NEW GRADUATE INITIATIVES

PROPOSAL PROCEDURES CHECKLIST

Academic units should adhere to the following procedures when requesting new curricular initiatives (degrees, concentrations or certificates).

☐ **Obtain the required approval from the Office of the Provost to move the initiative forward for internal ASU governance reviews/approvals.**

- Establishment of new curricular initiative requests; degrees, concentrations, or certificates
- Rename requests; existing degrees, concentrations or certificates
- Disestablishment requests; existing degrees, concentrations or certificates

☐ **Submit any new courses that will be required for the new curricular program to the Curriculum ChangeMaker online course approval system for review and approval.**

- Additional information can be found at the Provost's Office Curriculum Development website: Courses link
- For questions regarding proposing new courses, send an email to: courses@asu.edu

☐ **Prepare the applicable proposal template and operational appendix for the proposed initiative.**

- New degree, concentration and certificate templates (contain proposal template and operational appendix) can be found at the Provost's Office Curriculum Development website: Academic Programs link

☐ **Obtain letters or memos of support or collaboration. (if applicable)**

- When resources (faculty or courses) from another academic unit will be utilized
- When other academic units may be impacted by the proposed program request

☐ **Obtain the internal reviews/approvals of the academic unit.**

- Internal faculty governance review committee(s)
- Academic unit head (e.g. Department Chair or School Director)
- Academic unit Dean (will submit approved proposal to the curriculumplanning@asu.edu email account for further ASU internal governance reviews (as applicable, University Graduate Council, CAPC and Senate)

Additional Recommendations - All new graduate programs require specific processes and procedures to maintain a successful degree program. Below are items that Graduate Education strongly recommends that academic units establish after the program is approved for implementation.

☐ **Set-up a Graduate Faculty Roster for new PhD Programs** – This roster will include the faculty eligible to mentor, co-chair or chair dissertations. For more information, please go to http://graduate.asu.edu/graduate_faculty_initiative.

☐ **Establish Satisfactory Academic Progress Policies, Processes and Guidelines** – Check within the proposing academic unit and/or college to see if there are existing academic progress policies and processes in place. If none have been established, please go to http://graduate.asu.edu/faculty_staff/policies and scroll down to the **academic progress review and remediation processes** (for faculty and staff) section to locate the reference tool and samples for establishing these procedures.

☐ **Establish a Graduate Student Handbook for the New Degree Program** – Students need to know the specific requirements and milestones they must meet throughout their degree program. A Graduate Student Handbook provided to students when they are admitted to the degree program and published on the website for the new degree gives students this information. Include in the handbook the unit/college satisfactory academic progress policies, current degree program requirements (outlined in the approved proposal) and provide a link to the Graduate Policies and Procedures website. Please go to http://graduate.asu.edu/faculty_staff/policies to access Graduate Policies and Procedures.

Check Box Directions – To place an "X" in the check box, place the cursor on the left-side of the box, right click to open the drop down menu, select ***Properties***, under ***Default value***, select ***Checked*** and then select ***Ok***.

ARIZONA STATE UNIVERSITY
PROPOSAL TO ESTABLISH A NEW GRADUATE DEGREE

This template is to be used only by programs that have received specific written approval from the University Provost's Office to proceed with internal proposal development and review. A separate proposal must be submitted for each individual new degree program.

DEGREE PROGRAM

College/School(s) offering this degree: Ira A Fulton Schools of Engineering

Unit(s) within school responsible for program: The Polytechnic School

If this is for an official joint degree program, list all units and colleges/schools that will be involved in offering the degree program and providing the necessary resources: N/A

Proposed Degree Name: Doctor of Philosophy (Ph.D.) in Systems Engineering

Doctoral Degree Type: Ph.D.

Proposed title of major: Systems Engineering

Is a program fee required? Yes ☐ **No** ☒

Requested effective term: Spring 2016
(The first semester and year for which students may begin applying to the program)

PROPOSAL CONTACT INFORMATION

(Person to contact regarding this proposal)

Name: Dr. Brad Rogers

Title: Associate Professor of Engineering

Phone: 480-727-1034

email: Brogers@asu.edu

DEAN APPROVAL

This proposal has been approved by all necessary unit and College/School levels of review, and the College/School(s) has the resources to offer this degree program. I recommend implementation of the proposed degree program. (*Note: An electronic signature, an email from the dean or dean's designee, or a PDF of the signed signature page is acceptable.*)

College Dean name: James S. Collofello

College Dean Signature James S. Collofello **Date:** 3/12/2015

ARIZONA STATE UNIVERSITY
PROPOSAL TO ESTABLISH A NEW GRADUATE DEGREE

This proposal template should be completed in full and submitted to the University Provost's Office [mail to: curriculumplanning@asu.edu]. It must undergo all internal university review and approval steps including those at the unit, college, and university levels. A program **may not** be implemented until the Provost's Office notifies the academic unit that the program may be offered.

