

Toward Next Generation of Railroad Professionals – Collaboration by NURail and Rail Industry

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ABSTRACT

Rail transportation has undergone a dramatic renaissance in the past several decades, creating a strong demand for graduates with rail expertise, particularly in engineering and related technical fields. Rail industry and government organizations recognize the importance of academic partners in educating and supplying the next generation workforce. Several universities in the academic community are at various stages of developing and implementing rail-related programs.

The National University Rail (NURail) Center is a rail-focused University Transportation Center (UTC) funded under a grant managed by the US Department of Transportation (DOT) Office of the Assistant Secretary for Research & Technology (OST). One of the key objectives for the seven-university consortium is educating a rail transportation and engineering workforce to design, deploy, operate, and maintain the complex rail, transit and multi-modal transport systems of the future. NURail has introduced several activities to meet the objective, many of them in collaboration with AREMA and other industry organizations.

This paper will identify several challenges related to developing academic programs necessary for a new generation of railway employees. We introduce NURail education, workforce development and outreach activities, such as the Affiliate University Program, Railway Engineering Education Symposium, student projects, and various K-12 activities. We also provide examples of collaboration with the rail industry and discuss the outcomes of a session conducted by NURail to brainstorm approaches and strategies for attraction, recruitment and retention of industry professionals.

Keywords: Generation change, railroad engineering education, industry-university cooperation,

INTRODUCTION

Rail transportation has undergone a dramatic renaissance in the past several decades. Freight rail has been the growth leader in the U.S. [1], but passenger rail is also witnessing an increase in demand for services which must be provided with limited resources. The growth is creating a strong demand for graduates with rail expertise, particularly in engineering and related technical fields, further exacerbated by aging rail employee demographics [2]. Rail industry and government organizations recognize the importance of academic partners in educating and supplying the next generation workforce and several universities in the academic community are at various stages of developing and implementing rail-related programs [3, 4, 5, 6].

The development of next generation leaders comes with challenges, both for industry and academia. The rail industry faces stiff competition from other industries, while academia must find its balance between providing education and doing meaningful, funded research. This paper will provide insight into the development of academic resources and next generation leaders through the National University Rail Transportation Center (NURail), one of the national University Transportation Centers [7] funded by the United States Department of Transportation (USDOT). The paper will discuss the approaches taken by NURail members to address the situation, including challenges faced along the way. The paper concludes with a summary of a recent NURail session where students, faculty and industry representatives brainstormed potential approaches and strategies for improving the attraction, recruitment and retention of next generation railroaders.

INTRODUCTION TO NATIONAL UNIVERSITY RAIL CENTER (NURAIL)

The Surface Transportation and Uniform Relocation Assistance Act of 1987 authorized the funding of ten regional University Transportation Centers (UTC), providing a formal federal commitment to supporting university based transportation research. Subsequent surface transportation bills increased the number of centers and broadened their research scope to permit all surface transportation modes.

The current UTC program mission is *“To advance U.S. technology and expertise in the many disciplines comprising transportation through the mechanisms of education, research and technology transfer at university-based centers of excellence.”* [8].

The National University Rail Center is the first UTC dedicated to railway research and education. NURail is a seven-member consortium led by the University of Illinois at Urbana-Champaign (Figure 1). The team’s 2011 proposal had a theme that emphasized the improvement and expansion of rail education, research, workforce development, and technology transfer. With the growing interest toward passenger rail and the challenges of intermixing passenger and freight trains, the team selected *shared rail corridors* as the theme of its research program. Following the initial funding in 2012, MAP-21 called for a new UTC competition in late 2012. The solicitation required a theme matching one of the USDOT strategic goals. The NURail team selected Economic Competitiveness and responded with a second proposal addressing the following topical areas: (1) Railway Systems: Economics, Safety and Operations and (2) Railway Vehicles and Infrastructure: Analysis, Design, and Performance.

This proposal, featuring the same team, earned a UTC grant award in mid-2013. In 2015, NURail operates under UTC grants that end in early 2016 and late 2018. Besides planning to seek future UTC funding, the team is working to attract additional sponsors for its research and education activities.

