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Cover Sheet for In-State Institutions
New Program or Substantial Modification to Existing Program

Institution Submitting Proposal	Johns Hopkins University

Each action below requires a separate proposal and cover sheet.

- (●) New Academic Program
- ( ) New Area of Concentration
- ( ) New Degree Level Approval
- ( ) New Stand-Alone Certificate
- ( ) Off Campus Program
- ( ) Substantial Change to a Degree Program
- ( ) Substantial Change to an Area of Concentration
- ( ) Substantial Change to a Certificate Program
- ( ) Cooperative Degree Program
- ( ) Offer Program at Regional Higher Education Center

Payment Submitted: (●) Yes ( ) No

Payment Type: ( ) R*STARS (●) Check

Date Submitted: 8/15/2018

Department Proposing Program	Whiting School of Engineering
Degree Level and Degree Type	Master's (Level) Master of Science (Type)
Title of Proposed Program	MS in Healthcare Systems Engineering
Total Number of Credits	30
Suggested Codes	HEGIS: CIP: 14.2701
Program Modality	( ) On-campus ( ) Distance Education (*fully online*) (●) Both
Program Resources	(●) Using Existing Resources ( ) Requiring New Resources
Projected Implementation Date	(●) Fall ( ) Spring ( ) Summer Year: 2018
Provide Link to Most Recent Academic Catalog	URL: https://ep.jhu.edu/student-services/academic-services/academic-catalogs
Preferred Contact for this Proposal	Name: Natalie Lopez Title: Senior Academic Compliance Specialist Phone: (410) 516-6430 Email: nlopez13@jhu.edu
President/Chief Executive	Type Name: Sunil Kumar Signature: Date: 8/13/2018
	Date of Approval/Endorsement by Governing Board: N/A

Revised 6/13/18

The Johns Hopkins University
G.W.C. Whiting School of Engineering
Proposal for a New Academic Program
Master of Science in Healthcare Systems Engineering

A. Centrality to Institutional Mission and Planning Priorities

1. Provide a description of the program, including each area of concentration (if applicable), and how it relates to the institution's approved mission

The Johns Hopkins University G.W.C. Whiting School of Engineering is pleased to submit a proposal for a new Master of Science in Healthcare Systems Engineering. This program is an outgrowth of the established Master of Science in Systems Engineering curriculum within the Whiting School of Engineering's Engineering for Professionals (JHU-EP) Program. This Master of Science in Healthcare Systems Engineering will be offered as an online program (with in-person options for selected electives), making it available to a broader population of engineers and healthcare professionals seeking to understand and apply the principles of system engineering to improving the delivery of healthcare.

The proposed Master of Science in Healthcare Systems Engineering is intended to provide engineers and healthcare professionals with a perspective on how systems engineering can be applied to healthcare to improve healthcare productivity, patient outcomes, and patient safety, and to identify and address problems using systems approaches in the delivery, management, safety, policies and evaluation of healthcare and related systems. Graduates will learn how systems engineering can be applied to healthcare, so that they can become leaders of this revolution. The course content will be based on the foundational content embodied in the current core systems engineering courses modified to provide relevant examples in the healthcare setting. Additional courses will be offered that include additional focus on medical sensors and devices, healthcare systems, healthcare networks and databases, and patient safety. Elective courses will include advanced system engineering courses and related courses offered by the Bloomberg School of Public Health in biostatistics, patient safety and medical errors, human factors in patient safety, quality of medical care, and epidemiology. If approved, the program would commence in fall 2018.

The mission of The Johns Hopkins University is to educate its students and cultivate their capacity for life-long learning, to foster independent and original research, and to bring the benefits of discovery to the world. In addition, the mission of the JHU Whiting School of Engineering is to provide educational programs of the highest quality that will attract the most qualified and driven students and faculty and will be a world-recognized leader in engineering education, to lead in the creation and dissemination of knowledge, and to translate those educational and research activities into solutions to important societal problems. The proposed degree program aligns with both of these missions as discussed below.

2 Explain how the proposed program supports the institution's strategic goals and provide evidence that affirms it is an institutional priority

A strategic priority of the JHU Whiting School of Engineering is to provide students with innovative and distinctive educational opportunities. Part of the mission of the JHU Whiting School of Engineering is to "[p]provide an outstanding engineering education that is innovative, rigorous, and relevant, and that prepares its graduates to be 21st century leaders." The Whiting School of Engineering plans to support this mission by developing a comprehensive suite of contemporary master's degree offerings, for full- and part-time students, with flexible formats that respond to the needs of industry in both the domestic and international markets. It is clear that an online program offers a flexible format and enables this program to more easily reach the international markets cited in this goal.

The Johns Hopkins University professional programs in the fields of engineering and applied science are among the oldest and largest in the United States. Administered by the Whiting School of Engineering through JHU-EP, this activity seeks to meet the lifelong education needs of working professionals in engineering and applied science. JHU-EP offers state-of-the-art courses combined with the convenience, flexibility, and accessibility that make these educational opportunities feasible for working adults.

In recent years, JHU-EP has moved steadily into the field of distance education, offering more and more courses online. This development meets two needs: (1) it contributes to the convenience and flexibility of existing offerings, by allowing students to take a mix of classroom and online courses, and (2) it opens this educational opportunity to a much larger market, enabling students throughout the country and, indeed, the world to take courses at Johns Hopkins University.

Johns Hopkins University is recognized as providing world-class education and practice in systems engineering and medicine, unparalleled in tradition, quality and size to any other institution. Through this online program (with in-person options for selected electives), JHU-EP will continue its leadership role in defining, developing, and promulgating the theory, methodologies and best practice in healthcare and patient safety from a system engineering perspective. The role of systems engineering in the healthcare field has gained popularity and importance and since the healthcare field is so complex, it would benefit from systems thinking and processes. This degree will be coordinated by the JHU-EP program in the Whiting School of Engineering, responsible for directing the content and quality of the curriculum and coordinated with the Bloomberg School of Public Health and the School of Medicine. Where possible, the program will draw on the strengths of other JHU programs and courses from the Bloomberg School of Public Health and the JHU School of Medicine.

Through this proposed degree, medical researchers will develop the skills needed to apply systems thinking and processes in developing products and delivering healthcare in the future. The program will provide professionals with in-depth knowledge and technical skills in the field of healthcare systems engineering and prepare students for technically significant careers within industry and governmental organizations.

3. **Provide a narrative of how the proposed program will be adequately funded for at least the first five years of program implementation**

The JHU-EP Program sets aside a portion of its tuition revenue each year as part of its budgeting process to fund the development of new programs and new courses. In addition, the tuition revenue from enrollments in the courses in any program is used to cover the instructional costs of the program before any excess is used for other JHU-EP efforts. If a new program finds that its instructional costs are greater than the tuition revenue, funds are allocated from elsewhere in the overall JHU-EP Program to cover the startup program's shortfalls during the first five years. Additional related information is provided in section L.

4. **Provide a description of the institution's commitment to:**

   a. **Ongoing administrative, financial, and technical support of the proposed program**

   The best evidence for the commitment that the JHU-EP Program makes to its students and to their employers to maintain ongoing support for the administrative, financial, and technical support for this program is the history of the JHU-EP Program. Several EP master's degree programs have been in existence for over 50 years going back to the days of the JHU Evening College. The programs developed more recently have flourished as well. JHU-EP does a careful program viability study for new programs based on prospective student and employer feedback, as well as the sort of information provided elsewhere in this proposal addressing market demand. The Whiting School of Engineering greatly values these part-time graduate offerings and the impact that they provide to the engineering community and society. The proposed program would receive the same sort of administrative, financial, and technical support as the other programs in JHU-EP's portfolio.

   b. **Continuation of the program for a period of time sufficient to allow enrolled students to complete the program**

   The JHU-EP Program is committed to providing all enrolled students the opportunity to complete the degree program, including under circumstances of low demand. Again, a historical example is the best evidence for this commitment. In the early 2000s, the part-time undergraduate programs administered by JHU-EP were discontinued after six decades due to a reduction of interest in the programs by both employers and students. After ceasing enrollment of new students, the program developed plans for each remaining student to complete the degree at significant cost to JHU-EP, since many classes needed to be offered with only two or three students attending.

B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan

1. Demonstrate demand and need for the program in terms of meeting present and future needs of the region and the State in general

The Maryland Department of Labor Licensing and Regulation (DLLR), Maryland Long Term Occupational Projections (2014-2024) show a need for up to 3,823 healthcare systems engineers (percent change of 58%).

The President's Council on Science and Technology released a publication in May 2014 on "Better HealthCare and Lower Costs: Accelerating Improvement through Systems Engineering." That report stated: "Health care could benefit from the range of available systems engineering approaches...that has often produced dramatically positive results." Table 1 from that report is reproduced here:

Table 1. Potential impact of systems engineering on different segments of the health system, showing selected challenges alongside potential systems methods and tools approaches.

