PART 4

# Education and Training

# Transportation Engineering and Planning Education in Europe

C. J. KHISTY, S. LELEUR, J. G. LAURSEN, W. BRILON, AND F. FUZY

The role of transportation engineering and planning education in Europe and the likely direction it might take in the future are described. The experience of five academics provide information about transportation education in Denmark, Germany, and Hungary with the objective of providing a spectrum of transportation education in Europe that should be of interest to North American educators and practitioners. Comments and broad comparisons, as they relate to programs in North America are discussed. These comments may help educators on both sides of the Atlantic to modify future programs within the constraints of prevailing socioeconomic and academic conditions.

Since the end of World War II, we have witnessed profound changes associated with the transportation of goods and people world-wide, but particularly in Europe and North America. The professional skills required to plan, build, operate, and maintain these extensive transportation systems were developed over the years through educational programs in a variety of disciplines, including transportation engineering and planning. European and North Americans have each, in their own sphere, moved to the cutting edge of technological advancement and innovation. North Americans have enjoyed the benefits of their more-experienced European counterparts who have dealt with such areas as the problem of urban blight, scarce resources, and high energy costs. Europeans have, in a similar way, gained considerably from their American counterparts with solutions to such problems as transportation systems planning, computer applications, signaling systems, and traffic flow theory. Both European and North American advancements in transportation are technically driven, and universities on both sides of the Atlantic have contributed considerably in many ways toward this success. In this new decade, the North Americans are carefully scrutinizing their transportation needs and goals, and there appears to be a new energy at the state and local levels to move ahead. In 1992, Europe is facing a radical change, when the frontiers of its transportation system are being united in a single internal market.

In North America, we know a great deal about our universities through extensive literature published in recent years, e.g., transportation education in the United States (*1*). Comparatively little is known about European universities, particularly in the area of transportation education. This paper combines the experience of five educators to provide a spectrum of transportation education in Denmark, Germany, and Hungary that should be of interest to North American practitioners and educators. It is not the intention of the authors to suggest whether any of the customs, practices, or procedures followed by European universities should be adopted by North American universities. The comments and comparisons offered by the authors indicate some of the advantages of the European universities that may have a bearing on North American universities within the constraints of the prevailing socioeconomic and academic climate.

C. J. Khisty, Department of Civil Engineering, Illinois Institute of Technology (IIT Center), Chicago, Ill. 60616. S. LeLeur and J. G. Lauren, Institute of Roads, Transport, and Town Planning, Technical University of Denmark, DK-2800 Lyngby, Denmark. W. Brilon, Department of Traffic Engineering, Ruhr University Bochum, University Str. 150, Postfach 102148, 4630 Bochum, Germany. F. Fuzy, Technical University of Budapest, Transportation Engineering, Bertalan, Lu, 2-4, H1111 Budapest, Hungary.

## TRANSPORTATION ENGINEERING EDUCATION IN DENMARK

### General Information

In Denmark, transportation engineers are educated at the Technical University of Denmark (TU), Lyngby, and at the University Centre of Aalborg (AUC). These are the two places where a Master of Science (M.S.) degree in engineering can be obtained. Minor differences exist between the education at TU and AUC. The following concentrates on the education at TU in Lyngby.

TU Denmark was founded in 1829 as "Den Polytekniske Laereanstalt," known today as "Den Tekniske Hojskole," in close association with the University of Copenhagen. The degree awarded to candidates was that of *civilingenior* to distinguish them from the military engineers, as the army until then was the only place where engineers were educated. Currently, TU still awards a *civilingenior* degree in chemical, civil, mechanical, and electrical engineering, which is equivalent to the master's degree in North America.

Students who want to enroll in the education program at TU Denmark must have entrance qualifications equivalent to those at the intermediate level in the Danish upper-secondary school, such as the *abitur* examination from Germany; the General Certificate of Education from the United Kingdom in at least five different subjects, with mathematics and physics at the A-levels; or a high school diploma from the United States, followed by at least 2 years of a 4-year university program in mathematics and physics.

