# An Innovative Transfer Track from Associate in Applied Science in Electrical Engineering Technology to Bachelor of Science in Electrical Engineering

**Dr. Robert A. Strangeway, Milwaukee School of Engineering**

Dr. Robert A. Strangeway is a Professor of Electrical Engineering and Computer Science at Milwaukee School of Engineering (MSOE). He was the Program Director of the BS Electrical Engineering Technology program at MSOE from 1997-2003 and is currently the AAS-EET to BS-EE Transfer Track Coordinator. He earned his Ph.D. from Marquette University in 1996. He has 34 years of experience in microwave/millimeter-wave technology and is currently performing research on millimeter-wave components and systems at Medical College of Wisconsin, Milwaukee, WI. He is a member of the IEEE and teaches courses in circuits, signals, electromagnetic fields, and RF/microwaves.

**Dr. Stephen M. Williams P.E., Milwaukee School of Engineering**

Dr. Stephen Williams, P.E. is a Professor and Chair of the Electrical Engineering and Computer Science (EECS) Department at Milwaukee School of Engineering. He has over 25 years of engineering experience across the corporate, government, and university sectors specializing in: engineering design, electromechanical systems, sensor technologies, power electronics and digital signal processing. His professional activities include: program chair of the Electrical and Computer Engineering Division of the American Society for Engineering Education; chair of a new IEEE program on Early Career Faculty Development; editorial board of IEEE/HKN The Bridge magazine; and ABET EAC program evaluator.

**Dr. Edward W. Chandler P.E., Milwaukee School of Engineering**

Dr. Chandler is Professor of Electrical Engineering and Computer Science at Milwaukee School of Engineering (MSOE). He received the Ph.D. degree in electrical engineering from Purdue University in 1985 and is a registered Professional Engineer in Wisconsin. He previously was a Member of Technical Staff at L-3 Communications and currently performs systems engineering consulting in the area of communications for DISA (U.S. DoD). He is a Senior Member of the IEEE, and teaches courses in circuits, signals, communication systems, and networking.

**Dr. Richard W. Kelnhofer, Milwaukee School of Engineering**

Dr. Kelnhofer is the Program Director of Electrical Engineering and an Assistant Professor at Milwaukee School of Engineering (MSOE). Formerly, he held engineering and managerial positions in the telecommunications industry. He received his Ph.D. in Electrical Engineering from Marquette University in 1997 and is a Professional Engineer registered in the State of Wisconsin. Dr. Kelnhofer teaches courses in circuits, communication systems, signal processing, and information and coding theory.

**Dr. Owe G. Petersen, Milwaukee School of Engineering**

Dr. Petersen is Assistant VP of Institutional Research and Assessment, Professor Emeritus and former Department Chair of Electrical Engineering and Computer Science at Milwaukee School of Engineering (MSOE). He is a former Member Technical Staff at AT&T Bell Laboratories and received his Ph.D. degree from the University of Pennsylvania in 1971. His technical work ranges over topics such as Optical Data Links, Integrated Circuit Technology, RF semiconductor components, and semiconductor component reliable. He is a Senior Member of the IEEE and an ABET EAC program evaluator in Electrical Engineering.

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Abstract

A new curriculum path has been developed to achieve a Bachelor of Science in Electrical Engineering (BSEE) degree via an efficient transfer track from eight different Associate in Applied Science in Electrical Engineering Technology (AAS-EET) programs. The transfer from an AAS-EET program into a BS engineering program often requires three or more years of courses beyond the AAS degree to complete the BS engineering degree, whereas the transfer from an AAS-EET program to complete a BS engineering technology program can typically be accomplished with two additional years. The latter is referred to as a two-plus-two transfer track. The track described in this paper is not pure two-plus-two, but is two additional academic years plus a small set of general education courses. Other transfer track features include articulation agreements with the two-year colleges, tightly coordinated curricula, and sustained, close interaction between the faculties of the two- and four-year institutions.

