

BUILDING AN EDUCATION INFRASTRUCTURE FOR RAILWAY TRANSPORTATION ENGINEERING

Renewed Partnerships on New Tracks

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Attracting a new generation of engineering and transportation professionals to replenish the ranks of the North American railroad industry has become a challenge. A large percentage of railroad industry employees are reaching retirement age, and the demand for railroad expertise has increased substantially with the growth in railroad traffic and in construction projects to expand capacity.

The railroad industry, other transportation modes, and other sectors need new engineers. But the situation for railroads is unusual and more problematic. The problem is solvable, however, and the solution could yield direct and indirect benefits.

To understand the situation with railroads, it is

instructive to consider highways, which are the principal competing form of land transport. Railroads compete for business with highway transport, especially with the trucking industry, and the competition extends to engineering talent and expertise.

Academic Infrastructure for Highways

Each year, thousands of students graduate from U.S. colleges and universities having taken one or more introductory courses in highway transportation engineering. Many take advanced courses in highway planning and design, traffic engineering, intelligent transportation systems, pavement systems, and other aspects of transportation facilities and sys-



PHOTO: INTERNATIONAL ASSOCIATION OF PORTS AND HARBORS



Photo: UIUC

Eric Maple of CN (the Canadian National Railway) explains the dispatching system to a class during the 2008 Engineering Open House at the University of Illinois at Urbana-Champaign.

tems analysis that focus on highway transport. Many students complete summer internships on highway projects with state or local departments of transportation (DOTs) or with engineering firms. Hundreds more graduate with master's degrees that concentrate studies and research on an area of highway transportation engineering, analysis, or planning. More than 100 each year complete doctoral programs that explicitly or implicitly focus on topics in highway transportation.

These students—and the faculty who develop the curricula, teach the courses, serve as mentors, oversee graduate research, and present and publish research results—accept this as academic normalcy. Like many other academic subdisciplines, transportation engineering involves hundreds of faculty at universities throughout the United States and beyond. The faculty and students form an intellectual community that sustains a rich and vibrant dialogue on a variety of topics important to the field, and they often engage in cutting-edge research to advance the state of the art in highway transportation.

All of this benefits the individuals involved, the firms and agencies that use the results and that hire the graduates, and the nation's transportation system. A core function of the Transportation Research Board—as it was of its predecessor organization, the Highway Research Board—is to provide forums for the exchange of new results and information.

With such a network or infrastructure of people and organizations intensely engaged in and devoted to advancing highway transportation, thousands of engineering graduates each year choose to pursue careers in highway-related fields. Americans grow up with a world-class highway system. As a result, the extensive academic infrastructure devoted to

education and research related to highway engineering and transportation is not surprising to college students. Many are inspired to make highways their career goal as practitioners or academics.

The academic and practitioner communities have built and maintained this intellectual and institutional infrastructure in the past 60 years to create new knowledge for the improvement of the U.S. highway transportation system and to educate successive generations of engineering and transportation professionals to solve problems and advance new solutions for the highway transportation system. This marriage of the academic and highway practitioner communities has worked well.

Railroads' Situation

Railroads are a critical element in the nation's transportation system, but several key differences reduce their visibility to students and university faculty. Highways are encountered daily, but the nation's rail system—especially its most successful element, the freight railroads—operates largely unnoticed. In some ways, this is a mark of success. The goods transported by rail reach their destinations reliably and economically and generally without incident, allowing the nation's commerce to function smoothly and efficiently.