DEGREE PROGRAM INFORMATION

Doctoral Type: Ph.D.
Proposed title of major: Systems Engineering

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1. PURPOSE AND NATURE OF PROGRAM:

A. Brief program description:

The Doctor of Philosophy (Ph.D.) in Systems Engineering is a trans-disciplinary graduate program offered by The Polytechnic School. The program is aimed at advancing the understanding of complex engineering systems, where these systems are inclusive of technological aspects as well as social, cultural, environmental, and other interacting components that impact the input, output, and interactions within a system. The program will prepare students to identify, model, analyze, interpret, optimize and manage the multidimensional interactions of the ever-increasing complexity of modern societal and technological challenges. A typical incoming student in this program would have a master's degree in engineering or related discipline. Students will be required to complete a core of five courses of three credits each. The core provides the foundation for systems thinking, systems identification, systems modeling, systems design and analysis, and perspective taking using diverse disciplinary methodological approaches. Students graduating from this Ph.D. degree program will possess the necessary expertise to advance systems integration of key industry and government sectors, and to contribute to the body of knowledge on interdisciplinary methods, techniques, and strategies for designing and managing complex systems over their life cycle.

B. Will concentrations be established under this degree program? ☐ Yes ☒ No

2. PROGRAM NEED - Explain why the university should offer this program (include data and discussion of the target audience and market).

The case for a new Ph.D. program in Systems Engineering is based on four interacting aspects of current technology and Ira A Fulton Schools of Engineering evolution:

1. A new global driver based in system connectivity
2. Industry direction and applications
3. Widen scope of ASU/FSE leadership in research, and
4. Faculty development in The Polytechnic School

This proposal is a natural culmination of a decade of growth and development of engineering programs at the Polytechnic campus. The emphasis of this growth and development has been on combining skills from all our engineering disciplines to address systems issues. The proposal builds on the deep disciplinary expertise of many faculty and their ability to address an evolving set of new engineering challenges where the whole solution has to be greater than the sum of the parts.

Connectivity as a technology driver:
For more than 40 years, Moore's Law has been the driver for communications, computing and control technologies – and all the productivity improvements that follow. However, a new driver is emerging as these technology components are massively interconnected and touch every aspect of our personal and professional lives. It has the uninspired colloquial title 'The Internet of Things' (IoT) but its implications are important. It enhances the need for innovation and development in every

engineering discipline but it also adds several integration layers for software, enterprise management, hardware and functional evolution. This proposal is mainly concerned with the latter two areas.

The characteristic feature of massively interconnected systems is their scale and permanence. There may be many thousands of computers each with hundreds of Input/Output (I/O) devices and data rates in the range of a terabyte/day. That's a big enough engineering challenge but on this scale, such systems cannot be designed, installed, used for a fixed life and then replaced. They have become permanent functions that define every aspect of the way our enterprises work. Growth in scale and functionality is accomplished by addition that cannot detract from what's already there. The scope for PhD projects lies in finding solution paths that meet hugely complex boundary constraints. There's also a complementary opportunity to create new data and control links within existing systems to realize entirely new levels of functionality.

Industry interest:
The level of industry interest is high. In Arizona, we have a high concentration of both enabling companies (Intel, ON-Semi, Freescale, Microchip) and users (GD, Raytheon, Boeing, Honeywell, SRP, APS). We already have good working relationships with these companies and we anticipate many opportunities for them to collaborate on PhD projects as well as employ some of the graduates. These companies are vital to the Arizona's economic development and they all see complex systems as essential both to their future operations in Arizona as well as to their next-generation products and competitiveness.

Industry has already analyzed the future skill profiles it needs for its future engineering leaders. (This was done as part of the JACMET Chief Engineer program, an ASU/Industry collaboration for professional training.) Specialists will always be needed and the university system does a good job in their provision. However, the combination of breadth and depth is always difficult. The solution is to have a broad basic education combined with work experience on multi-disciplinary projects (the norm for these companies). However, they see a need for an additional component. Engineers who aspire to technical leadership should have studied at least one system feature in depth and in a realistic context. This is the experience profile we seek to provide for the PhD graduates from this program.

Research leadership:
Complex systems provide a technical ecosystem that delivers the functionality that is needed to operate in a highly developed economy. The research opportunities lie in using existing and anticipated system features to improve:

- Efficiency
- Flexibility
- Agility
- Reliability
- Productivity

Although these attributes could be studied for any system, the initial plans for the Ph.D. program envisage concentration on:

- Energy management
- Process and assembly manufacturing
- Environmental management
- Humanitarian applications

Faculty development:
The Polytechnic School is growing rapidly, with several junior faculty position searches underway. In addition, 33% (10/30) of current tenure track faculty are Assistant Professors. Access to Ph.D. students and programs is essential for recruitment, retention and career development and while many projects will continue to be run through departments in Tempe, a vibrant program on The Polytechnic School is also very critical. This proposed degree embraces a multi-disciplinary theme that builds on the existing high level of collegiality in the School and encourages new faculty collaborations.

Systems Engineering Programs

Systems Engineering is a field that seeks to advance the understanding of complex engineering problems, the solution of which usually requires more than a single disciplinary perspective. There are about 25 institutions in the United States that offer PhD degrees with the title "Systems Engineering," and many more that offer a similar degree with a slightly modified title, such as "Space Systems Engineering" or Management Systems Engineering." Investigation of these programs reveals that both the curricula and the program emphases are much more varied than is found in disciplinary focused programs. For example, the program at the Stevens Institute of Technology (http://www.stevens.edu/sse/academics/doctoral-studies) emphasizes creation and management of complex systems and the complex enterprises that are necessary to manage them through their life cycle, such as large government sponsored programs through the Department of Defense or the Department of Energy. The program at Boston University (http://www.bu.edu/se/gradprog/phd/) emphasizes complexity that arises in disciplinary specific applications. Finally, the Massachusetts Institute of Technology (http://esd.mit.edu/default.htm) is developing an approach to the engineering of systems that embraces a much broader range of disciplinary expertise to systematically approach extremely difficult problems in society in which technological innovations are provided within the context of social constraints. The curriculum that is proposed in this document embraces some aspects of these programs, but is more specifically focused on the scholarship of human created complexity, especially in technological systems. As such, the curriculum that is described in the following narrative is designed to accomplish three primary goals:

- To develop mathematical maturity,
- To develop the capacity to evaluate complex systems, and
- To develop a depth of expertise in a discipline in which technological complexity is impeding the advancement of the field.