The primary attribute underlying this innovative transfer track is the utilization of bridge courses in both the AAS-EET program and the BSEE transfer program. Bridge courses are designed to efficiently transition students from an AAS background to meeting BSEE requirements without unnecessary repetition. The AAS-level bridge courses in this transfer track begin this transition in content, rigor, and perspective from an engineering technician to an engineer. The BS-level bridge courses, which occur early in the BSEE transfer curriculum, continue and complete the transition.

This new transfer track is a modification of an existing two-plus-two AAS-EET to BS-EET transfer track. An accumulation of ten years of assessment data for the existing AAS-EET to BS-EET transfer path was used in designing the new transfer path to the BSEE degree. This paper provides the rationale for making the change from BS-EET to BSEE, reviews some historic enrollment and retention data on the BS-EET program, describes general experiences with the articulation agreements, describes in detail the AAS-EET and BSEE curricular structures and bridge courses, identifies the different types of sustaining institutional interactions, and reviews the early success in attracting transfer students from the AAS-EET programs to the BSEE program. Other aspects, such as AAS-EET faculty qualifications and the applicability of the approach to other institutions, are discussed.

## Introduction

The recognition of engineering technology programs in the academic engineering community has been a controversial issue for decades despite industry being generally more concerned about the performance of graduates from engineering or engineering technology programs hired into engineering positions.[1,2,3,4,5] (Accredited four-year engineering technology programs are assumed in this paper unless stated otherwise.) In academia, engineering technology programs have been generally viewed as inferior to engineering programs in student preparation for industry, despite position and wage evidence to the contrary for graduates of some but not all engineering

technology programs. There is some differentiation by industry, especially for research and development positions. Some companies have blanket policies preventing engineering technology graduates entering engineering positions, often due to the wide variation in graduate preparation by engineering technology programs. Furthermore, graduates of engineering technology programs experience widely varying extents of acceptance for entry into graduate-level engineering programs. Cumulatively, these perceptions and realities of engineering technology programs have been drawbacks that have persisted for decades[2,6,7,8,9,10] and have shown no significant amelioration despite numerous proposals to the contrary, including no progress in the "applied engineering" degree title.

Graduates of two-year associate degree engineering technology programs, hereafter referred to as AAS-ET programs, that decide to pursue degrees in four-year engineering programs, essentially start over due to the low number of courses that transfer. There has been significant progress in general education course transfers from two-year technical colleges into four-year colleges and universities due to public pressure for improved transferability. However, little if any technical coursework transfers, often due to the incongruity between the educational approaches in the first two years of an engineering program and a typical AAS-ET program. Some notable transfer models and studies of AAS-ET to BS-ET exist, but the fundamental issue of the engineering technology degree title is not addressed.[11,12,13,14,15]

An alternative approach is to have curricula at the AAS and BS levels that maintain the objectives of the two-year degree and that also provide an efficient path to the BS-level engineering degree. In particular, the AAS electrical engineering technology (AAS-EET hereafter) program must prepare students to function as engineering technicians in industry and it must initiate the transition in rigor and perspective from that for a technician to that for an engineer. The transfer track in the BS electrical engineering (BSEE hereafter) program must continue and complete this transition.

The subject of this paper is a well-defined path from AAS-EET programs into a BSEE program. The primary contribution here is the path within the BSEE program for AAS-EET transfer students. The path overcomes the "start over" drawback traditionally encountered in AAS-ET to BS engineering transitions. More importantly, the path deliberately engenders a transitional experience from a technician-based outlook to an engineering-based disposition. The transitional experience is started in the AAS programs and "bridges" into the BS program using specially designed courses. We believe these "bridge courses" are vitally strategic to ultimate success of transfer students in the BSEE program. There is a consequence for this transitional experience: the transfer arrangement is not two-plus-two. However, it is significantly less than the three or more post-AAS-ET years usually encountered in AAS-ET to BS engineering arrangements that utilize course-for-course transfers.

