IMPORTANT NOTE: This report presents the status of on-going academic planning in the Department of Civil and Environmental Engineering. The report is incomplete, and subject to change. At this time, only the Department Purpose, Mission and Research Vision have been approved by the Department faculty; other sections of the academic plan are currently under review and development by the faculty. ** ACCORDINGLY, THIS DOCUMENT IS NOT TO BE CIRCULATED, COPIED OR QUOTED WITHOUT THE PERMISSION OF PROFESSOR S. RITCHIE, CHAIR OF THE DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING.**
1. INTRODUCTION

An Academic Planning Committee was appointed by the Chair of the Department of Civil and Environmental Engineering (CEE) in the Summer of 1998 to develop recommendations for a new and comprehensive 5-10 year Academic Plan for the Department. The members of the Committee are:

Professor W. Recker, Committee Chair
Professor S. Grant
Professor J. Yang
Professor C. Chrysikopoulos, Chair of CEE Graduate Affairs Committee, ex officio
Professor M. McNally, Chair of CEE Undergraduate Affairs Committee, ex officio
Professor S. Ritchie, Department Chair, ex officio

A faculty retreat was held in February 1999, with participation of students and the CEE Affiliates (which comprises senior executives and engineers of leading local firms and agencies), to review the recommendations of the CEE Academic Planning Committee and to develop consensus for finalizing the elements of the CEE Academic Plan. To date, the Purpose, Mission and Research Vision statements have been formally adopted by Department faculty; other sections of this planning document remain under discussion by the Department faculty. The Research Vision, in particular, is a vital element in the development of the complete Academic Plan, including plans for curricula at undergraduate and graduate levels, faculty growth and recruiting, student recruiting, and space, equipment and support staff needs.

This draft report essentially presents a snap-shot of on-going academic planning in the Department, and at this time is necessarily both incomplete and subject to change. The CEE Academic Plan is expected to be completed by Winter Quarter, 2000.

2. PURPOSE

The purpose of the Department is to pursue and foster excellence in the field of civil and environmental engineering through cutting-edge research programs, innovative and challenging curricula, faculty dedication to graduate and undergraduate education, and effective faculty service. The Department’s academic programs will lead to the award of Bachelors, Masters and Doctoral degrees.

3. MISSION

The faculty of the Department will strive to achieve excellence in all of their activities, including research, teaching and professional and University service, for the benefit of their students and society as a whole. This will be manifested in:

a) cutting-edge research programs that create and disseminate significant new knowledge in civil and environmental engineering,
b) innovative, rigorous curricula that prepare students for successful careers in professional practice, research and teaching, and also for life-long learning and technical self-improvement, in civil and environmental engineering and allied fields, and

c) effective faculty leadership and service addressing key areas of importance to the civil and environmental engineering profession, the University, and the Department.

4. GOAL

A major goal of the Department is to gain recognition as one of the leading Departments of Civil and Environmental Engineering in the country, based on its contributions to scholarship and its achievements in undergraduate and graduate education.

With respect to the stature of its graduate programs, the Department heavily weighs the doctoral program rankings of the National Research Council (NRC). Accordingly, a specific goal of the Department is to be solidly ranked within the top 20 publicly supported Civil and Environmental Engineering programs in the nation in the NRC doctoral program rankings of 2005, and within the top 10 publicly supported programs in the nation in the NRC rankings of 2015.

5. VISION

5.1 Research

Although the Department’s core research strengths will continue to be in the areas of earthquake and structural systems engineering, transportation systems engineering, and water resources and environmental systems engineering, during the next five- to ten-year period a major new initiative will be launched that will focus the Department’s research programs around the common overall theme of civil applications in integrated intelligent systems engineering.

This overall research theme will address the innovative development, application and integration of emerging technologies and concepts to fundamentally improve the analysis, design and operation of critical civil and environmental infrastructure systems, as illustrated in Figure 1. The basic elements of this theme will emphasize:

- a systems approach
- emerging technologies and concepts
- performance of critical infrastructure systems

Critical civil and environmental infrastructure systems are often required to function effectively and safely under conditions that in reality are quite dynamic and which may vary significantly over time, even to degrees that threaten the viability of the system itself and the safety of its users. The performance, and particularly the dynamic behavior, control and management of such systems is therefore of particular importance to civil and environmental engineers and to society.
Faculty research will therefore concentrate at the interface of technologies and concepts emerging from fields such as microelectronics, automated control, networking and communications, computer science, materials science, operations research, and the social sciences, and the problems faced in achieving improvements in the performance of critical civil and environmental engineering systems.

A major thrust under this overall theme will be the development of sustainable, multidisciplinary, adaptive and real-time (SMART) Civil and Environmental Infrastructure Systems, with SMART system foci in the following areas:

- Systems Analysis and Operations Research Techniques
- Intelligent Earthquake and Structural Systems
- Intelligent Transportation Systems
- Advanced Water Resources and Environmental Systems
- Advanced Materials

Such SMART systems will sense and adapt to changing conditions in their environment, in order to sustain and even improve their performance in terms of specific criteria, such as level of service, safety and cost. Important examples include hybrid and semi-active control of structures to more effectively resist and survive earthquake, wind and wave loading; advanced transportation management and information systems to utilize existing highway and transit facilities more effectively based on real-time system data, communications, traveler guidance and control; real-time control and analysis techniques and advanced sensors for improved methods of operating water supply, water and wastewater treatment, and flood control infrastructure, as well as for locating, characterizing and remediating contaminants in surface and ground waters.

This research thrust will involve leading edge research efforts in the areas of sensors and data collection devices, instrumentation techniques, structural health monitoring, system and component modeling, system behavior and identification, damage detection methods, testing and experimental analysis, computational methods, real-time control, advanced systems analysis and operations research techniques, and the use of new and innovative high performance materials and structural forms, including advanced composite materials, as applied to civil and environmental infrastructure systems.

The facilities currently available to support this research in the Department include the Structural Engineering Test Hall, Biaxial Shake Table Facility, structural dynamics laboratory, traffic control laboratory, geotechnical laboratory, environmental fluid mechanics laboratory, environmental biotechnology and chemistry laboratories, and state-of-the-art computational laboratories. In addition, the Institute of Transportation Studies offers extensive computational facilities linked to the real-time surveillance and control infrastructure of the California Testbed adjacent to the campus to support all aspects of advanced transportation management and information systems research. These facilities will be enhanced and expanded in the future to further support the Department’s research thrust in SMART Civil and Environmental Engineering Infrastructure Systems.
UCI Civil and Environmental Engineering Core Research Strengths

Systems Analysis
- Transportation Systems
- Critical Civil and Environmental Engineering Infrastructure Systems
- Engineering Technologies and Concepts from Fields External to CEE

Earthquake and Structural Systems
- Water Resources and Environmental Systems

Allied Fields
- Electrical and Computer Engineering
- Mechanical Engineering
- Chemical Engineering
- Bioengineering and Biotechnology
- Materials Science
- Information and Computer Science
- Operations Research
- Management Science
- Social Ecology
- Social Sciences

CEE Research Thrust

Sustainable, Multidisciplinary, Adaptive and Real Time (SMART) Solutions for Critical Civil and Environmental Infrastructure Systems

Focus Areas:
- Systems Analysis and Operations Research Techniques
- Intelligent Earthquake and Structural Systems
- Intelligent Transportation Systems
- Advanced Water Resources and Environmental Systems
- Advanced Materials

Figure 1. Overall CEE Research Theme and SMART Infrastructure Systems Research Thrust.
5.2 Education

5.2.1 Undergraduate Education

Just as the research thrust of the department is predicated on the role of the civil and environmental engineer to increasingly function at the interface of technologies and concepts emerging from related fields in microelectronics, automated control, computer science and communications, so is our undergraduate curriculum designed to position graduates as leaders in the creation and management of new systems for civil infrastructure. The challenges facing today’s civil and environmental engineers, and the corresponding intellectual skills required, are vastly different from those for which traditional science-focused curricula offer preparation. Dominated by issues of global competition, virtually ubiquitous sharing of knowledge, the availability of increasingly “intelligent” technology, and an awareness that environment and safety must be an explicit part of the design process, these challenges require that our engineers be more integrators and managers of technological systems than designers and analysts of their component parts. They will increasingly find their work as part of team efforts, requiring effective communication of high-level ideas as important as the soundness of engineering design; they will deal with a built environment that increasingly functions more as an actor in the operation of a complex dynamic system than as an inanimate stage prop in its support; they will work across many disciplines and fields, using a systems approach to position their work within the context of ethical, political, environmental and economic considerations.

To address these issues, Joseph Bordogna, the assistant director for engineering in the Engineering Directorate of the National Science Foundation, has proposed that the traditional fractional baccalaureate engineering curriculum be replaced by a more holistic approach in which engineering is viewed as an integrative process that is designed to develop the capacity to:

- design, in order to meet safety, reliability, environmental, cost, operational, and maintenance objectives;
- realize products;
- create, operate, and sustain complex systems;
- understand the physical constructs and the economic, industrial, social, political, and international context within which engineering is practiced;
- understand and participate in the process of research; and
- gain the intellectual skills needed for lifelong learning.\(^1\)

As a guide to operationalizing these concepts in a manner that realizes philosopher José Ortega y Gasset’s call to the University to “call out a kind of scientific genius which hitherto has existed only as an aberration: the genius for integration … specializing in the construction of the

whole,”2 Bordogna offers the components of a holistic baccalaureate education, that are presented in Table 1.

