SYSTEMS ENGINEERING
COLORADO STATE UNIVERSITY

The Goals and Content of the Doctorate of Engineering (DEng) Process in Systems Engineering

Thomas H. Bradley, Department Head for Systems Engineering

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. This document seeks to develop and communicate a common understanding of the goals of each aspect of the Doctorate of Engineering in Systems Engineering (D. Eng. in SE) program so that faculty and students can work to achieve these goals. The objectives of the D. Eng. in SE program is to train students in a comprehensive and applied mastery skillset in SE, and to develop new knowledge in SE through an applied and translational research process.

Graduate research training for the D. Eng. in SE consists of four primary activities: (1) SE and Applied/Translational coursework, (2) completion of the preliminary examination, (3) Practicum, and (4) completion and defense of the dissertation. Each of these student-led activities is advised and monitored by the D. Eng. advising committee.

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

1. Qualifying Process (Coursework):

The goals of the coursework activity are to develop the student's applied mastery of SE and applied research. The objectives of this activity are developing the student's analytical, evaluation, and creative mindset, instilling a Systems Thinking capability, and developing the skillset to enable enterprise change. 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). The foundational SE courses will seek to build a breadth, depth and quality of the student's skillset in core SE disciplines, while applied/translational and professional courses will build a broad knowledge base in disciplines including leadership, organizational change, organizational psychology, and management.

2. Completion of the Preliminary Examination:

The next stage of research education at the doctoral level is preparation for and completion of the preliminary examination. The preliminary examination should be completed before the first 3 units of the Practicum are completed. Preparation for the preliminary examination includes advising and practicum-related tasks that would include development of in-depth learning (for example, the development of a practical knowledge-base and expertise), but also one-on-one and group mentorship (for example, research practice, innovation), and the development of students' intrinsic motivation for research tasks (for example, in-person collaboration, preparation for and presentation at conferences). The form of the

preliminary examination will be defined by the advising committee. The objective of the preliminary examination is to evaluate the student's research readiness in terms of:

- *The student's depth of knowledge within the specifics of their practicum research topic.* Students should document and defend their understanding of their applied knowledge of SE, and context of the enterprise in which their practicum research is sited, which must be defined as a subset of government, industry, services sector, or entrepreneurship. In the applied and/or clinical research that is appropriate for the D. Eng., the research effort must motivated by and responsive to the needs of the subject enterprise.
- *The logical coherence and practical utility of the student's research objectives, research questions, and proposed findings.* The components of the research program 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 of the practicum:

The applied and translational research tasks within the Doctorate of Engineering should be primarily performed during the practicum phase of the degree. The practicum itself provides students, enterprise stakeholders, and academic advisors with the opportunity and justification to perform sited research at the enterprise or system under study. The research tasks such as problem definition, planning, testing, evaluation, reflection/review and action should be performed in the period leading up to and including the practicum. Upon completion of the practicum, the student should be able to demonstrate near-completion of the enterprise-specific research tasks in preparation for the development of the dissertation.

4. 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 dissertation itself can take many forms that might serve to document, evaluate and communicate the research effort, its artifacts, and assertions. The goals of the completion and defense of the dissertation is that the student:

- *Demonstrate a great breadth and depth of practical 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 enterprise.
- *Demonstrate a philosophically consistent and systematic approach to the development of new knowledge.* The student should describe the model of knowledge generation (induction, action research, program evaluation, 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 research achievement.* The student must justify the results of the dissertation research effort as a significant and recognized unit of new knowledge. The dissertation research effort must represent an actionable contribution to the advancement of the

enterprise, and should be recognized by the dissertation advising committee and other stakeholders 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 communicate the research results of the dissertation for public consumption.

- *Demonstrate the general utility and continued value of this knowledge to the field of Systems Engineering.* Translational 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 department will place these goals and activities for the D. Eng. in SE into the website and graduate handbook for faculty, student, and public discourse and revision.