In addition to curricula that are designed for transferring students, the two and four-year programs should also have operational infrastructure that supports the transfer path, and this infrastructure needs to be at both the institutional and academic levels. The former is often in place for many colleges and universities, but the latter is not.

This paper is organized as follows. In the Background section, the two-plus-two AAS-EET to BS-EET transfer arrangement from seven colleges in the Wisconsin Technical College System (Fox Valley Technical College, Gateway Technical College, Madison Area Technical College, Milwaukee Area Technical College, Northeast Wisconsin Technical College, Waukesha County Technical College, and Western Technical College) and College of Lake County in Illinois, hereafter referred to as the AAS colleges, to Milwaukee School of Engineering (MSOE) will be reviewed. The AAS-EET bridge courses that have been utilized in this previous two-plus-two AAS-EET to BS-EET transfer arrangement will be re-examined in terms of the insights and experience gained over the past decade. Performance measures of BS-EET students and graduates from this transfer arrangement are summarized. In the BSEE Transfer Path Curriculum section, an overview of the current BSEE program is given as a context. The overall constraints of an AAS-EET to BSEE transfer arrangement are stated. The major curricular feature that distinguishes this path within the BSEE program, bridge courses within the post-transfer curriculum, is examined in detail. Accreditation and assessment processes are discussed. In the Transfer Infrastructure Operation section, various aspects of the faculty, transfer student recruitment, and transfer agreement maintenance are examined to document proven sustainability practices. In the Discussion section, initial results, AAS-EET faculty qualifications, the applicability of the transfer model to other institutions, and benefits to the university are discussed.

## Background

A two-plus-two AAS-EET to BS-EET transfer arrangement has been operating successfully at MSOE for the past ten years. In this arrangement, AAS-EET students from the AAS colleges who decided to continue their education at MSOE could transfer and complete the BS-EET degree in two full-time academic years, or four calendar years on a part-time track. MSOE had AAS-EET to BS-EET transfer agreements with the eight AAS colleges previously identified. The details of this AAS-EET to BS-EET transfer arrangement are described in a paper by Strangeway et al.[15] and are summarized in this section.

The typical foundation of these AAS-EET programs is an algebra-based electronics technology program. The primary curricular feature of this transfer arrangement is that four bridge courses, two in calculus and two in advanced circuit analysis, are typically taken during the second year in the AAS-EET program. These courses were prerequisites to entry into the BS-EET program and have proven to provide essential transitional experience for transfer students, both in terms of academic background and rigor appropriate for baccalaureate studies. The AAS-level bridge courses extend student background and analysis capabilities by increasing requirements of developments and derivation approaches as the courses progress. The calculus courses provide a mathematical foundation for rigor at the BS-EET level.

The circuit analysis bridge courses, referred to as electronics bridge courses, begin the transition in the students from a task-based technician mentality into an engineering problem solving outlook. In addition, a higher level of mathematical development and usage is infused into the courses preparing the student for the transition. The first electronics bridge course is AC phasor-based circuit analysis, common to most ETAC-accredited EET programs but not emphasized in many unaccredited AAS electronics technology programs. The main topics

include AC series-parallel circuit analysis, complex power, nodal analysis, Thevenin and Norton equivalent circuits, ideal transformers, and balanced three-phase circuits. The students become conditioned to the rigor of complex number-based circuit analysis. In the second course, circuit analysis with frequency as a variable is the central theme. The major topics are AC steady-state transfer function development and Bode plots of first order, three-element RL and RC circuits, development of resonant circuit equations, and development of transistor amplifier bias equations, mid-band gain equations, and AC steady-state transfer functions for frequency response. This course extends previous complex number-based circuit analysis techniques to a level of variable-based circuit analysis that has students formulating algebraic strategies, a clear level above the first electronics bridge course.[16] Macroscopically, the students are transitioning to the next level of abstraction and complexity in both the calculus and the electronics bridge courses, essential skills for engineers. A notable benefit of these bridge courses is the more uniform background that results among transfer students that entered the BS-EET program.

