optimized methods for including new power generation methods and episodic generators. As part of the Cyber Security program[7], there are almost certainly opportunities for research related to program protection planning, extensions of the SE methods to include cyber protection planning, and even human interaction systems frameworks for cyber security consideration. As a final example, the WPI Health Care Delivery Institute (HDI)[8] offers a wide range of potential research topics in areas related to healthcare systems engineering and modeling, healthcare informatics and data analytics, digital health (mobile/wireless health; tele-health; healthcare IT), robotics in healthcare (surgical, rehabilitative, and assistive), medical devices (biomedical engineering and medical technology) and even SE topics related to disease management.

## How to Choose a Research Topic

Students should explore potential research areas by reviewing other web sites for examples of completed and on-going SE research topics. A few are listed here.

- MIT Portugal SE Research    http://www.mitportugal.org/research-topics/fundamentals-of-engineering-systems.html
- SE Research Center (SERC)    http://www.sercuarc.org/research/research-program-and-projects/
- Conf. on SE Research (CSER)    http://cser13.gatech.edu/
- INCOSE areas of Research Interest    http://www.incose.org/secoe/topics.htm
- SE Grand Challenges    http://www.lboro.ac.uk/research/systems-net/grandchallenges/researchgrandchallengesforsystemsengineering/

Here are some hints regarding what to think about and the process of choosing a research topic.

1. Consider your job and other interests. What were you really curious, stymied, or excited about?

2. Whatever topic you start focusing on, do some preliminary research on the web - what is known or unknown about the topic? What seem to be the important development issues? What are the key or most relevant papers that summarize the research topic area?

> *Selecting a research topic is perhaps the most intimidating aspect of any Ph.D. program. The graduate seminars, courses taken to fulfill the minor requirements, and discussions with dissertation committee members will help students identify an area of research.*

3. Try not to select a topic that is totally unfamiliar to you, rather pick one you have some knowledge or background in and want to develop further. Being interested in the selected topic goes a long way toward improving the research outcomes!

4. Remember that your objective is to earn the Ph.D., not win a Nobel Prize.

5. Talk to potential Research Advisor(s)s. They often have ideas, areas of focused interest, and tend to know what would and would not make a good topic.

6. It is imperative that there be a Research Advisor(s) who can actually advise your selected topic, and that the advisor be interested in your topic.

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[5] http://wp.wpi.edu/cr3/project-portfolio/scrap-characterization-to-optimize-recycling-processes/

[6] http://cpe.wpi.edu/power.html

[7] http://wp.wpi.edu/cybersecurity/

[8] http://www.wpi.edu/research/hdi.html

7. Refine the selected topic in consultation with your advisor(s).

8. Remember that research is often about answering questions (why, how, what…) and/or meeting needs (if.. then..). Think about your choice of topics in terms of the questions being asked and answered, or needs that would be met if . . .,

9. Ultimately, when you pick a topic you won't please everyone. That is of course not the goal, the goal is to have a well-defined and interesting topic that your Dissertation Committee approves of.

10. An overly ambitious topic will be - *overly ambitious*! Whatever topic you select, make sure you spend some time with your Research Advisor(s) agreeing in advance what the goals and endpoints are. Sounds like systems engineering right?

11. Make sure whatever topic you are interested in can actually be solved because data, experts, previous research and other material is available to help guide you. Further, try to ascertain if others are interested in your outcomes and will value your work if completed successfully.

## Selecting a Research Advisor(s)

There are many resources on the web that address this issue. Try this one to start:

http://www.emory.edu/NEUROSCIENCE/Program-And-Curriculum/How%20to%20choose%20a%20dissertation%20advisor.pdf

Also, this paper: https://hst.mit.edu/sites/default/files/Barres%20BA.Neuron.80.275.2013.pdf seems to have a number of citations on the web as an excellent source of information for selecting an advisor.

Regardless of the Advisor(s) selected, it is important to:

- Have weekly meetings and/or progress reports.
- Attend conferences suggested by the advisor.
- Meet with the full committee at least once a semester to discuss progress and present preliminary results.
- Participate on a regular basis in symposiums, lectures and other professional development events.
- Identify opportunities to publish and present you results.

## External Examiners

In the Dissertation Committee description above, it was noted that:

- At least one committee member must be a *faculty member not affiliated with the WPI SE Program*, or a *recognized subject matter expert from government or industry*.

There are two ways to satisfy this Committee requirement. <u>First</u>, and perhaps the most common, is to find someone on-campus that is familiar with the subject matter and ask him/her to be on your committee (with the approval of the committee chair/advisor(s)). The problem with this approach is that systems engineering is a relatively new, or at least not as well known, subject area and it is likely that there are few, if any non SE Program WPI faculty who are sufficiently well versed with SE material to be effective contributors to your Dissertation Committee and research development efforts. Thus, the <u>second</u> way to satisfy this Committee requirement is to ask a subject matter expert from outside WPI to be a member of your committee. For example, a recognized area consultant, a faculty member from another university, or even a corporate engineer (with at least an MS degree) who is well versed (and

ideally published) in an area related to your SE Dissertation topic could be a valuable addition to your Committee.

Bottom line, make sure you have a discussion with your Research Advisor(s) about the make-up of your Dissertation Committee!

## Financial Aid and Program Costs

Fellowships are available on a competitive basis to outstanding graduate students in the SE Ph.D. program. A decision on financial aid is made separate from and on a rolling basis after the admissions decision. All program students will be considered for fellowship support on an annual basis. Criteria for funding will include academic promise, progress toward degree, course grades, and course and dissertation research references from program faculty.

