Report on Government Policy in Selected Countries Supporting Research and Development in Construction and Transportation Technology

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○ 기　　간 : 2006 년　9 월　29 일 ~ 2007 년　5 월　28 일

○ 참여연구진

- 주관기관 : 한국과학기술기획평가원(KISTEP)
- 위탁연구기관 : SRI International

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조사 내용	세부내용	추진방법	자료수집
주요국 건설교통기술 정책	- 건설교통기술정책 비전 및 목표 - 건설교통기술개발 추진체계 및 전략	- 각국의 건설교통 기술정책공식문서에 대한 조사 분석	미: OSTC, DOE 내 EERE, DOT 산하 각 부서 일: 종합과학기술회의, 국토교통성 영: DTI, DFT, TSB EU: Framework programme 호주 : CRC, DOTARS 싱가포르 : MND, MOT
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주요국 건설교통기술 혁신지원시책	- 건설산업 육성 정책 - 건설교통기술 인력양성 제도 - 건설교통기술개발 자금지원 및 세제 - 산학연 협력체제	- 건설교통관련부처 정책자료 수집 분석 - 건설산업협회의 홈페이지 자료 분석 - 특히 건설교통기술 혁신 지원 제도를 심층 분석	
건설교통기술 관련 법령	- 표준/인증 관련 - 규제관련 - 신기술보급확산관련 - 연구개발사업관련	- 건설교통기술관련 부처의 웹사이트 - 법률정보웹사이트 조사	

□ 조사 범위

국가	대상 기관	관련 문헌 및 웹사이트
미국	DOT, NIST, DOE, OSTP (과학기술정책국)	·DOT Strategic plan for FY 2006-2011(DOT, 2006) ·DOT Research, development and technology plan (DOT, 2005) ·5 year strategic plan for research, development and

		technology (FHWA, FMA,FRA, FMCSA, FTA, 2002) .www.bfrl.nist.gov/ ·Building Technologies Program; Research, development and demonstration plan(EERE, 2005) ·www.eere.energy.gov/buildings/ ·FY2006 federal research and development budget ·www.ostp.gov/ ·FY2006 Budget-in-Brief (EERE, DOT, 2006) 등
일본	종합과학기술회의 국토교통성	·과학기술 연구개발전략 (종합과학기술회의, 2006) ·제 3 기 과학기술기본계획 (종합과학기술회의), 2006) ·평성 17 년 운수기술 연구개발 평가결과 개요 (국토교통성, 2006) ·평성 16 년 운수분야 연구과제 ·국토교통성기술기본계획(국토교통성, 2006) ·www.mlit.go.jp/tec/gijutu/index.html 등
EU	Framework	·cordis.europa.eu/sustdev/ ·Thematic priority; Sustainable development, Global change and Ecosystems; Sustainable Surface Transport (EU framework, 2005) 등
영국	DTI, EPSRC	·Future of transport, a network for 2030 (DFT, 2004) ·Transport Innovation Fund; Guidance (DFT,2006) ·Evidence and research strategy(Dft,2006) ·Research programmes overview (Dft, 2006) ·Sustainable construction strategy (DTI,2006) ·Rethinking construction innovation and research (DTI, 2006) ·Built environment technology strategy (DTI, 2006) ·Strategic plan 2003-207, EPSRC (EPSRC, 2003) 등
호주	CRC, DOTARS	·Commonwealth of Australia Law ·Cooperative Research Center for Construction Innovation ·Department of Transport and Resional Services ·www.constructiion-innovation.info
싱가포르	MND, MOT	·www.mnd.gov.sg ·Center for Transortation Research ·Land Transport Authority of Singapore ·Building Control Act ·Ministry of National Development ·Ministry of Transport ·Land Transport Authority Annual Report 2006 등

□ 연구 결과

○ 중앙집중적 R&D 정책 국가 : 일본, 영국, 싱가포르 등

- 중앙정부 차원의 건설 전담부처가 존재하며 이의 주도하에 국가적 차원의 건설정책, 연구개발정책의 수행

- 각 나라들은 건설 산업의 특수성에 주목하는 연구개발 정책이 최근에 수립되었고, 연구 자금의 경우 제품 개발을 넘어서는 프로세스 혁신, 가격보다 가치를 강조하는 정부 조달 정책, 산업계와 정부의 협력을 강조