3. **IMPACT ON OTHER PROGRAMS -** Attach any letters of collaboration/support from impacted programs. (see Checklist coversheet)

This new doctoral program will provide additional support for other PhD programs in the Fulton Schools of Engineering by expanding the available course offerings and teaching additional sections of highly subscribed courses on the Polytechnic campus that may otherwise not have been available to these existing doctoral programs. These additional resources will more than offset a small impact from approximately 10 students per year that may seek to take specialized courses offered by the other schools. The School of Computing, Informatics and Decision Systems Engineering offers an online Master of Engineering degree in which in Systems Engineering is one area of study, but not part of the formal degree name. This program is described in more detail at: https://asuengineeringonline.com/degree-programs/me-systems-engineering. There is no indication that a Ph.D. program is being planned.

4. **PROJECTED ENROLLMENT -** How many new students do you anticipate enrolling in this program each year for the next five years? Please note, The Arizona Board of Regents (ABOR) requires nine masters and six doctoral degrees be awarded every three years. Thus, the projected enrollment numbers must account for this ABOR requirement.

The projected enrollment in the PhD program in Systems Engineering is based on the number of faculty in January 2015 (30), the number of junior faculty (10), the relative numbers of PhD students that the faculty in these classifications are expected to supervise, and projected growth rates in faculty numbers and demographics. It is assumed that the program will reach equilibrium after four years, at which time junior faculty will continuously supervise 2 PhD students, and senior faculty will average 1. A four-year graduation rate among the students is assumed, as is a 10% attrition rate, and the projected numbers have been rounded to the nearest multiple of 5. The result is shown in the following table:

5-YEAR PROJECTED ANNUAL ENROLLMENT					
Please utilize the following tabular format	**1st Year**	**2nd Year** (Yr 1 continuing + new entering)	**3rd Year** (Yr 1 & 2 continuing + new entering)	**4th Year** (Yrs 1, 2, 3 continuing + new entering)	**5th Year** (Yrs 1, 2, 3, 4 continuing + new entering)
Number of Students Majoring (Headcount)	10	20	25	30	35

5. **STUDENT LEARNING OUTCOMES AND ASSESMENT:**
   - **A. List the knowledge, competencies, and skills** students should have attained by graduation from the proposed degree program. (You can find examples of program Learning Outcomes at (http://www.asu.edu/oue/assessment.html).

      1. Graduates of the PhD in Systems Engineering will be able to use their mathematical and theoretical knowledge to elucidate and contextualize complex problems.
      2. Graduates of the PhD in Systems Engineering will be able to identify and pursue important research topics in the field.
      3. Graduates of the PhD in Systems Engineering will contribute to the to the body of knowledge of complex engineering systems.
      4. Graduates of the PhD in Systems Engineering will participate in the community of scholars by disseminating their contributions to Systems Engineering at professional conferences and by publishing in peer-reviewed journals.
      5. Graduates of the PhD in Systems Engineering will produce a portfolio of research accomplishments that position them to be competitive for appropriate level of employment opportunities in academia, industry, and government. Such a portfolio would include the dissertation, publications in impactful journals, conference publications, and participation in the development of research proposals that PhD students will naturally assemble as they complete their studies.

   - **B. Describe the plans and methods to assess** whether students have achieved the knowledge, competencies and skills identified in the Learning Outcomes. (You can find examples of assessment methods at (http://www.asu.edu/oue/assessment.html).

Means of Assessment:

Outcome 1: Graduates of the PhD in Systems Engineering will be able to use their mathematical and theoretical knowledge to elucidate and contextualize complex problems.

- *Performance criteria1: Doctoral Dissertation*
  80% or more of doctoral dissertations will receive a rating of "Very Good" or "Outstanding" for methods, using the Lovitts (2007) rubric (see citation at end of this section)
- *Performance criteria 2: Comprehensive Exam*
  90% or more of students earn a rating of "meets expectations" on the written sections of the comprehensive exam.

Outcome 2: Graduates of the PhD in Systems Engineering will be able to identify and pursue important research topics in the field.

- *Performance criteria 1: Proposal paper in EGR 602*

90% of the students will earn a B or better on the proposal paper in EGR 602.

- *Performance criteria 2: Dissertation Prospectus/proposal*
  90% or more of students will meet expectations on the written research proposals
- *Performance criteria 3: Defense of Dissertation Prospectus*
  90% or more of students will earn a grade of B or better on the oral defense of research proposals

Outcome 3: Graduates of the PhD in Systems Engineering will contribute to the to the body of knowledge of complex engineering systems

- *Performance criteria 1: Journal Publications 1*
  100% of graduates will have principle authorship on at least one publication in a reputable journal prior to graduation.
- *Performance criteria 2: Conference Proceedings*
  90% of students will publish their work in the proceedings of an appropriate professional conference

Outcome 4: Ph.D. Graduates of the PhD in Systems Engineering will participate in the community of scholars by disseminating their contributions to Systems Engineering at professional conferences and by publishing in peer-reviewed journals.