Graduate tuition costs are provided on the WPI web site: http://www.wpi.edu/offices/acc/tuition.html. Assuming a student enters the SE Ph.D. program with a previous MS degree, the cost and duration of the Ph.D. program is approximately as follows *for a part time student* (making no allowance for tuition increases). A full time student will, of course, typically register for 9 credits/semester and complete the program correspondingly faster.

| Year[**] | Fall Semester | Spring Semester | Summer | Program Milestone(s) | Credits (tot) Tuition[++] |
|---|---|---|---|---|---|
| Year 1 | 3.cr course 0.cr seminar | 3.cr course | 3.cr course | | 9 credits (9) $ 11,970 |
| Year 2 | 3.cr course 0.cr seminar | 3.cr course 1.cr dir. res. | 3.cr course 1.cr dir. res. **Qual. Exam** | seminar req. satisfied Qual. Exam satisfied | 11 credits (20) $ 14,630 |
| Year 3 | 3.cr course | 3cr course 1cr dir. res. | 3.cr course | minor courses requirement satisfied | 10 credits (30) $ 13,300 |
| Year 4 | 4.cr disser. res. | 4.cr disser. res. | 4.cr disser. res. **Area Exam** | Area Exam satisfied | 12 credits (42) $ 15,960 |
| Year 5 | 4.cr disser. res. | 4.cr disser. res. | 4.cr disser. res. | | 12 credits (54) $ 15,960 |
| Year 6 | 3.cr disser. res. | 3.cr disser. res. **Diss. Defense** | DONE! | Defense satisfied Residency satisfied | 6 credits (60) $ 7,980 |

[**] For simplicity, a year in this table relates to a calendar year.

[++] Tuition is assumed to be $**1330**/cr.

It is important for students to remember that simply completing 60 credit hours of advanced course work and research is necessary, but not sufficient to complete the SE Ph.D.. It is critical to remember that the research must be approved by the Ph.D. committee, that clear goals and research activities have been established and met, that the research that has been completed is judged by the doctoral committee to be of high quality and original, and that the total of the research and course work is worthy of the Ph.D. degree.

> *The research described in the dissertation must be original and constitute a contribution to knowledge in the major field of the candidate.*

The plan shown above is the minimum the WPI SE program faculty would like to see a student register for to be judged as making good progress toward the Ph.D. degree. Students can, *subject to the program and student's Doctoral Committee approval and acceptance of the quality of the work performed*,

accelerate their own program and reduce the time needed to complete the degree by registering for more credit/semester.

## *Leave of Absence*

All SE Ph.D. students are expected to register for at least 3 credit hour during the fall, spring and summer semesters to be considered making good academic progress. However, the program recognizes that in some situations a student may want to take a semester "off" for significantly valid reasons (e.g. birth of a child, extended work travel, extended family sickness, etc.). To support such extended absences, students may request on a semester by semester basis, in writing to the SE program office, a leave of absence from Ph.D. studies. To request a leave of absence, a student must provide proper documentation of the need for a leave in their request to the SE program office. Examples of proper documentation include the following.

| | |
|---|---|
| Medical Condition: | To balance the need for verification against the need to maintain confidentiality, a note from a physician or other medical official that simply states that the request for leave is warranted is sufficient. |
| Military Duty: | A verification letter from an approved armed services representative. |
| Personal or Family Hardship: | A letter explaining the hardship or need for the leave. |
| Work Travel: | A brief letter from the student's employer/work-supervisor. |
| Courses at Another University: | The SE program faculty do not consider taking a course at another university as a leave of absence, but rather as part of the program of study for an individual student. As noted elsewhere in this document, courses can be transferred into the Ph.D. program, subject to prior approval and certain restrictions. As long as a student is taking an *approved* course of at least 3 credits somewhere, not necessarily at WPI, then that student is considered to be making good academic progress. |

*. . . .and so forth.*

# 5. Student Issues and Concerns

The material in this section represents a collection of topics and material that is germane to almost any graduate program of study at WPI, but was modified slightly to be more relevant to the SE Ph.D. program.

## Exceptions and Petitions for Change

Exceptions to general and specific degree requirements, committee rules, or any other aspect of the Ph.D. program specified herein, may be requested by written petition to the WPI Committee on Graduate Studies and Research (CGSR) at WPI. Such a petition should be initiated by the student and should include support for the petition and an endorsement by the student's Research Advisor(s).

### *Grade Appeal Process*

If in the rare case a student disagrees with a grade assigned for a specific course, WPI has a formal grade appeal process, described here: http://www.wpi.edu/offices/registrar/grade-appeal.html

## Academic Integrity and Honesty, Student Affairs

It probably goes without saying (but we will!) that academic integrity and honesty are paramount and a foundation of any research program. The WPI policies are listed as follows:

| | |
|---|---|
| Student Affairs: | http://www.wpi.edu/campuslife/index.html |
| General WPI Policies: | http://www.wpi.edu/offices/policies.html |
| Academic Integrity: | http://www.wpi.edu/offices/policies/honesty.html |
| Academic Honesty: | http://www.wpi.edu/offices/policies/honesty.html |

## Graduate Student Government and Organizations

All graduate students are encouraged to participate, to the extent possible, in WPI student organizations. The Graduate Student Government portal, https://orgsync.com/43823/chapter, may be of particular interest to SE Ph.D. students.

Other portals of interest can be found through this link: http://wpi.orgsync.com/Student_Orgs#

Finally, there are numerous on-campus organizations that may be of interest to SE program students. These organizations and offices, while primarily available to on-campus full time students, include the offices for international students, and health and wellness activities. The Student Affairs and Campus Life link can be found here: http://www.wpi.edu/campuslife/index.html.