- 특히, 교통분야의 경우 상대적으로 중앙집중화 된 강력한 교통 전담 부처 존재

  ※ 일본의 경우 국토교통부가 우리와 비슷한 구조

- 대개 중앙집중적 정부 구조를 가진 국가들의 경우 정부 주도하에 연구개발 정책을 실행하나, 영국의 경우 시장 위주의 정책을 실행하는 예외를 보임

○ 연방제 중심의 R&D 정책 국가 : 미국, 호주, EU 등

- 건설분야에는 전담 부처가 없는 경우가 많고, 교통분야에서도 지방분권화가 활발

- 건설분야의 경우 따로 특별한 관심을 기울이지 않고 일반적인 산업개발의 일부로 취급

  ※ 미국, 호주 등의 경우 시장지향성으로 시장이 최적의 자원배분을 할 수 있다는 철학에 근거해 정부의 역할을 최소화

- 교통분야의 경우 독립성이 강한 하부부처들이나 지방정부들이 독자적인 업무처리를 하는 경향이 많음

※ 대부분의 연방제 국가들은 시장위주의 정책을 펴고 있으나 독일의 경우 정부 주도하의 연구 개발 정책을 실행하는 예외를 보임

□ 시사점

○ 중앙집중적 정부구조를 가진 한국의 경우 주요국의 정치·사회·경제 구조의 차이를 감안하여 시장위주의 정책을 참고하여야 함

- 시장위주의 정책을 지향하는 국가의 경우 시장의 안전성 및 유연성에 대한 균형이 정착화 되어 있어 내외부 충격에 급격한 변화를 보이지 않음

- 시장위주의 정책을 펴는 정부의 입장은 연구개발사업의 구체적인 상품화보다는 기초 단계 및 상품화 이전 단계의 일반기술에 대한 투자가 많음

○ 정부의 R&D 투자에 대한 이질적 개념 극복

- 미국의 경우 안점 및 테러 등의 위협으로부터의 시설 보호 등 국가적 존재의 이유에 대한 투자로 보고 있으며, 연구개발 투자를 통한 국가 경쟁력 강화 측면은 핵심목표가 아닌 부수적인 정책 목표로 보고 있음

○ 국가별 연구개발 정책의 시사점 (국가별 주요 정책은 본문 참조)

- 연구개발은 항상 실패의 위험을 내포하고 있으므로 혁신적인 R&D 프로그램과 점진적인 R&D 프로그램과의 균형을 이룬 포트폴리오를 구성할 필요성

- 기술의 특성상 항상 일반대중의 지지를 얻기 위하여 노력하고, 신기술에 R&D 를 전적으로 집중하기 보다는 기존기술을 이용하는 것도 고려하는 것이 바람직

- 국가의 물리적인 인프라의 경우, 재료와 기술 뿐만 아니라 방법이나 절차 등의 혁신도 중요함을 강조

- 정부 응찰 제도를 최저가 모델에서 최상가치 모델로 전환하고 특히, 일본을 비롯한 대부분의 나라에서 적용하고 있는 세금혜택과 비용분담 정책을 적극 고려할 필요

- 산업, 학교, 정부 등과의 공조가 중요함을 제시하고 있음. 따라서 이런 측면에서 국내 대학의 ERC, SRC, RRC 와 같은 우수 연구센터의 설립을 건설·교통분야에서도 적극 추진할 필요

- 건설·교통 분야에 대한 일반 학생들의 흥미증진을 위하여 미국의 REU 프로그램을 모방한 대학생 건설교통분야 연구경험을 위한 여름캠프 (연구소) 운영 검토 제안

II. INTRODUCTION

The goal of this study is to review and document various policy measures in selected countries that support R&D in the construction and transportation sectors. Conceptually, the first challenge for this study was how to define each of the following in ways that are compatible across countries: construction and transportation; construction and transportation technology; and R&D policy supporting construction and transportation technology. Different countries have different interpretations of these terms. Furthermore, any international comparison of policy should take into account different political and cultural contexts.

Thus, SRI employed a systematic approach that can guide the study and limit the boundaries for comparative analysis of R&D policy in construction and transportation. The following list shows SRI's proposed framework for comprehensive country reports. In conducting this study, SRI collected and reviewed as many websites, policy reports, and academic journal articles as possible, given the time and resource constraints.