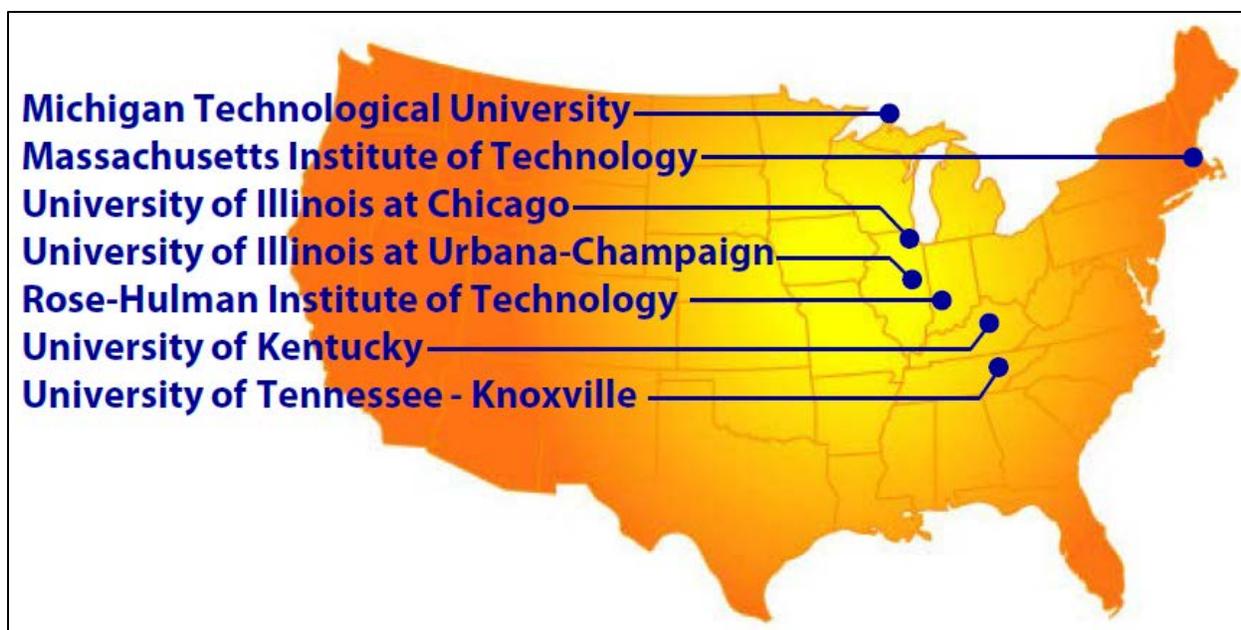


FIGURE 1: NURail Consortium Members

CHALLENGES IN WORKFORCE DEVELOPMENT AND NURAIL ACTIVITIES

While the need for a new generation of leaders, and workforce development in general, in the rail industry is not disputed, the challenges faced by both industry and academia—and the methods to address those challenges—have received less attention. Table 1 and the following paragraphs highlight three core groups of challenges identified by the authors and review activities undertaken by NURail to address the challenges. The list provided is not comprehensive and, as evident from the table, NURail has not yet addressed some of the challenges. A brief discussion outlines potential future approaches to address those challenges, either by NURail or other industry stakeholders.

TABLE 1. Challenges and NURail Activities

Challenge	NURail Activity
ACADEMIC PROGRAM DEVELOPMENT	
Limited industry/academia awareness and interaction	Executive Advisory Board (EAB), Technical Advisory Committee (TAC) and Affiliate Program
Perception of rail as a low-tech industry with limited research opportunities	Sponsor letter to Affiliate Program members and Railroad Engineering Education Symposium (REES)
CURRICULUM DEVELOPMENT	
Lack of curriculum guidelines and standards	REES
Lack of instructional resources	REES & collaborative projects
ATTRACTION, RECRUITMENT AND RETENTION	
Poor visibility and attractiveness among youth and students	K-12 events and student projects
Insufficient coordination of recruitment process/activities	----
Retention of employees	----

Academic Program Development

Despite the well-documented resurgence of the railway industry over the past 30 years and strong railway industry demand for new graduates the engineering academic community continued a decades-long trend of ignoring railway transportation [9]. An American Railway Engineering and Maintenance-of-Way Association (AREMA) Education and Training Committee survey found that railroad engineering was included as a topic in general transportation courses at less than 15 percent of North American universities and offered as a separate course at approximately three percent [10]. A later survey of civil and transportation engineering professors found interest in incorporating railroad engineering material into current transportation courses and development of new courses devoted to the subject [11].