## Intellectual Property

A core value of any Ph.D. program is the expectation, through dissertation research, of the development of new intellectual property (IP). Should IP development occur, the university policies on IP should be referenced: http://www.wpi.edu/offices/policies/intell.html

## Library

All program students will have full access to the WPI Library and library support systems:

Gordon Library: http://www.wpi.edu/academics/library.html

Library Mission and Vision: http://www.wpi.edu/academics/library/about.html

Library Policies: http://www.wpi.edu/academics/library/about/policies.html?

## Network Operations

Finally, program students will have full access to the WPI educational network. Clearly, there are both many services and policies affecting the use of the WPI network.

Comp. and Comm. Center: http://www.wpi.edu/Academics/CCC/

Netops: http://www.wpi.edu/Academics/CCC/Netops/

Network Policies: http://www.wpi.edu/offices/policies/netsec.html

## 6. Program Organization

### Academic Contacts for Program, Course and General Research Topic Questions

| | |
|---|---|
| Fred J. Looft, Ph.D. | Academic Director, Systems Engineering Program<br>Prof. Systems Engineering (SE) *and* Electrical and Computer Engineering (ECE)<br>*fjlooft@wpi.edu* and *SEphd@wpi.edu* |
| Shams Virani, Ph.D. | Instructional Professor of Systems Engineering<br>*ssvirani@wpi.edu* |
| Tom Gannon, Ph.D. | Prof of Practice, Systems Engineering (SE) *and* Electrical and Computer Engineering (ECE)<br>*tgannon@wpi.edu* |
| Robert S. Swarz | Adjunct Professor of Systems Engineering (SE) *and* Electrical and Computer Engineering (ECE)<br>*rswarz@wpi.edu* |

### Corporate and Professional Education (CPE) Contacts for Development, Scheduling and Administrative Support

| | |
|---|---|
| Donald S. Gelosh, Ph.D. | Director, Systems Engineering Programs<br>Corporate and Professional Education (CPE)<br>dsgelosh@wpi.edu |
| Joan Deal | Senior Administrator of CPE Academic Programs<br>jdeal@wpi.edu |

Faculty who are interested in supporting the SE Ph.D. program, and who have expressed an interest in advising SE Ph.D. students, are listed in **APPENDIX II.**

# Appendices

## I. SE Program Courses

*Updated:* 10 October 2014

### *SE Program Courses*

**Core** (500-509)

| | |
|---|---|
| SYS 501 | Concepts of Systems Engineering |
| SYS 502 | Business Practices for Systems Engineers |

**Systems Engineering** (510-519)

| | |
|---|---|
| SYS 510 | Systems Architecture and Design |
| SYS 511 | Systems Integration and Test SYS |
| SYS 512 | Requirements Engineering |

**Modeling and Analysis** (520-529)

| | |
|---|---|
| SYS 520 | System Optimization |
| SYS 521 | Model Based Systems Engineering |
| SYS 579X | Model Based Systems Engineering II *(being discussed)* |
| SYS 579_ | Modeling and Simulation in Engineering Systems *(cross listed with RBE)* |

**Risk and Security** (530-539)

| | |
|---|---|
| SYS 579D | Dependable Systems and Networking |
| SYS 579_ | System Security Engineering *(being developed)* |
| SYS 579_ | Supply Chain Risk Management *(being developed)* |
| SYS 579_ | Protection Planning Across the Program Life Cycle *(being developed)* |
| SYS 579_ | Practical Applications of Systems Security Engineering *(being developed)* |

**Complexity, Systems Thinking** (540-549)

| | |
|---|---|
| SYS 540 | Introduction to Systems Thinking |
| SYS 579S | System of Systems Engineering *(being developed)* |

**Reserved** (550-579)

tbd

**Projects, Thesis, Dissertation, Independent Study** (580- ...)

| | |
|---|---|
| SYS 579Z | Current Topics in Systems Engineering *(place holder)* |
| SYS 585 | Systems Engineering Capstone Experience |
| SYS 596 A&B | Graduate Seminars *(zero credit: A-Fall, B-Spring)* |
| SYS 597 | Independent Study |
| SYS 598 | Directed Research |
| SYS 599 | MS Thesis |
| SYS 699 | Ph.D. Dissertation |

Complete course descriptions are provided here: http://cpe.wpi.edu/syseng-courses.html

## Related Program Courses

The following course listing is not meant to be exhaustive, but rather is provided here to indicate the breadth and depth of courses available to the SE Ph.D. student depending on specific topic, research and career interests. Special Note: Some courses may require perquisites or permission of instructor.

**School of Business: http://www.wpi.edu/academics/business/gradcourses.html**

| | |
|---|---|
| MIS 500 | Innovating with Information Systems |
| MIS 573 | System design and Development MIS |
| 576 | Project Management |
| MIS 582 | Information Security Management |
| OBC 501 | Interpersonal and Leadership Skills |
| OIE 541 | Operations Risk Management |
| OIE 554 | Global Operations Strategy |
| BUS 501 | Integrating Business Concepts to Lead Innovation |
| BUS 546 | Managing Technological Innovation |
| ETR 500 | Entrepreneurship and Innovation |
| FIN 500 | Financial Information and Management |