Health system	Selected challenges	Example systems methods and tools to address selected challenges
Patients	- Uncoordinated care - Inefficient use of their time and effort - Care not centered on their needs, goals, and circumstances	- Operations management to ensure resources are available when needed - Checklists or dashboards to ensure reliable care delivery - Reengineering processes to incorporate patient input
Small clinical practices	- Clinician stress and burnout - Inefficient workflows for delivering care - Inconsistent usability of different health- information tools	- Lean techniques for eliminating waste in workflows and clinical processes - Human-factors engineering techniques to ensure health-information tools are easily usable
Large health-care organizations	- Managing new payment models that reward outcomes vs. process - Errors and gaps in care - Wasted resources from inefficient workflows - Wasted resources from unnecessary administrative processes	- Standardized protocols that incorporate new evidence and can be tailored to individual patients - Predictive analytics to identify potential risks before problems occur - Supply-chain management to minimize waste in supplies and pharmaceuticals

Communities	- Little coordination among community organizations, local governments, and health-care organizations - Partnering to address the many factors that affect people's health	- Modeling how policies can build on community resources - Operations research to identify at-risk community members and efficiently deliver preventive health services - Big-data methods for identifying patients who need more intensive coordination of their healthcare

The President's Council goes on to recommend that the nation should "build competencies and workforce for redesign of healthcare; and specifically, there should be programs for developing innovative health-professional curricula that includes systems engineering and implementation science."

In an editorial entitled "Engineering and the Health Care Delivery System" (published in the National Society of Engineering's March 1, 2008 issue of *The Bridge*), W. Dale Compton and Proctor Reid state:

> "Unfortunately, most healthcare professionals do not even know what questions to ask systems engineers nor what to do with the answers, and vice versa. Most engineers only have contact with the healthcare system as patients, and few of them understand the constraints under which healthcare providers operate. In short, these two groups of professionals often talk to each other but seldom understand each other."

There are today numerous publication and Journals that provide input and research forums for faculty and students to mature the concepts and application in the healthcare field. The growth of literature further substantiates the interest and attention given to healthcare topics.

The Journal of Global Health Care Systems	http://jghcs.info/index.php
Health systems- OR Society	http://www.palgrave-journals.com/hs/index.html
Journal of Health Care Engineering	http://www.multi-science.co.uk/jhe.htm
International Journal of Healthcare Information and Informatics	http://www.igi-global.com/journal/ijhisi
Health Service Research Journal	http://www.hsr.org
International Journal for Quality in Health Care	http://intqhc.oxfordjournals.org
Journal of Patient Safety	http://journals.lww.com/journalpatientsafety

2. Provide evidence that the perceived need is consistent with the Maryland State Plan for Postsecondary Education

The proposed program is well aligned with the 2017–2021 Maryland State Plan for Postsecondary Education. The Master of Science in Healthcare Systems Engineering is intended to prepare highly trained scientists and engineers to work in organizations where they can contribute to the needs of society. The long-term success of JHU-EP programs for working professionals attests to the quality and effectiveness of these programs.

Candidates can undertake course-related activities at a time and a location most convenient to them, allowing students to participate in and to complete their program even if their work schedules do not permit regular class attendance or if they move away from the Maryland region, thus supporting Goal 1, "Access: Ensure equitable access to affordable and quality postsecondary education for all Maryland residents"

Similarly, the proposed program is consistent with Goal 3, "Innovation: Foster innovation in all aspects of Maryland higher education to improve access and student success," which articulates Maryland's aspiration to be "a national leader in the exploration, development, and implementation of creative and diverse education and training opportunities that will align with state goals, increase student engagement, and improve learning outcomes..." By leveraging technology in innovative ways to make JHU-EP offerings more accessible and interactive, candidates can pursue "anytime, anywhere" learning opportunities.

The proposed program is also consistent with Goal 5, "Economic Growth and Vitality," which is centered on supporting a knowledge-based economy through increased education and training. The proposed program will prepare highly qualified local scientists and engineers to contribute to the economic growth and vitality by providing life-long learning to scientists and engineers so they can maintain the skills they need to succeed in the workforce.

C. Quantifiable and Reliable Evidence and Documentation of Market Supply and Demand in the Region and State:

1. Describe potential industry or industries, employment opportunities, and expected level of entry (*ex: mid-level management*) for graduates of the proposed program

In a 2013 National Academy of Sciences presentation [Zayas-Castro, J., et. al., Healthcare Systems Engineering Programs, National Academy of Science (20 Sept 2013)], which identified thirteen Healthcare Systems Engineering degree and certificate programs, the authors also conducted a job search based on a Healthcare Systems Engineering job profile of 1-5 years for project managers or quality engineers and +7 years for senior positions. The job titles they found included:

Under the category of Process Improvement Analyst or Health Center Process Improvement Specialist: Process Engineer; Manager for Strategy & Operations; Health Care Providers Performance Improvement; Healthcare Industrial Engineer; Continuous Quality Clinical Documentation Improvement Specialist; Business Process Analyst; and Lean Six Sigma Black Belt Analyst.

Under the category of Data Analyst or Healthcare Analytics Manager: Data management; Quality Data Analyst; Healthcare/Big Data/Image Processing; and Principal Research Engineer.

Under the category of Quality Engineer or Senior Quality Assurance Engineer: Sr. Quality Engineer - Regulatory/Quality Healthcare Diagnostics/Medical Instrumentation;

Director, Division of Quality; Medical Device Quality Engineer; Design Quality Engineer; Product Engineer; and Reliability Engineer.

Under the category of Healthcare Clinical Operations Consultant or Clinical Engineer: Manager of Clinical Quality Analysis; and Health Economics and Decision Support Consultant.

Web searches for jobs with these titles reveal many opportunities available at numerous healthcare supply manufacturers and device providers. All of these job opportunities could be filled by graduates of this proposed program. It is expected that the program will provide mid-level manager and senior manager graduates for the workforce.

2. Present data and analysis projecting market demand and the availability of openings in a job market to be served by the new program

According to the Bureau of Labor Statistics (BLS), nation-wide employment of healthcare practitioners and technical workers is projected to grow 13.8 percent from 2014 to 2024. This is an imprecise job category, but one can expect that job opportunities for which this new degree will prepare students should grow at least as fast as the healthcare field overall. Pursuing a degree like this Master of Science in Healthcare Systems Engineering is a significant way to maintain career viability. Job opportunities for the graduates of this program include positions in corporations and government organizations.

In addition to the national employment projections made by the Bureau of Labor Statistics noted above, the State of Maryland projects that employment opportunities for healthcare practitioners and technical workers will grow 18.2 percent from 2014 to 2024.

Based on the projected market demand and the accessibility and convenience of an online program, we expect this degree program to be successful.

3. Discuss and provide evidence of market surveys that clearly provide quantifiable and reliable data on the educational and training needs and the anticipated number of vacancies expected over the next 5 years

Healthcare systems engineering is an emerging discipline that will play an increasingly important part in the healthcare workforce in this region. During a recent web search, the number of job openings in Maryland for healthcare analysts yielded over 600 postings. We expect the interest from students in this Master of Science in Healthcare Systems Engineering to be strong.

4. **Provide data showing the current and projected supply of prospective graduates**

There are no Maryland schools that currently offer a graduate program in healthcare systems engineering so there are no past data to present.

D. Reasonableness of Program Duplication

1. **Identify similar programs in the State and/or same geographical area. Discuss similarities and differences between the proposed program and others in the same degree to be awarded**

There are no Maryland schools that offer a graduate program in Healthcare Systems Engineering. Responding to the strong interest in the healthcare community, other universities are starting to give consideration to systems engineering practices. In the 2013 National Academy of Sciences presentation [Zayas-Castro, J., et. al., Healthcare Systems Engineering Programs, National Academy of Science (20 Sept 2013)], thirteen Healthcare Systems Engineering degree and certificate programs were identified based on information available online at the time. Most of the healthcare systems programs are offered through public health schools, schools of medicine, health administration schools, and healthcare management departments that offer healthcare related mechanical, industrial, operations, manufacturing, and systems engineering programs. There are far fewer healthcare systems master's-level engineering programs offered through engineering schools.

The course content and focus of the proposed JHU-EP Master of Science in Healthcare Systems Engineering program is different from the healthcare systems programs offered by other universities. The JHU-EP Program has its foundation in applied system and system-of-systems engineering practices and discipline, whereas many of the other programs are based more on operations research, Lean Six-Sigma practice, and industrial and manufacturing engineering.

None of the program providers have the world-class combination of expertise in both healthcare and engineering as does JHU. Only a few of the programs offer a fully available online content and no comparable systems engineering program has been found available online. More details on the proposed JHU-EP program course content can be found in Appendix A.