Websites of major government agencies, their policy think tanks, and funding organizations were reviewed and major funding programs were studied. However, the topic areas were broad and, depending on the country, information was not easily obtained. In several countries, there is no single government agency in charge of the construction industry, complicating the search for information. At some point, the SRI study team had to limit search efforts and accept the gaps in the coverage for parts of the framework.

In many countries, it was especially challenging to find information on human resource development programs designed to train the R&D workforce relevant to construction and transportation. General R&D workforce development programs exist for all fields and often for entire sectors, but not ones designed to serve the R&D workforce in construction and/or transportation. SRI has produced an extensive list of references and websites so that, when needed, further research is possible at later date. Below is the proposed framework used in this study:

1) The laws and regulations that define various government bodies' responsibility and authority related to construction and transportation technology development;

2) The organizations responsible for developing plans and priorities for R&D policy in construction and transportation in the country;

3) The content of the most recent "plan" or set of priorities in construction and transportation;

4) A description of research funding organizations and their funding programs that are instrumental for carrying out the "plan";

5) Institutions responsible for conducting the research and development called for by the strategic plan or set of priorities;

- Public and private research universities and other institutions of higher education
- Government laboratories, and/or institutes
- Industrial R&D performers
- Consortia, organizations, or other groups linking R&D performers
- Non-profit, non-governmental R&D organizations, research hospitals, and other R&D performing organizations

6) Indicators of R&D that can be compared among selected countries;

   - National Gross Expenditure for R&D (GERD)
   - The portion of GERD devoted to construction and transportation

7) R&D programs that promote the collaboration among government research institutes, universities, and industry; and

8) Government programs that support the further training of students and those who are already in the workforce in the fields relevant to construction and transportation research.

III. COUNTRY REPORT

U.S. CONSTRUCTION R&D

A. Construction

1. Introduction

According to a National Institute of Standards and Technology (NIST) estimate, annual costs for construction and buildings in the U.S. are $1.3 trillion total, which breaks down to $850 billion for new construction, $294 billion for renovation, and $153 billion for maintenance and repair. By sub-sector, annual costs are $651 billion for residential, $176 billion for public works, and $286 billion for commercial and institutional, with $31 billion for industrial buildings. The construction sector employs 11.2 million workers, or 7.9% of the total U.S. workforce. A result of 1.8 million of these workers are self-employed, the construction industry is made up of many small firms and is more fragmented than sectors such as manufacturing. (Sunder 2007)

NIST reports that, while productivity of non-farm industries overall has increased about 1.8% per year in the past 40 years, productivity in construction has declined at -0.6% per year during the same period. The construction industry accounts for 4.9% of the GDP, yet R&D is only 0.5% of construction value added. Government research institutes perform the bulk of construction-related R&D at 62.9%. Industry (16.3%), academia (12.2%), and others, such as non-profit research institutes, (8.6%) are responsible for much smaller percentages of construction-related R&D, (Sunder 2007).

No single federal government agency is responsible for construction activities or construction-related R&D. Federal as well as state and local governments are heavily involved in the regulation of the construction industry. There is no central focus or champion for the construction sector. Instead, various agencies deal with particular concerns such as acquisition of public works, technology development, safety, consumer protection, and infrastructure building and maintenance. Many industry associations represent individual parts of the construction sector, but there are no clear leaders who can represent the sector as a whole to the senior levels of government.

Currently, there is no significant public policy interest in construction innovation other than as a part of general industrial development. In the U.S., the prevailing view is that the market allocates resources in the most efficient manner through the bidding process and that government, although a significant purchaser of construction goods and services is just another participant in the market place. There are concerns that the highly regulated and risk averse nature of the industry may constitute a disincentive to innovation. The "National Construction Goal" addressed many of challenges that the industry faces in adopting innovative technologies:

- The regulatory barrier is a serious concern since local, state, and federal governments each require the industry to conform to its individual regulations. The industry is not eager to try something new that may make it difficult to satisfy regulatory requirements and cause delays.

- The construction companies compete on cost and the profit margin is tight. If the initial cost for innovation is higher, even though it may reduce the life-cycle cost in the long run and deliver higher value, the industry has a disincentive to adopt innovation.