**Social Sciences and Policy Studies: http://www.wpi.edu/academics/ssps/grad-courses.html**

| | |
|---|---|
| SD 550 | System Dynamics Foundation: Managing Complexity |
| SD 551 | Modeling and experimental Analysis of Complex Problems |
| SD 553 | Model Analysis and Evaluation Techniques |
| SD 556 | Strategic Modeling and Business Dynamics |
| SD 560 | Strategy Dynamics |
| SD 561 | Environmental Dynamics |
| SD 562 | Project Dynamics |

**Computer Science: http://www.wpi.edu/academics/cs/gradcourses.html**

| | |
|---|---|
| CS 509 | Design of Software Systems |
| CS 548 | Knowledge Discovery and Data Mining |
| CS 557 | Software Security Design and Analysis |
| CS 548 | Computer Network Security |
| CS 569 | Advanced Topics in Computer Security |
| CS 578 | Cryptography and Data Security |
| CS 586 | Big Data Analytics |

**Mathematics: http://www.wpi.edu/academics/math/grad-courses.html**

| | |
|---|---|
| MA 501 | Engineering Mathematics |
| MA 508 | Mathematical Modeling |
| MA 510 | Numerical Methods |
| MA 511 | Applied Statistics for Engineers and Scientists |
| MA 542 | Regression Analysis |
| MA 543 | Design and Analysis of Experiments |
| MME 528 | Mathematical Modeling and Problem Solving |

**Mechanical Engineering: http://www.wpi.edu/academics/me/courses.html**

| | |
|---|---|
| ME 543 | Design and Analysis of Manufacturing Processes |
| ME 5000 | Applied Analytical Methods in Engineering |
| ME 5101 | Renewable Energy |
| ME 5310 | Principles of Materials Science and Engineering |

**Electrical and Computer Engineering: http://www.wpi.edu/academics/ece/grad-courses.html**

| | |
|---|---|
| ECE 502 | Analysis of Probabilistic Signals and Systems |
| ECE 504 | Analysis of Deterministic Signals and Systems |
| ECE 505 | Computer Architecture |
| ECE 506 | Introduction to Local and Wide Area Networks |
| ECE 538 | Wireless Information Networks |
| ECE 578 | Cryptography and Data Security |

**Robotics Engineering: http://www.wpi.edu/academics/robotics/gradcourses.html**

| | |
|---|---|
| RBE 500 | Foundations of Robotics |
| RBE 501 | Robot Dynamics |
| RBE 502 | Robot Control |
| RBE xxx | Model Based Design (http://www.wpi.edu/academics/robotics/specialtopicscourses.html) |

## II. Faculty and Research Interests

| Name / Title | Background and Research Interests |
|---|---|
| **Fred J. Looft, Ph.D.**<br><br>Prof., SE and ECE<br><br>SE Academic Program Director<br><br>*fjlooft@wpi.edu* | Dr. Looft is the Academic Director of the Systems Engineering (SE) Program at WPI and collaborates directly with Dr. Gelosh and the SE Program corporate and academic advisory boards to continue the development and implementation of an SE program vision that includes partnerships with campus research programs and institutes, and the development of on-campus systems engineering research programs.<br><br>Dr. Looft has been with WPI as an Electrical and Computer Engineering (ECE) faculty member for more than 34 years. His academic interests have spanned a wide range of areas but most recently has been focused on SE program course development and delivery, and advising students working on their Systems Engineering Capstone Project (SYS 585). His Ph.D. program research interests are in the areas of readiness levels, workforce development, human factors in SE and SE education.<br><br>Dr. Looft received his Ph.D. in Electrical Engineering in 1979, a Master of Science in Computer, Information and Controls Engineering in 1976, an MS in EE in 1975 and a BS in EE in 1973, all from the University of Michigan (UM, Ann Arbor). Dr. Looft is a Senior Member of the IEEE and a member of INCOSE. |
| **Don S. Gelosh, Ph.D.**<br><br>Director of Systems Engineering Programs<br><br>*dsgelosh@wpi.edu* | Don Gelosh is Director of Systems Engineering Programs for the university's Corporate and Professional Education (CPE) division. In this role, Don will work closely with the Systems Engineering Advisory Board, foster partnerships among WPI and companies and organizations involved in the systems engineering field, and will also work with WPI's faculty in the development of the systems engineering programs. Don is very interested in advancing the overall state of practice for systems engineering through his efforts with the International Council on Systems Engineering (INCOSE) and the Systems Engineering Division of the National Defense Industrial Association.<br><br>Don has more than 36 years of systems engineering experience from various assignments with the US Air Force, government, industry and academia. He comes to WPI from the Department of Defense (DoD) where he was Deputy Director for Workforce Development for the Deputy Assistant Secretary of Defense for Systems Engineering at the Pentagon. In this position, he was responsible for managing the education, training, and experience certification standards for almost 40,000 DoD workforce members in the Systems Planning, Research, Development and Engineering career field. Prior to that, he worked as a senior systems engineer at SAIC (Science Applications International Corp.), where he developed a roadmap of several workforce development initiatives and was instrumental in the development and implementation of the government's Program Systems Engineer career field.<br><br>Don received his PhD in electrical engineering from the University of Pittsburgh in 1994, a master of science in computer system design from the University of Houston at Clear Lake in 1989, and a bachelor of science in electrical engineering from the Ohio State University in 1981. He also holds an INCOSE CSEP – Acquisition certification and is DAWIA Level III certified in Systems Engineering. |

Tom has over 40 years of experience in enterprise systems engineering, real-time control systems and information management systems. Prior to recently joining the faculty of WPI as a Professor of Practice, Tom was Director of Information Systems Engineering and Chief Engineer for the Technology and Innovation (T&I) Directorate of the Command and Control Center (C2C) at the MITRE Corporation, where he is responsible for the formation and management of the Directorate's technology strategy, investment plans, and science and technology (S&T). Previously, Tom served as Director of the Corporate Technology Transfer Office.