- *Performance criteria 1: Journal Publications 2*
  100% of graduates will be a co-author on at least three manuscripts accepted for publication in reputable journals before their graduation, including principle authorship on at least one of these publications.
- *Performance criteria 2: Conference Participation*
  90% of students will actively participate and present their work to an audience of their aspirational peers at an appropriate professional conference
- *Performance criteria 3: Development of Research Proposals*
  70% of students will have participate in the preparation of proposals to obtain funding for research projects

Outcome 5: Graduates of the PhD in Systems Engineering will produce a portfolio of research accomplishments that position them to be competitive for appropriate level of employment opportunities in academia, industry, and government.

- *Performance criteria 1: Job Placement*
  85% or more of graduates will have successful placement in positions and careers that are in their field of study within one year of graduation
- *Performance criteria 2: Alumni Survey*
  85% or more of alumni survey respondents will report that they are currently employed in a field that is related or closely related to their degree program.

Lovitts, Barbara E. (2007). *Making the Implicit Explicit: Creating Performance Expectations for the Dissertation*, Stylus Publishing LLC, Sterling, VA.

6. ACCREDITATION OR LICENSING REQUIREMENTS (if applicable):

Provide the names of the external agencies for accreditation, professional licensing, etc. that guide your curriculum for this program, if any. Describe any requirements for accreditation or licensing.

None

7. FACULTY, STAFF, AND RESOURCE REQUIREMENTS:

A. Faculty

1. **Current Faculty -** List the name, rank, highest degree, area of specialization / expertise and estimate of the level of involvement of all current faculty members who will teach in the program.

Note: (a): Committee Chair; (b): Co-Chair or member and (c): Teach courses

Name	Rank	Expertise	Level of Involvement

Name	Rank	Expertise	Level of Involvement
Allenby, Brad, PhD	Professor	Earth systems engineering, Management industrial ecology science and technology policy	a, b and c
Andino, Jean, PhD	Associate Professor	Air pollution and energy, air pollutant sensing and control, chemical kinetics	a, b
Bekki, Jennifer, PhD	Assistant Professor	Simulation modeling and analysis of manufacturing systems, engineering education	a, b and c
Brunhaver, Samantha, PhD	Assistant Professor	Use Inspired Design, Engineering Education	a, b and c
Carberry, Adam, PhD	Assistant Professor	Engineering Design and Material Science, Modeling in engineering Standards	a, b and c
Csavina, Kristine, PhD	Clinical Assistant Professor	Biomechanics, Engineering Education	b and c
Scott Danielson, PhD	Associate Professor	Manufacturing Systems, Student learning in engineering mechanics.	a, b, and c
Gibson, G. Edward	Professor	Front end planning, risk management, construction productivity, organizational change, dispute resolution	a, b
Grau, David, PhD	Assistant Professor	Sustainable design and construction, information technologies, lean construction	a, b
Grondin, Robert, PhD	Associate Professor	Electrical Engineering	a, b and c
Halden, Rolf, PhD	Professor	Bioremediation of environmental contaminants, Pharmaceuticals and personal care products, Environmental proteomics, Public health preparedness	a, b
Helm, Jim, PhD	Lecturer	Systems and ICT	C
Henderson, Mark, PhD	Professor	Humanitarian Engineering, Engineering design	a, b and c
Hristovski, Kiril, PhD	Assistant Professor	Environmental and Chemical Engineering, Waste and Hazardous Materials	a, b and c
Hsu, Keng, PhD	Assistant Professor	Nanotechnology, Additive Manufacturing	a, b and c
Johnson, Nathan, PhD	Assistant Professor	Energy System, Humanitarian Engineering	a, b and c
Jordan, Shawn, PhD	Assistant Professor	STEM Education, Engineering Education, Community outreach	a, b and c
Kannan, A. M., PhD	Professor	Nanotechnology, Batteries, Concentrating Solar Power and Fuel Cells	a, b and c
Kellam, Nadia, PhD	Associate Professor	Engineering education	a, b and c
Kuitche, Joseph, PhD	Lecturer	Information Technology, Alternative Energy Systems	b and c
Kuo, Chen-Yuan, PhD	Associate Professor	Mechanical Systems	a, b and c
Lande, Micah, PhD	Assistant Professor	Engineering Innovation, Design	a, b and c
Landis, Amy, PhD	Associate Professor	Industrial ecology, Byproduct synergies, Biofuels, Biopolymers	a, b
Lewis, Sharon, PhD	Senior Lecturer	Industrial Engineering	b and c
Lou, Yingyan, PhD	Assistant Professor	multi-modal transportation networks and systems, transportation planning and network operations, transportation safety	a, b