- Liability and fear of law suits from the failure of products to perform as the customer expected discourage investment in innovations and the adoption of new materials or processes.

- Adversarial relations in construction projects often discourage participants from innovating.

- Financial disincentives for innovation exist because most construction organizations are too small to invest substantially in research. It is difficult to protect intellectual property with a highly mobile workforce and when innovations in non-proprietary practices, materials, and system designs are evident to observers.

- Lack of a skilled workforce and the generally negative stereotype of the construction industry make it difficult to attract top talents to the construction industry in general, and to construction related R&D in particular.

During the 1990s, the U.S. construction industry was losing its share in the global construction market and there have been serious concerns about the competitiveness of the U.S. construction industry. The National Construction Goal is partly a government response to this perceived crisis.

2. Government Organizations Responsible for R&D Policy

The Subcommittee on Construction and Building (C&B), under the National Science and Technology Council was an active leader of construction R&D policy during the Clinton administration (1994 – 2001). The C&B attempted to provide public leadership and central coordination for construction R&D. Fourteen federal agencies participated in the subcommittee; each agency's activities were limited to the part of construction R&D related to the agency's mission.

The closest successor of the C&B is the Physical Structures and Systems Interagency Working Group (IWG). The purpose of the IWG is to coordinate and focus federal construction and buildings R&D in partnership with the private sector to achieve greater safety, security, efficiency, and global competitiveness. Reflecting the current emphasis on homeland security, the IWG is primarily concerned with the protection of the infrastructure. The IWG is not as active as the C&B but may qualify as the only central coordinating body for construction R&D within the federal government.

Below is the member agencies of the C&B and the IWG that are most involved in construction R&D related policy discussions. However, R&D in the construction industry is, at best, a secondary concern of the agencies and only marginally related to their primary mission. Other quasi-government organizations, such as the National Academy of Engineering, and industry and professional associations are also active in the construction R&D policy area, but their role is limited to advising and consulting.

- Department of Commerce
  - National Institute of Standards and Technology
- Department of Energy
  - Office of Energy Efficiency and Renewable Energy
- Department of Housing and Urban Development
  - Office of Policy Development and Research (PD&R)
- National Science Foundation

        - Civil, Mechanical, and Manufacturing Innovation Division
    - Department of Defense
        - US Army Corps of Engineers

- Quasi-governmental organizations
    - National Academies (National Academy of Engineering)
        - Board on Infrastructure and the Constructed Environment
    - National Institute of Building Sciences
        - Chartered by Congress to develop, promulgate, and maintain building-related performance criteria and assemble, store, and disseminate building-and construction-related technical data and other information.

- Industry and professional associations
    - National Association of Home Builders Research Center
    - Construction Industry Institute
    - American Public Works Association
    - American Society of Civil Engineers
        - Civil Engineering Research Foundation
    - National Association of Homebuilders Research Foundation (NAHBRF)
    - FIATECH (a consortium devoted to fully integrated and automated life cycle construction project processes)
    - Owner Association Alliance
    - Building Owners and Managers Association (BOMA)

3. Planning and priority setting

Together with industry, the C&B came up with many interesting ideas and policy initiatives, notably "National Construction Goals" (1995). However, Congress, at the time dominated by the Republican Party, was not responsive and the Subcommittee became inactive after the Bush administration took over. C&B's efforts were strongly supported by the industry sector and were highly promising. Since the National Construction Goals, there has been no significant federal government-level plan for construction-related R&D. Although National Construction Goals was not fully implemented, it was an important policy initiative.

- Most recent: *National Construction Goals (1995)*, Subcommittee on Construction and Building, Committee on Civilian Industrial Technology, U.S. National Science and Technology Council
    - Goals relate to:
        - Better constructed facilities
        - Health and safety of the construction workforce

National Construction Goals (1995)

- Federal strategy for R&D and deployment in support of the construction industry
- Developed *in conjunction with industry* (through workshops) by the Construction and Building Subcommittee, Committee on Civilian Industrial Technology, National Science and Technology Council