**Thomas F. Gannon, Ph.D.**

Prof. of Practice, ECE & SE

Consultant

*tgannon@wpi.edu*

Before joining MITRE, Tom held senior management positions in RD&E at Digital Equipment and Bell Laboratories. While at Digital, he was responsible for establishing and guiding the evolution of several national research consortia, including the Microelectronics and Computer Technology Corporation (MCC), the Microelectronics Center of North Carolina (MCNC), SEMATECH, and the Semiconductor Research Corporation (SRC), as well as managing Digital's investments in those consortia. While at Bell Laboratories, he was responsible for the development of real-time digital control systems for military applications and the integration of large-scale information systems across the Bell System.

Tom was also recently appointed as Assistant Director for Academic Communications and member of the INCOSE Academic Matters Leadership Team. His research interests include: enterprise and system architecture development, architecture frameworks (DODAF, TOGAF, etc.), systems integration and test, high-reliability and fault tolerant systems, system of systems (SoS), Model Based System Engineering (MBSE); technology readiness and risk assessment; information systems engineering, management, and analysis; modeling and simulation. He holds a PhD in Electrical Engineering and Computer Science from Stevens Institute of Technology, as well as an MS from Purdue University and a BS from the Illinois Institute of Technology, both in Electrical Engineering.

**George T. Heineman, Ph.D.**

Prof. Computer Science

*heineman@wpi.edu*

Teaching is a major part of my professional life, and I enjoy sharing my knowledge and understanding with my students. George works with students on a number of projects including component-based software engineering and object-oriented design. His research and teaching interests include adaptation of software components, component-based systems, distributed computing, component models, and software engineering.

His non-teaching experience includes stints as a visiting scientist at BBN Technologies, a wholly owned subsidiary of Raytheon Company. Here he worked in the Distributed Objects group on guaranteeing Quality of Service in component-based software compositions. George was also a visiting scientist at MIT Lincoln Laboratory where he worked in the Weather Sensing group.

George received his BA from Dartmouth College, and his MS and PhD in Computer Science from Columbia University. He is a member of the Association for Computing Machinery.

**Jamie P. Monat, Ph.D.**

Dir. Exec. Education, Sch. of Business & Prof., SE and Mgmt

*jmonat@wpi.edu*

Jamie has both management and teaching experience in the medical device, separations, food & beverage, consulting, and environmental industries, having served as President of Harvard Clinical Technology, President and founder of Business Growth Specialists, Inc., as Sr. Vice-President of Pall Corporation, and in a variety of positions for Koch Membrane Systems, Inc.

As Director of Executive Education and Adjunct Assistant Professor, Jamie teaches courses in Operations Risk Management, Productivity Management, Operations Management, and Project Management.

Current interests include productivity management, quality in service and manufacturing environments, corporate productivity, employee performance metrics, business applications of logistic regression, operations risk analysis, decision analysis, modeling of industrial customer purchase decisions, and modeling of sales lead conversion. He has a B.S. in Aerospace and Mechanical Sciences from Princeton, and an M.S. and Ph.D. in Environmental Engineering from

Stanford.

**Robert S. Swarz, Ph.D.**

Adjunct Prof., SE & ECE

Consultant

*rswarz@wpi.edu*

Dr. Swarz is Co-Director of the Systems Engineering Practice Office of The MITRE Corporation, where he is involved in developing methodologies for systems security engineering and other systems engineering practices. Before joining MITRE, Bob was a researcher at Digital Equipment Corporation (DEC) and an engineer at Pratt and Whitney Aircraft. Bob is co-author of the textbook *Reliable Computer Systems: Design and Evaluation*, now in its third edition, and is the author of other published papers on systems engineering, and dependable systems.

He has had a lengthy association with the IEEE Dependable Systems and Fault Tolerance community, and is co-chair of the INCOSE Corporate Advisory Board. Bob holds a Ph.D. degree from New York University, an M.B.A. from Boston University, a Master's degree from Rensselaer Polytechnic Institute, and a B.E. from New York University.

**Shamsnaz S. Virani, Ph.D.**

Teaching Professor of Systems Engineering

*ssvirani@wpi.edu*

Shamsnaz S. Virani, Teaching Assistant Professor of Systems Engineering at Worcester Polytechnic Institute, earned her Ph.D.in Industrial and Systems Engineering from The University of Alabama at Huntsville. She also holds a M.S in Human Factors Engineering from Wright State University and a B.S. in Electrical Engineering from The University of Pune, India.

Dr. Virani's research interests include Modeling Based Systems Engineering (MBSE), Engineering Education and Team Mental Models. She is currently looking at reusable architectural patterns that can be applied to systems architecture. She in collaboration with a local the high school and educators developed a four year engineering curriculum to teach engineering in high school.

She also works with a multidisciplinary research group that uses an artificial intelligence (AI) based technique to develop shared team mental models to better understand team mental model convergence. She has published in several peer-reviewed journals and conferences in Systems Engineering, Engineering Education and Engineering Management. She routinely reviews journal and conference papers, and NSF proposals.

Dr. Virani is a member of International Council of Systems Engineers (INCOSE), American Society of Engineering Education (ASEE) and Institute of Industrial Engineers (IIE).

Prior to joining WPI, Dr. Virani worked with The Pennsylvania State University and The University of Texas at El Paso developing and teaching systems engineering courses.

