



Missouri University of Science and Technology

Graduate Certificate Program in Standards and Safety in Electrical and Computer Engineering

Pourya Shamsi

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Greetings

These slides cover

- ▶ Introduction
- ▶ Goals and Objectives
- ▶ Course Development
- ▶ Delivery
- ▶ Lessons Learned
- ▶ Next Steps

Introduction – Title and Institutions

Graduate Certificate Program in Standards and Safety in Electrical and Computer Engineering

Award Number: 70NANB23H237

- **Lead Organization:**
 - Missouri University of Science and Technology
 - 202 Centennial Hall, 300 W. 12th St., Rolla, MO
 - 65409-1330
 - Phone: (573) 341-4134
 - Email: research@mst.edu
- **Subcontract Organization:**
 - ELTEK International Laboratories
 - 248 Hughes Ln, St Charles, MO 63301
 - Phone: (636) 949-5835
 - Email: Ed.Vanvooren@ELTEKlabs.com

Introduction – Team Members

- Lead IHE Organization:

Principal Investigator:

- **Pourya Shamsi**, PhD, Woodard Associate Professor of Excellence in Electrical and Computer Engineering,
- shamsip@umsystem.edu

Co-Investigators:

- **Mehdi Ferdowsi**, PhD, Associate Dean of Research and Schlumberger Professor of Electrical and Computer Engineering,
- ferdowsi@umsystem.edu
- **Jonathan Kimball**, PhD, Department Chair and Fred W. Finley Distinguished Professor in Electrical and Computer Engineering,
- kimballjw@umsystem.edu

Subcontract Organization:

Lead Investigator:

- **Ed Van Vooren**, President and CEO of ELTEK International Laboratories,
- Ed.Vanvooren@ELTEKlabs.com

Co-Investigators:

- **Jeniffer Palmer**, Vice President of ELTEK international laboratories,
- Jennifer.Palmer@ELTEKLabs.com

- We did not have another IHE as a formal project partner, so there isn't a additional IHE partner role to report.

Introduction – Period of Performance

- Period of performance: 3 years
- Award date: Sep. 2023
- Project start date: Jan. 2024
 - (delays due to federal registrations of the subcontractor)
- Status: We are nearing the end of our 3rd year (Dec. 2026)
- Change of scope:
 - In March 2024, the planned industry workshop component became infeasible due to cost constraints. We had a meeting with the program officer at the time, Dr. Raj Madhavan, and he emphasized that the priority is with academic education. So, we did not transfer additional funds for the workshops and instead, redirected the scope to create more course modules.

Introduction – Big Picture and Workforce Development

- The anticipated short-term impact of this program is the development of a framework to increase the prevalence of standards and standardization education at U.S. accredited institutions of higher education.
- The long-term impact of this program is training the next generation of engineers who are aware of how standards are developed and maintained, different standardization agencies, testing methods, and how to properly choose and apply standards in their respective fields of engineering.
- This program will strengthen U.S. workforce development by equipping graduate and undergraduate students, as well as industry professionals, with practical knowledge of standards, testing, and certification processes—ensuring a pipeline of highly qualified engineers who can enhance product quality, safety, and compliance across critical industries.

Goals and Objectives – Proposal Goals

- The main objective of this project is to develop curricula and educational material for training graduate and undergraduate-level students to understand standards, standard development, and standardization processes in engineering and sciences.
- This program will explore rules and guidelines in developing standards, testing, certification processes, and common standards used in engineering and particularly in electrical and computer engineering including IEC, UL, ISO, VDE, ITU, CSA, IPC, SAE, ... as well as MIL-STD

Goals and Objectives – Outcomes

- **Graduate Certificate Program**

- A fully developed certificate in standards and standardization at Missouri S&T (will take 2 years from the end of the program and submission of the full package to Missouri S&T)
- Develop course modules related to standards and standardization processes as well as to explore some of the common standards in EE

- **Course Delivery Options**

- Offered in both synchronous (regular semester) and asynchronous (accelerated distance learning) formats, allowing completion in as little as 3–5 weeks.

- **Replicable Model**

- A certificate “package” (curricula, course modules, recordings, training materials, and instructor guides) designed for easy deployment at other U.S. institutions.

- **Dissemination and Publication**

- Conference presentations at Missouri S&T Teaching and Learning Conference (a long-standing regional conference on education and educational technologies)
- Papers on course development methods, program impact, and outcomes.
- Public access to materials via Missouri S&T’s Scholarsmine server.