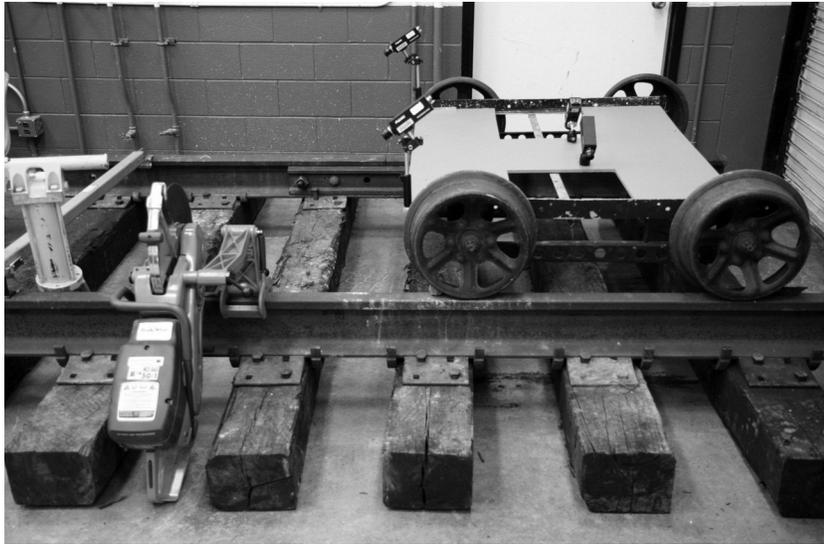
What happens behind the scenes is not a concern to the general public—except when something goes awry. But because freight railroads function as a “stealth” mode, few understand or appreciate the role of rail and what railroads can offer in terms of interesting and rewarding careers in engineering and transportation.

The transportation community, including the highway sector, recognizes the importance of the railroad freight transportation system and its critical



Photo: UIUC

University of Illinois at Urbana-Champaign researcher Jeremiah Dirnberger documents the impact of misrouted and missorted railcars near the I-294 bridge in Bensenville, Illinois.



NS track panel used for demonstrating tools and equipment to engineering students and trainees.

role in the future (1). Railroads not only are surviving but are beginning to thrive in a way not seen in the United States for nearly a century. Many in the railroad industry believe a railroad renaissance has begun in North America. Freight traffic—particularly intermodal freight—has been increasing steadily, and railroads have streamlined operations—trimming excess physical plant, renewing and upgrading the core network, and developing, testing, and implementing new technologies to enhance safety, efficiency, and reliability.

As a result, the profitability of the railroad industry is increasing, providing value to shareholders and encouraging new investment on Wall Street. As congestion mounts on the highways and airways, as fuel prices rise, and as concerns about safety, emissions, and land use become more pressing, railroads will take on a greater role in the transportation system, not only for freight but also for passenger service.

Society benefits from efficient, economical, and environmentally sustainable transport. But who is going to develop the technology to expand rail capacity and improve efficiency, and where are the skilled personnel for the necessary planning and engineering going to come from?

Decline of a Relationship

In the first half of the 20th century, railroad transportation and engineering were well represented on college and university campuses. Several universities housed departments of railway engineering, and many universities included railroad transportation, engineering, and economics in their curricula. But after World War II, when highway and air transportation began their dramatic ascendancy, railroads were perceived as obsolete. Many in the academic community focused on the exciting new engineering

challenges and educational opportunities associated with the new modes.

Railroad programs, research, and classes disappeared as professors retired and were replaced by faculty interested in the newer modes. In academic circles, institutional knowledge of rail transport vanished almost completely. The omission from the curriculum is troubling from a public policy perspective. As faculty lost sight of the role of rail transport, transportation engineering classes evolved into classes in highway engineering, often without a change in the course title. Students consequently associated the discipline with the mode.

Ramifications

According to an observation attributed to psychologist Abraham Maslow, “If the only tool you have is a hammer, you tend to see every problem as a nail.” For at least two generations, transportation engineering professionals have been taught to use tools primarily based on highway transport.

The implications are profound. As transportation professionals at the local, state, and federal levels had less knowledge of the rail mode, rail became less important in their thinking and planning. Questions involving rail met with less understanding about the exigencies of railroad infrastructure and operations.

The railroad industry encountered complementary problems. Public officials lack understanding of the industry’s needs, and the public often opposes industry plans for needed expansion. The industry is frustrated by an inability to hire young engineers educated in the principles of railway engineering and to find people willing to consider a career in what many still perceive as an obsolete and fading enterprise.

Industry Retrenchment

These problems have been masked for half a century while the railroads retrenched. From 1956 to 2007, U.S. Class I railroad mileage shrank from about 210,000 to 94,000, and employment dropped from approximately 1 million to 167,000. Two generations of railroaders have spent their careers managing dwindling physical plants and work forces.