Name	Rank	Expertise	Level of Involvement
Macia, Ciso, PhD	Associate Professor	Electronics Systems	a, b and c
Mayyas, Abdel, PhD	Assistant Professor	Automotive Engineering	a, b and c
McKenna, Ann, PhD	Professor	Design education, Engineering Education, Innovation	a, b and c
Meitz, Robert, PhD	Instructor	Dynamics	b and c
Middleton, Jim, PhD	Professor	Student learning of mathematical concepts; motivation and mathematics learning; application of technology to mathematics teaching and learning.	a, b
Mikellides, Pavlos, PhD	Associate Professor	Orbital Mechanics, Rocket propulsion	a, b and c
Morrell, Darryl, PhD	Associate Professor	Electronic Systems, Control	a, b and c
Nam, Changho, PhD	Associate Professor	Aero elasticity, Aerospace Systems	a, b and c
Olson, Larry, PhD	Associate Professor	Environmental Chemistry, Industrial Hygiene and Toxicology	a, b and c
Parsey, John, PhD	Professor of Practice	Electrical and Electronic Systems	b and c
Pavlic, Ted, PhD	Assistant Professor	Complex adaptive systems	a, b and c
Phelan, Pat, PhD	Professor	Energy applications including nanofluids, solar cooling and thermal storage, waste heat utilization, thermogalvanic energy conversion.	a, b
Phillips, Stephen, PhD	Professor	Applications and integration of microsystems including microelectromechanical systems (MEMS), microactuators, neural recording and neural stimulation; applications of systems and control including adaptive control	a, b
Rajadas, John, PhD	Associate Professor	Mechanical Systems, Energy, Thermo-Fluids, Optimization	a, b and c
Rajan, S.D., PhD	Professor	High-Performance and Parallel Computations, Automated Design Methodologies, Engineering Product Development	a, b
Ramakrisha, B, PhD	Associate Professor	Materials, Humanitarian Engineering	a, b and c
Redkar, Sangram, PhD	Associate Professor	Robotics, Dynamics and Controls	a, b and c
Ren, Yi, PhD	Assistant Professor	Design optimization, product/configuration design, human-computer interaction and machine learning	a, b
Robertson, John, PhD	Professor	Electrical and Electronic Systems	a, b and c
Rogers, Brad, PhD	Associate Professor	Energy and Thermo-Fluid Systems, Humanitarian Engineering	a, b and c
Ruddell, Ben, PhD	Assistant Professor	Civil and Environmental Systems	a, b and c
Seager, Tom, PhD	Associate Professor	Ethics education for sustainable engineers, Environmental impacts of alternative energy	a, b

Name	Rank	Expertise	Level of Involvement
Shah, Jami, PhD	Professor	Computer aided design and analysis, Design computing & software development, Artificial Intelligence & Knowledge based Systems (AI/KBS) applied to design/manufacturing	a, b
Sodemann, Angela, PhD	Assistant Professor	Robotics, Manufacturing systems	a, b and c
Sugar, Tom, PhD	Professor	Robotics, Dynamics and Controls	a, b and c
Sullivan, Kenneth, PhD	Associate Professor	Performance measurement, Risk management, Best value contracting, Accountability systems, Facility management	a, b
TamizhMani, Govindisamy, PhD	Research Associate Professor	Alternative Energy	a, b and c
Tsakalis, Kostas, PhD	Professor	Control Systems (Adaptive, Linear, Time-Varying, Nonlinear, Embedded), System Identification, Optimization, Applications to Semiconductor Manufacturing Processes, Biomedical Applications: Prediction and Control of Epileptic Seizures	a, b
Ying, Lei, PhD	Associate Professor	Information networks including wireless, mobile ad hoc, P2P and social networks	a, b
Zhang, Junshan, PhD	Professor	Network optimization and management, cyber-physical systems with applications to smart grid, wireless communications, complex network dynamics, information theory, and stochastic modeling and analysis.	a, b

2. **New Faculty -** Describe the new faculty hiring needed during the next three years to sustain the program. List the anticipated hiring schedule and financial sources for supporting the addition of these faculty members.

   This program will be supported with current faculty and new faculty hired under the existing hiring plan. The addition of this program will aid in recruitment of highly qualified junior faculty by providing opportunities for professional growth that are closely aligned with the other schools in the college.

3. **Administration of the program -** Explain how the program will be administered for the purposes of admissions, advising, course offerings, etc. Discuss the available staff support.

   Administration of the program will be the responsibility of the Graduate Program Chair and the Systems Engineering Graduate Program Committee within the Engineering program in the Polytechnic School. The Systems Engineering Graduate Program Committee, appointed by the faculty, will have the responsibility of screening applicants to the Ph.D. program and sending these recommendations to Graduate Education, as well as Director of the Polytechnic School and the office of the Dean of the Ira A. Fulton Schools of Engineering. This committee is likewise responsible for assuring the integrity of the program and distribution of monetary awards, including internal scholarships, and graduate teaching and research assistantships that are not directly funded by faculty research programs.

   The existing graduate advising staff of the Polytechnic school will provide procedural advising for the program, and the Engineering Graduate program chair will coordinate technical and programmatic advising. The Polytechnic school will provide additional staff support for the program including preparing and disseminating materials such as recruiting information, graduate applications, admission decisions and evaluations of student progress. It is anticipated that required support will be part time as the program develops, but will require full time staff as the program grows beyond 30 students.

B. Resource requirements needed to launch and sustain the program: Describe any new resources required for this program's success such as new staff, new facilities, new library resources, new technology resources, etc.

No new resources will be required.