- Context: Component of national technology policy developed by National Science and Technology Council (through committees) to enhance international competitiveness of U.S. industry through federal technology policies/programs
- Vision: A competitive U.S. industry producing high quality, efficient, sustainable and hazard resistant constructed facilities
- Goals: Better constructed facilities and improved health and safety of the construction workforce
    - Technologies/practices capable of achieving goals to be available for general industry use by 2003 (8 year time frame)
    - Seven key technology areas
- Strategy: All sectors of construction industry work closely together
- Deployment: Utilize federal government construction for demonstration projects
- Goal: Better constructed facilities
    - 50% reduction in delivery time
    - 50% reduction in operation, maintenance, and energy costs
    - 30% increase in productivity and comfort
    - 50% fewer occupant related illness and injuries
    - 50% less waste and pollution
    - 50% more durability and flexibility
- Goal: Health and safety of construction workforce
    - 50% reduction in construction work illnesses and injuries
- Key technology areas to meeting goals
    - Information and decision technologies
    - Automation in design, construction, and operation
    - High performance materials, components, and systems
    - Environmental quality
    - Risk reduction technologies
    - Performance standards systems
    - Human factors

It should be noted that these technologies are "generic" technologies that can be adopted by any construction company; they are not application-specific or application-oriented technologies.

4. R&D Funding Organizations and Programs

Construction related government R&D funding programs

Some government R&D funding programs provide research grants to industry and academia. However, compared to the overall U.S. R&D enterprise, these programs are not particularly ambitious and relatively small. There have been numerous calls from industry to increase federal R&D funding in the construction sector, but no significant new government funding program has been implemented in recent years with the exception of PATH. The following list is not by any means exhaustive, rather representative programs were selected to show the federal governments'.

- Department of Housing and Urban Development
    - Office of Policy Development and Research (PD&R)
        - The Partnership for Advancing Technology in Housing (PATH)

PATH was initiated in 1998 when Congress appropriated funds for HUD to begin implementing the concept created by the National Science and Technology Council, Construction and Building Subcommittee (NSTC C&B). The program was funded at approximately $10 million annually from FY1999 through FY2001 and at $8.75 million in FY2002. Private industry and academic institutions participate in planning and directing the PATH. The program addresses the development and diffusion of technologies industry wide. PATH works to identify and reduce barriers that impede innovation, including regulatory barriers. PATH set a fairly ambitious goal for itself, but its small funding level limits the scope of new ideas that can be implemented.

- Department of Energy
  - Office of Energy Efficiency and Renewable Energy
    - Building Technologies Program

    Run by DOE's Office of Energy Efficiency and Renewable Energy in partnership with the private sector, state and local government, national laboratories, and universities, the Building Technologies Program works to improve the efficiency of buildings and the equipment, components, and systems within them. The program supports R&D activities and provides tools, guidelines, training, and access to technical and financial resources. The R&D areas of interest include the building envelope, space conditioning, water heating, appliances, lighting, and whole buildings. For example, this program is a home for Energy Star, a government led system of certification for energy consumption at home.

- Department of Health and Human Services
  - National Institute for Occupational Safety and Health (NIOSH)

    NIOSH, under the Center for Disease Control (CDC), has eight programs, one of which is construction safety. It conducts intramural research projects with partnering organizations to address construction safety and health issues. For example, NIOSH supports targeted surveillance activities involving a number of state health departments on important construction topics such as lead exposure. NIOSH also supports extramural construction research projects conducted by academic and other researchers through grants and cooperative agreements. For example, past projects have addressed important causes of injuries and fatalities, such as falls and electrical hazards.

Government R&D funding programs with partial support for construction R&D

- Advanced Technology Program (ATP)
  - National Institute of Standards and Technology, Department of Commerce
  - Cost-shared funding for high-risk industrial R&D
- Manufacturing Extension Partnership (MEP)
  - National Institute of Standards and Technology, Department of Commerce
  - Nationwide resource/services network and regional centers for small and medium-sized manufacturers
- Small Business Innovation Research (SBIR) program/Small Business Technology Transfer Research (STTR) program
  - Coordinated by the Small Business Administration for federal government R&D agencies
  - Provides R&D funding awards to small businesses (<500 employees)
- Engineering Research Centers/Other cooperative research centers
  - Funded by the National Science Foundation and housed at universities

    - Centers for conducting collaborative R&D (industry-university, multi-university)
- National Science Foundation Industry/University Cooperative Research Centers.
    - Website: http://www.nsf.gov/eng/iip/iucrc/directory/index.jsp
    - Civil infrastructure systems centers are: Center for Engineering Logistics and Distribution; Center for the Built Environment and Center for Repair of Buildings and Bridges with Composites.