When the transfer students entered the BS-EET program, they continued their development in first-term courses that included differential equations; a periodic signal, Fourier series-based circuits and signals course; and a VHDL digital course with design. Beside reinforcement of previous AAS-EET coursework, these courses served as the interface to the higher level of rigor and expectations in baccalaureate studies. The circuits and signals course was the focal point in this regard. Calculus was used extensively in the course for determination of average and effective values of periodic waveforms and for deriving Fourier series coefficients. The authors are unanimous in their opinions that this course, and the first academic term in the BS-EET program in general, was the focal point in the transition from the AAS-EET outlook to an engineering perspective (within the BS-EET program). The AAS-EET to BS-EET transfer transition is further described in Strangeway et al.[15] Although it was not required that the senior project was a design project, all BS-EET senior projects were design projects that were indistinguishable in level and scope from projects completed by traditional BSEE students at the same institution.

Since fall term 2003, 231 students from these AAS-EET programs transferred into the BS-EET program at MSOE, 44 are currently attending, six have changed programs to EE, and 147 have graduated to date. The graduation rate, not counting students currently in the BS-EET program and those who changed programs to EE, is 81 percent. If students who left the program before graduation in good academic standing are removed from the data, the graduation rate is 96 percent. The BS-EET placement rate into industry or graduate school within six months of graduation for those who registered with the university placement office was 94 percent from 2005 through 2012. For each of the years during this period, the average starting salary for BS-EET graduates was normally within ten percent of the average for BSEE graduates at MSOE, sometimes under, sometime greater. The vast majority BS-EET graduates took entry-level positions as engineers. For example, of the 41 BS-EET graduates from the 2009-10 through the 2012-13 academic years who reported their job titles, 35 titles explicitly contained the word "engineer," "design," or "designer;" four titles implied engineering functions, such as consultant; and two titles were clearly not engineering positions. Furthermore, 13 graduates are known to have entered engineering graduate school and four graduates entered other master's degree programs. Nine of those 17 are known to have graduated and six are currently enrolled. Overall, the graduates of this AAS-EET to BS-EET transfer arrangement were obtaining

engineering positions in industry at the going placement rates and wage levels of BSEE graduates, and a substantial number were entering graduate school. The majority of those who entered graduate school entered MS engineering programs. These BS-EET graduates are engineers with a BS-EET credential.

BSEE Transfer Path Curriculum

The current BSEE program at MSOE is a mainstream EAC-accredited EE program. It is broadly-based in core EE coursework, that is, circuits, digital and analog electronics, embedded systems, programming, analog and digital signal processing, dynamic and feedback control systems, electromechanical energy conversion, electromagnetic fields and transmission lines, communications, and an academic year-long senior design project sequence. There are four EE program technical electives that allow for some specialization at the undergraduate level.

Students who previously transferred from an AAS-EET program usually required three or more additional years to complete the traditional four-year BSEE program at MSOE due to the incongruity between programs in the first two years. In particular, circuits and physics of mechanics in the AAS-EET programs are typically algebra-based as opposed to calculus-based in the EE program. Analog and digital electronics and microcontroller courses usually do not have significant design content in AAS-EET programs compared to their EE counterparts. Any remaining calculus coursework required in the BSEE program that is not taken at the AAS college needs to be completed by transfer students. Thus, the first year or more in the BSEE program taken by these transfer students was needed to remedy these deficiencies.

The transfer path described in this paper overcomes the inefficiency of the previously described, typical transfer process. The strategic innovation was the realization that bridge courses at *both* the AAS-EET level and the BSEE level could greatly improve both the time efficiency and effectiveness in the AAS-EET to BSEE transition. The AAS-EET bridge courses, established and time-proven, were retained for this AAS-EET to BSEE transfer arrangement. Hence, the salient task became the definition of the bridge courses at the BSEE level. The deficiencies previously identified for those AAS-EET graduates who transferred into the BSEE program prior to the existence of a transfer arrangement became the source material to design the bridge courses. Ironically, and in hindsight not surprisingly, the BS-EET “front-end” courses used in the AAS-EET to BS-EET transfer arrangements addressed most of the deficiencies and required only modest changes to fulfill the requirements of the AAS-EET to BSEE transition. These courses are described below.