8. COURSES:

A. Course Prefix(es): Provide the following information for the proposed graduate program.

i. Will a new course prefix(es) be required for this degree program?
Yes ☐ No ☒

ii. If yes, complete the **Course Prefixes / Subjects Form** for each new prefix and submit it as part of this proposal submission.

B. New Courses *Required* for Proposed Degree Program:

1. **EGR 602 Principles of Independent Research (3 cr)**
   In depth discussion of research topics developed and presented by students. (Prerequisite: Admission to the PhD program.)

2. **EGR 608: Advanced Simulation (3 cr)**
   Agent based modeling, Monte Carlo, continuous, and discreet event simulation; and concepts from supporting disciplines including probability and statistics, systems modeling, simulation model development, input analysis, and verification and validation approaches, software applications. (Prerequisite: EGR 507 (Simulation) or equivalent)

3. **EGR 611 Complex Engineering Systems (3 cr)**
   Advanced concepts in design and evaluation of Engineering Systems: Subsystems, seamless integration of subsystems. (Prerequisite: EGR 510 (Analysis of Systems) or equivalent)

It is our hope that courses with an EGR prefix, which will likely be taught on the Polytechnic campus, will provide additional opportunities for students in Ira A. Fulton Schools of Engineering programs located on the Tempe campus and that courses used by students on both campuses (MAE 501 Linear Algebra in Engineering and MAE 502 Partial Differential Equations in Engineering) can foster collaboration by expanding faculty resources and increasing the availability of fundamental courses for all students within FSE.

A table of available elective courses is listed in Appendix II.

APPENDIX I
OPERATIONAL INFORMATION FOR GRADUATE PROGRAMS

(This information is used to populate the Graduate Programs Search/catalog website.)

1. Provide a brief (catalog type - no more than 150 words) **program description.**

The Ph.D. in Systems Engineering is a multidisciplinary program that focuses on advancing the understanding and development of complex engineering systems and prepares graduates for careers in research in both academic and industrial environments. The program is designed for students that have completed a master's degree in engineering or a closely related field, and that have demonstrated excellent mathematical aptitude.

Breakdown of requirements for the academic catalog:

Core (15)
Electives (15)
Research (12)
Previously awarded master's degree (30)
Culminating Experience: EGR 799 Dissertation (12)
Total credit hours required for the program: 84

2. Campus(es) where program will be offered:

(Please note that Office of the Provost approval is needed for ASU Online campus options.)

☐ **ASU Online only (<u>all</u> courses online)**

All other campus options (please select all that apply):

☐ Downtown ☒ Polytechnic
☐ Tempe ☐ West

☐ **Both** on-campus **and** ☐ ASU Online **(*) -** (Check applicable campus from options listed.)

(*) Please note: Once students elect a campus option, students will not be able to move back and forth between the on-campus (in-person) or hybrid options and the ASU Online campus option.

3. Admission Requirements:

Degree: Minimum of a Master of Science in Engineering or a closely related discipline from a regionally accredited College or University in the United States or from appropriately credentialed institutions in other countries.

GPA: Minimum of 3.25 cumulative GPA (scale is 4.0 = A) in the applicable Master's degree.

English Proficiency Requirement for International Applicants: The English proficiency requirements are the same as the Graduate Education requirement. (see Graduate Education requirement http://graduate.asu.edu/admissions/international/english_proficiency): ☒ **Yes** ☐ **No**

Foreign Language Exam:

Foreign Language Examination(s) required? ☐Yes ☒No

Required Admission Examinations: ☒**GRE** ☐**GMAT** ☐**Millers Analogies** ☐ **None required**

Letters of Recommendation: ☒Yes ☐No

4. **Application Review Terms (if applicable Session):** Indicate all terms for which applications for Admissions are accepted and the corresponding application deadline dates, if any:

☒ Fall (regular)	*Deadline:* Fall 2016 *International Applicants:* For admission in the fall semester you must apply by January 1st of the same year *Domestic Applicants:* For admission in the fall semester you must apply by March 1st of the same year
☒ Spring (regular)	*Deadline:* Spring 2016 *International Applicants:* For admission in the spring semester you must apply by August 1st of the preceding year *Domestic Applicants:* For admission in the spring semester you must apply by October 1st of the preceding year

5. **Curricular Requirements:**

5A. Will concentrations be established under this degree program? ☐ Yes ☒ No

5B. Curricular Structure:

Required Core Courses for the Degree			**Credit Hours**
Prefix & Number	**Course Title**	**(New Course?) Yes or No?**	**Insert Section Sub-total** **15**
EGR 602	Principles of Independent Research	Yes	3
MAE 501	Linear Algebra in Engineering	No	3
MAE 502	Partial Differential Equations in Engineering	No	3
EGR 608	Advanced Simulation	Yes	3
EGR 611	Complex Engineering Systems	Yes	3
Approved Elective Courses as specified by the supervisory committee			**Credit Hours**
(Prefix & Number)	**(Course Title)**	**(New Course?) Yes or No?**	**(Insert Section Sub-total)** **15**
Examples of elective coursework are found in Appendix II. Other courses may be used with approval from the academic unit. Student electives are customizable based on the student's focus area. For example, four focus areas were identified in the "Program Need" section of this document that would each require a unique set of electives.			