The number of new students every year is close to 1,000. The studies for an M.S. degree normally take 5 years. A

modular structure has been adopted, which makes it possible for individual students to compose their own curriculum, within certain restrictions, from a total of approximately 800 courses at TU. A course equivalent to one module consists of 50 to 60 lesson hours in class and 60 to 70 hours of homework. Transportation engineering is one of the subjects covered by several courses. To fulfill their studies, students must pass approximately 50 courses, with 4 compulsory courses in mathematics and 3 in physics. Out of the 50 courses in the basic sciences (mathematics, physics, applied mathematics, and chemistry) students must select 6 optional courses. The study ends with the student writing a thesis with a workload equivalent to that of six courses and a duration of 4 months. Practical training is not a necessary part of the studies at TU Denmark. However, at a period late in their studies, some students may get part-time employment related to their engineering subjects.

Since the courses are taught in Danish, a working knowledge of Danish is necessary. Non-Nordic students must take a Danish test. English-speaking students, however, can be accepted for Master's thesis projects, for some of the specialized courses, and for postgraduate work. The studies are free of tuition fees, but books and study equipment must be purchased by the students themselves (*2*).

## Current Program at TU Denmark

The transportation subjects are, with a few exceptions (e.g., vehicle mechanics and internal transport in factories), offered by the Institute of Roads, Transport and Town Planning. Divided into three equally sized divisions, the Institute comprises a faculty of 11 persons. The Transport Division is staffed by a professor and three associate professors.

Courses are not divided into undergraduate and graduate courses as there is really no bachelor degree program. Also, situated on the campus in Lyngby is the Engineering Academy, which offers a program similar to a bachelor's degree program. Students wanting to change from the TU to the Academy or vice versa may do so in accordance with certain rules. This exchange possibility has limited the need for developing a bachelor program within the TU.

Transportation courses within the civil engineering branch are "Town and Traffic Planning" and "Highway and Traffic Engineering." For several civil engineering students these will be the only transportation courses they will take if they are specializing in other fields. In "Highway and Traffic Engineering," students go through a lot of simplified numerical exercises in planning and designing a highway: traffic analysis and evaluation, capacity calculations, road geometry, pavement design, earth work calculation, and traffic economic assessment.

Of the 100 to 120 students taking the introductory courses each year, approximately 20 to 25 will continue with a course entitled "Transport Systems Analysis." This course emphasizes transportation engineering and planning methodology. Some of the major subjects are transport system characteristics; transport modeling; transport networks and flow theory; estimation; assessment of various transportation effects, such as accidents, noise, air pollution, and energy consumption; and transport project evaluation and decision-making. Students can specialize in various transportation subjects if they wish to. Courses offered at the specialized level are "Road Traffic Engineering," "Public Transport by Rail, Road, and Air," and "Urban Traffic, Problems, and Solutions." Transportation problems especially related to third-world countries are treated in "Highway and Traffic Engineering in Developing Countries."

In addition to the above-mentioned semester courses, students also follow more project work-oriented courses covering a 3-week period. These 3-week courses offer students an in-depth study of specific topics and enable them to deliver their results and findings in small professional written reports. Often the students work together in two- or three-person groups, which serve as a preparation for teamwork later on in their professional lives.

The final thesis work is the center of much attention from students, teachers, and possible employers and professionals. Much effort is put into the search and selection of an interesting, relevant, and suitable subject. Some recent M.S. theses have been related to developing countries, such as the Philippines and Indonesia. Around five students per year complete their M.S. theses in transportation. About 1 out of every 10 continues on for a Ph.D. The research topics of the Transport Division are on bicycle traffic, urban transport environment, city and intercity goods traffic, highway capacity and flow studies, safety studies, and assessment of social effects of transport projects.

All transport engineering candidates in recent years have been employed soon after finishing their studies, most of them by major Danish consulting firms, some by ministries and directorates, and others by municipalities and small consulting firms.

## Characteristics of the AUC Program

Although the Technical University at Lyngby may be seen as a "supermarket" of various courses within the modular structure, AUC has a project-oriented, group-work-based study program with various topics, following a 1-year basic course. Both bachelor's and master's degrees can be obtained. A major characteristic here is the emphasis on group work, whereas the study at TU Denmark is more individualistic. The project work of groups is evaluated at the end of the semester, and the report is delivered as an end product of the process.

## The Future

The transportation programs at TU Denmark, because of their affiliation with the Institute of Roads, Transport, and Town Planning, have a strong connection with town planning and highway construction. In many instances, faculty from all three divisions contribute to the same course. This exchange is felt to be a strength of the transportation program, and this integration is expected to be preserved within the ongoing development of the program.