Several factors are slowing the development of academic programs. From the perspective of university higher administration, railways are typically perceived as a low-tech industry that does not align with current strategic plans. Consequently, there is minimal interest in allocating institutional resources to rail program development. In addition, except for the very few well-established U.S. railway engineering programs, the broader rail industry is not aware of emerging academic programs. A lack of organized and targeted marketing and direct interaction avenues with industry hinder these new programs. At the same time, such programs have a disadvantage in recruiting and retaining highly qualified students with interest in rail engineering. While NURail's main mission is to continue growth of rail activities in the consortium, it has also helped academic development in other institutions and increased their interactions with the industry, mainly through the industry advisory board and affiliate program.

NURail Executive Advisory Board (EAB) and Technical Advisory Committee (TAC)

Two NURail bodies provide key resources to strengthen academia/industry coordination: the External Advisory Board (EAB) and the Technical Advisory Committee (TAC). The eight-member EAB reviews center activities and helps to set strategic directions. Members are senior personnel representing passenger and freight railroads, government agencies and engineering firms. The sixteen (current number) TAC members assist the NURail education/research program by evaluating proposals, participating in project reviews, and providing feedback on education/research products. The TAC membership represents railroads, railway suppliers, academia, and government. All have special expertise in areas relevant to NURail education/research. Both TAC and EAB provide valuable linkages between academia and industry.

NURail Affiliate Program

NURail is committed to promoting and facilitating railway engineering academic program development in North America. Through its Affiliate Program, the center has expanded its activities beyond the formal consortium membership. NURail is working to: (i) engage affiliate members in current and future research and education initiatives; (ii) offer affiliates assistance and guidance on curriculum development; (iii) facilitate and contribute to the development of affiliates' instructional and education material; (iv) collaborate and cooperate with affiliates on research initiatives and (v) help affiliate members develop rail sector contacts in the rail sector. As of May 2015, fifteen North American institutions have joined the program (Table 2). Affiliate institution rail programs are at different levels of development ranging from one faculty and one rail related course offered to over ten faculty members and a comprehensive railroad engineering curriculum. Penn State Altoona is the only institution in the U.S. offering a BS degree in Railroad Engineering. The University of South Carolina is the first institution among the affiliates, and among a very few in the U.S., that offer Civil Engineering graduate degrees in Railroad Engineering. The University of Wisconsin Madison offers eleven no-credit continuing education courses annually. Most institutions have a chartered AREMA student chapter, an active railway related research program and have been relatively successful in providing graduates to the rail industry.

TABLE 2. Railroad Engineering Activities at Affiliated Institutions

Institution	Faculty	Courses (enrolm/yr)	Industry Placement	Degrees	AREMA Chapter	Research
Colorado State – Pueblo						
North Dakota State	3	1 (35-40)	(n/a)	in planning	in planning	Y
Oregon State	2	2 (40)	1+	no	10	Y
Penn State – Altoona	4	8(15)	9	BS	30	Y
U British Columbia	1	1 (6)		no	Y	Y
U Dayton						
U Kansas						
U Manitoba	1	1+	3+	no	~25	Y
U Maryland	4	2 (44)	5+	no	-	Y
U Mass – Amherst						
U Nevada – Las Vegas	10+	6 (60+)	(n/a)	in planning	Y	Y
U South Carolina	4+	7 (50+)	14+	MS/ME/PhD	~38	Y
U Wisconsin – Madison	3	11* (40)	(n/a)	no	~5	Y
Villanova University						
Virginia Tech						

Table 3 shows the courses offered at the affiliated institutions. All schools offer introductory courses in rail engineering/planning and most schools have an operations related course.. Additional courses pertain to track design and signaling while two members include a capstone design project in the curriculum. Most schools have reported that other transportation and infrastructure related courses in their curriculum include modules in railroad engineering.