2. **Provide justification for the proposed program**

This Master of Science in Healthcare Systems Engineering is unique in terms of the content and offering modality. The broad set of online healthcare systems engineering courses (with in-person options for selected electives) available to engineers and healthcare professionals with a systems perspective will attract a broad range of students. JHU is highly regarded as having expertise in these areas by practitioners and researchers alike, such that the value proposition of reputation, quality, and convenience is readily understood. There is no Healthcare Systems Engineering master's degree program offered in the State of Maryland. In view of the market demand for such a program, the

online offering of the JHU-EP Master of Science in Healthcare Systems Engineering clearly meets a currently important need in the region.

E. Relevance to High-demand Programs at Historically Black Institutions (HBIs)

1. Discuss the program's potential impact on the implementation or maintenance of high-demand programs at HBI's

There is no comparable degree program offered at any of the Historically Black Institutions in Maryland.

F. Relevance to the identity of Historically Black Institutions (HBIs)

1. Discuss the program's potential impact on the uniqueness and institutional identities and missions of HBIs

By definition, an appropriate student for the proposed Master of Science in Healthcare Systems Engineering would apply after completing a baccalaureate degree at any undergraduate institution, including any of Maryland's Historically Black Institutions. The proposed program would not directly affect the implementation, maintenance, uniqueness, identity or mission of these institutions.

G. Adequacy of Curriculum Design, Program Modality, and Related learning outcomes (as outlined in COMAR 13B.02.03.10):

1. Describe how the proposed program was established, and also describe the faculty who will oversee the program

This program was first conceived during discussions between the program chair of the JHU-EP Systems Engineering program and a faculty member in the Johns Hopkins School of Medicine while they worked collaboratively on a research project in which systems engineering principles were applied to the analysis of failures in medical devices. The discussions were broadened to include faculty from the Bloomberg School of Public Health when it was realized that the application of systems engineering principles to healthcare delivery would greatly increase the effectiveness of healthcare delivery. Over the past two years, the plans for this program were developed resulting in this degree proposal. The qualifications of the faculty who will oversee this program are provided in Appendix B. Program oversight will be provided by Whiting School of Engineering faculty members who are leading practitioners in the field.

2. Describe educational objectives and learning outcomes appropriate to the rigor, breadth, and (modality) of the program

Educational Objectives

Within 2-5 years after graduation, graduates from this program will be able to:

- Apply systems engineering in healthcare environments to improve healthcare productivity, patient outcomes, and patient safety

- Identify and address problems using systems approaches in the delivery, management, safety, policies and evaluation of healthcare and related systems

Student Learning Outcomes

By the end of this program, students will be able to:

- Develop a systems description or design for healthcare related systems;
- Describe the requirements, drivers, functions, components, interdependencies, risks and quality factors for various healthcare systems;
- Lead the development of new medical devices, drugs, informatics, or policies in healthcare;
- Direct the evaluation of healthcare system components and recommend improvements in performance and efficiency;
- Lead interdisciplinary teams in the development of complex healthcare systems;
- Evaluate technical alternatives using models and tools to obtain the optimal system design; and
  Incorporate humans in the engineering systems design for patient safety and care.

3. Explain how the institution will:

a. **Provide for assessment of student achievement of learning outcomes in the program**

During the design of the program's courses, the instructional designers on the JHU-EP staff assist the instructors in preparing learning assessments (assignments, projects, papers, exams, etc.) that are carefully linked to the program's learning outcomes. The instructors then grade these assessments using grading rubrics. The assessment grades indicate the achievement level of each learning outcome.

b. **Document student achievement of learning outcomes in the program**

The learning assessment scores are retained for the purposes of accreditation and program improvement. Grades are kept in the gradebook in Blackboard and in separate learning assessment scorecards that are submitted to the EP Associate Dean at the end of each academic year. If learning outcomes are not met in a given year, the program is expected to change the way the outcome is taught in the related class and then reassess post adjustment.

4. Provide a list of courses with title, semester credit hours and course descriptions, along with a description of program requirements

A full course listing with course titles and descriptions is provided in Appendix A. All JHU-Engineering for Professionals courses are three (3) credits. Credits vary for Bloomberg School of Public Health courses.

Admission Requirements

General admission requirements for master's degree candidates and others seeking graduate status are as follows: applicants must be in the last semester of undergraduate study or hold a bachelor's degree from a regionally accredited college or university.

In addition, applicants for the Master of Science in Healthcare Systems Engineering will likely have prior educational experience that includes an undergraduate or higher major in engineering, science or healthcare (e.g. nursing, therapy, pharmacy, public health, or medicine). Applicants typically have earned a grade point average of at least 3.0 on a 4.0 scale (B or above) in the latter half of their undergraduate studies. Transcripts from all college studies must be submitted. When reviewing an application, the candidate's academic and professional background will be considered. Applicants will likely have at least two years' experience in engineering or the healthcare field.

Degree Requirements

In order to earn a Master of Science in Healthcare Systems Engineering, the student must complete 30 approved credits within five years. The curriculum consists of 18 credits of core courses and 12 or more credits of electives. An elective may be substituted for a required course if the student has previously completed an equivalent graduate-level course. Only one grade of C can count toward the master's degree. All course selections are subject to advisor approval.

Core Courses from JHU-EP Healthcare Systems Engineering

655.662 Introduction to Healthcare Systems Engineering (3)
655.667 Management of Healthcare Systems Projects (3)
655.767 Healthcare System Conceptual Design (3)
655.768 Healthcare System Design and Integration (3)
655.769 Healthcare System Test and Evaluation (3)
655.800 Healthcare Systems Engineering Capstone Project (3)

Elective Courses from JHU-EP Healthcare Systems Engineering

655.771 Healthcare Systems (3)
655.772 Healthcare Networks and Databases (3)
655.773 Designing for Patient Safety (3)
655.774 High Reliability Organizations (3)
655.775 Medical Sensors and Devices (3)

Elective Courses from JHU-EP Systems Engineering

645.650 Foundations of Human Systems Engineering (3)
645.651 Integrating Humans and Technology (3)
645.742 Management of Complex Systems (3)
645.754 Social and Organizational Factors in Human Systems Engineering (3)
645.755 Methods in Human-System Performance Measurement and Analysis (3)
645.761 Systems Architecting (3)
645.771 System of Systems Engineering (3)

Elective Courses from JHU-Bloomberg School of Public Health

(Note: the JHU-EP credit amount is what applies to the HSE degree)

140.611.81 Statistical Methods in Public Health I (3 BSPH credits / 2 JHU-EP credits)
140.612.81 Statistical Methods in Public Health II (3 BSPH credits / 2 JHU-EP credits)
140.651 Methods in Biostatistics I (3 BSPH credits / 2 JHU-EP credits)
140.652 Methods in Biostatistics II (3 BSPH credits / 2 JHU-EP credits)
309.600.81 Evaluating Quality Improvement and Patient Safety Programs (3 BSPH credits / 2 JHU-EP credits)
309.730.81 Patient Safety and Medical Errors (3 BSPH credits / 2 JHU-EP credits)
309.732 Human Factors in Patient Safety (3 BSPH credits / 2 JHU-EP credits)
311.615.81 Quality of Medical Care (3 BSPH credits / 2 JHU-EP credits)
340.751.81 Epidemiologic Methods 1 (5 BSPH credits / 3.3 JHU-EP credits)
340.752.81 Epidemiologic Methods 2 (4 BSPH credits / 2.7 JHU-EP credits)

Bloomberg courses ending in .81 refer to on-line courses; Bloomberg courses without .81 refer to in-person courses, which are offered for selected electives should a student prefer a classroom setting.

5. **Discuss how general education requirements will be met, if applicable**

   Not applicable.

6. **Identify any specialized accreditation or graduate certification requirements for this program and its students**

   Not applicable.

7. **If contracting with another institution or non-collegiate organization, provide a copy of the written contract**

   Not applicable.

8. **Provide assurance and any appropriate evidence that the proposed program will provide students with clear, complete, and timely information on the curriculum, course and degree requirements, nature of faculty/student interaction, assumptions about technology competence and skills, technical equipment requirements, learning management system, availability of academic support services and financial aid resources, and costs and payment policies**

   All specific course-related information (e.g., course requirements, nature of faculty/student interaction, assumptions about technology competence and skills, and technical equipment requirements) is provided in the syllabus for each course and is available on the Blackboard course site. Program-related information (e.g., degree requirements, learning management system information, availability of academic support services, financial aid resources, and tuition payment policies) can be found both on the JHU-EP website (http://ep.jhu.edu) and as well as in the Engineering for Professionals Academic Catalog (https://ep.jhu.edu/files/2018-2019-catalog.pdf).

9. **Provide assurance and any appropriate evidence that advertising, recruiting, and**

admissions materials will clearly and accurately represent the proposed program and the services available.