At the same time, however, railroad ton-miles tripled from 589 billion in 1956 to 1.772 trillion in 2006. Railroads survived this era partly through the development and implementation of technologies that enabled them to reduce physical plant and personnel yet increase output. The downsizing in personnel mostly occurred by attrition—employees who retired were not replaced, and recruitment was curtailed. Although this did not pose immediate problems, the results were an aging work force and a declining relationship with the academic community.

The demographics would have posed eventual difficulty for the railroads, but changes in Railroad Retirement have made the problem more acute. Allowing railroad employees to retire earlier with full benefits has generated an exodus of extensive engineering and institutional knowledge. Approximately 50 percent of railroad employees may become eligible for retirement within five years (Figure 1). This limits opportunities for senior personnel to mentor young employees and undermines the on-the-job learning that railroads depend on to educate new employees in the principles of railroad engineering.

Documenting Practices

To address this, railroads have developed comprehensive documentation of their engineering practices. This is good, because many changes and innovations in railroad engineering practice had not been consistently well recorded and organized. The American Railway Engineering and Maintenance-of-Way Association (AREMA) has developed the *Practical Guide to Railway Engineering*, representing a multiyear effort by industry experts.

These measures will preserve and transmit much of the acquired knowledge of railroad practices. Nonetheless, the documents focus on what is done and how it is done but do not necessarily explain the why. As circumstances change and new situations or technologies arise, railroad professionals will need a deeper understanding of the principles to be able to adapt and respond—in other words, in addition to skilled craftsmen, railroads need knowledgeable engineers.

Short-Term Research

Railroads have engaged mostly in short-term research addressing immediate, practical problems. In an era of survival and austerity, the most efficient way to obtain results was to rely on specialized experts to carry out most of the research. Industry and government programs alike depended on a small group of specialists employed by the Association of American Railroads (AAR), the Federal Railroad Administration (FRA), and a few consulting and technology development firms and organizations.

This approach has developed beneficial results that address many current problems. But railroads also paid a price—with the removal of most rail research from academia, faculty lost interest in, and understanding of, rail transportation, and this reinforced the perception that the industry was disappearing, increasingly irrelevant, and not interested in innovation.