- **Evaluation Results**

- Data on trainee learning outcomes, feedback, and workforce impact to measure program effectiveness and guide improvements.

Goals and Objectives – Alignment with National Priorities

- This project aligns tightly with U.S. national and NIST priorities by creating a standards-literate engineering workforce through stackable academic credentials and openly packaged for replication across universities and industry.
- It directly supports NIST’s mission to “**advance measurement science, standards, and technology**” and FY-25 priorities to drive standards for critical and emerging technologies while strengthening U.S. manufacturing and supply chains;
- It also advances the U.S. Government’s National Standards Strategy for Critical and Emerging Technology, which explicitly calls for educating and training a new standards workforce and expanding standards-related curricula in higher education;
- And it complements the National Strategy for Advanced Manufacturing’s goal to grow and diversify the advanced-manufacturing talent pool.
- By training students and incumbent engineers in standards selection, testing, and certification—and disseminating asynchronous, portable courseware nationwide—the program enhances product quality, safety, and compliance, with particular benefits for small and medium manufacturers.

Course Development – Course 1: EE5571

- **EE5571:** Introduction to Standards and Standardization, aims to teach students the processes of developing, coordinating, and maintaining standards, including forming working groups, drafting and revising standards, exploring metrics and measurement challenges, and understanding testing and compliance requirements.
- **Reference Book:** *Primer on Engineering Standards*, O. Greulich, M. Jawad, 9781119466178
- **Modules:** Introduction, Role of Standards, Voluntary Consensus Standards, Limited Consensus Standards, Jurisdictional Standards, Standard Development Processes, Types and Conformity, Standard Interpretation, Good Standards and How to Get Involved
- EE5571 has been released as a Canvas course but does not count towards our degree program yet. But students can take it and then count is as a 3-hour special study course under my approval.

Course Development – Course 2: EE5572

- **EE5572:** Common Standards and Testing Practices in Electrical and Computer Engineering, is designed to introduce students to major ECE-specific standards (e.g., UL, IEC, ISO, SAE, MIL-SPEC), with emphasis on safety integrity levels, testing methods, and practical requirements for compliance in electrical and computer engineering applications
- **Modules:** Modules will include individual standards that we are covering and adding. Such as UL1741, IPC2221, FCC47 Part 15, DO-160,
- The goal is to have an open course where new modules can constantly be added over the years.
- EE5572 has not yet officially been released as a Canvas course.

Course Development – Course Structure and Offline Courses

- Due to shortage of teachers on our campus, we decided to deliver this course (and some of our existing courses) in the offline asynchronous mode for now.
- Our Power Engineering Group went from 5 professors down to 4, and Dr. Kimball is now acting as the department chair and Dr. Ferdowsi is acting as the Associate Dean for Research. So we are down to two effective professors for all of our power courses. As a result, for now, course modules for some of our 6000 level courses as well as non-mandatory courses such as the two courses developed under this program, are being offered as offline classes.
- Offline mode means a teacher pre-records all course videos and prepares course notes and places them on our campus Canvas server. Students will take the course without any live class sessions. They can watch the videos on their own time and submit the assignments when due.
- The professor will set up the assignments and updates the due dates for each semester the course is offered and grades them when submitted.
- This will minimize the burden on the department for higher level classes where students can manage on their own.

Course Development – Curriculum (slide 1 of 3)

- Course 1 has the following key modules:
 - History of Standards and Standardization
 - Role of the U.S. Government in Standards
 - Common Types of Standards Including Codes, Voluntary and Limited Consensus, ..
 - Standard Development Processes and Assessment
- Course 1 has the Learning Objectives:
 - Learn the fundamentals of standards and the need for them
 - Demonstrate an understanding of standard types, governmental, jurisdictional, and voluntary consensus standards
 - Understand the process of developing a standard
 - Develop a concern/comment and participate in a mock standard revision session

Course Development – Curriculum (slide 2 of 3)

- Course 2 is being developed as an expandable modular standards library. The current collection does not yet constitute a full standalone course.
- Course 2 has the following key modules:

- Introduction to some of the most used standards and agencies related to electrical engineering

- Introduction to some commonly used consumer-level standards

- UL 94 → material flammability

- FCC Part 15 → conducted/radiated emissions

- UL/IEC 62368-1 → product electrical safety

- IEC 60664-1, UL 840 concepts → insulation coordination, creepage, clearance

- IEC 61000 family → EMC immunity/emissions concepts

- NEMA 1-15, UL 498, UL 1363, UL 1449, NEC → U.S. plug/interface requirements, power taps, and surge protection