The JHU-EP website (ep.jhu.edu) contains the same marketing, recruiting and admission materials that are used in print or other form and made available to the students. The JHU-EP academic catalog, which is available on the website, also contains the same material. We affirm that these materials represent a good faith effort to be totally clear and transparent all our communications with current and new students. Incidentally, this also applies to the employers who are a very important factor in supporting our students in their academic pursuits.

H. Adequacy of Articulation

Not applicable.

I. Adequacy of Faculty Resources (as outlined in COMAR 13B.02.03.11).

1. **Provide a brief narrative demonstrating the quality of program faculty. Include a summary list of faculty with appointment type, terminal degree title and field, academic title/rank, status (full-time, part-time, adjunct) and the course(s) each faulty member will teach (in this program)**

   See Appendix B for a representative list of faculty who will teach in the proposed program. The program currently has identified highly qualified faculty members. Each is a distinguished and experienced professional and all have advanced degrees (MS, MPH, PhD, or MD) in their fields of expertise. Each has demonstrated a strong commitment to excellence in teaching. Most are practicing engineers or scientists in the JHU Applied Physics Laboratory as well as faculty and researchers from the Bloomberg School of Public Health, the School of Medicine, or other local universities, corporations or government, and many hold influential positions in their organizations. The JHU-EP program provides engineering education rooted in practice by relying heavily on the practitioner faculty members.

2. **Demonstrate how the institution will provide ongoing pedagogy training for the faculty in evidenced-based best practices, including training in: a. Pedagogy that meets the needs of the students, b. The learning management system and c. Evidenced-based best practices for distance education, if distance education is offered**

   Faculty support for the development and instruction of online courses is provided by JHU-EP's Center for Learning Design (CLD) and Center for Digital and Media Initiatives (CDMI) professional staff consisting of eight instructional designers and five multimedia technicians and instructional technologists. Faculty have multiple opportunities to receive training on the Blackboard learning management system, and in the pedagogy of online learning. These opportunities are presented at various times throughout the year at events such as fall/spring annual faculty meetings, training webinars, and privately-scheduled training sessions. Once an instructor has been

identified to develop an online course, they are given access to a set of web-based resources that cover a broad range of topics on online pedagogy, use of instructional technologies and learning management system tutorials. Throughout the online course development, the instructor receives direct support and guidance from their assigned instructional designer, as well as from the instructional technology and multimedia staff. This could take the form of course design guidance based on best practices in online learning, course production support, audio and video recording support. Once the course is built, the support staff continues to provide assistance to the faculty member, offering best practices in course instruction and help desk support. After the course runs, these teams help the instructor make updates and improvements to the course.

J. Adequacy of Library Resources (as outlined in COMAR 13B.02.03.12).

Students have access to the Milton S. Eisenhower Library on the Homewood campus, which is ranked as one of the nation's foremost facilities for research and scholarship. Its collection of more than three million bound volumes, several million microfilms, and more than 13,000 journal subscriptions has been assembled to support the academic efforts of the University. The interlibrary loan department makes the research collection of the nation available to faculty and students. The library also provides easy access to a wide selection of electronic information resources, including the library's online catalog, and numerous electronic abstracting and indexing tools. Many of the databases are accessible remotely. Librarians help students electronically and the library maintains an extensive web site to take visitors through all of its services and materials. To this are added more than 10,000 audiovisual titles available for on-site consultation.

K. Adequacy of Physical Facilities, Infrastructure and Instructional Equipment (as outlined in COMAR13B.02.03.13)

1. **Provide an assurance that physical facilities, infrastructure and instruction equipment are adequate to initiate the program, particularly as related to spaces for classrooms, staff and faculty offices, and laboratories for studies in the technologies and sciences. If the program is to be implemented within existing institutional resources, include a supportive statement by the President for adequate equipment and facilities to meet the program's needs**

   All required courses in the proposed program will be offered online (with in-person options for selected electives). The program will have no discernible impact on the use of existing facilities and equipment beyond the standard requirements already in place. See additional details in section K.2 below.

2. **Provide assurance and any appropriate evidence that the institution will ensure students enrolled in and faculty teaching in distance education will have adequate access to: a) an institutional electronic mailing system, and b) a learning management system that provides the necessary technological support for distance education**

a) All JHU students receive an Office 365 account including email capabilities (built on Outlook Live), as well as 25GB of online storage, and collaboration, blogging, photo-sharing, event-planning, instant messaging, and other tools. The email account is accessible from a variety of browsers on both the PC and Mac, including full support for Internet Explorer, Firefox, and Safari.

b) This program will be delivered via JHU-EP's online programs infrastructure, which includes the Blackboard course management system and the Adobe Connect and Zoom video conferencing systems. These technologies are supported by the Whiting School and the university's IT infrastructure and provide password-protected online course sites and community management systems that enable ongoing collaborative exchange and provide convenient channels for synchronous and asynchronous learning. Blackboard is one of the world's leading providers of e-learning systems for higher education institutions. This software focuses on educational outcomes and provides a highly-flexible learning environment for students. Johns Hopkins is also outfitted with suitable technical and professional staff and a help desk to provide technical assistance to the students taking online courses. All of the student services such as application processes, course registration, bookstore, ID service, and advising are currently provided online as well.

   The Whiting School already successfully delivers all of its online and web-enhanced courses and programs using the above-mentioned platforms. As part of the program's development, the school's technical support team and business office have determined that JHU-EP possesses the necessary technology infrastructure and resources in place to support successful delivery of this online program.

L. Adequacy of Financial Resources with Documentation (as outlined in COMAR 13B.02.03.14)

Please see Appendix C.

M. Adequacy of Provisions for Evaluation of Program (as outlined in COMAR 13B.02.03.15).

1. Discuss procedures for evaluating courses, faculty and student learning outcomes

Once the Master of Science in Healthcare Systems Engineering program is launched, its courses will enter the course evaluation system. Students in all JHU-EP courses receive two evaluations each term -- one after the first half and one at the end of the term. These evaluations ask students to reflect on the course structure, the course content, and the instructor's performance. Summary reports are reviewed by the faculty member, the program chair, and the JHU-EP administration to determine whether changes are necessary. The Program Committee will discuss these results as well to consider the broader context of the program's curriculum and course delivery mechanisms.

As described in section G.3, student learning outcomes are carefully and deliberately linked to in-class learning assessments (assignments, projects, papers, exams, etc.)

throughout the curriculum. The instructors then grade these assessments using grading rubrics. The assessment grades indicate the achievement level of each learning outcome. If learning outcomes are not met in a given year, the program is expected to change the way the outcome is taught in the related class and then reassess post adjustment.

2. **Explain how the institution will evaluate the proposed program's educational effectiveness, including assessments of student learning outcomes, student retention, student and faculty satisfaction, and cost-effectiveness.**

   The same procedures will be used to evaluate these matters as were described in section M.1. The data that the program chair and program committee will need to evaluate performance and develop action plans where deficiencies are identified will be provided by the JHU-EP administrative staff.

N. Consistency with the State's Minority Student Achievement Goals (as outlined in COMAR13B.02.03.05).

Any student meeting the admissions requirements can apply to the Master of Science in Healthcare Systems Engineering. The program will work to help all accepted students improve their workplace competitiveness and reach their professional goals, an aim consistent with the State's minority student achievement goals.

O. Relationship to Low Productivity Programs Identified by the Commission:

Not applicable.

P. Adequacy of Distance Education Programs (as outlined in COMAR 13B.02.03.22)

1. **Provide affirmation and any appropriate evidence that the institution is eligible to provide Distance Education.**

   JHU-EP has decades of experience administering successful online graduate programs. The Healthcare Systems Engineering program will be supported in the same way as the other eighteen online master's degree programs in the Whiting School of Engineering.

2. **Provide assurance and any appropriate evidence that the institution complies with the C-RAC guidelines, particularly as it relates to the proposed program**

   a) **Online learning is appropriate to the institution's mission and purposes**

   The mission of The Johns Hopkins University is to educate its students and cultivate their capacity for life-long learning, to foster independent and original research, and to bring the benefits of discovery to the world. More simply stated, it's "Knowledge for the world." An online delivery format is not just appropriate, but truly a critical requirement of disseminating knowledge to students who are unable to travel to the Baltimore campus.