**Scott Doremus**

Senior Lecturer, CPE, SE

Consultant

*sdoremus@wpi.edu*

Scott received his B.S. degree in Information Technology from National University in San Diego and his M.S. degree in Telecommunications Engineering from DePaul University in Chicago. He has over 38 years of military and industrial experience in the department of defense, medical instruments, VoIP product development, telecommunications and consulting. His career highlights include the development of naval combat systems, the Tomahawk cruise missile system, F-22 fighter aircraft avionics, carrier grade VoIP equipment, Bayer diagnostic blood glucose monitors and urinalysis machines, sea and land based radar systems, and the DDG1000 class navy destroyer. His research interests lie in statistical process control and formal analytic models specifically as they apply to systems engineering, decision sciences, quantifying human behavior and the "art in science". He has taught courses in systems engineering, operations management, industrial engineering and business.

**Mark A. Flanders**

Adjunct Professor, SE

*maflanders@wpi.edu*

Mr. Mark A. Flanders is the Director of Engineering of the Special Programs Division, Command, Control, Communication, Intelligence and Networks (C3I&N) Directorate, Life Cycle Management Center, Air Force Materiel Command, Hanscom Air Force Base, Massachusetts. The Special Programs Division is responsible for developing, acquiring, integrating, and sustaining advanced intelligence, cyber, and classified solutions for the Air Force, Defense Department, and National agencies.

Mr. Flanders has thirty four years of Engineering and Program Management experience in the military aircraft, military weapon systems, space systems and special programs. Formerly Missile Defense Agency Mission Assurance Director for the Airborne Laser Program. Formally trained Level III SE and Level III PM through the DAU. Air War College University graduate. Senior Executive Service Program-OPM. Holds a BS in Physics & Chemistry and a MS in Mechanical Engineering both from the University of New Hampshire. His research interests include identification of factors influencing the success or failure of development programs through case studies, quantitative relationships between SE investments and the quality of project performance, innovative technical risk mitigation strategies and techniques, SE manpower forecast models and techniques, SE organizational structures applicable to various development programs and life cycle stages, systems Project Management methods and techniques, and subcontractor management-supply chain management.

**Sanford A. Friedenthal**

Adjunct Prof., SE

Consultant

*sfriedenthal@wpi.edu*

Sanford Friedenthal is an industry leader in model-based systems engineering (MBSE) and an independent consultant. Previously, as a Lockheed Martin Fellow, he led the effort to enable Model-Based Systems Development (MBSD) and other advanced practices across the company. His experience includes the application of systems engineering throughout the system life-cycle for a broad range of systems in the aerospace and defense industries.

Mr. Friedenthal has been a leader of the Industry Standards effort through the OMG and INCOSE to develop the Systems Modeling Language (OMG SysMLT). He is co-author of A Practical Guide to SysML, and teaches an MBSE course as part of a Master's Program in Systems Engineering. Mr. Friedenthal is an INCOSE Fellow. Most recently, he led a team to develop the Systems Engineering Vision 2025 for INCOSE.

**Michael Leonard**

Adjunct Prof., SE & Project Management

*mfleonard@wpi.edu*

Mike has over 20 years of experience in systems engineering, training & development, and program management involving human life support, electrochemical energy conversion, power electronics, hazardous material processing, and aerospace propulsion. He also brings 20 years of US Navy active duty and reserve component experience in Nuclear Submarine Engineering, Explosive Ordinance Disposal, and Special Warfare operations.

Mike is currently serving as a Deputy Product Integration Manager for the Controls and Diagnostics System team at United Technologies' Pratt & Whitney Division. This team is working highly advanced model based control systems for optimizing turbofan engine performance and aircraft systems integration.

Mike received his B.S. degree from Lesley University, and an M.S. in Systems Engineering from Worcester Polytechnic Institute. He is also an INCOSE Certified Systems Engineering Professional (CSEP) and a PMI Certified Project Management Professional (PMP).

**Jeffery S. Mayer**

Adjunct Professor, SE

*mayerjs@wpi.edu*

Jeff is the head of the Cyber Systems Engineering Division at the United States Air Force's Life Cycle Management Center, Hanscom Air Force Base, MA. He leads teams that provide engineering support in security engineering, security test and evaluation, facilities engineering, software architecture, software engineering and software systems integration.

Jeff has over 23 years of experience with the Department of Defense in systems engineering, systems test and evaluation, security engineering and program management. He is a member of International Council on Systems Engineering (INCOSE), International Test and Evaluation Association (ITEA) and the Institute of Electrical and Electronics Engineers (IEEE). His research interests include applications of SE to agile development scenarios, system security engineering, including comprehensive methods of integrating cyber security into the SE process, and changing paradigms in Systems Engineering (e.g.: Are the methods and processes effective and efficient based on how technology is advancing especially with advancements made in MBE/MBSE?).