- Introduction to some commonly used industrial and power converter standards

- UL 1741, UL 508A → Inverters, converters, controllers, interconnection equipment, and control panels

- IEEE 1547 → Interconnection of DER with electric power systems

- DO-160, DO-254, DO-178C → Environmental/EMI qualification and design assurance for airborne electronic hardware

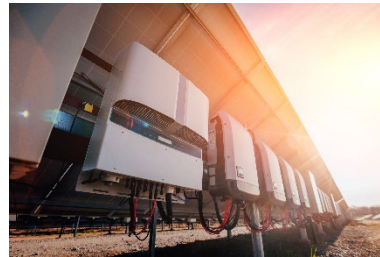
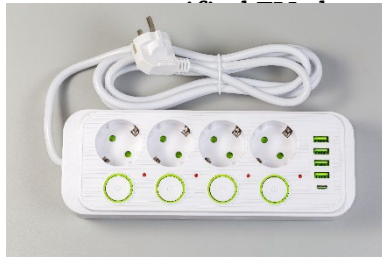
- ISO 26262, SAE J1772, ISO 16750 → Functional safety, environmental/electrical testing, and charging of automotive electrical/electronic systems

- IEC 61508 → Functional safety of electrical/electronic/programmable systems

- IEEE C37, C57, and 519 → Switchgears, transformers, and harmonics in power systems

Course Development – Curriculum (slide 3 of 3)

- Course 2 has the Learning Objectives:
 - Understand various agencies and standards used in the field of electrical power engineering
 - Understand the safety, performance, environmental, and compliance requirements addressed by engineering standards.
 - Apply selected standards and compliance concepts to evaluate representative products, including:
 - Consumer power strip with USB-C charging
Deceptively simple. This device needs more standard coverage than most residential appliances
 - Solar inverter
Exposes students to significant industrial standards in our field such as UL1741 and IEEE1547
 - EV charger
Exposes students to transportation standards and how standards such as ISO 26262 and SAE J1772



Course Development – Course Infrastructure

- Courses are developed in Canvas framework:
 - Course modules in a clear modular format with submodules dedicated to each specific topic
 - Module submodules include recorded videos and uploaded class notes of each sub-topic
 - Each module will have an assessment
 - Solution to the assessment is recorded and will be automatically released when the student uploads their response
 - Courses are planned for asynchronous delivery
 - Our goal was to have completely independent modules so that a student or an instructor would be able to skip modules
- Course 2 is aimed for expansion over the years with new modules on additional standards in electrical engineering as more faculty participants start to create modules for standards relevant to their fields
- As of now, the main focus of our course 2 is Electrical Engineering -> Standards directly related to students in power engineering: motor drives, power electronics, power systems, and consumer electronics