The institution's plans for developing, sustaining, and, if appropriate, expanding online learning offerings are integrated into its regular planning and evaluation processes

JHU-EP has fully embraced online education, to the extent that when a new program is developed, it is fully expected that the program will be delivered through an online modality. This part-time online division now reports up to the Whiting School of Engineering's Vice Dean for Graduate Education, who also oversees all full-time residential graduate programs. As such, online education has increased exposure to Whiting School of Engineering leadership and is included in long-term planning, including student and faculty support systems. There is a clear vision for JHU-EP's online education enrollment growth documented in the program's five-year budget plan.

b) Online learning is incorporated into the institution's systems of governance and academic oversight

Johns Hopkins University reviews new online program proposals using the same systems of governance and academic oversight as that for new on-site programs. Before being shared with the deans of all JHU academic divisions, all proposals must first undergo a review by internal academic bodies, including discussions of fit with School mission, program viability, program rigor, instructor quality, and redundancy with existing programs. For Whiting School of Engineering programs, this entails a review by the Whiting School Graduate Committee, a faculty body with representation from both the part-time online and full-time residential program faculty. If approved, a proposal is then forwarded to the Homewood Academic Council for review by faculty from both the Whiting School of Engineering and the Krieger School of Arts and Sciences. As discussed in M.1, once a program is launched, its courses will enter the course evaluation system. Students in all JHU-EP courses receive two evaluations each term -- one after the first half and one at the end of the term. These evaluations ask students to reflect on the course structure, the course content, and the instructor's performance. Summary reports are reviewed by the faculty member, the program chair, and the JHU-EP administration to determine whether changes are necessary. The Program Committee will discuss these results as well to consider the broader context of the program's curriculum and course delivery mechanisms. Lastly, JHU-EP, and all of the programs that it offers, undergoes a rigorous review by the Homewood Academic Council faculty every five years.

c) Curricula for the institution's online learning offerings are coherent, cohesive, and comparable in academic rigor to programs offered in traditional instructional formats

In most cases, a JHU-EP program's online courses are first developed and run as on-site courses, and this provides a suitable benchmark for course rigor and workload. A formal online course development process is then used to support the development of all online courses. This process incorporates the Quality Matters™ research-based

set of eight standards for quality online course design also ensure the academic rigor of the online course is comparable to or better than the traditionally offered course. A JHU-EP program is composed of courses that are appropriately sequenced to ensure students have adequate background for courses later in the program. Courses are offered frequently enough to ensure that students can complete a degree program within the 5-year maximum allowable timeframe. All JHU-EP courses have a maximum of 19 student enrollees to ensure that students have adequate access to the instructor. Courses are built with components such as discussion boards to facilitate student-student and student-faculty interaction.

d) The institution evaluates the effectiveness of its online learning offerings, including the extent to which the online learning goals are achieved, and uses the results of its evaluations to enhance the attainment of the goals

As discussed in M.1, once a program is launched, its courses will enter the course evaluation system. Students in all JHU-EP courses receive two evaluations each term -- one after the first half and one at the end of the term. These evaluations ask students to reflect on the course structure, the course content, and the instructor's performance. Summary reports are reviewed by the faculty member, the program chair, and the JHU-EP administration to determine whether changes are necessary. The Program Committee will discuss these results as well to consider the broader context of the program's curriculum and course delivery mechanisms.

As discussed in G.3, during the design of the program's courses, the instructional designers on the JHU-EP staff assist the instructors in preparing learning assessments (assignments, projects, papers, exams, etc.) that are carefully linked to the program's learning outcomes. The instructors then grade these assessments using grading rubrics. The assessment grades indicate the achievement level of each learning outcome. The learning assessment scores are retained for the purposes of accreditation and program improvement. Grades are kept in the gradebook in Blackboard and in separate learning assessment scorecards that are submitted to the EP Associate Dean at the end of each academic year. If learning outcomes are not met in a given year, the program is expected to change the way the outcome is taught in the related class and then reassess post adjustment.

e) Faculty responsible for delivering the online learning curricula and evaluating the students' success in achieving the online learning goals are appropriately qualified and effectively supported

Any new instructor recruited to teach online must meet the same qualifications as those teaching in a traditional site-based program. They must have a terminal graduate degree in a relevant field, and they must have professional experience related to the course content.

Faculty support for the development of online courses is provided by JHU-EP's Center for Learning Design (CLD) and Center for Digital and Media Initiatives

(CDMI) professional staff consisting of eight instructional designers and five multimedia technicians and instructional technologists. Faculty have multiple opportunities to receive training on the Blackboard learning management system, and in the pedagogy of online learning. These opportunities are presented at various times throughout the year at events such as fall/spring annual faculty meetings, training webinars, and privately-scheduled training sessions. Once an instructor has been identified to develop an online course, they are given access to a set of web-based resources that cover a broad range of topics on online pedagogy, use of instructional technologies and learning management system tutorials. Throughout the online course development, the instructor receives direct support and guidance from their assigned instructional designer, as well as from the instructional technology and multimedia staff. This could take the form of course design guidance based on best practices in online learning, course production support, audio and video recording support. Once the course is built, the support staff continues to provide assistance to the faculty member, offering best practices in course instruction and help desk support. After the course runs, these teams help the instructor make updates and improvements to the course.

f) The institution provides effective student and academic services to support students enrolled in online learning offerings

JHU-EP maintains numerous web-based resources to inform prospective students on the information they may need as an online student. These resources include: JHU-EP main website (http://ep.jhu.edu) and the JHU-EP online catalog (https://ep.jhu.edu/files/2018-2019-catalog.pdf), which both include detailed programmatic information, academic support services, financial aid, costs, policies, etc. and specific information for online learning. As new online students are admitted, they're introduced to the JHU-EP program and procedures through the fully online New Student Orientation, that includes information on registration, student advising, ordering textbooks, the JHU email system, and other online student services. All students who enroll in an online course are also enrolled in the New Online Student Orientation module, which focuses on introducing students to techniques that will enable them to be successful in an online course and trains them on the Blackboard learning management system. Lastly, all new students are enrolled in a mandatory Academic Integrity training course -- a zero-credit, zero-tuition course that is geared towards helping students avoid behaviors linked to plagiarism, cheating and other violations of academic integrity.

Students are assigned an advisor when accepted. Students work individually with the advisor to develop a course of study that meets the requirements of the program and the career goals of the student. Courses that deviate from the program plan and have not been approved by an advisor may not count toward degree requirements. All advising can be received remotely.

Students have online access to the Milton S. Eisenhower Library on the Homewood campus, ranked as one of the nation's foremost facilities for research and scholarship.

The interlibrary loan department allows students access to resources at any other university in the nation. The library also provides easy access to a wide selection of electronic information resources, including the library's online catalog, and numerous electronic abstracting and indexing tools. Many of the databases are accessible remotely. Librarians are available to assist students remotely and the library maintains an extensive website to take visitors through all its services and materials.

The Johns Hopkins University is committed to making all academic programs, support services, and facilities accessible to qualified individuals with disabilities. Students with disabilities who require reasonable accommodations can contact the JHU-EP Disability Services Administrator and receive support remotely.

The Johns Hopkins Student Assistance Program (JHSAP) is a professional counseling service that can assist students with managing problems of daily living. Stress, personal problems, family conflict, and life challenges can affect the academic progress of students. JHSAP focuses on problem solving through short-term counseling. Online students may call a phone number for consultation and will be directed to the appropriate resource or office. JHSAP services are completely confidential. The program operates under State and Federal confidentiality legislation and is HIPAA compliant.

g) The institution provides sufficient resources to support and, if appropriate, expand its online learning offerings

The JHU-EP program prepares a five-year budget every year that includes sufficient resources to maintain all online programs and expand offerings, if desired. This budget. The budget contains funding for marketing and recruitment for all programs as well as staffing all programs in terms of admissions services, students and faculty support services, finance and administration services, and instructional design and instructional technology services. The budget also contains funding for new program viability analyses, new program marketing launches, and new course development costs. Faculty and staff development costs are included, as described in greater detail in section P.2.f above.

The JHU-EP Program collaborates with central Johns Hopkins University Information Technology to provide a robust and scalable, but also flexible, technical infrastructure that serves student and faculty member needs. These programs are delivered via JHU-EP's online programs infrastructure, which includes the Blackboard course management system and the Adobe Connect and Zoom video conferencing systems. These systems provide password-protected online course sites and community management systems that enable ongoing collaborative exchange and provide convenient channels for synchronous and asynchronous learning.

h) The institution assures the integrity of its online offerings

The Higher Education Opportunity Act (HEOA) enacted in 2008 requires that an academic institution that offers distance education opportunities to students 1) has a

process established to verify that the student who registers is the same student who participates in and completes the offering and receives academic credit for it, 2) has a process established to verify that student privacy rights are protected, and 3) has a process established that notifies the student about any additional costs or charges that are associated with verification of student identity. In JHU-EP programs, the following actions have been taken to satisfy these requirements: 1) students may only enter the academic website for the online courses they take by providing the unique student ID and password assigned after admission, 2) all FERPA privacy rights are preserved by limiting access very specifically in the University student information system to only those permitted by law to have access to restricted student information, and 3) there are no additional costs assessed to the student for the measures we use to verify student identity.

Other measures are taken as well to assure the integrity of JHU-EP online offerings. The Whiting School of Engineering's Graduate Academic Misconduct Policy applies to all JHU-EP online students, it clearly defines misconduct, and it includes references to the most common online student infractions. As referenced in section P.2.g, all new JHU-EP students are enrolled in a mandatory Academic Integrity training course -- a zero-credit, zero-tuition course that is geared towards helping students avoid behaviors linked to plagiarism, cheating and other violations of academic integrity. Lastly, JHU-EP has recently required that all essay-based coursework be submitted to SafeAssign, a Blackboard integrated tool used to prevent plagiarism by identifying unoriginal content and creating opportunities to help students identify how to properly attribute sources rather than paraphrase.