Culminating Experience ***E.g.*** - *Capstone course, applied project, **thesis** (**masters only** – 6 credit hours) or **dissertation** (**doctoral only** – 12 credit hours) as applicable*	**Credit Hours (Insert Section Sub-total)**
EGR 799 Dissertation	**12**
Other Requirements ***E.g.*** **-** *Internships, clinical requirements, field studies as applicable*	**Credit Hours (Insert Section Sub-total)**
EGR 792 Research	**12**
For doctoral programs – *when approved by the student's supervisory committee, will this program allow 30 credit hours from a previously awarded master's degree to be used for this program? If applicable, please indicate the 30 credit hour allowance that will be used for this degree program.*	**30**
Total required credit hours	**84**

- List all required core courses and total credit hours for the core (required courses other than internships, thesis, dissertation, capstone course, etc.).
- *Omnibus numbered courses cannot be used as core courses.*
- Permanent numbers must be requested by submitting a course proposal to Curriculum ChangeMaker for approval. Courses that are new, but do not yet have a new number can be designated with the prefix, level of the course and X's (e.g. ENG 5XX or ENG 6XX).

6. Comprehensive Exams:

Doctoral Comprehensive Exam (required), please select the appropriate box.

(Written comprehensive exam is required)

☒ Oral comprehensive exam is required – in addition to written exam

☐ No oral comprehensive exam required - only written exam is required

7. For Doctoral Degrees that require a dissertation, submission of a written dissertation prospectus and its oral defense are required. (Please include any required timelines for defense of the prospectus.) It is expected that the submission of a written dissertation prospectus and its oral defense will take place no later than the end of the fourth year.

Students will be expected to submit a dissertation prospectus/proposal and hold the oral defense by no later than the end of the third year.

8. Allow 400-level courses: ☐ **Yes** ☒ **No** (No more that 6-credit hours of 400-level coursework can be included on a graduate student plan of study.) (6 hours maximum)

9. Committee: Required Number of Thesis or Dissertation Committee Members (must be at least 3 including chair or co-chairs): **3** committee members

10. Keywords: engineering, complex systems, process and assembly manufacturing, Energy management, Humanitarian applications

11. Area(s) of Interest

A. Select **one (1)** primary area of interest from the list below that applies to this program.

- ☐ Architecture & Construction
- ☐ Arts
- ☐ Business
- ☐ Communication & Media
- ☐ Education & Teaching
- ☒ Engineering & Technology
- ☐ Entrepreneurship
- ☐ Health & Wellness
- ☐ Humanities
- ☐ Interdisciplinary Studies
- ☐ Law & Justice
- ☐ Mathematics
- ☐ Psychology
- ☐ STEM
- ☐ Science
- ☐ Social and Behavioral Sciences
- ☐ Sustainability

B. Select **one (1)** secondary area of interest from the list below that applies to this program.

- ☐ Architecture & Construction
- ☐ Arts
- ☐ Business
- ☐ Communications & Media
- ☐ Education & Teaching
- ☐ Engineering & Technology
- ☐ Entrepreneurship
- ☐ Health & Wellness
- ☐ Humanities
- ☐ Interdisciplinary Studies
- ☐ Law & Justice
- ☐ Mathematics
- ☐ Psychology
- ☒ STEM
- ☐ Science
- ☐ Social and Behavioral Sciences
- ☐ Sustainability

12. Contact and Support Information:

Office Location (Building & Room):	Peralta Hall, 335Q
Campus Telephone Number:	7-1034
Program email address:	polygrad@asu.edu
Program website address:	http://poly.engineering.asu.edu/degrees/
Program Director (Name):	Dr. Brad Rogers
Program Support Staff (Name):	Amy Wolsey, Grant Griffin
Admissions Contact (Name):	Amy Wolsey

13. Application and iPOS Recommendations:

List the Faculty and Staff who will input admission/POS recommendations to Gportal **and** indicate their approval for Admissions and/or POS:

Name	ADMSN	POS
Amy Wolsey	yes	yes
Grant Griffin	yes	yes
Brad Rogers	yes	yes

APPENDIX II
Elective Courses Examples

The following are examples of courses offered within the Ira A. Fulton Schools of Engineering Polytechnic School for the Ph.D. students that are not among the core requirements (Courses with MET, AET and ALT prefixes will be changed to EGR and numbered appropriately in the upcoming fall catalog review cycle).

Prefix and Number	Title	Cr	Description	Campus	Status
AET 524	Application of Heat Transfer	3	Theory and application of heat transfer concepts in engineering systems	Poly	
AET 525	Advanced Propulsion	3	High speed gas dynamics and application to aerospace propulsion systems	Poly	
ALT 505	Power Conditioning	3	Fundamentals of power electronics, DC-DC converters and DC-AC inverters, battery charge controllers.	Poly	
ALT 515	Alternative Energy Reliability and Standards	3	Alternative energy systems and their reliability issues, accelerated life and safety testing, standards and codes, regulatory requirements.	Poly	
ALT 512	Village Energy Systems	3	Leadership in the development of energy resources at the Base of the Economic Pyramid (BoP). Individual Problem-Based Learning (PBL) investigations of potential solutions to energy-poverty.	Poly	
ALT 545	Automotive and Stationary Fuel Cell Systems	3	Exponential growth and demand for renewable energy conversion and storage as well as transition to hydrogen economy triggered the growth of high power and energy systems for portable electronic devices, stationary and automotive applications.	Poly	
ALT 507	Evaluation of PV and FC systems	3	Field testing, data collection, and evaluation of real-world photovoltaic and fuel cell systems available on campus and data analysis.	Poly	
ALT 535	Photovoltaics	3	Term projects, overview of solar radiation, operating principles, qualitative analysis on influencing parameters, market trends, basics of PV systems.	Poly	
EGR 510	Complex Systems	3	Framing engineering design problems within complex socio-technical spaces. Team-based project course.	Poly	CM
EGR 520	Analysis for Engineers	3	Analytical and Numerical Methods for evaluating deterministic problems and systems	Poly	
EGR 521	Engineering System and Design Analysis	3	Central tendency and dispersion, Regression analysis, Sigma R&R, Seven QC tools and Control charts for data analysis and interpretation; Process capability, 6-Sigma, Design of Experiments, and Quality system.	Poly	