### Table 1. Components of a Holistic Baccalaureate Education

<table>
<thead>
<tr>
<th>Vertical (in-depth) thinking</th>
<th>Lateral (functional) thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract learning</td>
<td>Experiential learning</td>
</tr>
<tr>
<td>Reductionism – Fractionization</td>
<td>Integration – Connecting the parts</td>
</tr>
<tr>
<td>Develop Order</td>
<td>Correlate Chaos</td>
</tr>
<tr>
<td>Understand certainty</td>
<td>Handle Ambiguity</td>
</tr>
<tr>
<td>Analysis</td>
<td>Synthesis</td>
</tr>
<tr>
<td>Research</td>
<td>Design / Process / Manufacture</td>
</tr>
<tr>
<td>Solve problems</td>
<td>Formulate problems</td>
</tr>
<tr>
<td>Develop ideas</td>
<td>Implement ideas</td>
</tr>
<tr>
<td>Independence</td>
<td>Teamwork</td>
</tr>
<tr>
<td>Technological – Scientific Base</td>
<td>Societal Context / Ethics</td>
</tr>
<tr>
<td>Engineering Science</td>
<td>Functional core of engineering</td>
</tr>
</tbody>
</table>

The development of our undergraduate curriculum explicitly supports and incorporates these principles and their underlying philosophy.

### 5.2.2 Graduate Education

Graduate education naturally mirrors the research strengths of the Department’s faculty. Although we will continue to offer both graduate coursework and research opportunities across a broad range of civil and environmental engineering topics, our growth and thrust will be in the development of Ph.D.-level foci in SMART civil and environmental infrastructure systems in the following areas: Systems Analysis and Operations Research Techniques, Intelligent Earthquake and Structural Systems, Intelligent Transportation Systems, Advanced Water Resources and Environmental Systems, and Advanced Materials. To support such development we have structured our graduate program of study in each of our focus areas around a “backbone” of cross-cutting methodological courses, designed to provide the foundation for advanced research in active civil and environmental engineering systems. And, while individual programs of study and the extent to which the various research focus areas draw from the backbone vary, it nonetheless defines the character and basic philosophy of graduate inquiry within the Department.

---

6. UNDERGRADUATE CURRICULUM

6.1 B.S. Degree in Civil Engineering:

Our proposed Civil Engineering undergraduate curriculum has been designed in the spirit of the holistic paradigm offered by Bordogna and presented previously in Table 1, subject to limitations imposed both by university academic requirements and over-riding educational philosophy, as well as by the size of our department. A conceptual mapping of the basic “building blocks” of our undergraduate curriculum relative to the components of the holistic educational approach articulated above is shown in Figure 2. Figures 3, 4 and 5 identify course requirements within each building block for the core and elective portions of the B.S. Degree in Civil Engineering program of study.

The key features that distinguish the undergraduate curriculum in Civil Engineering are:

- Emphasis on the development of a set of basic skills that lay the foundation for lifelong learning in a dynamic technical environment;
- Explicit recognition that software development and its use is integral to the practice of engineering in the modern world;
- Explicit recognition that the path to leadership roles in the professional practice of civil and environmental engineering relies as much on entrepreneurial skills and cost-effective management as it does on technical ability;
- Emphasis on a systems-level approach to the analysis and design of civil infrastructure;
- Balanced treatment of engineering problem-formulation and problem-solution techniques;
- Integrated treatment of the analysis and design of civil and environmental engineering systems, using modern computer-aided analysis and design software, and culminating in a design practicum in which a team of students, under the supervision of faculty and professional engineers, execute a comprehensive design exercise;
- A modular format that facilitates revision of and/or augmentation to the constituent “building blocks” as either the state-of-the-art or the needs of the profession evolve;
- Optional tracks for qualified students to gain advanced in-depth training in specialty areas while completing their undergraduate requirements and/or to complete training in allied minor fields of study or accelerate progress toward an advanced degree in civil and environmental engineering.
Figure 2. Conceptual Mapping of Undergraduate Curriculum to Holistic Paradigm
### Mathematical Sciences
- Math 2A Differential Calculus (4,0)
- Math 2B Integral Calculus (4,0)
- Math 2C Infinite Series (4,0)
- Math 2D Calculus in 2-3 Dim. (4,0)
- Math 3A Linear Algebra (4,0)
- Math 2F Vector Calculus & Diff. Eqns. (4,0)
- Units = 24  Design Units = 0

### Physical Sciences
- Chemistry 1A Gen. Chemistry (4,0)
- Physics 7B, 7LB Classical Phys (5,0)
- Physics 7C, 7LC Classical Phys (5,0)
- Physics 7D Classical Phys (4,0)
- Science/Math Elective (4,0)
- Units = 22  Design Units = 0

### Engineering Mechanics
- MAE 30 Applied Mechanics (4,0)
- MAE 80 Dynamics (4,0.5)
- MAE 130A Fluid Mechanics (4,0)
- MAE 150L Mech. of Materials Lab (1,0)
- MAE 130, 130L Mech. of Materials (5,0)
- Units = 22  Design Units = 1.5

### Methods of Analysis
- ECE 11 Comp Methods in ECE (4,0)
- CEE 15 Applied Prob & Statist (4,0)
- Units = 8  Design Units = 0

### Methods of Synthesis & Design
- CEE 105 Modeling & Simul (4,0)
- CEE 115 Systems Anal & Des (4,2)
- ECE 20 System Programming I (4,1)
- Units = 12  Design Units = 3

### CEE Anal, Synthesis & Design
- CEE 121 Transp. Anal & Des I (4,2)
- CEE 131 Found. Anal & Des I (4,2)
- CEE 151 Struct. Anal & Des I (4,2)
- CEE 161 Envir. Anal & Des I (4,2)
- CEE 171 Hydr. Anal & Des I (4,2)
- CEE 100A Design Practicum (2,2)
- CEE 100B Design Practicum (2,2)
- Units = 24  Design Units = 14

---

### Economics
- Econ 20A Basic Economics (4,0)
- Select one from:
  - Econ 20B Basic Economics (4,0)
  - Econ 20C Basic Economics (4,0)
- Units = 8  Design Units = 0

### Environmental Science
- E8 Environ. Anal. & Design (4,0)
- Units = 4  Design Units = 0

### Professional Practice Specialization
- CEE Specialization Electives (12,0)
- Environ. Engineering & Analysis
- Hydraul. Engineering & Analysis
- Structur. Engineering & Analysis
- Transp. Engineering & Analysis
- Career Specialization Electives (24,0)
- Management Option
- Software Applications Option
- Public Sector Practice Option
- Advanced Study Option
- General Practice Option
- Environmental Engr. Option
- Systems Engineering Option
- Intell. Transp. Systems Option
- Units = 36  Min Design Units = 8

---

**Figure 3. CE Core Undergraduate Course Requirements**
Figure 4. CE Undergraduate Specialization Electives
**Career Specialization Options**

### Career Specialization Options

#### Management Option
- Mgt 5 Manag. Contemp. Orgs. (4.0)
- Mgt 181 Manag. Org. Behavior (4.0)
- Mgt 183 Quant. Meth. For Mgt. (4.0)
- Mgt 185 Intro. to Fin. Accnting (4.0)
- Mgt 186 Intro. to Mgt. Finance (4.0)
- Mgt 188 Intro. Mgt. Info. Sys. (4.0)

**Units = 24  Design Units = 0**

**Needed to Complete Minor in Management**
- Mgt 187 Intro. to Maketing (4.0)

#### Software Applications Option
- ICS 6A Discrete Math for C.S. (4.0)
- ICS 21 Introduction to C.S. (4.0)
- ICS 22 Introduction to C.S. II (4.0)
- ICS 23 Fund. Data Structures (4.0)
- ICS 52 Intro. to Software Eng. (4.0)
- ICS 121 Software Tools & Meth (4.0)

**Units = 24  Design Units = 0**

**Needed to Complete Minor in Information & Computer Science**
- One Upper Division ICS Course (4.0)

#### Public Sector Practice Option
- E105U Environmental Law (4.0)
- E107U Urban & Reg. Planning (4.0)
- E141U Urban & Reg. Analysis (4.0)
- E148U Cities & Transportation (4.0)
- E155U Water Resources Policy (4.0)
- E159U Urban Econ. Dev. Policy (4.0)

**Units = 24  Design Units = 0**

**Needed to Complete Minor in Urban & Regional Planning**
- Two courses selected from:

#### Advanced Study Option
- Math 13 Intro. Abstract Math. (4.0)
- Math 140A Elementary Anal. (4.0)

**Total of 16 units selected from:**
- Math 105A, 105LA Num. Anal (6.0)
- Math 106A, 106LA Num. Anal (6.0)
- Math 107, 107L Num. Diff. Eq. (6.0)
- Math 112 A Math Meth for Eng. (4.0)
- Math 112 B Math Meth for Eng. (4.0)
- Math 112 C Math Meth for Eng. (4.0)
- Math 118 A Differential Eqns. (4.0)
- Math 118 B Differential Eqns. (4.0)
- Math 118 C Differential Eqns. (4.0)