Appendix A

Course List and Descriptions

Healthcare Systems Engineering Core Courses:

655.662 Introduction to Healthcare Systems Engineering (3)
This course introduces students to the fundamental principles of healthcare systems engineering and their application to the development of complex systems. It describes how the systems engineering viewpoint differs from that of the healthcare provider, as well as the essential role that systems engineering plays as an integral component of program management. Topics include requirements analysis, concept definition, system synthesis, design trade-offs, risk assessment, interface definition, engineering design, system integration, and related systems engineering activities. The course defines the breadth and depth of the knowledge that the healthcare systems engineer must acquire concerning the characteristics of the diverse components that constitute the total system. Special topics such as simulation and models and test and evaluation are discussed in relation to the healthcare systems engineering viewpoint. Students address typical systems engineering problems that highlight important healthcare issues and methods of technical problem resolution.

655.667 Management of Healthcare Systems Projects (3)
The course addresses the management of a technical project from concept to operational use, with emphasis on the functions, roles, and responsibilities of the healthcare systems project manager. From the development of a proposal to the delivery of a product to a customer, the efforts to conceive, plan, budget, schedule, monitor, control/direct, and report the progress of the project are discussed. Throughout the project life cycle, the need for good communications, interface and configuration management, and conflict resolution is emphasized. Students assume the role of project managers who must use management tools such as WBS, EVM, and CPN and who must address typical problems that arise in the conduct of a high-technology systems project.

655.767 Healthcare System Conceptual Design (3)
This course addresses in detail the healthcare systems engineer's responsibilities and activities during the conceptual phases of a healthcare system development program. Systems engineering tools commonly employed at this stage of a program are presented along with selected problems that illustrate both the applicability and limitations of commonly employed tools and procedures to the solving current healthcare issues. The course steps through conceptual design beginning with analysis of needs and objectives and proceeding to the exploration of alternative concepts and the selection of a concept that best meets goals of performance, timeliness, and affordability. Topics include definition of operational scenarios, functional analysis, risk assessment, system trade-offs, measures of effectiveness, and requirements formulation. Emphasis is on the application of these systems engineering techniques in a team environment to a class project. Students apply systems engineering methods learned from reading and lectures to the development of a realistic system in an ongoing project in a team format.

Prerequisites: *655.662 Introduction to Healthcare Systems Engineering and 655.667 Management of Healthcare Systems Projects, or permission of the student's faculty advisor and the course instructor*

655.768 Healthcare System Design and Integration (3)
This course addresses the systems engineering objectives, responsibilities, and activities during the demonstration and validation and the engineering and manufacturing development phases of a healthcare system development program. Systems engineering procedures and tools used during these phases are identified and their use illustrated. Topics include the relationship between a system specification and the system design, systems engineering management plans, risk management, system development models, customer integration into the design process, and design disciplines and practices. The course uses a healthcare system problem scenario extensively to illustrate systems engineering principles and specific product design issues.

Prerequisite: *655.767 Healthcare System Conceptual Design or permission of the student's faculty advisor and the instructor*

655.769 Healthcare System Test and Evaluation (3)
This course focuses on the application of systems engineering principles to the test and evaluation of healthcare system elements and, ultimately, of the total system. Test requirements, selection of critical test parameters, analysis of test results, and determination of remedial action in the event of discrepancies are all systems engineering functions. Topics include validation and verification, similarities and differences in the nature of hardware and software testing, test tools and test procedures, testing during hardware-software integration, quality assurance test, environmental test, and operational test and evaluation. Student problems include scenario case studies using examples developed in the several previous courses.

Prerequisite: *655.768 Healthcare System Design and Integration or permission of the student's faculty advisor and the instructor.*

655.800 Healthcare Systems Engineering Capstone Project (3)
This course provides the experience of applying systems engineering principles and skills learned in the formal courses to a specific practical healthcare system project that is suggested by the student and is presented in a formal proposal. The product of the system project is a final report; also required are interim reports and an oral presentation to permit review of the project objectives and approach. A student typically has a mentor who is a member of the systems engineering faculty. The program chair, vice chair, and mentor review proposals and reports. The total time required for this course is comparable to the combined class and study time for the formal courses (formerly 645.770). It is self-paced and often takes more than one semester to complete.

Prerequisite: *655.769 Healthcare System Test and Evaluation or permission of the program chair or vice chair.*

Healthcare Systems Engineering Elective Courses (to be developed):

655.771 Healthcare Systems (3)
This course will cover the fundamental elements of modern healthcare systems, including system structure, processes, and their relation to information systems and system interfaces. It also covers the organization, financing, and delivery of healthcare in the U.S. It would also discuss several potential small and large-scale reforms to the U.S. healthcare system and evaluates their likely effects on healthcare spending, quality of care, and access to care.

Prerequisite: *655.767 Healthcare System Conceptual Design or permission of the student's faculty advisor and the instructor*

655.772 Healthcare Networks and Databases (3)
This course covers the various healthcare databases, both internal and external to care centers, and how they are networked together. The course will look at the capabilities and interfaces of current electronic medical records (EMRs) that serve as the starting point for patient care. Data collection and data entry limitations will be discussed in terms of how they can affect patient care.

Prerequisite: *655.767 Healthcare System Conceptual Design or permission of the student's faculty advisor and the instructor*

655.773 Designing for Patient Safety (3)
This course will cover the identification, assessment, and mitigation of risk in healthcare systems. Specific topic will examine the causes of and systematic ways of preventing medication errors, patient handoff process issues, and procedural mistakes.

Prerequisite: *655.767 Healthcare System Conceptual Design or permission of the student's faculty advisor and the instructor*

655.774 High Reliability Organizations (3)
This course will cover how the healthcare industry's complexity and the risk of significant consequences requires the field to adopt and implement the principles of high reliability proven successful by other similarly complex industries: preoccupation with failure; reluctance to simplify; deference to expertise; and commitment to resilience. Students will learn how to characterize healthcare's complexity and risk and will develop creative and mindfully engineered solutions that instill the principles of high reliability into everyday operations.

Prerequisite: *655.767 Healthcare System Conceptual Design or permission of the student's faculty advisor and the instructor*

655.775 Medical Sensors and Devices (3)
This course covers the basic and advanced principles, concepts, and operations of medical sensors and devices.

Prerequisite: *655.767 Healthcare System Conceptual Design or permission of the student's faculty advisor and the instructor*

Systems Engineering Elective Courses (existing courses):

645.650 Foundations of Human Systems Engineering (3)
Systems are designed, built, and used by humans. Their purpose is to help people meet their goals and perform their tasks. This course introduces the foundations of human systems engineering (HSE) from which system requirements and design elements are derived. The objective is to provide students with the knowledge of human capabilities and introduce human systems engineering concepts and design principles. Human capabilities include visual, auditory, and touch senses; motion; cognitive processing; and decision making. Human systems engineering concepts and design principles include human factors engineering; training; maintenance; environmental, safety, and health; survivability; habitability; manpower; and personnel.

Prerequisite*: 645.662 Introduction to Healthcare Systems Engineering*

645.651 Integrating Humans and Technology (3)
In this course students will learn how to integrate the human into the system and to derive human-based system requirements and design elements. Design preparation will comprise collecting/compiling missions, scenarios, user profiles, and conceptual designs. Human-system analysis processes will introduce work flow; task; social and communications networks; and gap, function, decision, and risk analyses. Topics include culture and team dynamics; modeling and simulation of human capabilities; human-centered prototyping, human performance measurement; supervision of automation; human considerations in system integration, production, and deployment; and user support.

Prerequisite: *645.662 Introduction to Healthcare Systems Engineering*

645.742 Management of Complex Systems (3)
Traditional systems engineering is usually applied to closed, precise, and recursive systems, with the assertion that the methodologies used can be scaled up to more elaborate systems of systems. This course addresses the more realistic and emerging field of the management of complex systems, where multiple current development efforts with disparate and nonlinear attributes characterize the system components. Engineering complex systems must account for the likelihood of multiple disciplines, differing scales, often unpredictable future states, irreducible uncertainty, and non-linear behavior. Multiple customers, corporations, governments, technologies, and systems now must be considered on a global scale with a mix of new and legacy systems. The student will be encouraged to think differently and creatively about the management approaches to developing complex systems and to use adaptive strategies and tools including modeling and simulation, pattern recognition, nonlinear dynamics, chaos theory, and control systems. Special attention will be given to risk assessment and management for dynamic systems. Case studies and examples will be drawn from commercial industry and DoD systems acquisition programs. Students will be expected to discuss several readings and complete an academic paper to explore in depth one or more of the concepts discussed.