TABLE 3. Courses offered at Affiliated Institutions

Institution	Intro to RR Eng/Planning	Track Design	Operations	Signals	Capstone Project	Other
Colorado St. Pueblo						
North Dakota State	○					
Oregon State	○					○
Penn State Altoona	○	○	○	○	○	○
U British Columbia	○					
U Dayton						
U Kansas						
U Manitoba	○		○			○
U Maryland	○					○
U Mass Amherst						
U Nevada LV	○	○	○			○
U South Carolina	○	○	○	○	○	○
U Wisc. Madison	○	○	○	○		○
Villanova University						
Virginia Tech						

Affiliate Member Sponsorship Letter

To address both core challenges of academic program development, NURail and its affiliates developed a support letter that targeted affiliate university administrations. The letter, signed by the Center Director and EAB members, has the objective of making administrators aware of rail transportation and its demands. It recognizes the faculty efforts related to educational and research activities in rail transportation, presents the need to engage and educate a new generation of rail professionals and emphasizes the importance of academic partners as part of the solution.

Railroad Engineering Education Symposium (REES)

The Railway Engineering Education Symposium (REES) is another activity that addresses the challenges of limited industry awareness and the perception of rail as a low-tech industry. Since REES is also closely aligned with challenges related to curriculum development, the next section of this paper covers it in more detail.

Curriculum Development

Development of comprehensive and effective curricula in rail engineering inherently depends on industry-wide accepted guidelines and standards related to the fundamental set of skills a college graduate should possess in pursue of employment in the industry. However, a lack of instructional resources currently hinders the development of rail engineering courses. Although several valuable resources, like books, monographs, and manuals, exist, they lack the rigor consistent with academic standards. In addition,

such resources typically do not include solved demonstration examples, case studies and practice and homework problems and are not considered effective textbooks.

Railroad Engineering Education Symposium (REES)

A highlight of NURail education and workforce development activities is support of the innovative REES event. REES resulted from a AREMA/academia collaboration to encourage railway engineering education programs and stimulate development of new railway engineering courses.

In a “hands-on” classroom setting, civil and transportation engineering professors—most with highway backgrounds—learn the basics of rail transportation engineering and work through rail course content materials. One goal is for participants to enhance existing classes to incorporate new railroad content and to develop new railway engineering courses at their institutions. A second, but equally important, goal is to promote and facilitate networking between the engineering professor participants, their academic peers specializing in railway topics, and professionals representing North American railroads, consultants and research facilities.

NURail representatives were involved in planning and developing the initial 2008 REES held at the University of Illinois at Urbana-Champaign and have since been integral to each subsequent event (2010, 2012 and 2014). After NURail’s formation, the center became an official REES partner, supporting the development of new and expanded academic content for the 2012 and 2014 events. In 2015, NURail is working with the American Public Transportation Association (APTA) and AREMA on a sister event, the Passenger Railway Engineering Education Symposium (p-REES). REES is a unique partnership between industry practitioners (railroads and engineering consultants), academia (NURail), and AREMA. While NURail and affiliated faculty develop academic content, AREMA and its industry members provide financial and administrative event support.

Response to follow-up surveys sent to attending professors after each event indicate that NURail is having a positive effect on the state of railway engineering education through REES. Since 2008, attendees indicate that 19 courses have been modified to include railway engineering content or developed solely to cover railway topics [12]. This figure does not include additional new courses developed at the NURail partner institutions as education projects with direct NURail support. REES has also been a factor in growing the number of AREMA student chapters. These organizations promote interest in and knowledge of railway engineering among students. This is vital to the sustainability of railway academic programs and intern and management trainee hiring programs at major railroads. Through AREMA student chapters, student research collaboration and activities organized by the NURail Student Leadership Council, the center is helping to develop a stronger professional network among the future generation of railway industry leaders.