**Units = 24  Design Units = 0**

**Needed to Complete Minor in Mathematics**
- One Upper Division Math Course Numbered 100-169 (4.0)

---

*Figure 5a. CE Career Specialization Options with Potential for Minors*
Career Specialization Options

General Practice Option
CEE xx Comm/Graphic Repres. (4,0)

Three remaining CEE Anal&DesII courses from non-CEE Specialty:
CEE 162 Envir. Anal&Des II (4,2)
CEE 152 Struct. Anal&Des II (4,2)
CEE 172 Hydr. Anal&Des II (4,2)

E145 Envir. Impact Studies (4,0)
Technical Elective (4,4)

Units = 24  Design Units =8+x

Environmental Engr. Option *
Chem 1C Gen. Chemistry (4,0)
Chem 51A, 51LA Organ. Chem. (6,0)
ChE 40 Material Balances (5,1)
ChE 60 Thermodynamics (5,1)
ChE 160 Chem. Kin/React Des. (4,2)

Units = 24  Design Units =4

* Students must select Chem 1B, 1LB as their Science/Math Elective

Systems Engineering Option
Math 171A Linear Programming (4,0)
Math 171B Nonlinear Progr. (4,0)
Math 171C Int. & Dyn. Progr. (4,0)
ECE 40 System Programming II (4,2)
CEE 1xx Stochastic Systems (4,0)
Technical Elective (4,4)

Units = 24  Design Units =2+x

Intelligent Transp. Systems Option
MAE 140 Intro to Eng Anal (4,0)
MAE 170 Intro to Control Sys (4,2)
MAE 171 Digital Control Sys (4,2)
ECE 40 System Programming II (4,2)
ECE 70 A Network Anal I (3,1)
ECE 70 B Network Anal II (4,1)

Units = 24  Design Units =9

Figure 5b. CE Career Specialization Options (Continued)
The extent to which we are able to capture the spirit of a holistic baccalaureate educational experience under this curriculum is limited both by the faculty resources of the department and its strong commitment to graduate study and research, as well as by the fragmentation that exists in the disciplines outside of civil and environmental engineering crucial to implementation of the holistic concept. However, we note with some optimism that many of the factors that shape the rethinking of engineering education are common to these fields also. We also recognize that implementation of the proposed curriculum is highly reliant on the cooperation of allied departments both within the School of Engineering as well as external to it. Such cooperative effort is an inherent aspect of the educational philosophy on which the proposed curriculum is based, and is viewed as one of its greatest strengths.

6.2 B.S. Degree in Environmental Engineering

The vision and curriculum for the B.S degree in Environmental Engineering is currently under development through a School-wide initiative being led by Professor S. Grant.

6.3 Exploratory Proposal for a Joint SOE Undergraduate Concentration in Transportation Systems Engineering

UCI is already counted among leading centers for transportation research; the UCI Department of Civil and Environmental Engineering offers a graduate program which is distinguished by its interdisciplinary approach to the study of contemporary urban transportation issues, and by its unique relationship with the UC Irvine Institute of Transportation Studies. The CEE graduate program focuses on the planning, design, operation, and management of modern urban transportation/activity systems. Emphasis is on the development of fundamental skills and knowledge in engineering, systems analysis, modeling, and planning, combined with advanced computational techniques, to address transportation problems affecting urban travelers.

Both in recognition that the solutions to modern transportation engineering problems are as much dependent on principles in communications and control as they are in transportation theory, as well as to capitalize on the strengths and national recognition that the UCI transportation systems engineering program has achieved, we are advancing a concept for a school-wide undergraduate concentration in intelligent transportation systems. The overall theme of this joint SOE initiative in transportation systems engineering would address the innovative development, application and integration of emerging technologies and concepts to fundamentally improve the analysis, design and operation of the nation’s most advanced transportation systems. The basic elements of this theme emphasize:

- a systems approach
- emerging technologies and concepts
- real-time systems performance capabilities

Transportation systems are required to function effectively and safely under conditions that in reality are quite dynamic and which may vary significantly over time, even to degrees that threaten the viability of the system itself and the safety of its users. The performance, and
particularly the dynamic behavior, control and management of such systems is therefore of particular importance to society. The federal government has recognized this importance with the allocation of unprecedented levels of funding for research and development of intelligent transportation systems.

Consistent with the overall vision of the Department, the proposed undergraduate concentration is predicated on the role of the transportation engineer to increasingly function at the interface of technologies and concepts emerging from related fields in microelectronics, automated control, computer science and communications; our proposed undergraduate curriculum is designed to position graduates as leaders in the creation and management of new systems for transportation.

Although it is recognized that the development and implementation of an undergraduate concentration in transportation systems engineering is a formidable task from an institutional standpoint, we nonetheless herein outline such a program, both as a concept of what properly defines the modern transportation knowledge domain as well as to demonstrate that the School currently has virtually all of the requisite educational components to mount such an effort. A preliminary draft of the course makeup of the undergraduate program of study for this concentration is displayed in Figure 6.
Figure 6. Undergraduate Curriculum Concept for Transportation/Activity Systems Engineering
7. GRADUATE EDUCATION AND RESEARCH

Graduate education and research in the Department has been organized into three primary focus areas:

- Transportation Systems Engineering,
- Water Resources and Environmental Systems Engineering, and
- Earthquake and Structural Systems Engineering.

The specific plans for development of each of these areas of graduate education and research are summarized below.

7.1 Transportation Systems Engineering

Current Ph.D. study and research in Transportation Systems Engineering are focused on two distinct areas – Advanced Transportation Systems (ATS) and Activity Systems Analysis (ASA) – that are on the cutting edge of systems research in transportation. Each of these thrust areas is inherently interdisciplinary and the programs of study and research are designed to integrate knowledge from the contributing disciplines; each program is supported by a formal research center within the UCI Institute of Transportation Studies. Together, the ASA and ATS graduate thrusts provide a unique research perspective to contemporary transportation demand and supply issues. A total of fourteen Ph.D. graduates from these programs have gone on to academic positions during the past five years alone.

Under this plan, faculty research in transportation/activity systems engineering will concentrate at the interface of technologies and concepts emerging from fields such as microelectronics, automated control, networking and communications, computer science, materials science, operations research, and the social sciences, and the problems faced in achieving improvements in the real-time performance capabilities of transportation/activity engineering systems.

Advanced Transportation Systems (ATS)

The ATS Program brings the creative capabilities of academia to bear on the challenging intelligent transportation systems research and development tasks before it and to integrate this work within the larger effort needed to achieve the goals of the nation’s ATS Program. It is designed to research and develop the potential of applying electronic, telecommunication and other technologies to transportation systems to address the significant mobility, environmental and economic challenges in the state and the rest of the nation.

Current research expenditures in advanced technology applications by CEE transportation faculty are approximately $2 million per year and constitute a substantial portion of the campus’ research effort in transportation, particularly in the area of advanced transportation systems. These trends are expected to continue, based on the growing trend on this campus of our CEE transportation faculty to concentrate their research in the area of advanced technology in transportation and the increasing research investment in this area by both federal and state government, as well as by
the developers of high technology in the private sector. The impact of this research program is
not measured solely by its ability to attract substantial amounts of extramural resources, which is
itself only an input, but rather by the scholarship produced by these resources. One measurable
component of such impact has been the success of the CEE ATS graduate program in
transportation systems engineering – twelve Ph.D. graduates from the ATS program have gone
on to academic positions in the past five years alone.

Together, the transportation systems engineering faculty have developed a research Testbed
program that is the center of the California ATMS research effort. Study and research in this
area is supported by the California Advanced Transportation Management Systems Testbed, a
comprehensive research program that was initiated in early 1991 under research agreements
between the California Department of Transportation, the U.S. Department of Transportation and
UCI. The Testbed is an integrated approach to the development and deployment of advanced
technologies in the operation and management of Intelligent Transportation Systems. The
Testbed provides an instrumented, multi-jurisdictional, multi-agency transportation operations
environment linked to university laboratories for real-world development, testing, and evaluation
of near-term technologies and applications of advanced technologies in the operation and
management of urban transportation based on real-time, computer-assisted traffic management
and communication.

The Testbed is anticipated to incorporate a national transportation detection center that will be
the foremost ITS surveillance center in the United States. In addition, negotiations are currently
underway that are anticipated to lead to the designation of the Testbed as the site for two major
federal research programs – the federal dynamic traffic assignment initiative, and the federal
ramp metering project.