Prerequisite: *655.767 Healthcare System Conceptual Design or permission of the student's advisor and the instructor.*

645.754 Social and Organizational Factors in Human Systems Engineering (3)
The objective of this course is to provide students with the knowledge of organizational structure, social interaction, and group behavior needed to reflect the full context of use in the practice of systems engineering. It examines the characteristics of organizations and of social contexts that influence system requirements and design and describes systems engineering processes for discovering, representing, and analyzing such information in practice. It covers the application of these factors throughout the system life cycle. Additional topics include systems in high-reliability organizations, system support for group situational awareness and distributed decision making in command and control systems, and systems engineering for context-aware and social media systems.

Prerequisite: *655.662 Introduction to Healthcare Systems Engineering*

645.755 Methods in Human-System Performance Measurement and Analysis (3)
This course focuses on human-system performance measurement (HsPM) methods used to determine whether human-system requirements are met and whether the system's design provides effective and efficient human-system performance. Students will gain knowledge of HsPM study design protocols, data collection tools and methods, analysis techniques and processes, and procedures required to execute studies with human participants. The course will provide students with an understanding of HsPM in the context of system design; workplace design; environment, safety, and occupational health; training and maintenance. Students will be exposed to heuristic evaluations; modeling and simulation of human tasking, including tools for measuring physical limitations, cognitive load, and fatigue; and system testing with the human element.

Prerequisite: *655.662 Introduction to Healthcare Systems Engineering*

645.761 Systems Architecting (3)
As the systems that systems engineers face become more complex, it is no longer sufficient to use "good engineering practices." The complex systems of today need to be architected before design work can begin. This course examines the principles and art of systems architecting when developing both individual systems and systems that are components of a system or federation of systems. The objective is to provide students with the principles, techniques, and hands-on experience of architecting modern, complex systems. Students will learn the latest architecture development techniques using DoD and commercial architectural frameworks, then extend those frameworks to specific problems involving unique systems development environments. Topics include the management of underlying system and data models and the special architecting requirements of command, control, and communications systems. Special attention will be placed on visualizing architecture artifacts—qualitatively and quantitatively evaluating architectures and the systems model they represent—and using system architectures for investment decisions. Case studies from actual experiences will be presented.

Prerequisite: *655.767 Healthcare System Conceptual Design or permission of the student's faculty advisor and the instructor*

645.771 System of Systems Engineering (3)
This course addresses the special engineering problems associated with conceiving, developing, and operating systems composed of groups of complex systems closely linked to function as integral entities. The course will start with the underlying fundamentals of systems' requirements, design, test and evaluation, and deployment, as well as how they are altered in the multisystem environment. These topics will then be extended to information flow and system interoperability; confederated modeling and simulation, use of commercial off-the-shelf elements, and systems engineering collaboration between different organizations. Advanced principles of information fusion, causality theory with Bayesian networks, and capability dependencies will be explored. Several case studies will be discussed for specific military systems of systems, including missile defense and combatant vehicle design, as well as selected commercial examples.

Perquisite: *655.767 Healthcare System Conceptual Design or permission of the student's faculty advisor and the instructor*

Elective Courses from JHSPH (existing courses):

140.611.81 Statistical Methods in Public Health I (3 BSPH credits / 2 JHU-EP credits)
Description: Provides students with a broad overview of biostatistical methods and concepts used in the public health sciences. Emphasizes the interpretation and conceptual foundations of statistical estimation and inference. Introduces examples of different types of data arising in public health studies, how to interpret differences in data distributions via visual displays, and how to calculate and interpret confidence intervals for population means and proportions and incident rates using data from single samples. Demonstrates methods of computing the mean difference and explain why a mean difference can be used to quantify differences in a continuous measure between two samples (and ultimately two populations), computing risk differences, relative risks and odds ratio, and how to compare, contrast, and interpret relative risks and odds ratios when comparing binary outcomes between two populations as well as how to Compute incidence rates and incidence rate ratios. Presents how to perform hypothesis tests for populations comparisons and interpret the resulting p-values.

Prerequisite*: Introduction to Online Learning is required prior to participating in any of the School's Internet-based courses; permission of student's faculty advisor; permission of the student's faculty advisor.*

140.612.81 Statistical Methods in Public Health II (3 BSPH credits / 2 JHU-EP credits)
Description: Provides a broad overview of biostatistical methods and concepts used in the public health sciences, emphasizing interpretation and concepts rather than calculations or mathematical details. Develops ability to read the scientific literature to critically evaluate study designs and methods of data analysis. Introduces basic concepts of statistical inference, including hypothesis testing, p-values, and confidence intervals. Topics include comparisons of means and proportions; the normal distribution; regression and correlation; confounding; concepts of study design, including randomization, sample size, and power considerations; logistic regression; and

an overview of some methods in survival analysis. Draws examples of the use and abuse of statistical methods from the current biomedical literature.

Prerequisite: *Introduction to Online Learning is required prior to participating in any of the School's Internet-based courses; permission of student's faculty advisor; 140.621 Statistical Methods in Public Health I and permission of the student's faculty advisor.*

140.651 Methods in Biostatistics I (3 BSPH credits / 2 JHU-EP credits)
Description: Presents fundamental concepts in applied probability, exploratory data analysis, and statistical inference, focusing on probability and analysis of one and two samples. Topics include discrete and continuous probability models; expectation and variance; central limit theorem; inference, including hypothesis testing and confidence for means, proportions, and counts; maximum likelihood estimation; sample size determinations; elementary non-parametric methods; graphical displays; and data transformations.

Prerequisite: *Working knowledge of calculus and linear algebra and permission of the student's faculty advisor.*

140.652 Methods in Biostatistics II (3 BSPH credits / 2 JHU-EP credits)
Description: Presents fundamental concepts in applied probability, exploratory data analysis, and statistical inference, focusing on probability and analysis of one and two samples. Topics include discrete and continuous probability models; expectation and variance; central limit theorem; inference, including hypothesis testing and confidence for means, proportions, and counts; maximum likelihood estimation; sample size determinations; elementary non-parametric methods; graphical displays; and data transformations.

Prerequisite: *140.651 Methods in Biostatistics I and permission of the student's faculty advisor.*

309.600.81 Evaluating Quality Improvement and Patient Safety Programs (3 BSPH credits/ 2 JHU-EP credits)
Description: Prepares students to evaluate Quality Improvement/Patient Safety (QI/PS), projects by developing their competencies in the following areas: 1) Critiquing evaluations of QI/PS projects; 2) Designing a robust evaluation of a QI/PS project; and 3) Conducting a small scale qualitative study.

Prerequisite: *Introduction to Online Learning is required prior to participating in any of the School's Internet-based courses; permission of student's faculty advisor.*

309.730.81 Patient Safety and Medical Errors (3 BSPH credits / 2 JHU-EP credits)
Description: Provides an introduction to the science of safety, and how it relates to problems with patient safety in healthcare. Explains the role of both individuals and systems in improving patient safety. Reviews institutional responses to adverse events, including the topics of risk management and medical malpractice. Emphasizes the importance of communication and teamwork. Students learn the basics of conducting an incident investigation, gain an understanding of the advantages and limitations of error reporting, learn how to disclose errors and adverse events, and learn models for improving safety in hospitals and other healthcare organizations from both the micro and macro points of view.

Prerequisite: *Introduction to Online Learning is required prior to participating in any of the School's Internet-based courses; permission of student's faculty advisor.*

309.732 Human Factors in Patient Safety (3 BSPH credits / 2 JHU-EP credits)
Description: Provides students with the essential concepts, methods and tools to enable them to design effective patient safety interventions and evaluate their impact.

Prerequisite: *309.730 Patient Safety and Medical Errors is strongly recommended, or students must get instructor's and faculty advisor's consent.*

311.615.81 Quality of Medical Care (3 BSPH credits / 2 JHU-EP credits)
Description: Introduces quality issues, including the extent to which customary care for specific health problems improves quality of life and reduces mortality, and quality assessment and assurance performed by caregivers, professional societies, government-sponsored professional review organizations, and government and other third-party organizations who pay for care. Provides a basis to judge the effectiveness of quality assessment and assurance activities.