Collaborative Projects

NURail education and research projects are not mutually exclusive. There are many synergies between research activities and course development: students benefit through an enriched educational experience while research projects benefit from student research assistants with the background knowledge and theory required to make innovations and discoveries on railway topics. An excellent example of this can be found at the University of Illinois at Urbana-Champaign (UIUC) where the NURail research in three main areas (safety of hazardous materials transportation by rail, design of railway infrastructure, and railway network capacity) provides a direct match between three of courses developed as NURail education projects:

- CEE 498TSR Transportation Safety & Risk provides an introduction to transportation risk management, and risk assessment concepts and methodologies to address safety and security of freight transport by railways, roads, waterways and pipelines. This course introduced student researchers to fundamental concepts required at make advances on NURail research of risk of shared corridor operation and flammable liquid derailment release events.

- CEE 598ATE Advanced Track Engineering examines the detailed science and theory of track design; the practical application of track engineering principles; and technological advances in track evaluation, modeling and maintenance. These concepts are essential for students engaged in field testing and finite element modelling of track components supported by NURail.
- CEE598RTD Railway Terminal Design & Operations focuses on the design of classification yards, intermodal facilities and bulk terminals, and how these facilities are organized into an optimized and efficient network to provide different types of freight transportation service. Students in this course obtained background necessary to being a NURail project investigating the terminal capacity and its relationship to mainline capacity.

Similar collaborative education efforts with industry take place at other NURail partner campuses, each having their own synergies with NURail research.

Attraction, Recruitment and Retention

While much of the concentration among NURail partners has been in attracting students to industry, it has become also evident that there is room for improvement when it comes to recruitment practices and industry/academia coordination, and for retention of new industry professionals. The railroad industry is rarely considered as a potential future career by today's youth and heavy competition from other industries may hinder the recruitment of even those individuals who have expressed their interest. Activities targeting K-12 students may provide awareness of the rail industry, but they do little for successful recruitment of graduates. The following sections review some NURail activities to attract the next generation, and discuss the outcomes of a recent mini-workshop that was conducted during the 2015 NURail Annual Meeting to brainstorm ideas for improving attraction, recruitment and retention.

NURail K-12 Activities

K-12 activities are a high priority to NURail and consortium partners have use approaches, such as summer youth programs, engineering open houses and Boy Scout merit badges to engage these students. For example, Michigan Technological University, in collaboration with the University of Wisconsin-Superior, has been running a week-long Summer Youth Program (SYP) in Rail and Intermodal Transportation. The SYP had six participants during its inaugural run in 2010, but has since expanded 400% to attract up to 25 students from grades 9-11, nationwide. Much of the expansion occurred after NURail became involved in the program in 2013. With NURail funding, Michigan Tech was able to match the 50% scholarship initially provided by industry gifts and a special focus was added to attract minorities to the program. Collaborative effort with UIUC and from Hanson Professional Services brought two minority students into 2014 program and another two (female) minority students will participate in 2015 cohort.

The program includes classwork, industry tours (Figure 2), and hands on activities. The highlight has been consistently the numerous field visits to various industry facilities, including Lake Superior and Ishpeming Railroad, Halvor Lines (trucking company), CN ore/taconite docks, BNSF rail yard and North Shore Railroad Museum.



FIGURE 2: Summer Youth Program Participants in Duluth, Minnesota

NURail Student Projects

One of the best methods to attract current university students to a specific field are through activities. Active learning is a concept that has existed for long period of time, often in the form of apprenticeships, but more recently attention has been placed into shifting higher education from a lecture-based format to more hands-on approaches [13]. This shift is partially taking place due to a change in the learning preferences of the current student body who have grown up in a digital environment and are accustomed to technology, both in communication and the learning process.