Research in the UCI ATS effort primarily has involved faculty from the Departments of Civil and
Environmental Engineering and Electrical and Computer Engineering, with some involvement
from faculty in the Department of Information and Computer Sciences. These faculty were
brought together largely through the Testbed Research Program; a number of subsequent
individual research projects have been spawned from this involvement. Graduate study in ATS
has been based on a combination of coursework offered in CEE and ECE. Although most of the
interaction has involved the migration of CEE graduate students toward ECE-related
transportation research, a number of ECE and ICS students also have developed successful
dissertation topics in ATS. Developing a more formal structure for these informal interactions
would not only better position UCI engineering faculty to attract even more federal research
funding but would also place UCI in a leadership role in redefining the transportation discipline
from a base of communications, control, and computing rather than its traditional base of design
and construction.

This research thrust will involve leading edge research efforts in the areas of sensors and data
collection devices, instrumentation techniques, system and component modeling, system
behavior and identification, system failure detection methods, testing and experimental analysis,
computational methods, and real-time control, as applied to the management and control of
transportation systems.
The Institute of Transportation Studies offers extensive computational facilities linked to the real-time surveillance and control infrastructure of the California Testbed adjacent to the campus to support all aspects of advanced transportation management and information systems research. These facilities will be enhanced and expanded in the future to further support the Department’s research thrust in Advanced Transportation Systems Engineering.

**Activity Systems Analysis (ASA)**

The ASA Program provides a focus for research pioneered at UCI in activity-based approaches for transportation modeling. Since 1979, researchers at UCI have been on the leading edge of evolving research in activity-based models and dynamic approaches to complex travel behavior. This work draws from such diverse fields as the application of pattern recognition techniques to activity pattern classification, the development of joint models of activity and travel demand using structural equations modeling, and microsimulation of activity patterns to produce dynamic origin-destination matrices. Research in this area is supported by the Center for Activity Systems Analysis within the Institute of Transportation Studies.

Transportation graduate teaching and research in ASA relies on programs outside of civil and environmental engineering to provide expertise and courses in selected areas. One of these areas, operations research, is often covered in industrial, systems, or electrical engineering departments. At UCI, there are virtually no engineering faculty or courses in this area beyond those already offered by the CEE transportation faculty. This failing was recognized explicitly by the recent external academic review committee for UCI’s Institute of Transportation Studies, which noted in its report to the Academic Senate that logistics is the one major area of transportation research in which UCI had no activity, principally because of the absence of academic departments at UCI in disciplines traditionally associated with this area of research. As a result, this area was targeted for growth in the CEE faculty recruitment plan, and the first appointment in the OR area made recently with the addition of Professor Regan.

However, this recent addition in combination with existing ad hoc specialization in application of OR techniques in ASA are neither sufficient to address complex systems research issues in transportation nor do they provide a base upon which a modern educational concept of engineers as the integrators of technology can be developed.

In the ASA program, there is a need to develop coordinated research and teaching expertise in such topics as 1) Location and logistics theory, 2) Operations Research analysis of freight and inter-modal transportation, 3) Multi-modal Transportation network optimization, and 4) Intelligent transportation systems including Commercial Vehicle Operations. The general courses expected to be developed and taught on two or more of the general topics such as 1) Nonlinear/Integer/Dynamic/Network Programming, 2) Stochastic Processes, 3) Queuing theory, 3) Optimal control theory, 4) Decision Analysis, and 5) Combinatorial/heuristic optimization.

The ITS Center for Activity Systems Analysis provides a research focal point for coordinated development of OR-based research in engineering. Under this umbrella, the School would have
a mature and stable research environment to develop an OR presence in its teaching and research programs; one that subsequently could be expanded to a more general, and independent, focus.

**Graduate Curriculum in Transportation/Activity Systems Engineering**

Graduate education naturally mirrors the research strengths of the School’s transportation faculty. Although we will continue to offer both graduate coursework and research opportunities across a broad range of transportation engineering topics, our growth and focus will be in the development of Ph.D.-level thrusts in Intelligent Transportation Systems and OR-based research in the logistics of activity systems. To support such development we have structured our graduate program of study around a “backbone” of cross-cutting methodological courses, designed to provide the foundation for advanced research in both modern and emerging transportation engineering systems. Using this backbone as a core, the graduate program of study in transportation/activity systems engineering is outlined in Figure 7.

**7.2 Water Resources and Environmental Systems Engineering**

The water resources and environmental systems engineering group in the Department has chosen to focus its research and teaching efforts on a few key areas of national and international importance. In January 1998, the National Academy of Engineering, the Association of Environmental Engineering Professors, and the National Science Foundation co-sponsored a workshop entitled “Environmental Engineering Frontiers”. The workshop participants, most of whom were members of the NAE, identified four key research frontiers in environmental engineering, including: (I) Sustainable Environmental Resources, (II) Complex Environmental Systems, (III) Analytical and Molecular Tools, and (IV) Process Technologies. As described in more detail below, the research activities of the faculty in water and environmental engineering cover the four research frontiers identified by the NAE/AEEP/NSF workshop. Furthermore, these research areas are consistent with the department’s over-arching theme of sustainable, multidisciplinary, adaptive, and real-time (SMART) engineering.

I. **Sustainable Environmental Resources.** A major challenge for the field of environmental engineering is developing sound technological approaches for sustaining environmental resources, particularly water resources. This is especially true in Southern California, where population growth coupled with an ever diminishing supply of imported water could lead to severe water shortages in the near future. A frontier topic in environmental sustainability is the recycling of wastewater (typically municipal sewage) into potable water for drinking and irrigation. Large scale water recycling projects are currently being developed or expanded in California (L.A. County, Orange County, San Diego County, and Alameda County), Arizona, and Florida, to name a few. An important and as yet unresolved human health concern associated with this practice is the possibility that microorganisms (viruses, bacteria, and protozoa) present in the wastewater may find their way into drinking water supplies, and cause outbreaks of waterborne disease. Ongoing research by three faculty in the department (S. Grant, T. Olson, and C. Chrysikopoulos) is addressing this key issue, by looking at the effectiveness of soil aquifer treatment as a barrier to the transmission of human viruses. Current and recent
funding for this research, which has totaled over $1,000,000, has come from the National Science Foundation, the Environmental Protection Agency, the National Water Research Institute, the UC Water Resources Center, the L.A. County Sanitation District, and the Orange County Water District. Paradoxically, California also experiences relatively short periods of intense rain fall that can lead to devastating flood events, as occurred in the Sacramento and San Joaquin river valleys in the winter of 1997/98. One of the faculty members in the Department (B. Sanders) has proposed a novel approach for minimizing the civilian and economic impacts of flood events, that involves deliberately breaching river levees at optimal locations and times. This research, which is currently funded by a grant from the UC Water Resources Center, has focused on the development of real-time algorithms for numerical analysis of flood wave propagation and the identification of optimal breach sites. The optimization methods developed in this research are also being extended to other important topics in environmental sustainability, including the adaptive control of fresh water diversions to manage estuarine salinity and the optimal control of flood control infrastructure to lessen the impact of urban runoff on coastal water quality.

II. Complex Systems. Historically, the focus of environmental engineering has been on the development and application of technology for treating a particular medium, for example, water or wastewater treatment. The NAE/AEEP/NSF workshop emphasized that the future of environmental engineering will increasingly involve the analysis and management of complex environmental systems, for which traditional single-discipline approaches will not be successful. Pollutant transport in natural subsurface systems, for example, is controlled by a complex coupling of physical, biological, geological, and chemical processes. Practical solutions to these complex problems require an interdisciplinary and cross-disciplinary approach in which engineers collaborate with biologists, geologists and environmental chemists. The Department is uniquely suited to be a leader in this particular research frontier, because of the demonstrated ability of its faculty to carry out research projects at the interface of engineering and science. Examples of research questions in this category that are being actively pursued by faculty in the Department include:

(i) How do the chemical properties of non-aqueous phase liquids (like gasoline and solvents) influence their fate and transport in groundwater aquifers?
(ii) What are the key chemical and biological processes that control the removal of particulate pollutants from water by physicochemical filtration?
(iii) Can fractal scaling concepts developed in the physics literature be applied to the coagulation and sedimentation of particles in water?
(iv) How do biological and physical processes interact to regulate the downward flux of particulate organic matter in the ocean?
(v) How does the molecular scale structure of virus particles influence their physicochemical properties and transmission in the environment?
Figure 7. CEE Graduate Transportation Systems Engineering Option
III. **Analytical and Molecular Tools.** Recent advances in analytical techniques have revolutionized the fields of biology and chemistry. Application of these same techniques to environmental systems could lead to quantum leaps in our ability to characterize natural systems, and to understand the mechanisms by which pollutants are transported and transformed in the environment. The NAE/AEEP/NSF workshop highlighted several examples where emerging technology could have significant environmental applications, and each of these are active areas of research within CEE. One of the examples discussed by the workshop was the application of molecular methods for characterizing microbial communities, and for microbial pollutant identification. Research in Prof. Grant’s lab has focused on the use of polymerase chain reaction (PCR) and DNA hybridization techniques to identify and quantify specific bacterial pollutants. It is interesting to note that several other research groups at UCI are using the same basic approach—most notably faculty in the Department of Environmental Analysis and Design—and, consequently, there is significant potential for expanding these activities through interdepartmental collaborations. Another faculty member (Prof. Olson) is applying cutting edge analytical techniques to study colloidal processes and pollutant transformation mechanisms. Examples include the use of atomic force microscopy to examine single particle-surface interactions and GC/MS to evaluate the effectiveness of novel oxidation processes and elucidate disinfection by-product formation pathways in drinking water treatment.