Prerequisite: *Introduction to Online Learning is required prior to participating in any of the School's Internet-based courses; permission of student's faculty advisor.*

Appendix B

Healthcare Systems Engineering Faculty
(* indicates faculty committed to developing course content and to teaching initial offering)

Faculty Member	Degree	Field	Academic Title	Status	Classes Taught
Biemer, Steven M*	M.S.	Computer Science	APL Staff	PT	EN.655.768, EN.655.771
Bos, Nathan D	Ph.D.	Psychology	APL Staff	PT	EN.655.754
Crownover, William	Ph.D.	Engineering Management & Systems Engineering	APL Staff	PT	EN.655.742
Davis, Timothy Andrew	Ph.D.	Systems Engineering	APL Staff	PT	EN.655.467, EN.655.769
Dever, Jason*	Ph.D.	Systems Engineering	APL Staff	PT	EN.655.462
Dixon, Jeffery Scott	M.S.	Astronautic	APL Staff	PT	EN.655.767
Fidler, Charles Robert*	M.S.	Systems Engineering	MANT Staff	PT	EN.655.467, EN.655.768, EN.655.771, EN.655.769
Fitzpatrick, William B	M.S.	Human Factors	APL Staff	PT	EN.655.451
Flanigan, David Alan*	Ph.D.	Systems Engineering / Operations Research	APL Staff	PT	EN.655.767
Gorrell, Zac	M.S.	Systems Engineering	APL Staff	PT	EN.655.467
Hein, Erin K	M.S.	Systems Engineering	Kairos Staff	PT	EN.655.467
Henry, Matthew H	Ph.D.	Systems & Information Engineering	APL Staff	PT	EN.655.761
Holub, Brian L	M.S.	General Engineering	APL Staff	PT	EN.655.462
Kane, Jed C	M.S.	Systems Engineering	Mitre Staff	PT	EN.655.462
Montoya, Matthew*	Ph.D.	Systems Engineering	APL Staff	PT	EN.655.771
O'Connor, John	M.S.	Aeronautical Engineering	TPS Staff	PT	EN.655.769
Olson, Christopher Lee	M.S.	Engineering	Navy Staff	PT	EN.655.462, EN.655.767

Ryder, Christopher Martin	M.S.	Software Systems Engineering	APL Staff	PT	EN.655.767, EN.655.768
Ravitz, Alan*	Ph.D.	Systems Engineering	APL Staff	PT	EN.655.800
Saunders, JoAnne Louise	M.S.	Computer Science	Raytheon Staff	PT	EN.655.467, EN.655.768
Saxon, Mark A	M.S.	Chemical Engineering	APL Staff	PT	EN.655.767, EN.655.768
Schneider, Bruce Walter	M.S.	Public Administration	APL Staff	PT	EN.655.767, EN.655.761
Secen, Albert	M.S.	Airway Science	Lockheed Martin Staff	PT	EN.655.462, EN.655.767, EN.655.768
Smithson, Clyde Spruill	M.S.	Electrical Engineering	APL Staff	PT	EN.655.761
Sprigg, Gordon L	M.S.	Digital Systems	Northrop Grumman (retired)	PT	EN.655.769
Starr, William Clyde	M.S.	Systems Engineering	APL Staff	PT	EN.655.767
Straub, Kathleen A	Ph.D.	Psychology	APL Staff	PT	EN.655.451
Sweeney, Robert L	M.S.	Operations Research	APL Staff	PT	EN.655.462
Syed, Daniel Patrick	M.S.	Electrical Engineering	APL Staff	PT	EN.655.462
Tarchalski, Stanislaw E	M.S.	Technical Management	APL Staff	PT	EN.655.769
Topper, John Stephen	M.S.	Information Systems	APL Staff	PT	EN.655.767 EN655.761
Utara, Christian	M.S.	Systems Engineering	Navair Staff	PT	EN.655.467, EN655.768
Wells, Frank	M.S.	Physics	Mitre Staff	PT	EN.655.462
White, Michael E	M.S.	Aerospace Engineering	APL Staff	PT	EN.655.768
Wolfrom, Theresa	M.S.	Software Development Lifecycle	APL Staff	PT	EN.655.761
Ziarko, Janice A	Ph.D.	Science and Technology Policy	Mitre Staff	PT	EN.655.769

School of Public Health Faculty (Electives)

Faculty Member	Degree	Field	Academic Title	Status	Classes Taught
Bandeen-Roche, Karen	Ph.D.	Biostatics	Professor	FT	140.621 140.622
Crainiceanu, Ciprian	Ph.D.	Biostatistics	Professor	FT	140.651 140.652
Golub, Elizabeth	Ph.D	Epidemiology	Senior Lecturer	FT	340.752
Diener-West, Marie	Ph.D.	Biostatistics	Professor	FT	140.621 140.622
Dy, Sydney M.	M.D.	Health Policy & Management	Professor	FT	311.615
Ehrhardt, Stephen	M.D., M.P.H.	Epidemiology	Associate Professor	FT	340.752
Gurses, Ayse	Ph.D.	School of Medicine	Assistant Professor	FT	309.732
Gange, Stephen	Ph.D.	Epidemiology	Professor	FT	340.752
Celentano, David	Sc.D	Epidemiology	Professor	FT	340.751
Morlock, Laura	Ph.D.	Health Policy and Management	Professor	FT	309.730
Pronovost, Peter	M.D., Ph.D.	School of Medicine	Professor	FT	309.730
Rosen, Michael	Ph.D.	School of Medicine	Assistant Professor	FT	309.732
Deal, Jennifer	Ph.D.	Epidemiology	Associate Scientist	FT	340.751
Wu, Albert	M.D., M.P.H.	Health Policy & Management	Professor	FT	309.730

APPENDIX C

Table 1: Program Resources

RESOURCES	2018-19	2019-20	2020-21	2021-22	2022-23
1. Reallocated Funds	$0	$0	$0	$0	$0
2. Tuition/Fee Revenue (c + g below)	$203,399	$354,253	$555,291	$696,335	$848,949
a. Number of F/T Students	0	0	0	0	0
b. Annual Tuition/Fee Rate	0	0	0	0	0
c. Total F/T Revenue (a x b)	$0	$0	$0	$0	$0
d. Number of P/T Student Enrollments	48	80	120	144	168
e. Credit Hour Rate	$1,412	$1,476	$1,542	$1,612	$1,684
f. Credits Per Course	3	3	3	3	3
g. Total P/T Revenue (d x e x f)	$203,399	$354,253	$555,291	$696,335	$848,949
3. Grants, Contracts & Other Ext Sources	$0	$0	$0	$0	$0
4. Other Sources	$0	$0	$0	$0	$0
TOTAL (Add 1 – 4)	$203,399	$354,253	$555,291	$696,335	$848,949

Resources Narrative

1. Reallocated Funds: The proposed program will be funded by tuition revenue, and will make no use of reallocated funds.
2. Tuition and Fee Revenue: The enrollment projections in Table 1 are a reasonable estimate based on growth of other JHU-EP master's degree programs. The Master of Science in Healthcare Systems Engineering is a part-time degree program, so no full-time students are expected. JHU-EP students take, on average, three 3-credit courses per year, which is reflected in the "Annual Credit Hour Rate."
3. Grants and Contracts: No grants or contacts are required for the successful implementation of the program.
4. Other Sources: The program does not expect any funding from other source.

Table 2: Program Expenditures

EXPENDITURES	2018-19	2019-20	2020-21	2021-22	2022-23
1. Faculty (b + c below)	$83,589	$160,491	$209,741	$203,500	$196,925
a. # FTE	1	2.2	3	3	3
b. Total Salary	$77,397	$148,602	$194,205	$188,426	$182,338
c. Total Benefits	$6,192	$11,888	$15,536	$15,074	$14,587
d. # Sections offered	6	13	18	18	18
2. Admin. Staff (b + c below)	$15,735	$17,815	$18,171	$20,334	$20,741
a. # FTE	0.2	0.2	0.2	0.2	0.2
b. Total Salary	$14,570	$16,495	$16,825	$18,828	$19,205
c. Total Benefits	$1,166	$1,320	$1,346	$1,506	$1,536
3. Support Staff (b+c below)	$36,720	$44,945	$53,485	$46,761	$15,899
a. # FTE	0.4	0.4	0.6	0.4	0.1
b. Total Salary	$27,200	$33,293	$39,618	$34,638	$11,777
c. Total Benefits	$9,520	$11,652	$13,866	$12,123	$4,122
4. Equipment	$0	$0	$0	$0	$0
5. Library	$0	$0	$0	$0	$0
6. New or Renovated Space	$0	$0	$0	$0	$0
7. Other Expenses	$68,921	$107,046	$157,726	$193,419	$232,013
TOTAL (Add 1 – 7)	$204,965	$330,296	$439,123	$464,014	$465,579

Expenditures Narrative

1. Faculty: The Engineering for Professionals lecturers are paid $9,106 (for 2018-19) per course taught or developed. This was used as the base rate. For years 1 – 5, an additional 2% was added to the salary rate. The fringe rate is estimated at 8%.
2. Administrative Staff: Includes salary for Program Chair and advisors.
3. Support Staff: Includes pro-rated salaries for F/T Instructional Designers to assist in developing online courses.
4. Equipment: No direct equipment costs are identified.
5. Library: Existing library facilities are sufficient to meet the needs of the program.
6. New or Renovated Space: No new or renovated space will be needed.
7. Other Expenses: Indirect program costs (based on enrollments) plus direct expenses associated with the Program Chair (conferences, travel, task support) are provided here.