SYSTEMS ENGINEERING
COLORADO STATE UNIVERSITY

The Goals and Content of the Doctor of Philosophy (PhD) Process in Systems Engineering

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Systems Engineering (SE) is a discipline of Engineering which develops an inter-disciplinary and systems-level viewpoint to enable the research and design of large-scale, complex, socio-technical systems. SE scholarship requires interdisciplinary training in disciplines as diverse as engineering, management, organizational sociology, behavioral economics, information theory, statistics, and computing. A core strength of the SE Department at CSU is that it has foundations as an interdisciplinary graduate program where faculty from various disciplines and departments advise SE graduate students towards a SE graduate degree. This document seeks to develop and communicate a common understanding of the goals of each aspect of the SE PhD graduate program so that faculty and students can work to achieve these goals.

Graduate research training for the PhD in SE consists of three primary activities: (1) coursework, (2) completion of the preliminary examination, and (3) completion of the dissertation. Each of these student-led activities should be advised and monitored by the faculty advisor and the dissertation advising committee.

Each fall semester before Dec. 1, every PhD student must meet with their faculty advisor and have a discussion regarding their progress over the last year (this is the PhD Student Annual Evaluation). Following each discussion, the student will submit the completed Annual Evaluation form to the Systems Engineering program as part of a progression portfolio.

1. Qualifying Process (Coursework):

The goals of the coursework activity are to develop the student's skillset in SE, to develop the student's analytical, evaluation, and creative mindset, and to instill a Systems Thinking capability. Mastering the SE body of knowledge involves mastering subjects with various multi-disciplinary content.

In CSU's SE curriculum, the student is expected to develop deep expertise in technical and mathematical subjects (defined in the INCOSE SE Handbook as technical processes), as well as in qualitative analysis and soft-skills (defined in the INCOSE SE Handbook as project, enterprise, and agreement processes). While foundational SE courses are broad in disciplinary scope, later courses build the depth and quality of the student's skillset in core SE disciplines. Throughout the curriculum, the courses emphasize aspects of Systems Thinking including feedback, design, emergence, mental models, uncertainty, learning systems and more.

PhD students are required to earn no less than a grade of "B" in their coursework to pass the Qualifying Process (B- and below are not accepted toward the degree). If a student does not earn at least a B, they will be given one opportunity to repeat the course.

2. Completion of the Preliminary Examination:

The next stage of research education at the PhD graduate level is preparation for and completion of the preliminary examination. Preparation for this examination includes advising tasks that would include development of in-depth learning and recall (for example, publication of literature review, verification of previous work), but also one-on-one and group mentorship (for example, research advising, lab group meetings, conference attendance), and the development of students' intrinsic motivation for research tasks (for example, publication, and presentation at conferences). The form of the preliminary examination

(whether presented in a dissertation draft form, presentation form, NSF-type proposal form, etc.) is up to the advisor. The objective of the preliminary examination is to evaluate the student's research readiness in terms of:

- *Student's depth of knowledge within the specifics of their research topic*. Students should document and defend their understanding of the fundamentals and context of the field in which their research is sited. In engineering research, the research effort must be referenced to the current actors, processes, and engineering practice in human-designed systems.
- *The scholarly value and intellectual rigor of their research objectives, research questions, and proposed findings*. Students must demonstrate philosophically disciplined and logical thinking in their development of the research topic. The components of the research topic must be logically connected, and the hypothesized outcomes of the research effort must be complementary to the development of new knowledge.
- *The scope and timeline of the proposed research effort*. The student must demonstrate their understanding of their research process by presenting their work-to-date, proposed tasks, resource requirements (including data, funding, equipment, support personnel) , and timeline. During the period of the examination, the committee and student should come to a shared understanding of the remaining and required content for the dissertation. This should lead to a consensus on the scope, task content, remaining tasks, and proposed timeline.

3. Completion and defense of the dissertation:

In preparation to defend the dissertation, the student should compose a dissertation document (aligned with the formatting of the CSU Graduate College, and the content guidelines of the advisor), and a defense presentation. The goals of the completion and defense of the dissertation is that the student:

- *Demonstrate a great breadth and depth of knowledge in their field of research*. The student must again describe their research context, and must be able to defend their processes and conclusions in the context of new developments or reasoned challenges from within or outside their field.
- *Demonstrate a philosophically consistent and logical approach to the development of new knowledge*. The student should describe the model of knowledge generation (scientific method, hypothesis testing, observation, critique, etc.) that they have used to develop the new knowledge asserted in their dissertation. This method of knowledge generation should be consistent and justified throughout a particular research effort.
- *Demonstrate a significant and recognized scholarly achievement*. The student must justify the results of the dissertation research effort as a significant and recognized unit of scholarship. The dissertation research effort must represent a significant contribution to the field, and should be recognized by the dissertation advising committee as an increment in new knowledge. Although the justification can take different forms for dissertations that include controlled information, in general, the student must author, guide through peer review, and publish the research results of the dissertation multiple times as they move through the dissertation research process.
- *Demonstrate the utility and continued value of this knowledge to the field of Systems Engineering*. Research in Systems Engineering seeks to inform and advance the practice of Systems Engineering. The value of the research results of a dissertation must be placed into the context of the practice.

Concluding Statement

The program will place these goals and activities for the PhD in SysEng into the website and graduate handbook for faculty, student, and public discourse and revision.