The primary consideration for the transfer path is that AAS-EET transfer students efficiently transition into and complete the remaining requirements of the traditional BSEE track. Because transfer students will complete most of the same upper division courses in the traditional BSEE track, their educational background will be equivalent to that of students who complete the traditional track. Thus, program standards and assessment measures apply equally to both the traditional and transfer students in those courses after the transition.

The BSEE bridge courses are in the first year of the transfer track at MSOE. The first term (quarter system) consists entirely of bridge courses:

- Signals and Circuits I
  - Pre-requisites: AAS-EET electronics bridge courses, technical calculus
  - Power, average and effective values of periodic waveforms, and passive circuit responses to periodic signals reinforce and extend previous circuit analysis as well as incorporate calculus in a signals context, for the first time for most AAS-EET transfer students.
  - Dependent source and ideal operational amplifier circuit analysis strengthen circuit analysis aspects that are not emphasized at the AAS-EET level. The development of the input-output equations for a wide variety of linear operational amplifier circuit configurations is emphasized.
- Design of Logic Systems
  - Pre-requisites: AAS-EET digital circuits and microcontrollers courses
  - Design of combinational and sequential logic and storage elements
  - VHDL is used for design and an FPGA is used for logic realization, culminating in a major design project.
  - Design methodologies are emphasized.
- Engineering Mathematics
  - Pre-requisite: one year of typical technical calculus
  - Aspects of engineering calculus that are not covered in technical calculus
  - Vectors and vector functions, line integrals, parametric equations, directional derivatives, and so forth
- Differential Equations
  - Pre-requisite: one year of typical technical calculus
  - Essentially the same content as the standard differential equations course in the traditional BSEE track
  - Transitions technical calculus rigor to engineering differential equations rigor
- Orientation
  - Pre-requisite: transfer student status (24 quarter credits) for previous experience with college logistics
  - A one-day Saturday course for transfer students of all majors, usually held at the end of the first week of classes, informs students of policies, procedures and resources unique to MSOE.

Three of the five courses in the second term are bridge courses with an increasing alignment to traditional track BSEE courses:

- Signals and Circuits II
  - Pre-requisite: Signals and Circuits I, Differential Equations
  - Analytic and graphical expression of aperiodic waveforms, emphasizing the ramp, step, and impulse functions and the associated interpretations
  - Calculus-based development of the i-v relations for reactive components
  - Analysis of first and second order circuits in the time domain using differential equations
  - Passive circuit analysis using Laplace transforms
  - Operational amplifier integrator and differentiator circuit analysis
  - Completion of this course brings students to the same status in circuit analysis as the corresponding BSEE traditional track course.

- Embedded Systems
  - Pre-requisites: AAS-EET digital circuits and microcontrollers courses
  - Design and implementation of real-time applications using interrupts, and interfacing external devices to the system
  - High level programming language used for programming purposes
  - Design, including a major project, is emphasized.
  - Completion of this course brings students to a comparable status in embedded systems as the corresponding traditional track courses.
- Chemistry
  - Pre-requisites: technical calculus, AAS-EET physics of mechanics
  - Essentially the same course content as the sophomore-level chemistry course in the traditional engineering tracks at MSOE
  - Does not have a high school chemistry prerequisite, but the course is conducted at the junior level (strong problem-solving skills are assumed) to make up background relative to the traditional track course

The two other courses in the second term, both of which are in the traditional BSEE track, are Linear Algebra and a career/professional guidance course. The third term has only one bridge course:

- Dynamic Systems (electromechanical system modeling, state space)
  - Pre-requisites: algebra-based physics of mechanics, Signals and Circuits II (which guarantees calculus, differential equations, and Laplace transforms backgrounds)
  - Co-requisite: Linear Algebra
  - Front-end emphasis on the calculus of translational and rotational mechanics is used to remediate the algebra-based physics of mechanics (this bridge course has one extra credit relative to the traditional track course for this topic).
  - Mechanical, thermal, electromechanical, fluid, and operational amplifier systems—same content as the traditional track course

All remaining 27 courses in this transfer path are courses in the traditional BSEE track. There are no bridge courses in the senior year. All of the bridge courses are prerequisite to other traditional track core courses except for Design of Logic Systems (a terminal core course with possible subsequent electives). The summarized details of these bridge courses convey the intent to transition the technician outlook to an engineering perspective. Hence, the bridge courses do "bridge" the AAS-EET student backgrounds and disposition to the BSEE requirements.

The incorporation of bridge courses on the baccalaureate side of the AAS-EET to BSEE Transfer Track forced the scheduling of six general education courses (18 quarter credits) outside of the two full-time academic years on the transfer track, which is why the program is not two-plus-two. However, students can opt to take these general education courses at the AAS college, during summers, and/or in an additional term(s) at the end of the program. We have found that many students are at the AAS college beyond two years and request the identification of general education courses that can fill their final year there and also transfer to the BSEE degree-granting institution. Any suggested courses in this regard are thoroughly documented to ensure they are

transferrable to our university, to prevent redundant courses, and to check that general education requirements (such as social sciences/humanities balance) are satisfied.

The BSEE transfer path has admission constraints at the program level. The AAS-EET competency-based requirements are prerequisite to BSEE program entry, as established in the transfer agreements. The admission GPA from the AAS-EET program matches that for transfer students into any engineering program at the university, currently 3.0/4.0. A grade of 'C' or above is required in the pertinent courses from the AAS-EET program. Historically, we have observed that students who excel in the AAS-EET bridge courses perform well at our university.

Full-time and part-time tracks run simultaneously in the AAS-EET to BSEE transfer path. The first section of any given course is offered in the evening so that part-time working students also have access to the course. If enrollments are sufficient, then an additional day section is offered. The reader interested in these detailed logistics is referred to the paper that describes the previous AAS-EET to BS-EET transfer track.[15]

Program outcome assessment is structured within courses that are common to both the traditional and transfer tracks. There is additional assessment in the bridge courses to monitor program prerequisites with a feedback loop to the AAS-EET program faculty (described later). Finally, the credit counts of the transfer and traditional tracks are aligned when counted in terms of BSEE equivalent credits. There are more credits in an AAS-EET program than those counted toward the BSEE program. For example, all of the DC/AC and electronics bridge courses in an AAS-EET program, nominally 16.5 quarter credits, are counted as nine credits in the BSEE program.

Transfer Infrastructure Operation

A proper operational infrastructure is also essential to the success of the transfer program. Much of this support was already in place at MSOE for the AAS-EET to BS-EET transfer arrangement. Optimally, the infrastructure should provide support at the institutional and academic levels. At MSOE, the institutional infrastructure consists of admission counselors dedicated to transfer students, and the faculty and administration with defined duties that create an awareness of the transfer opportunities, that actively recruit potential AAS-EET transfer students, and that maintain relationships with the faculty and administration at the AAS colleges.

Transfer admission counselors are designated to handle transfer student recruitment and logistics. They manage the admission process for these students and are in frequent communication with them. They coordinate transcript evaluation with the transfer track program advisors, who are faculty members. Over one third of the prospective transfer students have transcripts from multiple colleges, each of which requires transfer credit evaluation. The transfer admission counselors communicate transfer evaluation results to the prospective students and coach them regarding subsequent steps in the admission process as needed. They coordinate open house and new student orientation events. They occasionally travel with the program faculty in AAS college recruitment visits. Their commitment and involvement to the transfer student recruitment and conversion process is indispensable.