IV. **Process Technologies** The traditional focus of environmental engineering has been on the application of process technologies for treating specific mediums, such as water and wastewater, as discussed earlier. The NAE/AEEP/NSF workshop suggested that continued research in this area should be a high priority, particularly with regard to improving the cost effectiveness of existing technologies, and for adapting existing technologies to the financial and operational constraints found in developing countries. Several faculty in the Department pursue research that satisfy these priorities. For example, faculty have developed and tested novel advanced oxidation processes for treating organic pollutants, investigated the effectiveness of conventional coagulation and sedimentation processes for removing viruses and protozoans from water, and developed approaches for sustaining denitrification operations in cold climates.

7.3 **Earthquake and Structural Systems Engineering**

Advanced study and research in Earthquake and Structural Engineering emphasizes the application of analytical and experimental approaches to the investigation of the effects of earthquakes and other extreme hazards on constructed facilities. Areas of specific interest include reliability of engineering systems, random vibration, passive, active and hybrid control of structural vibration, retrofit of buildings and bridges using composite materials, health monitoring systems, system and damage identification, damage detection, fiber optical sensors, elastomeric and sliding base isolation systems, dynamic behavior of liquid storage tanks, seismic response of equipment and other secondary systems, and stochastic fatigue, fracture and maintenance of structures. The objective of the program is to prepare graduates for responsible
positions in industry and research institutions by providing them with advanced skills in state-of-the-art methodologies applied to significant engineering problems.

In addition to excellent computer-based mathematical modeling facilities, the department has modern facilities for experimental testing (static, pseudo-dynamic, and dynamic) of structural components and advanced structural systems under intelligent control. In particular, the Structural Test Hall facility provides for large-scale experiments. This Hall is 80 ft. by 50 ft. and houses a reaction floor 70 ft. by 50 ft. on plan, a reaction wall 60 ft. long by 22 ft. high, an overhead traveling crane and a MTS dynamic load system. It is also equipped with shaking equipment, accelerometers, seismometers, signal processors, Fourier analyzers, and on-line computers. A new multi-axis shaking table capable of testing 20,000 lbs. payload with 20 inches horizontal and 10 inches vertical strokes will be operational in Summer 1999. The structures program provides excellent facilities for theoretical, numerical and experimental research.

Under the proposed plan, the strength and thrust area of research will focus on advanced and intelligent structural technology, including: the passive, active, semi-active and hybrid control of advanced structural systems; sensor technology; structural monitoring and identification; active damage detection; and applications of advanced composite materials in the retrofit of civil structures. This represents a consolidation and focusing of research emphasis; a majority of currently funded research projects in the structures program are already in precisely this area of research.

**Graduate Curriculum in Earthquake and Structural Systems Engineering**

The structures program provides a unique research perspective to smart and advanced structural technology in earthquake engineering. The graduate program of study emphasizes a solid background in theoretical, computational and experimental mechanics and has a strong interface with programs in MAE, ECE and MSE, as outlined in Figure 9.
Interface with Other CEE Courses
CEE 231 Advanced System Software
CEE 233 Computer Architecture
CEE 235 Design & Analysis of Algorithms
CEE 252 Distributed Computer Systems
CEE 253 Real-Time Computer Systems
CEE 254 Fault-Tolerant Computing
CEE 257 Advanced Database Systems

Interface with Communications & Computing
ECE 229A Computer Communication Networks
ECE 230A Digital Signal Processing
ECE 231 Advanced System Software
ECE 233 Computer Architecture
ECE 235 Design & Analysis of Algorithms
ECE 252 Distributed Computer Systems
ECE 253 Real-Time Computer Systems
ECE 254 Fault-Tolerant Computing
ECE 257 Advanced Database Systems

Earthquake & Structural Systems M.S. Core
CEE 242 Advanced Strength of Materials
CEE 247 Structural Dynamics
CEE 250 Finite Element Methods
CEE 283 Math Methods in Engineering Analysis
CEE 284 Engineering Decision and Risk Analysis

Earthquake & Structural Systems MS/PhD Core
CEE 245 Experimental Modal Analysis
CEE 251 Dynamics of Fluid/Struct Systems
CEE 253 Plates and Shells
CEE 257 Advanced Structural Analysis
CEE 281 Finite Element in Continuum Mech.
CEE 287 Random Vibrations
CEE 288 Advanced Random Vibrations

MS/PhD

Specialty

Structural Control Systems Analysis
CEE 241 Control of Structures
CEE 248 Wind Engineering
CEE 249 Earthquake Engineering
CEE 258 Earthquake-Resistant Struct Design
CEE 259 Structural Stability

Specialty

Structural Materials Systems Analysis
CEE 243 Mechanics of Composite Materials
CEE 246 Structural Performance and Failure
CEE 254 Advanced Reinforced Concrete
CEE 255 Advanced Steel Structures

Interface with Material Science
MSE 254A Mechanical Behavior of Materials
MSE 255B Science of Composite Materials
MSE 256A Fracture of Engineering Materials
MSE 256B Fatigue of Engineering Materials

Interface with Other CEE Courses
CEE 231 Foundation Engineering
CEE 232 Soil Dynamics
CEE 280 Computational Methods and Software
CEE 285 Reliability of Engineering Systems I
CEE 286 Reliability of Engineering Systems II

Figure 9. CEE Graduate Earthquake and Structural Systems Engineering Option
8. FACULTY REPLACEMENT, GROWTH AND RECRUITING PLANS

8.1 Overall Needs

As stated, a major goal of the Department is to be solidly ranked within the top 20 publicly supported Civil and Environmental Engineering programs in the nation in the anticipated National Research Council (NRC) rankings of 2005, and within the top 10 publicly supported programs in the nation in the anticipated NRC rankings of 2015.

In the last NRC rankings, which were published in 1995 and based on surveys in 1993, Civil Engineering at UCI was ranked 33rd in the nation overall, 21st in the nation amongst publicly supported institutions (see Table 2), and 2nd in the nation for improvement in program quality in the previous 5 years. In the NRC rankings of a decade earlier, Civil Engineering’s fledgling doctoral program did not qualify for inclusion, indicating that by 1995 the Department had achieved a truly remarkable rise in stature in a relatively short time. At the time of the 1993 NRC surveys, the Department had doubled in size over the previous decade to 17 regular rank faculty (Figure 10). In the 1995 NRC rankings, no other public university civil engineering program with faculty size comparable to Civil Engineering at UCI was ranked higher, providing strong evidence that the Department had effectively utilized the faculty positions provided to it by the campus and the School of Engineering.

However, in the last five years, the Department has suffered the loss of five faculty, one being due to a tenure decision (Professor Pires) and four being senior faculty retirements (Professors Guymon, Shepherd, Scherfig, and Professor Ang who, until his retirement, was the School of Engineering’s only non-Emeritus National Academy of Engineering member); it will lose an additional three faculty by the end of the current academic year – two by resignation (Professors Haroun and Olson), one by transfer to another SOE department (Professor Grant). The loss (including those impending) of eight faculty positions has been compensated only by two entry level Assistant Professor appointments in 1997. Consequently, the Department will enter 1999-2000 with only 11 regular rank faculty, with a corresponding loss of 24 course offerings, representing an almost 40 percent reduction in its academic program from that in 1993-94. These losses leave gaping holes in its ability to offer even its core undergraduate program, and jeopardize the viability of its graduate programs (Figure 11).

This Academic Plan calls for a commitment to an aggressive recruiting schedule over the next 5-10 years, and especially in the next few years, both to recoup the losses of faculty experienced in recent time, as well as to chart a course for the Department’s rise in the national rankings. Some insight to the department faculty size associated with the achievement of these goals can be found in the most recent NRC rankings of the top 20 civil engineering programs. The 1993 faculty sizes of the smallest programs (in faculty size) in each quartile of the top 20 publicly supported civil engineering programs range from 18 to 93; the median faculty size of the top 10 programs is 38.5, and that of the second decile is 31.5. The smallest program in the top 10 had a faculty size of 23.³

³ The UNC Chapel Hill program is apparently an Environmental Sciences and Engineering program in the School of Public Health, rather than a Civil Engineering program.
Table 2. 1995 NRC Relative Rankings of Publicly Supported Civil Engineering Ph.D. Programs