At this time, an ongoing discussion is in the process at TU Denmark about the future development of *civilingenior* education. One of the issues debated is whether a restructuring

of the four-branch structure—mechanical, chemical, electrical, and civil engineering—should be considered. With regard to civil engineering, there is a possibility that a construction branch and a planning/environment branch may be established. In this case, each of these branches might associate with existing institutes that at the moment are not part of the civil engineering department. This restructuring may open up possibilities for new courses and recommended sequences of courses tailored specifically for transportation planning/environment engineers.

Part of the reorganization is also to put a greater emphasis on international relations by getting involved in exchange programs. This is especially important for the transportation program as many of its candidates already are currently employed in part- or full-time jobs outside Denmark (*3*).

## TRANSPORTATION ENGINEERING EDUCATION IN GERMANY

### General Information

In Germany, every student needs the *abitur* as a basic requirement for the admission to a university. This *abitur* is the final examination that qualifies a student from a *Gymnasium*. A student needs 13 school years to be admitted to this examination, which is conducted by the state. Therefore, a student entering the university is at least 19 years of age. The German *abitur* is equivalent to 2 years of a North American 4-year university program. The universities in Germany do not conduct any entrance examinations.

### Programs at the Technical Universities

The full-scale universities or *Technische Hochschule* (technical university) provide a sequence of studies over eight terms plus one term for the diploma thesis. Most students, however, need at least 5 years to finish their studies. Having passed all examinations successfully, the student gets the degree of "Dipl. Ing." (diplome engineer), which is comparable to a master's degree in North America. The examinations must be passed in two stages. After four terms, the student has to apply for prediploma status, consisting of a series of examinations in the basic courses. No special degree is awarded after the student passes these examinations. Therefore, the prediploma is not regarded as a qualification of its own. Its main purpose is to eliminate unqualified students from the university and it is the precondition for continuation toward the main diploma examinations.

In Germany, the universities are operated by the state. This system has two consequences: (a) Studies are free of charge for all students; in addition, students from low-income families are subsidized by the state. (b) The general quality level of courses, lectures, and curricula is more or less the same in all universities. However, professors may put special emphasis on some of the courses they offer. At the university level, a transportation and traffic engineering course is taught within the department of civil engineering. Students are free to select their lectures and their courses and they are also free to attend lectures or not. This freedom allows them to take responsibility for their own careers at a very early stage. Lectures by the professors are accompanied by ungraded exercises that the students perform on their own.

Since transportation is a part of civil engineering, all students have to start their studies with such basic subjects as physics (4 credit hours), surveying (2 hours), geometry (5 hours), chemistry (2 hours) and very comprehensive courses in mathematics (19 hours) and mechanics (16 hours). After the prediploma is completed, special subjects of civil engineering are taught, including courses such as statistics (6 credit hours), concrete construction (8 hours), steel construction (6 hours), materials (7 hours), construction operations (6 hours), soil mechanics (8 hours), hydrology, water supply, water constructions, sewage treatment (11 hours), and transportation and traffic engineering (12 hours). The latter normally is composed of courses on transportation planning, design of highways and railways, and traffic engineering. These are the fundamental courses for all students of civil engineering.

During the last two terms of their studies, students can choose specialized studies and courses. Each faculty of civil engineering provides special courses in construction engineering, water resources, transportation, and environmental engineering. For specializing in the transportation field, courses are provided in land use planning, city and regional planning, transportation modeling, methods of analysis and prognosis, road and highway design and construction, traffic engineering, railway systems, air traffic and waterway operations, operations research, and environmental issues. The emphasis depends on the specialization of the professors and other teaching staff. Experts from outside the universities are brought in for teaching courses on specialized subjects.

One of the most important objectives of the university courses is to educate students to understand the scientific background behind the theory and practices. During their studies, the students have to work on a variety of thesis topics/projects that are designed individually for every student. Sometimes, these theses are closely connected with research projects being performed by the university institutes. Many students are financially supported at university institutes on research projects, and this cooperation contributes significantly to their training as researchers.

After gaining the final diploma, students normally get a job. Only a few of them stay on at the university as full-time research or teaching assistants, and this step is the basis for working toward a Ph.D. dissertation. The Ph.D. is not based on coursework, but on a close cooperation with the professor on some highly specialized research project. On the average, the completion of a Ph.D. takes about 5 years. Transportation engineering and planning can also be areas taught outside the civil engineering department, for example, through the department of mechanical engineering, economics, aeronautics, and psychology.