Research/project activities that are funded by the industry add yet another dimension of industry exposure and networking, both highly ranked approaches to better orient students with industry. Student contribution may be part of a larger research undertaking, but they may also be standalone student activities, such as senior design/capstone projects. In addition to attracting students, these projects often turn into recruitment tools for the rail industry, especially if students get involved prior to their senior year. Several NURail partners and affiliates look for opportunities to provide such activities/projects. As an example, Michigan Tech has completed eight undergraduate student projects since NURail was launched that have involved 50 students from seven disciplines and ten industry companies as sponsors and/or technical advisors, as presented in Table 4.

TABLE 4. Michigan Tech Student Projects

Student Project	Majors Involved*	Sponsor (Technical Advisors)
Type E Coupler Redesign	ME, MSE, CEE	Rail Transp. Program (Amsted, BNSF, TTCI)
RTP Promotional Video	HU, SBE	Rail Transp. Program
Intelligent Grade Crossing Signal Maintainer	ECE	Union Pacific, Norfolk Southern
Centerbeam Rail Car Conversion	ME	Rail Transp. Program (Escanaba & Lake Superior RR)
Tech Expert Network Market Study	ECE, SBE	Tech Expert Network
System to Measure the Effectiveness of a Rail Shunt	ECE	Union Pacific
Wayne Industries Warehouse Expansion	CEE	Wayne Industries (Engineered Rail Solutions)
Grade Crossing Surface Performance Evaluation	CM, CEE	Michigan Dept. of Transportation

* ME=Mechanical Engineering, MSE=Materials Science and Engineering, CEE=Civil and Environmental Engineering, HU=Humanities, SBE=School of Business and Economics, ECE=Electrical and Computer Engineering, CM=Construction Management

Other examples of NURail funded student projects include:

- Capstone designs conducted by the Rose-Hulman Institute of Technology, such as Terre Haute Rail Expansion Deming Park Alignment Design for The Indiana Rail Road.
- Project support to Monticello Railroad Museum by the AREMA student chapter at the University of Illinois at Urbana-Champaign.

Potential Approaches and Strategies for Attraction, Recruitment and Retention

While NURail railroad course offerings and course enrollment have had an upward trend since its initiation, the metrics reveal that job placement of graduates to the industry hasn't had as positive trend, both for internships and full time positions. Considering the unanimous call for more graduates by the industry, the trend was unexpected and led to a workshop session during the 2015 NURail Annual Meeting. The workshop objective was to identify strategies and activities related to the following three topic areas:

- Recruiting and Interacting with Students
- Making Railroad Industry the Preferred Destination
- Retaining the Next Generation

Each topic area included three specific questions. Six teams—each with various combination of students, faculty and industry representatives—participated in the workshop and contributed suggestions for potential approaches and strategies. Tables 5-7 summarize the questions and responses. Instead of providing a comprehensive (lengthy) list of all suggestions, the tables contain approaches identified by multiple groups, emphasizing the high level of consent.

TABLE 5. Recruiting and Interacting with Students

Question	Approaches/Strategies
<p>How can the industry make the most of on-campus career fairs/special events?</p>	<ul style="list-style-type: none"> • Show up consistently (especially if registered). • Sending more engineers, especially alumni, to compliment human resource specialists. • Concentrate on ways to make them tangible through product/job demonstrations, presentations and giveaways. • Make events more personal. Info sessions and rail specific career fairs with maximized opportunities to face to face personal discussions.
<p>What are other recruitment approaches/tools/resources/activities to consider beyond career fairs?</p>	<ul style="list-style-type: none"> • Internships (by far the most consistent response). • Site visits. • Using students groups (AREMA)/past interns to assist in recruiting. • Scholarships and student competitions. • Research assistantships for 1st/2nd year students.
<p>What are the best channels and strategies for effective and timely communication with candidates?</p>	<ul style="list-style-type: none"> • Face to face interaction. • More direct communication with engineers (especially with alumni). • Timing of communication crucial (especially for job offers, but also for negative responses).