<table>
<thead>
<tr>
<th>Institution</th>
<th>Public Ranking*</th>
<th>Overall Ranking</th>
<th>Faculty Size in 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of California, Berkeley</td>
<td>1</td>
<td>2</td>
<td>43</td>
</tr>
<tr>
<td>University of Texas at Austin</td>
<td>2</td>
<td>4</td>
<td>93</td>
</tr>
<tr>
<td>University of Illinois at Urbana-Champaign</td>
<td>3</td>
<td>5</td>
<td>71</td>
</tr>
<tr>
<td>University of Michigan</td>
<td>4</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td>Purdue University</td>
<td>5</td>
<td>11</td>
<td>56</td>
</tr>
<tr>
<td>University of Minnesota</td>
<td>6</td>
<td>13</td>
<td>32</td>
</tr>
<tr>
<td>University of Washington</td>
<td>7</td>
<td>14</td>
<td>34</td>
</tr>
<tr>
<td>University of North Carolina, Chapel Hill**</td>
<td>8</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>University of California, Davis</td>
<td>9</td>
<td>16</td>
<td>27</td>
</tr>
<tr>
<td>Texas A&amp;M University</td>
<td>10</td>
<td>17 (Tie)</td>
<td>63</td>
</tr>
<tr>
<td>Georgia Institute of Technology</td>
<td>11</td>
<td>17 (Tie)</td>
<td>41</td>
</tr>
<tr>
<td>Virginia Polytechnic Institute &amp; State University</td>
<td>12</td>
<td>19 (Tie)</td>
<td>34</td>
</tr>
<tr>
<td>University of California, Los Angeles</td>
<td>13</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>University of Wisconsin, Madison</td>
<td>14</td>
<td>22</td>
<td>33</td>
</tr>
<tr>
<td>University of Colorado</td>
<td>15</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>Colorado State University</td>
<td>16</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>University of Iowa</td>
<td>17</td>
<td>29</td>
<td>18</td>
</tr>
<tr>
<td>North Carolina State University</td>
<td>18</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>State University of New York at Buffalo</td>
<td>19</td>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>Pennsylvania State University</td>
<td>20</td>
<td>32</td>
<td>27</td>
</tr>
<tr>
<td><strong>University of California, Irvine</strong></td>
<td>21</td>
<td>33</td>
<td>17</td>
</tr>
</tbody>
</table>

* Relative ranking amongst all included publicly supported institutions.
** Presumably the Department of Environmental Sciences and Engineering in the School of Public Health.


A reasonable interpretation of these figures is that a minimum faculty size of 20-25 nominally is required by the time of the NRC survey year of 2003 to achieve the first part of the Department’s goal (a solid top 20 ranking amongst publicly supported programs). Moreover, a nominal faculty size of 30-35, should be realized at least several years prior to the anticipated NRC survey year of 2013, to achieve the Department’s principal goal (top 10 ranking amongst publicly supported programs).
Civil and Environmental Engineering 1993-1994

Figure 10. Faculty Size and Areas of Research at Time of NRC 1995 Ranking
Civil and Environmental Engineering 1999-2000

Figure 11. Anticipated Faculty Size and Areas of Research for 1999-2000
A realistic and perhaps conservative growth plan would be to grow at a rate of 2 new faculty per year for the next four years, as well as over the remainder of the decade, to achieve a medium term size of 30 - 35 faculty by 2010. A more aggressive growth plan would be preferred, especially in the early years, and a mix of senior and junior appointments would also be desirable. The Department’s Academic Plan is intended to guide such growth and to implement the Department’s research vision.

It is believed that the Department’s research vision capitalizes on and leverages the Department’s core strengths, and will position the Department’s programs at the leading edge of national trends and needs. Due to the expected resulting quality, uniqueness and visibility of these programs, increased student demand should follow. The most significant resource implications of this growth are likely to be adequate faculty set-up funds, laboratory space (wet and dry) and equipment, technician and staff support, graduate student office space and graduate student funding (particularly fellowships).

8.2 Transportation Systems Engineering

Realization of the proposed initiative in Transportation Systems Engineering, as described in section 7.1, will require both some focusing of existing faculty strengths as well as modest additional faculty resources. As discussed earlier, the research thrust of the transportation systems engineering group focuses on Intelligent Transportation Systems, and Systems Analysis and Operations Research, in two complementary areas: Advanced Transportation Systems (ATS) and Activity Systems Analysis (ASA). Requisite faculty growth naturally parallels this classification.

Position T1: Advanced Transportation Systems (ATS)

As discussed, the Testbed is anticipated to incorporate a national transportation detection center that will be the foremost ITS surveillance center in the United States. To support this growing area of research, faculty recruitment specializing in Advanced Surveillance for Intelligent Transportation Systems is proposed. The new faculty will be expected to develop courses and laboratories in the area of Advanced Surveillance for Intelligent Transportation Systems (ITS). Some classes that the candidate is expected to teach include detection systems, signal processing, communications software design, traffic flow theory, transportation engineering, and ITS strategies. The successful candidate will be expected to sustain a successful funded research program in Advanced Surveillance for Intelligent Transportation Systems.

The following position profile is advanced to satisfy these requirements:

Position Profile

The position requires either a Ph.D. in Civil Engineering (Transportation) and a M.S. or B.S. in Electrical Engineering, or a Ph.D. in Electrical Engineering and a M.S. in Civil Engineering (Transportation). Candidates with a Ph.D. in a closely related field and a strong background in both Electrical Engineering and Transportation Engineering will also be considered.
Research experience in the area of Advanced Surveillance Systems is an essential requirement. The necessary areas of expertise include 1) detection systems, 2) signal processing, and 3) communications hardware and software. Specifically, the areas of expertise include: 1) detection systems such as video, infrared, ultrasonic, acoustic, magnetic, and inductive; 2) signal processing of random signals which includes video image processing; 3) data communications and transmission theory and implementation.

Experience in the application of Advanced Surveillance Systems in Intelligent Transportation Systems is also beneficial. Examples of applications include incident detection, traffic management and control, and traveler information. A strong educational background in transportation engineering, sensor systems, and signal processing is desirable.

The appointment will be made at the rank of Assistant Professor (tenure-track). Adjunct or joint appointment to the Department of Electrical and Computer Engineering will also be considered in view of the candidate’s background and interests.

**Position T2: Activity Systems Analysis (ASA)**

This faculty recruitment is designed to support the development of OR-based research capability on topics related to Logistics, Inter-modal and Freight Transportation, and Delivery Systems. Research opportunities are abundant in the CVO (Commercial Vehicle Operations) area of Intelligent Transportation Systems. Many more private-sector source funding opportunities exist for research on this topic, compared to the other areas of Transportation which depend primarily on public-sector sources. There are very few Civil Engineering faculty doing research in this area of transportation in US universities. None exist in the UC system. This is a very significant reason to develop research on this topic. Another advantage is that the OR and optimization background of this faculty will be helpful in collaborative research with other faculty who work on optimization of traffic and transit systems.

The new faculty is expected to be able to develop and teach graduate courses in one or more of the specialized topics such as: 1) Location and logistics theory, 2) Operations Research analysis of freight and inter-modal transportation, 3) Multi-modal Transportation network optimization, and 4) Intelligent transportation systems including of Commercial Vehicle Operations. The general courses expected to be developed and taught on two or more of the general topics such as: 1) Nonlinear/Integer/Dynamic/Network Programming, 2) Stochastic Processes, 3) Queuing theory, 3) Optimal control theory, 4) Decision Analysis, and 5) Combinatorial/heuristic optimization.

The following position profile is advanced to satisfy these requirements:

**Position Profile**

The appointment is to be at the Assistant Professor level in the Department of Civil and Environmental Engineering. Depending on the successful candidate’s background and specific research interests, a joint appointment with the Department of Electrical and Computer Engineering is possible and, perhaps, preferable. The successful candidate should have
demonstrated research capabilities in at least one of the following areas: location and logistics theory, operations research analysis of freight and intermodal transportation, multi-modal transportation network optimization, and Intelligent Transportation Systems including Commercial Vehicle Operations and application of advanced computing and/or communication technologies to ATMS and ATIS. A strong interest in the application of advanced computing techniques toward real-world problem-solving, as well as a comprehensive background in analytical quantitative methods, are required. Candidates must have outstanding research capabilities, as well as strong interest in teaching and developing graduate and undergraduate courses in advanced transportation systems and in directing graduate students’ research. A Ph.D. in either Transportation Engineering, Electrical Engineering, Computer Engineering/Science, or Civil Engineering is required.

Position T3: Advanced Transportation Systems (ATS)

Real-time operation of advanced traffic systems involving the most sophisticated of modern traffic signal controllers is governed by theory grounded in discrete closed-loop systems. These systems are excellent candidates for adaptive control strategies; signal outputs are directly, and predictably responsive to a relatively rich set of control parameters (e.g., force offs, background cycle length, phase sequence, extensions, etc.) for any particular traffic arrival pattern as converted into an input signal in the form of “calls” measured by traffic sensors. To make such systems practical, a significant research effort is needed in real-time control of ramp meters and signalized intersections.

The success of this research relies on new developments in non-linear systems theory to address two continuing problems that are key to effective traffic system operation: traffic flow modeling and optimal signal control. First is the identification of the applicability of existing traffic flow models to the optimal signal control problem, followed by the development new traffic models that can match real traffic data closely and be efficiently implemented for real time traffic control. If successful, these traffic flow models can then be used to develop local and integrated traffic responsive signal control strategies under various traffic conditions.