### The Future

The present market for traffic and transportation engineers is excellent. There is a constant demand for such engineers by the state administration and city councils, consulting firms, and private construction enterprises. Because a high percentage of people in the professional field are over the age

of 45, there is an increasing demand for younger professionals. On the other hand, a shortage of students in transportation in recent years has resulted in the opening up of the field of transportation to nonengineers as well. This development has made quite popular nonengineering solutions in transportation in the last couple of years, particularly with problems concerning deficiencies in transportation systems and the environmental and socioeconomic effects caused by traffic. One can hope that this public awareness will increasingly attract qualified people to the professional field of transportation engineering, particularly now that a unified Germany has emerged (W. Brilon, personal communication, June 1991).

## TRANSPORTATION ENGINEERING EDUCATION IN HUNGARY

### General Information

The education of transportation engineers is organized at two levels. One level is similar to the B.S. degree awarded at the Szechenyi Istvan College of Technology (SICT) and the other is the M.S. (called "Engineer") at the Technical University of Budapest (TUB). Although both programs educate transportation engineers, the two institutions have different objectives, durations, and curricula.

### Technical University of Budapest

The education of transportation engineers at TUB h as been developed within the civil engineering program. The transportation engineering program originally was set up in 1951 at the Hungarian University of Szeged and was linked to railway operation. In 1969 its faculty merged with the Technical University of Budapest, where a new Faculty of Transportation Engineering was established, absorbing vehicle design from the Faculty of Mechanical Engineering. In 1978 a review of the courses was undertaken; it included the fundamental principles of transport operations, system management and informatics, irrespective of mode. The structure of education is based on transportation technology and transportation system management. Today, the faculty offers two degrees: one in Vehicle Engineering and the other in Transport Engineering.

### College of Technology

The education of transportation engineers at the engineering technology level has been developed with an emphasis on road construction, vehicle operation, transport technology, telecommunication technology, and management. The College of Transport and Telecommunication of Budapest was established in 1968. Its establishment in the city of Gyor was undertaken between 1974 and 1977 and named after István Széchenyi since 1986. In 1990 a new curriculum was introduced, including courses in economics and information engineering. Today the College offers eight degrees.

### Admission Requirements

The admission requirements are similar for all technical higher educational institutes. All applicants must have a high school certificate and pass an entrance examination. The entrance examination generally includes a written and verbal part in two areas—mathematics and physics. At TUB the capacity is 200 full-time students per year, and in 1990 the number of qualified applicants was 1.7 times the capacity. One-third of this enrollment is in transport engineering. SICT has a capacity of 480 full-time students per year, and in 1990 the number of qualified applicants was 1.9 times the capacity. One-fourth of the enrollment was for the field of transportation.

### Educational Process

#### *Technical University of Budapest*

The objective of the transportation section is to provide engineering specialists who can design, organize, control, develop, and research transportation systems and processes. The aim of the new structure was to reduce the number of compulsory subjects and to give more opportunity to choose a number of electives in the field of transportation. The course is modular, allowing students to select from a wide choice of courses in transportation engineering. The structure of modules is as follows:

1. The general module includes social sciences and foreign languages.
2. The basic module covers the general engineering subjects and an introduction to transportation. The general and basic modules are mandatory for all students.
3. The main module covers the engineering and scientific aspects of traffic engineering and provides the basis for choosing electives. There are two separate main modules: transportation planning and vehicle engineering. Students choose one of the two modules.
4. The side modules provide the special courses offered in the sixth through ninth semesters, covering the predominant modes of transport, such as railway, road, water, air, and freight transportation.
5. Submodules are special engineering modules that are offered in eighth and ninth semesters. The list of side modules for the transport planning section are development of transportation technology, transportation control informatics, urban transportation, transportation logistics, informatics of transportation control, shipment, water transport, railway automation and vehicles, and vehicle technology.
6. In the last semester students concentrate on their special work. The degree thesis is an exercise based on real-world problems provided by consulting companies and institutions linked to the faculty. During the last semester, students also undertake an 8-wk work experience module with consulting companies. The distribution of modules is given in Table 1.