Awareness of the transfer opportunities is created and promoted in several manners:[15]

- Support of the AAS colleges' recruiting efforts by attending their open houses
- Sample lectures given by BSEE faculty members in AAS-EET bridge courses and occasionally other AAS classes
- Transfer presentations in AAS-EET bridge courses and occasionally other AAS classes
- One-on-one advising of potential transfer students at the AAS college site
- Cross-participation on the programs' industrial advisory committees
- Participation in joint curriculum review and design
- Faculty and administration consultations on annual renewal of transfer agreements

These activities are always on-going. The BSEE program faculty and administration as well as the institution must support these activities for transfer program success. The transfer track program faculty must be dedicated to the implementation of the activities. It should be noted that sample lectures by the MSOE EE faculty given at the AAS colleges are also used to deliberately initiate awareness of the transition to increased rigor that prospective students will encounter.

At the academic level, support consists of dedicated faculty members versed in the "bridging" process. These faculty members coordinate the operation of and updates to the bridge courses, assist the AAS-EET to BSEE transition process, provide classroom materials to other faculty members, and mentor faculty. Mentoring is provided by the bridge course coordinators to adjunct faculty members, and institutional support is provided by in-service events. The program faculty must perform transfer track prerequisite assessment and feedback implementation.

The AAS-EET and BSEE faculty members must interact regularly. A subcommittee of the BSEE program's advisory committee was developed with AAS-EET program representatives. This subcommittee meets to formally discuss topics such as assessment data, curriculum, course issues, program promotions, and so forth. In addition, BSEE faculty members are on each of the AAS-EET advisory committees. Discussions are also held at a larger level at state-called meetings of the AAS electronics programs faculty (BSEE faculty members for transfer tracks are also regularly invited). The interactions of the faculty members at advisory committee meetings both at the AAS-EET and BSEE institutions has been constructive in evolving program updates and changes on a coordinated, consensus basis. Annual renewal of the transfer agreements inspires frequent conversations between faculty members and counters curricular drift.[15]

Discussion

The AAS-EET to BSEE Transfer Track was launched in the Fall 2013 term when 25 AAS-EET students transferred into the BSEE program. As of the second term, 23 of these students continued on track (one student continued off-track and one plans to return in the spring term). The most significant issue identified for this transfer group was students taking on heavy composite workplace/academic overloads, despite strong academic advising to the contrary. Earlier and more aggressive academic advising in this regard is planned for future transfer groups.

An early barometer of the transfer students' transition is their performance in the Signals and Circuits I bridge course because it is an indicator of their adjustment to the increased mathematical usage and rigor. Just three of the 23 final course grades were below 'C.' The final course grade average for the class was 2.7 on a 4-point scale with a standard deviation of 0.8. The performance is judged respectable. The more revealing performance will be in the Signals and Circuits II bridge course because it further indicates their adjustment to the increased mathematical usage and rigor as these students enter the mainline traditional track EE courses.

Near the end of the first academic term, all of the transfer students were academically advised on an individual basis before registration for the second term. Most of the students offered comments about their transition from AAS-EET programs into this transfer track. The comments are concisely summarized as: increased pace, increased rigor, and much larger outside-of-class workload. These themes have occurred every year in previous surveys of the students in the former AAS-EET to BS-EET transfer arrangement, so they were not surprising. Several students additionally commented that the electronics bridge courses and the calculus courses were the only AAS-level courses that approached the pace, rigor, and workload of the initial BSEE courses in the transfer track. All of these numerous comments and survey results continue to support the importance of the transitional experience incorporated into the AAS-EET to BSEE Transfer Track bridge courses.

The qualifications of the AAS-level faculty members to teach these critical AAS-level bridge courses are an important consideration. These qualifications were established in the initial transfer agreements of the AAS-EET to BS-EET transfer arrangements and have been continued for the AAS-EET to BSEE Transfer Track. The following wording is incorporated in one of the transfer agreement provisions:

> "For the instruction of the designated electronics bridge courses (see provision 9), the Two-year College will use faculty with at least a BS degree in electrical engineering, electrical engineering technology, or other related field (as approved by MSOE), and with at least one of the following: (a) an MS degree in electrical engineering, electrical engineering technology, or other related field (as approved by MSOE), (b) current registration as a Professional Engineer (PE), or (c) successful completion of a workshop offered by MSOE on instructional techniques for electronics bridge courses. The above-stated credentials are considered appropriate educational background for instructors of the electronics bridge courses. A faculty member who meets the above-stated requirements will be designated as an 'approved faculty' member."