The loss of railroad research funding for aca-

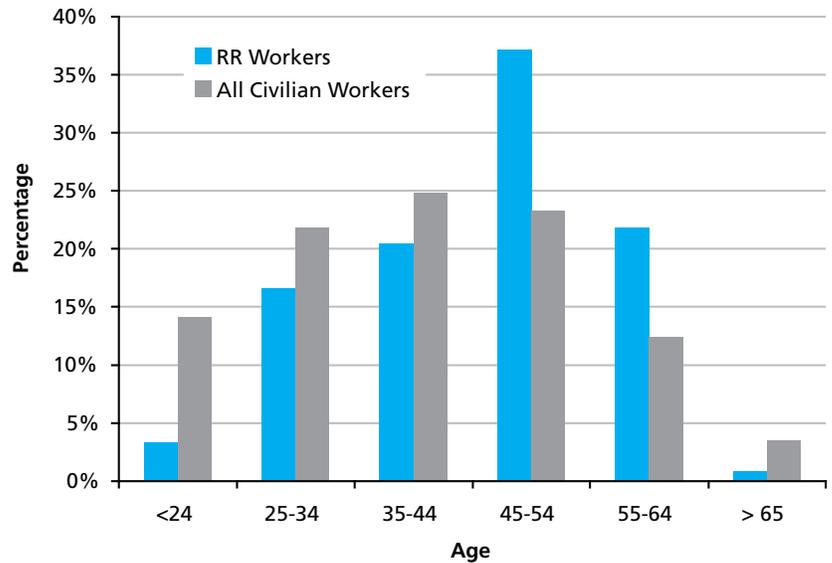


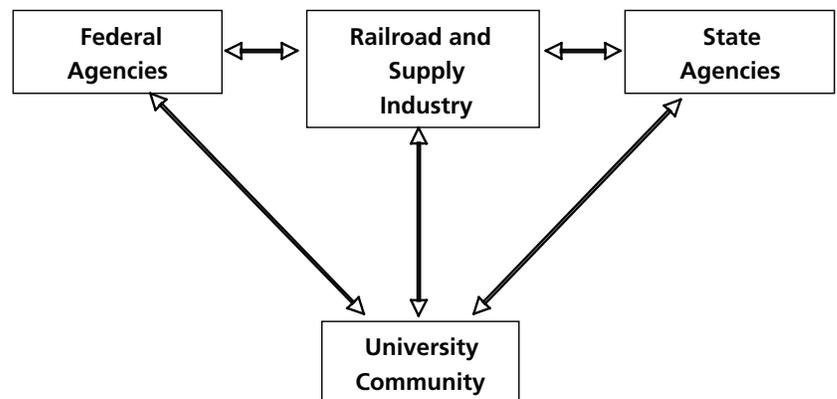
FIGURE 1 Employee Age Groups: Rail Industry and Civilian Sector
(Sources: Railroad Retirement Board, U.S. Census Bureau, and AAR.)

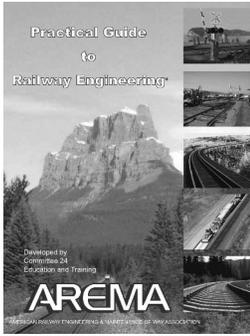
demics compelled faculty to look elsewhere. At major universities, faculty success is related to research funding, which supports the graduate students who conduct much of the work. Failure to obtain sufficient funding to support students and publish papers generally means no tenure or promotion. Transportation faculty therefore turned their attention to the funding available from state and federal agencies for highway-oriented research.

Renewing the Partnership

The railroad and academic communities should renew and expand their relationship, to yield both short- and long-term mutual benefits (Figure 2). The railroad industry would be able to recruit from a larger number of students, who would be more informed and aware of railroad transportation and of the career opportunities available. The diversity of jobs and the excitement of involvement in rail transportation will attract many students. The industry, however, must do more than increase recruitment at universities—it must develop relationships with the

FIGURE 2 New Railroad–Academic Partnership





AREMA's *Practical Guide to Railway Engineering*, with contributions from more than 50 railroad professionals, provides in-depth coverage of railway fundamentals.

Amtrak President David Gunn (*right*) views a track section in the Newmark Structural Engineering Laboratory crane bay with University of Illinois at Urbana-Champaign graduate student Mike Koob (*left*), working to develop technology to assess contained stress in rails, and Professor Richard Weaver, Department of Theoretical and Applied Mechanics.



Photo: UIUC

faculty and the administrations, as the highway sector and other industries do.

Faculty can leverage interest in railroads—faculty members typically have contact with dozens to hundreds of students each year. In the near term, the number of students exposed to careers in the railroad industry will increase. In the longer term, visibility and understanding of the importance of rail transport will expand among students and faculty and will increase the acceptance and credibility of rail as a key element in well-rounded transportation programs.

Railroad Community's Role

The railroad community—railroads, suppliers, consulting engineers, state DOTs, FRA, and industry organizations—should commit to a new partnership with the academic community. This will require a sustained commitment; hiring that does not ebb and flow in response to short-term business conditions; a competitive level of funding to support research and educational programs in railroad engineering and transport; and cooperative summer internship programs for students.

By developing a closer research relationship with the academic community, the railroad community can expand its range of intellectual interests and gain expertise in a wide array of new and emerging technologies. Most university research projects require extensive student involvement—in addition to the research deliverable, therefore, most projects also will produce students who have been intensively involved and educated in some aspect of railroad engineering or transportation. These graduates will enter employment with greater understanding and enthusiasm to apply their knowledge than would have been possible without the background received during their studies.

Academia's Role

Universities also must commit to a sustained relationship with the railroad community. This includes hiring and promoting faculty who specialize in rail engineering and transport; undertaking research valuable to the short- and long-term interests of the railroad industry; developing courses focused on various aspects of railroad engineering and transport, as well as a curriculum for students interested in pursuing careers in the field; and encouraging student interest in rail transportation topics.