Course Development – Pilot Deployment

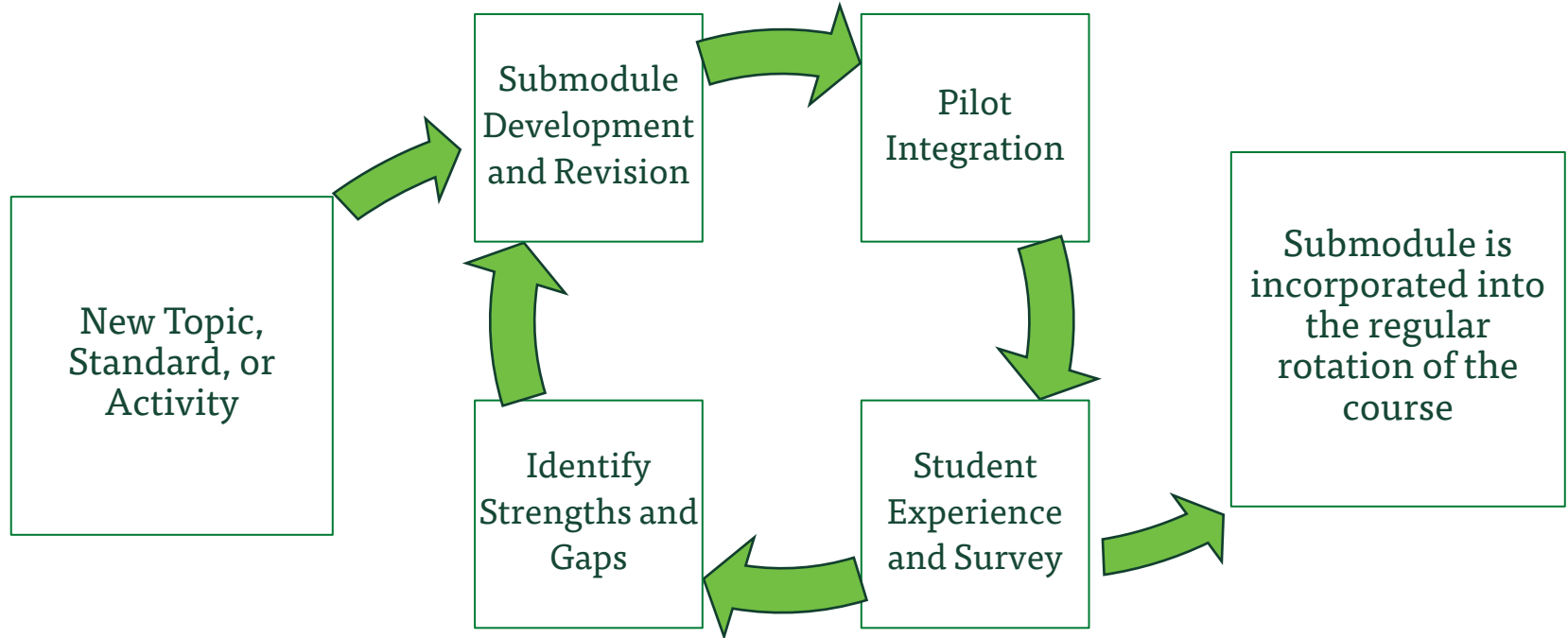
- As it was mentioned before, currently courses are going through pilot deployment with modules covered in our EE5570 (high voltage engineering), and EE6500 (AC motor drives).
- A student can take the courses voluntarily without being counted towards their degree program.
- A student can take the courses towards their degree program as a special study course. Graduate students can take both courses in this manner. However, undergraduate students can only take 1 special study course.
- The courses will be released as fully asynchronous registered courses counting towards the degree program of students within 1-2 years.
- After the release of the courses, the full certificate program will be executed.

Course Development – Assessments

- As these courses are not mathematical problem solving classes, assessments are made based on
 - Participation in a mock standard revision activity
 - Participation in a mock product certification checklist
 - Written explanatory responses to questions regarding standards and standardization
- Grading
 - Grading is based on participation on the assessment activities
 - Canvas engagement analytics, including video participation, may be used to assess student engagement and identify incomplete participation.
 - Grading scheme has to be suitable for an asynchronous deployment where instructor/student interactions can be very limited

Curriculum Evaluation Framework

- Our overall approach is as follows



Curriculum Evaluation Framework (continued)

- **Our metrics for evaluation are as follows.**
 - **Knowledge gained and usefulness as an engineering/design resource**
 - **Confidence in applying concepts professionally**
 - **Effectiveness of course delivery**
 - **Accessibility for working students**
- ▷ Student feedback is supplemented by faculty expertise and input from our industrial and entrepreneurial advisory board, particularly for evaluating technical relevance and industry applicability.

Portability and Adoption by Other IHEs

- **The following adoptions are possible and supported by our process:**
 - 1. Adoption of the full course content as an individual course
 - 2. Adoption of select submodules for integration into an existing course
 - 3. Adoption of our certificate program
 - Only applicable to institutions with similar graduate certificate programs: 2 certificate courses + 2 relevant courses of student's choosing

Modularity helps adoption:

- No immediate need to create a new degree program
- Faculty can select modules relevant to their discipline
- Asynchronous materials reduce instructor preparation burden
- Modules can be updated individually as standards evolve
- Common core material can be supplemented with discipline-specific standards

Portability and Adoption by Other IHEs (continued)

- Institutions that use Canvas can readily copy course content into their own Canvas.
- Lecture recordings are made via Zoom and are saved on our campus's PanOpto platform and is automatically transcribed. These can be downloaded and moved to another IHE's platform to be integrated back to Canvas.
- Institutions that do not have canvas can get the class notes as a PDF/PPT file and the lecture recordings as video files organized in folders according to modules and submodules.

Lessons Learned

- **Developing standards content outside the team's primary area of expertise:**
 - Standards knowledge is highly discipline-specific. Our original model anticipated contributions from faculty across multiple ECE areas; however, obtaining sustained faculty participation proved challenging given competing teaching and research responsibilities.
 - Development of discipline-specific standards modules benefits from combining faculty expertise with input from industry advisory boards and practicing engineers.
- **Industry expertise:**
 - Our team's direct experience with power-electronics product development and manufacturing provides practical knowledge of standards relevant to power engineering. However, standards knowledge is highly discipline-specific. Industry advisory boards and practicing engineers can therefore play an important role in identifying standards appropriate to other ECE disciplines.