The following position profile is advanced to satisfy these requirements:

Position Profile

The position requires either a Ph.D. in Civil Engineering (Transportation) and a M.S. or B.S. in either Electrical or Mechanical Engineering, or a Ph.D. in Electrical or Mechanical Engineering and a M.S. in Civil Engineering (Transportation). Candidates with a Ph.D. in a closely related field and a strong background in either Electrical or Mechanical Engineering and Transportation Engineering will also be considered. Research experience in the area of Advanced Control Systems is an essential requirement. The necessary areas of expertise include 1) adaptive control systems, 2) discrete systems, and 3) communications hardware and software. Candidates for the position should have demonstrated capabilities in the following areas: research in advanced real-time computer network technologies and/or advanced object-oriented real-time software technologies; application of
advanced computer network and/or object-oriented real-time software technologies to intelligent transportation systems, especially Advanced Transportation Management (ATMS) or Information Systems (ATIS); application of advanced distributed computing based simulation technologies to intelligent transportation systems. Strong abilities for application of advanced computing techniques toward real-world problem-solving are required.

The appointment will be made at the rank of Assistant Professor (tenure-track). Adjunct or joint appointment to the Department of Electrical and Computer Engineering or Department of Mechanical and Aerospace Engineering will also be considered in view of the candidate’s background and interests.

**Position T4: Activity Systems Analysis (ASA)/Stochastic (Dynamic) Systems**

Research is expected to be in the area of mathematical modeling and algorithm development to support the analysis of dynamic transportation and supply chain management systems. Expertise are required in the development of both deterministic (static) and stochastic (dynamic) modeling with and emphasis on stochastic (dynamic) systems preferred.

This area of research relies on using and advancing techniques in operations research and computer science and applying these to transportation systems engineering and analysis. These areas of research are rapidly growing and would complement the research efforts of existing faculty in and out of the transportation systems engineering group in important ways.

The following position profile is advanced to satisfy these requirements:

**Position Profile**

The appointment is to be at the Assistant Professor level in the Department of Civil and Environmental Engineering. The candidate should have demonstrated research capabilities in stochastic (dynamic) systems analysis and optimization applied to traffic network optimization and or freight network optimization. In addition, the successful candidate will have a strong interest in applications of advanced technologies and methods to transportation systems.

The successful candidate must be able to teach in some of the following areas: operations research methods and applications (both deterministic and stochastic), transportation systems analysis and design, demand analysis, applications of advanced computing methods to civil engineering systems. A Ph.D. in either Transportation Systems Engineering, Operations Research, Electrical Engineering, Computer Science/Engineering or Operations Management is required.

**Position T5: Activity Systems Analysis (ASA)/Optimization and Stochastic Modeling**

Research is expected to be in the area of computing, optimization and stochastic modeling applied to transportation, distribution and logistics, including some of the following areas:
vehicle routing and scheduling, distribution operations, distribution network design, yield management, terminal design and operations, logistics planning and control, multimodal transportation, intelligent transportation systems.

This area of research is rapidly growing and would complement the research efforts of existing faculty in and out of the transportation systems engineering group in important ways.

The following position profile is advanced to satisfy these requirements:

Position Profile

The appointment is to be at the Assistant Professor level in the Department of Civil and Environmental Engineering. The candidate should have demonstrated research capabilities in optimization and stochastic modeling applied to transportation, distribution and logistics, including some of the following areas: vehicle routing and scheduling, distribution operations, distribution network design, yield management, terminal design and operations, logistics planning and control, multimodal transportation, intelligent transportation systems. The successful candidate will be prepared to teach courses in operations research methods (deterministic and stochastic) and logistics and supply chain management. A Ph.D. in either Transportation Systems Engineering, Operations Research, Electrical Engineering, Computer Science/Engineering or Operations Management is required.

8.3 Water Resources and Environmental Systems Engineering

The water resources and environmental systems engineering group in the Department has made remarkable progress in developing innovative and challenging curricula for our undergraduate and graduate students, and in projecting an image of research excellence among our colleagues at other universities. These conclusions are based upon: (i) our faculty’s success rate in winning prestigious awards (two are recipients of the National Science Foundation’s young investigator awards—specifically, NYI and Career awards), (ii) our success rate in winning federal contracts for environmental research totaling over $3,000,000 for the past three years alone, (iii) our success rate in winning campus awards for teaching quality (together the faculty have won ten campus, school, and departmental teaching awards in the past 5 years), (iv) our success rate in placing graduates of the undergraduate program in the best environmental engineering graduate schools in the country (including Stanford, Berkeley, Michigan, U. of Illinois, and Johns Hopkins University), (v) our success rate in placing Ph.D. students in academic positions at other institutions (former students are now employed as Assistant Professors at The Ohio State University, at Chapman University, and at University of the Pacific, and another has just accepted an Assistant Professor position at Rutgers University after a postdoctoral research position at Princeton University), and (vi) our ability to host successful international conferences on important environmental topics (EnviroMEET ‘98 hosted by Prof. Chrysikopoulos).

The research focus of the water resources and environmental systems engineering group will be smart instrumentation and advanced technologies applied in the design and operation of civil infrastructure systems. Outlined below are the new faculty profiles that would dramatically
enhance the visibility and health of the program, and lead to a critical mass of faculty working at the set of research frontiers identified by the NAE/AEEP/NSF workshop described earlier in this document.

**Position W1: Innovative Water Pollution Treatment – Smart Instrumentation**

A faculty position is proposed in the area of contaminated surface and/or groundwater pollution remediation with emphasis on novel methodologies (e.g., in-situ remediation and nanoscale techniques for monitoring). Groundwater and surface water contamination threatens an ever-increasing proportion of the nation’s water resources, and often these projects are long-term and extremely costly due to technological limitations. The proposed position will address state of the art technologies to degrade, destroy, or remove hazardous water contaminants. In addition, the treatment technology will preferably facilitate in-situ remediation approaches.

The position will require the teaching of undergraduate and graduate courses in physicochemical processes, water resources quality, and water pollution remediation. The successful candidate will be expected to direct graduate student research, establish a strong, externally-funded research program and to collaborate with existing faculty in Civil and Environmental Engineering. The candidate should also interact with campus faculty such as MEMS technologists in the School of Engineering, chemists and physicists in the school of Physical Sciences, and biologists in the School of Biological Sciences. Furthermore, the successful candidate will be expected to interact with local regulatory agencies and advance technology for water and wastewater management.

An earned Ph.D. in Civil or Environmental Engineering, or closely related field, is required for appointment, and professional registration is highly desired.

**Position W2: Water Reuse - Nanotechnology**

There will be no additional new-water sources to meet the needs of the expanding California population (an additional 10+ million persons in the next 10-15 years). Consequently, the emphasis must be on increasing water reuse and the development of marginal water sources such as brackish groundwaters. This major shift towards greatly increased water reuse will be associated with more emphasis on physical/chemical treatment, specifically the use of nano filtration by means of synthetic membranes. Use of nanofiltration has been increasing in the last five years, and a few full scale plants are now being considered, both for drinking water and wastewater treatment. UCI, with its location near the largest water reuse systems in the US, OC Water District and Los Angeles County, is uniquely suited to contribute to and benefit from the research activities in this area. Research in this area will also complement the research efforts of the two existing faculty members because membrane technology may become attractive in water quality control for storm drains (Prof. Sanders), and because water reuse is closely connected to groundwater basin recharge (Prof. Chrysikopoulos).

It is proposed to fill one of the CEE department’s unfilled VERIP positions with a person with research expertise in physical/chemical processes, especially micro/nano filtration. Alternative research sub-areas are membrane fouling/cleaning, membrane nanostructure, or membrane
hydrodynamics. It is expected that the candidate will also interact with the Materials Science Faculty and be able to utilize some of the SOE existing materials science research equipment.

It is expected that the successful candidate will have at least the EIT, will be able to obtain the CA PE license, and have experience in working with civil/environmental engineering systems.

**Position W3: Coastal Sediment Transport (Intelligent Systems)**

A faculty position is proposed with research emphasis in the real-time detection and quantification of sediment transport in rivers, estuaries, and coastal waters. Sediments provide a vehicle to mobilize contaminants upon suspension, impede flood control infrastructure upon deposition, and perpetually degrade transportation corridors in channel and harbor waterways. This faculty member would be expected to establish a strong research program at UCI in the characterization and prediction of sediment fluxes using in-situ and remote sensors. Possible applications of this faculty’s research would include the short-term prediction of harbor and waterway morphology, and the long term prediction of beach evolution. In addition the research should lead to the development of strategies for sustainable coastal land uses and sediment flux control, and optimal operation of inland and coastal structures, including flood control structures, coastal protection systems, and water supply systems. The faculty member could interface with existing faculty in the Department to develop wave and circulation control strategies to optimize sediment fluxes (Sanders), and colloid/sediment/fluid interactions to predict contaminant transport (Chrysikopoulos). In addition, the faculty member would interface with remote sensing faculty in the School of Engineering and oceanographic modelers in the Earth Systems Science department of the School of Physical Sciences. This appointment would be at the Assistant Professor level. Preference will be given to candidates with an earned Ph.D. or Sc.D. in Civil Engineering, Coastal Engineering, or closely related field.