Working Models

The AAR Affiliated Laboratory Program was created in the early 1980s by William Harris, Jr., and colleague Scott Harvey of the AAR Research and Test Department. The program has been an exception to the declining relationship between railroads and academia, supporting research at three universities: the University of Illinois at Urbana-Champaign (UIUC), Virginia Tech, and Texas A&M University. The support has allowed UIUC to maintain a century-old railroad engineering program.¹ The AAR program has provided consistent research funding and frequent contact between members of the industry and the academics engaged in research and teaching. The program also has paid off for the railroads—many new and emerging technologies for rail transportation originated as Affiliated Lab projects, and the railroad industry has developed and implemented many of these innovations.

Signs of Rebirth

Two Michigan universities recently created new programs in rail engineering and transport. Michigan Technological University's rail transportation program has received industry support from CSX Transportation and from Union Pacific Railroad, and railroad executive Ed Burkhart has provided a generous endowment for the Michigan State University program in railroad transportation.

The University of Illinois has received industry support from BNSF, CN, CSX, NS, Hanson Professional Services, and the George Krambles Transportation Scholarship fund to reinvigorate and expand its research and educational program and add a second faculty position. These auspicious signs of a rebirth in rail education programs in the United States depend entirely on sustained industry support for continuation and success.

¹ The AAR program at the University of Illinois at Urbana-Champaign helped provide the rationale for hiring the author of this article 10 years ago to a faculty position devoted to teaching and research in rail transportation engineering.

Other Initiatives

In addition, the University of Kentucky has conducted a teaching and research program for many years, and Massachusetts Institute of Technology has maintained a strong element of rail in its teaching and research in transportation engineering. A few other universities occasionally have offered courses, but reestablishing railroad engineering and transportation in academic programs requires more than a handful of schools.

AREMA has established a goal of 10 universities with full-semester courses in railroad subjects by 2010. More schools are needed with more depth and breadth in their programs to establish an infrastructure in railway education. The AREMA 10 × 10 initiative, however, offers an achievable, near-term goal for building. Accomplishing the goal will require support from industry, state DOTs, and FRA.

Education Symposium

As a first step in renewing the relationship between academia and the railroad industry, AREMA's Education and Training Committee teamed with the University of Illinois at Urbana-Champaign, with assistance from the Rail Transportation Committee of the American Society of Civil Engineers' Transportation and Development Institute, to organize the first Railroad Engineering Education Symposium in June 2008. AAR, FRA, the Railroad Research Foundation, the University of Wisconsin Center for Freight and Infrastructure Research and Education, Norfolk Southern Corporation, and several other railroads, engineering firms, and individuals cosponsored the symposium. More than 30 faculty members from U.S. and Canadian colleges and universities attended lectures on railroad



PHOTO: MICHIGAN TECHNOLOGICAL UNIVERSITY

engineering principles, heard presentations about research opportunities, participated in discussions, and visited nearby railroad facilities to gain first-hand knowledge of railroad engineering and operating practices. Many plan to incorporate the material into their classes and curricula.

New Era for Rail

A new era has begun that demands a talented generation of railroad engineering professionals who will adapt and apply new technologies to meet the challenges of 21st century railroads. The nation needs not only to maintain but also to expand the capacity of North American railroads to accommodate increased transportation demand safely, reliably, and efficiently. A new generation of capable, well-educated railway engineering professionals is essential to plan, design, build, maintain, and operate the rail transportation system, yet the academic resources to satisfy the educational demand are in short supply at North American universities.

To increase the visibility of rail engineering as a viable career path and to provide the education to pursue this career, more colleges and universities must teach the principles of railroad transportation engineering. A partnership between the academic and railroad communities can achieve this by building a new infrastructure in railroad engineering and transportation education.

Reference

1. *Transportation: Invest in America—Freight-Rail Bottom Line Report*. American Association of State Highway and Transportation Officials, Washington, D.C., 2003. <http://freight.transportation.org/doc/FreightRailReport.pdf>.

Pasi Lautala (right), Director of the Michigan Tech Rail Transportation Program, talks with students at the Railway Engineering Activities Club model train exhibit during a student transportation showcase hosted by the Michigan Tech Transportation Institute.



Postdoctoral researcher Pooja Anand, University of Illinois at Urbana-Champaign, prepares to try an NS locomotive simulator.