Lessons Learned (continued)

- **Asynchronous Delivery:**
 - Asynchronous delivery has allowed us to offer new modules and courses that were otherwise impossible to be incorporated to our curriculum due to lack of resources, lack instructors, and not meeting the minimum class enrolment.
 - Asynchronous delivery allows students, and in particular, graduate certificate students, to take academic courses without them interfering with their work. Their companies often pay for these classes but “time restrictions” are the bottleneck for increased enrolment in such classes. Asynchronous and off-line offerings remove these burdens.
 - Asynchronous offering is of high interest for our working and graduate students. But our undergraduate students prefer interactions with a live teacher as well as the lively flow of conversation in the classroom.

Lessons Learned – Key Takeaway for Me, as the PI

- **Asynchronous Delivery:**

- The underlying observation is actually one of the more interesting things in the presentation: when you returned to teaching a previously asynchronous course live, you realized that student facial reactions caused you to pause, clarify, and expand material which is something a prerecorded instruction can't reproduce.

-> Our campus is moving towards this approach for our high-level classes. We develop a complete course as an offline course and will start offering it for students to take. In semesters that we have more teacher availability; we allow an in-person section for the same course. While students have access to the full content of the offline class, a lively fast review and summery of the course is offered in the class (which is also recorded) which allows for added content if questions rise up.

Student Surveys

- **There are 2 major topics we are getting feedback for:**
 - Delivery Method: Offline asynchronous is still considered as new on our campus
 - Course Content: The survey results change drastically as more modules are added

Delivery Method Assessment

- Questions Regarding the Async. Mode with Permanent Access to Recordings**

	Completely disagree	Somewhat disagree	No difference	Somewhat agree	Completely agree
An offline mode of the course allowed you to learn at your own pace.	7%	5%	10%	11%	67%
Missing sessions is an issue with in-person mode.	15%	2%	37%	21%	25%
I watched every recorded session.	13%	2%	4%	26%	55%
At least I watched the sessions that I deemed are relevant to my work.	3%	0%	2%	14%	81%
Offline mode allowed me to take this course without it interfering with my job.	0%	0%	7%	14%	79%
Offline mode allowed me to fast forward parts of the course I don't care for much.	3%	1%	13%	37%	46%
Offline mode allowed me to rewatch some sessions.	4%	0%	0%	9%	87%

Delivery Method Assessment (continued)

- Questions Regarding the Offline Delivery Method

	Completely disagree	Somewhat disagree	No difference	Somewhat agree	Completely agree
Live interactions with the teacher in the classroom makes me learn more.	8%	1%	34%	15%	42%
Canvas chat box and email do not fill the void of having live interactions with the teacher.	14%	4%	22%	30%	30%
Instead of offline classes, you should offer evening distance classes: * This semester, we have a short in-class session of our offline class	9%	10%	50%	18%	13%
If the class is offered in the evening synchronous mode instead, I would attend every sessions	20%	6%	35%	21%	18%
I took this class because no other classes were available.	62%	22%	9%	4%	3%
Offline course seemed longer than the in-person course.	27%	13%	33%	16%	11%
Overall, I was happy with the quality of the lectures and recordings.	1%	3%	2%	21%	73%

Content Assessment

- Questions Regarding the Content

	Completely disagree	Somewhat disagree	No difference	Somewhat agree	Completely agree
The topic of this course was not relevant to me.	84%	6%	10%	0	0
I feel I learned new topics.	0	3%	4%	20%	73%
feel I can speak with more confidence in a job meeting.	1%	7%	1%	29%	62%
I feel I got exposed to a strong tool I can use in my designs.	0	2%	8%	38%	52%
Overall, I was happy with the quality of the lectures and recordings.	1%	3%	1%	22%	73%

Next Steps

- Remainder of Project

- Complete and finalize the remaining Course 1 modules
- Continue development of priority Course 2 standards modules
- Complete recordings, notes, and assessments
- Continue pilot deployment and student evaluation
- Revise modules based on evaluation results

- Post-Project

- Transition modules into formally registered courses
- Continue expanding Course 2 as new standards become relevant
- Engage additional faculty/industry advisory board members to identify additional discipline-specific standards
- Package course materials for adoption by other IHEs
- Pursue formal implementation of the Graduate Certificate through Missouri S&T's established approval process

Acknowledgements

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Thank You