TABLE 6. Making Railroad Industry the Preferred Destination

Question	Approaches/Strategies
<p>How to improve visibility before education and career choices are made?</p>	<ul style="list-style-type: none"> • Generate more targeted rail events for younger audience, such as Boy Scout merit badges, operation lifesaver and elementary/junior high rail days. • Modernize communication to include more social media approaches (YouTube, animations, etc.). • Demonstrate the benefits of latest technology. • Provide past interns with bonus to promote their experience. • Get involved/develop engineering competitions.
<p>What are the positives of industry and how are they (should be) promoted?</p>	<ul style="list-style-type: none"> • Greatest positives: job security, benefits, diversity of jobs, advancement opportunities (vertical and horizontal) and travel opportunities • Important to highlight new technologies and eco-friendliness of the industry. • Transferability of skills. • Promote job challenges and problem solving. • Industry esteem and job satisfaction from completing projects and from affecting economy.
<p>What can the rail industry realistically do to compete for talented students with Google, airlines, automotive manufacturers, international design-build firms etc.?</p>	<ul style="list-style-type: none"> • Strengthen connection between classroom study and career activities, as early as possible. • Create active promotion environment for “industry positives” (identified in previous question). • Look at sponsorship programs of other industries, for example in sports. • Create internships that encourages ownership. • Approach candidates with honesty. • Industry salaries must be equal to commitment requirements (similar to oil industry). • Recruitment process must be responsive and timely. • Improve work-life balance or reward insufficiency.

TABLE 7. Retaining the Next Generation

Question	Approaches/Strategies
How can universities help find students and direct to correct subfield in industry (railroad, consultant, manufacturer, DOT, etc.) that fits their goals and lifestyle?	<ul style="list-style-type: none"> • Increase faculty-student discussions on rail careers. • Assist in obtaining internships and co-ops. • More active rail contents (assignments/projects). • Bring back alumni to classrooms on regular basis (“day at work” presentations) and organize rail-specific events. • Take better advantage of AREMA student chapters in reaching out to other organizations.
How can we take advantage of technology to help with work-life balance and job satisfaction while in the rail industry?	<ul style="list-style-type: none"> • Telecommuting and flexible work schedule. • Increased use of automation (such as inspections). • Research employees on their personal preferences. • Add more people to reduce dependency on an “individual”.
What makes people stay/leave their job...and what can we do to keep them ?	<ul style="list-style-type: none"> • Main reasons for staying; good managers and colleagues, promotions, fulfilling job, education opportunities. • Work-life balance a major concern (especially on freight railroads). • Treat employees as professionals, allowing more flexibility for life quality. • Tradeoff between consulting and railroad employment (railroads must pay better).

While each table summarizes different set of questions and challenges, it is evident that many of the strategies are recommended to address multiple challenges. For example, internship opportunities are considered as one of the most effective recruitment tools, but they are also recommended for increasing industry visibility, as a competition tool for talent, and as a way to closer faculty/student interaction. Similarly, the positive aspects of industry, such as good pay, advancement, eco friendliness, etc. are considered core items for increasing visibility, competing for talent and retaining the talent. However, those positives will only make difference, if they are efficiently communicated, and the need for improved communication is clearly highlighted throughout the responses.

CONCLUSIONS

Rail transportation has undergone a dramatic renaissance in the past several decades and is creating a strong demand for graduates with rail expertise, particularly in engineering and related technical fields. This paper starts by identifying several challenges related to the development of these graduates and academic programs necessary to educate them. This is followed by an introduction to actions taken by the National University Rail Center in educating the rail transportation and engineering workforce to design, deploy, operate, and maintain the complex rail, transit and multi-modal transport systems of the future.

NURail education, workforce development and outreach activities range from Railroad Engineering Education Symposium (REES) to the Affiliate University Program, student projects, and various K-12 activities. While activities reviewed in the paper have been considered successful, it has also become evident that more work is needed in the attraction, recruitment and retention of young graduates. As a first step toward addressing these challenges, NURail organized a workshop session as part of the 2015 NURail Annual Meeting to brainstorm approaches and strategies. The provided summary of session results that several common themes are prevalent in the recommendations, especially the importance of industry internships and improved communication to market the positive aspects on industry in general and as part of the recruitment process.

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