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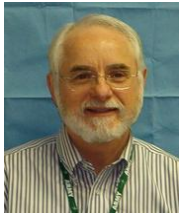
**Abraham W. Meilich, Ph.D.**

Adjunct Prof., SE &ECE

Consultant

*ameilich@wpi.edu*

Dr. Meilich is a system engineering and architecture consultant with over 40 years of experience mainly with the Lockheed Martin Corporation (LMC). He has been an outstanding contributor on successful application of project management, system engineering, enterprise and system architecture leadership and management experience on US classified and unclassified Space (DOD, Air Force, and NASA), Ground (NASA), US Civil agency (e.g., 2000 Bicentennial Census, US Customs Service Modernization), and DOD ground programs (Army, Marine Corp ) government systems. He was a recognized change agent at Lockheed Martin Corporation (LMC) for modern approaches to enterprise and system architecture development and assessment leveraging system of systems (SoS), new technologies, and capability engineering. He is a recognized instructor at Lockheed Martin Corporation on system and enterprise architecture development and design. He has served on the ISO/IEEE standards committee for Architecture Development and Definition for systems and software (ISO/IEC/IEEE 42010:2011, Systems and Software Engineering — Architecture Description). He was key contributor to the first version of the DoD SoS SE Guide, key contributor for the DoD CIO on the Federal Government Common Approach to the Federal Enterprise Architecture. He supported the development of the precursor to, and original, System Modeling Language (SySML) as a member of the INCOSE Object Oriented System Engineering (OOSE) WG, and has taught SySML courses. He is presently an instructor for the WPI online system architecture course.

Dr. Meilich's research interests include: enterprise and system architecture development and assessment; architecture frameworks (DODAF, TOGAF, etc.); system of systems (SoS); systems engineering of systems and SoS; Model Based System Engineering (MBSE); technology readiness and risk assessment; operational analysis; information systems engineering, management, and analysis; modeling and simulation. He holds a Ph.D. in Systems Management from Walden University, MS in Systems Management from USC, MS Mechanical Engineering from Stanford, and BS in Engineering from UCLA.

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**Max Miller, Ph.D.**

Adjunct Prof., SE &ECE

Consultant

*mhmiller@wpi.edu*

Dr. Miller has over 20 years of experience working in government, academia, and industry as a systems engineer with specialties in human factors, security engineering and data analytics. He has held positions at AT&T Bell Laboratories, AT&T Government Solutions, the Naval Research Lab and Raytheon Intelligence, Information & Services. Max began his career as a statistician for the Bureau of Labor Statistics. He has an undergraduate degree in Human Factors from California State University, a Master's degree in Human Factors and Ph.D. in Applied/Cognitive Science both from The Catholic University of America. He has been involved in adult and higher education throughout his career and is an Adjunct Associate Professor at the University of Maryland where he teaches Cybersecurity in the Graduate and Undergraduate schools.

His research interests include artificial intelligence, decision science, and information assurance. He is a member of INFORMS and ASA.

**Alice F. Squires, Ph.D.**

Adjunct Prof., SE & Business Management

*afsquires@wpi.edu*

Dr. Alice F. Squires has over thirty years of technical and leadership experience. Prior to joining Washington State University in Fall 2014 as an Associate Professor, Dr. Squires served as Manager of Systems Engineering at Aurora Flight Sciences, Senior Researcher for the nationwide University Affiliated Research Center in Systems Engineering, Online Technical Director for SSE at Stevens Institute of Technology, Senior Systems Engineer consultant to LM, IBM, and EDO Ceramics, Senior Engineering Manager at GD, Senior Engineering Manager at LM, and Advisory Engineer/Scientist at IBM. Dr. Squires is a contributing author and editor to the Systems Engineering Body of Knowledge (sebokwiki.org) and the Graduate Reference Curriculum for Systems Engineering (bkcase.org/GRCSE). She is certified by PMI as a Project Management Professional, and by INCOSE as a Certified Systems Engineering Practitioner, including in Acquisition.

Dr. Squires is a lifetime member of the Beta Gamma Sigma, Tau Beta Pi, and Eta Kappa Nu Honor Societies. She is a Senior Member of the IEEE, a member of and Director on the Systems Engineering Division board of the ASEE, a member of and co-chair of the Technical Planning Committee for the ASEM, and a member of NDIA, INCOSE, and PMI. Degrees earned include a BSEE from the University of Maryland; a MBA from George Mason University; and a Ph.D. in Systems Engineering from the Stevens Institute of Technology. Her areas of expertise include Systems Engineering, Technical Management, Project Management, Systems Thinking, Online Education, Engineering Education, and Workforce Competency Development.

**III. FORMS**

1. Qualifying Exam Form

2. Area Exam Form

3. Research/Dissertation Committee Form

4. Program of Study Form

5. Annual Ph.D. Progress Review Form

# Ph.D. Qualifying Examination Form

**Systems Engineering Program**

*Must be completed and returned to SE Graduate Administrative Assistant
prior to completing 18 graduate credit hours in the Ph.D. program.*

Ph.D. Student's Name: _____     ID #_____

Diagnostic Examination Date: _____

Research Advisor(s): _____
*(must be a WPI SE faculty member)*

**Examiners**:

*The diagnostic examination is administered by the Ph.D. student's Research Advisor(s) and at least one member of the committee. Full participation of the committee is recommended. At the discretion of the Research Advisor(s), additional faculty outside of the student's committee may also participate in the diagnostic examination.*

1._____     2._____
      Name/Affiliation                             Name/Affiliation

3._____     4._____
      Name/Affiliation                             Name/Affiliation

**Examination Outcome:**

**Check only one:**   ☐ Pass   ☐ Fail   ☐ Repeat*

* If Repeat, required remediation *(e.g.: coursework, reading assignments, and/or independent study)*:

_____

_____

_____

**Research Advisor(s) Approval**:

_____     _____
Research Advisor(s) Signature                                      Date

# Ph.D. Area Examination Form

**Systems Engineering Program**

*This form must be completed and returned to SE Graduate Administrative Assistant prior to writing the Ph.D. thesis dissertation and at least two (2) months prior to dissertation defense.*