**Position W4: Geochemical Processes**

A faculty position is proposed with research emphasis in the geochemical fate and transformation of contaminants in aquatic environments. Potential research applications might extend to either groundwater or coastal sediment contamination problems. Examples of possible research areas might include the development of fundamental speciation and kinetic models for contaminants, such as trace metals, marker methods to characterize geochemical contaminant transformation processes, or photocatalytic techniques to degrade organic pollutants on mineral surfaces. It is anticipated that the faculty member would establish an experimental research program. Preference will be given to individuals who will readily collaborate with existing faculty, such as those interested in subsurface hydrologic modeling, bioremediation, colloid transport, water treatment, or environmental biotechnology. The position would preferably be offered at the Assistant Professor rank.

**Position W5: Numerical Modeling in Subsurface Contaminant Transport**

The proposed faculty position would be filled by an individual with a strong background in groundwater flow and mass transport in porous formations, numerical simulation, and stochastic
modeling. Examples of research interests might include the development of accurate numerical models for regional groundwater flow, estimation methods, optimal sampling with emphasis in field-scale remediation strategies, or applied geostatistics. It is expected that the faculty member would establish close collaborations with the faculty in Environmental Engineering, such as those currently involved in reactive transport in heterogeneous formations, solute/colloid cotransport in the subsurface, nonaqueous phase liquid dissolution, environmental microbiology, or advanced water treatment. The position would preferably be offered at a senior level (Associate or Full Professor rank).

**Position W6: Hydroinformatics (Intelligent Systems)**

A faculty position is proposed in the field of Hydroinformatics. This evolving field is concerned with developing and applying mathematical models and advanced information technology to problems of hydraulic, hydrologic and environmental engineering. It provides the computer-based decision-support systems that now enter increasingly into the offices of engineers, water authorities and government agencies. It is expected that the faculty member will provide expertise in modeling complex processes in natural and engineered environments, provide intelligent methods of analysis for water related systems, engineer solutions to water related problems, and make the results available to designers and policy makers, including those in banking and insurance. The faculty member will be expected to collaborate with departmental faculty and campus faculty such as information technologists in the School of Information and Computer Science, decision analysts in the Graduate School of Management, and modelers in the Earth Systems Science department of the School of Physical Sciences. Emphasis will be placed on candidates whose research addresses coastal engineering problems and/or water resource problems of the arid West. This appointment would be at the Assistant Professor level. Preference will be given to candidates with an earned Ph.D. in Civil Engineering, Environmental Engineering, or closely related field.

**Position W7: Process Optimization and Control (Intelligent Systems)**

The increasing need for water reuse in California to meet the coming water demands will require improved process management and control, both to ensure reliability and to reduce the costs associated with the higher levels of treatment. Two engineering areas where significant progress is needed are improved process control, and better real time monitoring.

Recent research has shown that fuzzy algorithms can be used to estimate variables that at the present time cannot be measured in real time because of lack of appropriate sensors.

A new faculty member with expertise in water/wastewater treatment and specific research interests in process control using fuzzy logic is proposed. It is expected that the successful candidate will have the at least the EIT, will be able to obtain the CA PE license, and have experience in working with civil/environmental engineering systems.
The candidate is expected to work closely with the Transportation Group in CEE, and to be part of the intelligent systems thrust area within CEE while complementing the existing water systems faculty.

8.4 Earthquake and Structural Systems Engineering

As noted in section 7.2, the research focus of the earthquake and structural systems engineering program is smart and advanced structural technology. Planned faculty replacement and growth naturally follows the thrust area of research. In the past few years, this program has suffered from a loss of two senior and one junior faculty members, all without replacement to date. Consequently, the strength and morale of existing faculty in this program are currently at a critical stage. There is absolutely no critical mass of faculty members with which the program can be at the top of the nation. Without speedy replacement of lost faculty positions, further deterioration is expected despite excellent computational and experimental facilities. Such a trend is expected to have significant ramifications for the Department and the School of Engineering.

Any outstanding structures program, either nationally or internationally, requires excellent experimental research, which is currently the weakest link of this program. This is particularly true in the focus area of research. Any innovative smart structures and advanced technology (e.g., sensors, actuators, composite materials, etc.) should be verified and demonstrated experimentally, in particular on the real-time shaking table. Currently, some faculty members conduct experimental tests at other institutions and facilities, because of a lack of collaborative experimental research faculty. Consequently, recruitment of faculty specializing in experimental research in the focus area of research utilizing the state-of-the-art shaking table is planned.

Since the Structural Systems Engineering Program has lost 3 positions without replacement, 8 positions are suggested for recruitment in the next 10 years. These positions are in the area of smart and high-tech structural systems, including (1) Smart Structures, (2) Smart Instrumentation Systems for System Identification and Damage Detection, and (3) Application of Advanced and Smart Materials to Civil Infrastructures. These three subareas above are interrelated aiming at the deterioration, renewal and innovative advanced technologies for civil infrastructures. These areas are also strongly correlated with MAE, ECE and MSE.

Position S1 (Assistant~Associate Professor level).

This position has top priority: The appointment can be either Assistant or Associate Professor level. The candidate must have demonstrated (or demonstrated potential) for high quality teaching and research. In addition to solid background in structural dynamics, the position requires expertise in smart structures with a particular emphasis in earthquake engineering. Demonstrated interest or experience in smart and innovative experimental seismic testing of structural system or components is also required. The candidate is expected to be an active researcher in the Department’s Structural Test Hall and new Bi-Axial Shacking Table Facility, and to strengthen research thrust areas and programs in one of the following areas: (i) intelligent civil infrastructure systems, (ii) structural control, and (iii) advanced composite materials and
structures. The candidate is expected to teach undergraduate and graduate courses in structural engineering, direct graduate student research, interact with existing research programs, establish a strong externally-funded scholarly research program and be active professionally. A doctoral degree from an accredited engineering program is required and professional registration is preferred.

**Position S2** (Associate~Full Professor level) in the area of experimental research and field implementation of smart structures. The candidate is expected to be the Director of the shaking table facility, who has expertise in developing, integrating and implementing full-scale control systems and other smart devices, such as smart base isolation systems, smart damper systems and others, on full-scale structural systems. The new smart device or control systems are applicable not only to the construction of new facilities but also to the retrofit and renewal of aging civil infrastructures, including long-span bridges, tall buildings and critical facilities (nuclear power plants), etc.

**Positions S3 and S4** (Assistant Professor level) in the area of smart instrumentation systems for system monitoring, identification, and degradation (damage) detection. Some background in mechanical and electrical engineering is essential. In particular, the implementation of chips and other high-tech micro or nano devices in the smart instruments for monitoring environmental conditions (such as corrosion, fatigue and other conditions), and for interfacing and integrating complex centralized or decentralized control systems into a smart unit are important areas. These two positions will involve theoretical, experimental and field research. Strong interdisciplinary backgrounds are required.

**Positions S5 and S6** (Assistant Professor level) in the area of application of composite and smart materials to civil infrastructures. Such applications involve the development of new concepts for structural systems using composite and smart materials as well as the retrofit and renewal of aging civil infrastructures. In addition to strong theoretical/numerical background in mechanics and materials, expertise in experimental research using the Structural Test Hall facility and shaking table is essential. Candidates’ interest and capability in smart systems, such as fiber optic sensors and other micro devices imbedded in composite and smart materials for environmental monitoring and damage detection, is highly desirable.

**Position S7** (Assistant Professor level) in the area of geotechnical engineering with research emphasis on smart monitoring systems, smart field instrumentation and advanced technology. Candidates are expected to teach undergraduate and graduate geotechnical engineering courses. However, it is highly desirable that their research areas and interest have a synergistic effect with other faculty members in smart systems or environmental and water resources.

### 8.5 Faculty Replacement and Growth Strategy

As a means of accomplishing its goal, the Department advances a two-phase strategy of faculty replacement and growth – Phase1: Replacement of Faculty Position Losses; Phase 2: Faculty Growth in Strategic Areas. During the first phase, the Department proposes an aggressive recruiting campaign to recoup the dramatic losses during the period 1994-1999 and restore the
Department to the strength that was responsible for its strong position in the 1993-94 NRC national rankings. In accomplishing this, the Department has seized the opportunity presented by the large numbers of faculty departures to redirect the Department’s strengths according to the educational and research philosophy articulated in its current academic plan. Correspondingly, the initial phase of faculty recruiting, designed for the period 1999-2001, is shown in Figure 12, in which the highlighted positions represent planned additions during Phase 1. Following this initial phase, the Department will be at a level of faculty strength comparable to that in 1993-1994. Phase 2 of the recruiting is designed to advance the Department substantially in the national rankings by the year 2003–2004. Faculty growth planned during this phase is shown in Figure 13, in which the highlighted positions represent planned additions during Phase 2. A mapping of the Department’s research strengths following this recruitment plan is shown in Figure 14, where the positions have been rearranged to indicate concentrations of research focus and capabilities. An overall picture of the Department’s plan for stabilization and growth is shown in Figure 15.
Figure 12. Phase1: Faculty Replacement Recruiting Plan
Figure 13. Phase 2: Faculty Growth Recruiting Plan
Figure 14. Mapping of Planned Departmental Research Strengths
Figure 15. Overall Departmental Faculty Replacement and Growth Strategy

Growth = 1.3 FTE/Year