Prefix and Number	Title	Cr	Description	Campus	Status
EGR 506	Simulation	3	Simulation provides an efficient way to predict performance of complex systems without the risk and expense of construction. The course examines simulations for materials, processes, performance and operations.	Poly	
EGR 535 (EGR 560)	Engineering Innovation and Entrepreneurship	3	Knowledge and application of engineering design, innovation, & entrepreneurship practices. Focus on human-centered innovation, design thinking, and prototyping solutions. Team-based project course.	Poly	
EGR 525 (EGR 580)	Lean Systems	3	Creates a framework and model of lean engineering and a methodology for applying lean practices to systems engineering as a basis for lean product development.	Poly	
ERM 503	Principles of Toxicology	3	Interaction of chemicals with life and environment. Mechanisms of toxic action, dose-response relationships, toxicity testing models, predictive toxicology, and epidemiology.	Poly	
ERM 506	Chemistry of Hazardous Materials	3	Principles from inorganic, organic and physical chemistry applied to the proper handling, storage, and disposal of hazardous chemicals.	Poly	
CEE 561	Physical-Chemical Treatment of Water and Waste	3	Theory and design of physical and chemical processes for the treatment of water and wastewaters	Tempe	
CEE 562	Environmental Biochemistry and Waste Treatment	3	Theory and design of biological waste treatment systems. Pollution and environmental assimilation of wastes	Tempe	
CEE 563	Environmental Engineering Chemistry	3	Analyzes water, domestic and industrial wastes, lab procedures for pollution evaluation, and the control of water and waste treatment processes	Tempe	
CEE 564	Contaminant Fate and Transport	3	Fate and transport processes with emphasis on governing equations and parameters relevant to the migration of chemicals in the environment	Tempe	
MET 510	Manufacturing Resource Management	3	Measures like cycle time, throughput, capacity, work-in-process, inventory, variability, and how they drive operating relationships in a factory.	Poly	
MET 516	Applied Computer Integrated Manufacturing	3	Techniques and practices of computer-integrated manufacturing as applied in a broad range of industry.	Poly	
MET 518	Composite Materials Manufacturing	3	Introduces composite materials and associated manufacturing issues, including tooling, processes, and quality control. Related issues, including testing and joining.	Poly	

APPENDIX III
SUPPORT STATEMENTS

Ira A. Fulton Schools of Engineering - Official Submission

From: Jeremy Helm
Sent: Thursday, March 12, 2015 2:08 PM
To: Curriculum Planning
Cc: James Collofello; Ann McKenna; Bradley Rogers; Cindy Boglin
Subject: PhD in Systems Engineering Proposal

Hello,

Please find attached**:**

- Proposal for the PhD in Systems Engineering (Signed PDF)
- Proposal for the PhD in Systems Engineering (Word Document)
- A letter of support from the School of Computing, Informatics and Decision Systems Engineering

Jeremy Helm
Director, Academic Administration & Student Success
Ira A. Fulton Schools of Engineering
Arizona State University
Tempe, AZ 85287-8109
(480) 965-8931 voice
(480) 965-8095 fax

School of Computing, Informatics, and Decision Systems Engineering
Support Statement

Sunday, February 22, 2015 at 11:51:07 AM Mountain Standard Time

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Subject: FW: impact statement for systems engineering PhD proposal
Date: Wednesday, February 18, 2015 at 3:44:47 PM Mountain Standard Time
From: Ann McKenna
To: Bradley Rogers, Jeremy Helm

From: Ronald Askin <Ron.Askin@asu.edu>
Date: Wednesday, February 18, 2015 3:15 PM
To: Ann McKenna <ann.mckenna@asu.edu>
Subject: RE: impact statement for systems engineering PhD proposal

Ann,
The School of Computing, Informatics, and Decision Systems Engineering has no objection to the creation of a PhD in Systems Engineering. We see the proposed Systems Engineering degree as a timely and valuable addition to the options available for graduate study at ASU. While the Industrial Engineering PhD program has some core material in common with the proposed SE PhD, the broader focus across all engineering disciplines in the proposed SE degree distinguishes it from our current offerings. If interested the SE PhD students would be welcome to take our IE core courses in optimization and statistical modeling.

Ron
****
Ronald G. Askin, Professor and Director
School of Computing, Informatics, and Decision Systems Engineering
Arizona State University
Tempe, AZ 85287-8809
e-mail: ron.askin@asu.edu
Phone: 480-965-2567
http://cidse.engineering.asu.edu
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