Ph.D. Student's Name: _____ ID #_____

Area Examination Date: _____

Proposed Dissertation Title: _____

Research Advisor(s): _____
*(must be a WPI SE faculty member)*

**Examiners**:

*The format of the area examination is at the discretion of the Ph.D. student's Research Advisor(s) and committee but will typically include a presentation by the student describing the current state of their research field, their planned research activities, and the expected contributions of their work. The Research Advisor(s) and committee will determine the Pass/Fail outcome of the area examination.*

1._____      2._____
        Name/Affiliation                               Name/Affiliation

3._____      4._____
        Name/Affiliation                               Name/Affiliation

**Examination Outcome:** *(check one)***:**   ☐ Pass    ☐ Conditional-Pass    ☐ Fail

\* If Conditional-Pass, list the required remediation *(e.g.: coursework, reading assignments, and/or independent study)*:

_____

_____

_____

_____

**Research Advisor(s) Approval**:

_____      _____
Research Advisor(s) Signature                                    Date

*Ph.D. students are eligible to take the area examination after they have completed (i) the diagnostic examination, (ii) no less than 18 graduate credit hours, and (iii) no more than 42 graduate credit hours in the SE Ph.D. program.*

# Ph.D. Research Committee Form

**Systems Engineering Program**

*Must be completed and returned to SE Graduate Administrative Assistant within the first year of starting PhD degree program prior to the diagnostic examination.*

Ph.D. Student's Name: _____    ID # _____

Matriculation Date *(start date of Ph.D. Program)*: _____

Research Advisor(s): _____
        *(must be a WPI SE faculty member)*

**Thesis Committee**:

*The committee must consist of at least two (2) faculty members, at least one of which must be an SE faculty member and at least one which must be from outside the SE department or from outside WPI. The Committee is usually selected by the student in consultation with the Research Advisor(s). All members of the committee must be approved by the Research Advisor(s).*

1. _____    SE Department, WPI
        Name                                    Department/Company

2. _____    _____
        Name                                    Department/Company

3. _____    _____
        Name                                    Department/Company

4. _____    _____
        Name                                    Department/Company

**Research Advisor(s) Approval**:

_____    _____
Research Advisor(s) Signature                  Date

*Any changes made to the committee or Research Advisor(s) after the completion of either the diagnostic or area exam must be approved by the SE Program Academic Coordinator.*

# Doctor of Philosophy
## Plan of Study Form

**Systems Engineering Program**

Student Name: _____ ID Number: _____

(last)    (first)    (middle)

Address: _____

address/apt. #                city       state  zip

Phone Numbers:  home: (_____)_____-_____cell: (_____)_____-_____

Email: _____@wpi.edu  Other:_____@_____

Research Advisor(s): _____  email:_____@wpi.edu

name (print)

### Dissertation Credits (30 minimum)

| Course No. | Course Title | Term/Year | Grade | Credits |
|---|---|---|---|---|
| SE 699 | Ph.D. Dissertation | | | |
| SE 699 | Ph.D. Dissertation | | | |
| SE 699 | Ph.D. Dissertation | | | |
| SE 699 | Ph.D. Dissertation | | | |
| SE 699 | Ph.D. Dissertation | | | |
| SE 699 | Ph.D. Dissertation | | | |
| SE 699 | Ph.D. Dissertation | | | |
| SE 699 | Ph.D. Dissertation | | | |

### Required SE graduate seminar courses.

| Course No. | Course Title | Term/Year | Grade | Credits |
|---|---|---|---|---|
| SE 596 ____ | Graduate Seminar (full time students only) | | | |
| SE 596 ____ | Graduate Seminar (full time students only) | | | |

### Minor #1 - - 12 Credits

| Course No. | Course Title | Term/Year | Grade | Credits |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### Minor #2 - - 9 Credits

| Course No. | Course Title | Term/Year | Grade | Credits |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

*Other Courses taken to fulfill the Ph.D. 60 credit hour requirement.*

| Course No. | Course Title | Term/Year | Grade | Credits |
|---|---|---|---|---|
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

*Extra courses; do not count towards Ph.D. degree requirements.*

| Course No. | Course Title | Term/Year | Grade | Credits |
|---|---|---|---|---|
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

*Examinations for Ph.D. Degree:*

| Date | Examination | Committee, Chair | Result |
|---|---|---|---|
|  | *Qualifying Examination* |  | Pass \| Fail |
|  | *Area Examination* |  | Pass \| Fail |
|  | *Dissertation Defense* |  | Pass \| Fail |

Tentative Dissertation Title: _____

_____

**Approvals:** (*approval is subject to confirmation by the Registrar*)

Student Signature: _____   Date: _____

Research Advisor(s) Signature: _____   Date: _____

**Instructions:**

This form should be completed *(please type or print in ink)* by the student and approved by the student's research/academic advisor within the first year after admission to the PhD program. Completed form should be submitted to the SE Program office.

# Annual Progress Review
## *SE - Ph.D. Program*

**Systems Engineering Program**

*Date Submitted:* _____

Student Name: _____  ID Number: _____
                    (last)      (first)      (middle)

Phone Numbers:   home: (_____)_____- __ _____   cell: (_____)_____- _____

Email: _____@wpi.edu      Other:_____@_____

**Qualifying Exam Notes:** *(if incomplete or qualified pass)*

_____

_____

_____

**Area Exam Notes:** *(if incomplete or qualified pass)*

_____

_____

_____

**Research Progress:**

_____

_____

_____

**Papers Written, Conferences Attended, Posters or Presentations, Other:**

_____

_____

_____

**Additional Notes:**

_____

_____

_____

_____

Research Advisor(s): _____   email:_____@wpi.edu
                              *(print, then sign)*