These faculty qualification standards have been proven sufficient by evidence of the high success rate of the AAS-EET transfer students at MSOE over the past ten years. The qualifications of the mathematics faculty are already established by general education faculty credential requirements at the AAS colleges. We have found that all of the AAS colleges have been very cooperative in ensuring qualified faculty members teach these electronics bridge courses. However, it became apparent in the first year of the AAS-EET to BSEE Transfer Track that the student preparation in the AAS-level digital and microcontrollers areas might be an issue. This was never a significant issue in the former AAS-EET to BS-EET transfer arrangements. One of the changes in the AAS-EET to BSEE Transfer Track relative to the former BS-EET program is

the increased design requirements in these areas (see the Design of Logic Systems and Embedded Systems courses that were previously described). The preparation for these courses is more stringent than in the previous BS-EET counterparts. Both student feedback during academic advising and the instructor's feedback indicated some difficulty in these areas due to weaker preparation among some students. Establishing a more uniform student background preparation and possibly more uniform faculty credentials in these areas are to be addressed in the next round of the periodic faculty meetings between the two- and four-year colleges.

Another consideration is the applicability of this AAS-EET to BSEE transfer model to other institutions and systems. The incorporation of bridge courses, dedicated commitment of the faculty, and administrative support are the most significant investments. The incorporation of the AAS-level bridge courses may be the most challenging component. For institutions that are part of a system with two-year and four-year colleges, the bridge courses can be created and shared, even offered by a subset of institutions to the others using distance education. For specific transfer arrangements between two- and four-year institutions, the bridge courses could be incorporated into the transfer agreements. Faculty members from the four-year institution could teach the bridge courses if AAS faculty qualifications are an issue, either at the AAS college (recommended if feasible) or via distance education. Another approach is for the four-year institution to offer the AAS-level bridge courses on their campus, but at the expense of probably making the BS-portion of the transfer arrangement a full three years. We believe that this AAS-EET to BSEE transfer model is applicable to other institutions and systems with the nature of the changes particular to the institutions and programs involved.

The benefits of the AAS-EET to BSEE Transfer Track to the university and the BSEE program include:

- Increased student pool for upper division courses
- Fewer courses and more sections of courses offered relative to separate BSEE and BS-EET programs, with less diversity of course preparations by the faculty
- More frequent offering of courses inherently available with coordinated track designs
- Infusion of more diverse student talents into the BSEE program
- Developed, networked relationships between the AAS-EET and BSEE institutions

## Conclusion

A new curriculum path was developed and launched to provide an efficient transfer track from Associate in Applied Science in Electrical Engineering Technology programs at eight different two-year institutions into the Bachelor of Science in Electrical Engineering program at Milwaukee School of Engineering. This transfer track is time-efficient, requiring less than three additional academic years at the baccalaureate level, and academically effective in bridging AAS-EET to BSEE student backgrounds. The key enabling innovation was the implementation of bridge courses on both sides of the interface between the AAS-EET and BSEE programs. The bridge courses transition the mathematical usage, the rigor, and the perspective from an engineering technician level to an engineering level.

An institutional transfer infrastructure must be in operation to support the recruitment and transfer processes. Program infrastructure is required to support the AAS-EET to BSEE

academic transition. The faculty and administration of the two-year and four-year institutions must interact on a close, periodic sustaining basis to maintain effective articulation agreements and tightly coordinated curricula. Both the two-year colleges and the four-year university receive significant recruitment, curricular, and program administration benefits. Most importantly, the graduates of AAS-EET programs have a feasible path into an accredited BSEE program.

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