There can be up to six examinations at the end of each semester. To complete the course, students must also pass a

**TABLE 1 Distribution of Modules**

| Module | Distribution (%) |
|---|---|
| I. General module | 18 |
| II. Basic module | 42 |
| III. Main and side module | 24 |
| V. Sub module | 8 |
| VI. Thesis | 8 |

**TABLE 2 Distribution of Time and Effort**

| Level | Distribution (%) |
|---|---|
| A | 18 |
| B | 22 |
| C | 29 |
| D | 31 |
| Total | 100 |

state examination in a foreign language. Two practical training periods are included in the curriculum. The first is after the fourth semester at any company, and the second after the eighth at a chosen transportation enterprise. Students who have completed their study at SICT can join the TUB program in the fifth semester. Four years ago the faculty started a new program for foreign students (in English) based on the same format as that for Hungarian students. This program has been very successful and the interaction most useful.

The faculty offers a number of postgraduate study options in Transport Engineering and Engineering Economics. The postgraduate program covers four semesters. A doctoral degree from TUB can be conferred on students after a period of 3 years full-time study beyond the M.S. degree by the Hungarian Academy of Sciences.

### *István Széchenyi College of Technology in Gyor*

István Széchenyi College introduced a new course structure in 1989. Presently eight programs are available for engineers, economists, and technical teachers. Engineering courses cover architecture and informatics and civil, mechanical, transportation, and electrical engineering.

The objective of the education provided by the Transportation Engineering program is to provide engineering technology specialists who can direct the solution of technological, organizational, and economic problems in transportation and telecommunication. Although this objective is generally close to what TUB has, it emphasizes the practical applications and needs of transportation. The thrust is similar to the B. Tech programs in North America.

The length of study is 3 years, which is structured into two semesters per year of 15 wks each. The course is modular too. The structure of the modules is as follows:

- "A" level is a general module, covering a foreign language, social sciences, economics, and law.
- "B" level is a basic module that includes general engineering subjects.
- "C" level is a main module in transportation, which covers both engineering and economics courses and is compulsory for all transport students.
- "D" level is a side module covering a specialization in transportation. The list includes roads, railways, transportation, transport packing, shipping, forwarding, and postal management.

In the last semester, students continue their study at the College and work on their theses. This work is on a special transport problem provided by companies and institutions linked to the College. Students have extra consultations and practical training at the company. The time and effort distribution is shown in Table 2.

Practical training after the fourth semester is organized by the Department of Transport and Logistics. The transport program offers postgraduate courses over a length of four semesters in such fields as shipment, railway operation, computer techniques, and railways.

## Organization of Institutes

The Faculty of Transportation Engineering at TUB consists of two institutes and five departments in basic subjects and mechanization. The number of the academic staff is about 130. The Institute of Transport Technology and Management is responsible for the transport section. It contains three departments: Transport Automation, Transport Economy, and Transport Operation. At the Széchenyi István College of Technology there are six departments and six divisions. The number of the academic staff responsible for the transport section is composed of divisions of Road Transport, Railway Transport, Postal Management, and Transport Economics. The faculty in both institutions teach and research. Almost all of the research comes from consulting companies and government institutions.

## Supply and Demand of Transportation Engineers

At the Faculty of Transportation Engineering at TUB the total number of students is about 850, of which 40 to 50 graduate as transportation engineers out of a total of 150 graduates per year. Also, about 20 to 30 postgraduate students finish their studies. At the Széchenyi István College of Technology, the total number of students is about 2,000. The yearly number of transportation technology engineers in the whole college is about 150 out of a total of 520 undergraduates. Before 1990, the demand for transportation engineers was always higher than the supply; however, the situation has changed since, and the demand has declined somewhat.

Transportation engineers are employed at central and local governments, authorities, municipalities (transport and road departments); planning and research institutes, transport companies (Hungarian Railways, Budapest Transport Company, regional bus and freight transport companies, the Hungarian Shipping Company, Hungarian airlines, etc.) or at other companies with significant transport needs (construction companies, delivery services, trading companies, etc.) (*4,5*).

### The Future

There appears to be a need to maintain the two educational levels for transportation engineering. The system has to provide transportation engineers with a wide basic knowledge supplemented with a specialization in a wide variety of fields.

## COMMENTS AND BROAD COMPARISONS

Having given a brief description of programs in Denmark, Germany, and Hungary, we now give some personal observations, comments, and comparisons.

In general, the education of transportation engineers and planners in Europe has evolved over several hundreds of years, well before the label of "transportation" was attached to engineers and technicians. In more recent times the European universities established institutes and faculty in *verkerhswesen* (traffic engineering). In North America, particularly in the United States, the education of transportation professionals was closely related to the growth and development of its transportation system.

Students in European universities do not necessarily have to attend formal lectures as is expected of students in North America. The former have the freedom to choose only those lectures they wish to attend. Exercises set by faculty are completed only if a student feels it will help him or her understand the subject. On the other hand, large course projects in senior courses covering both theory and professional practice are the usual methods of introducing students to full-scale design in European schools.

The minimum time required to gain the Dipl. Ing. degree (M.S.) is 8 semesters or 4 years. This is really equivalent to 6 years of study, in North American terms, because entrance to the university is achieved by passing the *abitur* examination, which is equal to 2 years of college. In actuality, the Dipl. Ing. takes anywhere from 5 to 6 years to complete, so the equivalent in North American terms is about 7 to 8 years.

Table 3 provides a rough breakdown of the distribution of course clusters, both at the pre- and final diploma level in German technical universities. The Danish system is not significantly different from its German counterpart. Note that the transportation cluster comprises about 25 percent of the total time and is introduced as early as the fifth semester.

The Hungarian system of educating transportation engineers is quite different from the German or Danish system. Although associated closely with civil engineering, the transportation program by itself comprises about 40 percent of the program. All in all, the European curriculum exposes students to a much broader spectrum of content material in transportation than does the North American counterpart, and the level of coverage is deeper.

Letter grades (e.g., A,B,C, etc.) generally are not awarded to students at the end of each semester in European schools but are awarded at the time of the prediploma or final diploma examination. This system forces students not to "put the knowledge gained in a course behind" but to prepare for a set of examinations covering a wide variety of subjects at the end of the year. In contrast to the North American student, the European student is exposed to a set of more comprehensive and integrated problems.

**TABLE 3 Effort Needed to Complete the German Dipl. Ing. Degree (MS)**

| Prediploma (4 semesters) | Distribution (%) |
|---|---|
| Physics | 10 |
| Surveying | 5 |
| Graphics | 10 |
| Chemistry | 5 |
| Mathematics and statistics | 40 |
| Mechanics | 30 |
| | 100 |
| **Final Diploma (4 semesters)** | |
| Concrete construction | 10 |
| Steel construction | 10 |
| Materials | 10 |
| Construction operation | 10 |
| Soil mechanics | 15 |
| Hydrology, water, sewage | 20 |
| Transportation | 25 |
| | 100 |
| Thesis research (2 semesters) | 100 |

There is no question that major engineering universities in North America with transportation engineering programs are ahead of their European counterparts in computing and equipment facilities. European universities are driven to achieve the best they can, keeping cost and quality in mind.

Although European universities hire students as research assistants, their primary responsibility is to conduct research and not to complete their degree requirements; thus, students pursuing a Ph.D. may find it somewhat more difficult to attain their degrees in a reasonable period of time. The Ph.D. program does not require prescribed course work, and the degree is awarded based on original research work in a highly specialized area. Several years after gaining a Ph.D. instructors (or engineers) must take an oral and written examination called a *Habilitation* dissertation to qualify them to lecture in the university. This qualification reinforces the fact that candidates are able to apply their knowledge to a wide variety of theoretical and practical problems.

As in North America, faculty in Europe have ample opportunity to engage in consulting work, but the general feeling is that teaching and research claim a higher priority over consulting. In some cases a percentage of a professor's consulting fees may be retained by the university. Industry-sponsored research is becoming common in European universities in recent years.

## CONCLUSIONS

European universities have a highly specialized and focused transportation engineering and planning program that leads to the North American equivalent of a master's and Ph.D. degree. Because of their long tradition in technical education, the emphasis, at least in the early stages of their programs, is to provide a thorough grounding in mathematics and physics, buttressed further with courses in statistics, probability, and operations research. Although universities in Europe and North America have almost identical objectives in educating

the transportation engineer, European-educated engineers are more scientists/engineers than their North American counterparts. This is more obvious at the doctoral level.

In view of the impending single European Economic Commission in 1992, Europe is currently going through a series of rapid and radical changes at all levels, sponsored by the European Conference of Transportation Ministers and the International Road Transport Union. In many areas, their technologies and techniques are equal to, if not ahead of, ours. There is a wonderful opportunity for North Americans and Europeans to derive the potential benefits of learning from the research and technological advancements of one another.

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