5. Institutions conducting R&D

There are numerous government, academic, and industry labs conducting construction related research. The only data available about the construction related R&D performers and the type of research they conduct comes from the 1993 Civil Engineering Research Foundation report. The central finding of this report is that total civil engineering-related R&D funding amounted to $2.1 billion in 1992. The value of construction put in place in 1992 is estimated by the Commerce Department at $425.8 billion, indicating that the level of R&D investment by all sectors within the construction community is approximately 0.5%. The largest sponsor of civil engineering-related R&D is the federal government (62.9 %), followed by industry (16.3 %). The report documents a substantial amount of under-reporting of civil engineering-related R&D investment by the construction industry and notes that nearly three-fourths of all firms do not designate a budget line item for these expenditures. Though somewhat outdated, the table below shows type of research by performing sector. As one can see, in addition to the usual categorization of basic, applied, and development research, both federal and industry performers of R&D conduct quite a bit of demonstration work.

Table 1-1. Construction-related research by sector and type of research

Type of Research	Sector (%)				
	Federal	Industry	Academia	Other	Total
Basic	14	1	31	10	13
Applied	38	8	48	54	36
Development	34	56	11	20	34
Demonstration	11	19	5	12	12
Other	3	16	5	4	5
TOTAL	100	100	100	100	100

Source: CERF Report #93-5006

Academic and industry performers of construction R&D are too numerous to list. A list of government research institutes is provided below to provide some perspective on the diversity of government performers engaged in construction R&D.

- Department of Agriculture
    - Forest Products Laboratory
- Department of Commerce
    - National Institute of Standards and Technology
        - Building and Fire Research Laboratory
- Buildings Technology Center
    - Oak Ridge National Laboratory, Department of Energy
    - Government-industry collaborative R&D center focused on energy efficiency/environmental compatibility of residential/ commercial buildings

    - Also designated as the National User Facility: can be used by industry, universities, or other organizations for proprietary/non-proprietary R&D
- Department of Health and Human Services
    - National Institute for Occupational Safety and Health
      (Both intramural and extramural)
- Department of Interior
    - Bureau of Reclamation
        - Materials Engineering Research Lab
- Department of Defense
    - US Army Corps of Engineers
        - Engineering and Research Development Center
            - Eight R&D laboratories

6. R&D Collaborative Programs

Many of the R&D funding programs mentioned earlier support collaborative programs in some way. In addition, the programs listed below have creative approaches to collaboration.

- FIATECH

  The Subcommittee on C&B cooperated with the Construction Industry Institute (CII) to establish a not-for-profit R&D consortium called FIATECH (modeled after SEMATECH) with the aim of helping the industry achieve fully integrated and automated project processes. FIATECH's goal is to promote the seamless integration of 5advanced IT and automation technologies in capital projects through collaborative, leveraged R&D. FIATECH works to develop technologies that will significantly reduce project cycle time, improve quality, and reduce costs. One of the main products of FIATECH is the creation of the Capital Projects Technology Roadmap.

- Design Excellence Program:
    - Created and administered by the General Services Administration's (GSA) Public Building Service (PBS), which manages federal government buildings, this program encourages designers to enhance the use of innovative technologies. The program was conceived to provide incentive for public works companies to adopt innovative technologies.

- The High Performance Construction Materials and Systems Program (CONMAT):
    - CONMAT was originally intended to be a ten year, $2 billion, R&D program to accelerate the commercialization of innovative materials and systems for a revitalized infrastructure capable of withstanding the demands of the twenty-first century. The program was charged with supporting material innovation in new construction, repair, rehabilitation, and retrofit technologies. CONMAT was a consortium of over a dozen construction material industry representatives working closely with government and academia. However, it appears that this program has not been fully implemented as originally envisioned.

Partnership for Advancing Infrastructure and its Renewal (PAIR):

- Supported by C&B and administered by CERF, its objective is to put an end to the management by crisis approach to infrastructure repair and renewal. PAIR works with leaders from both the private and public sectors to form collaborative partnerships that bring the innovative construction technologies and processes to the marketplace. The Partnership seeks to shorten the long time frame normally needed to take state-of-the-art construction technologies and deploy them on a broad scale. Focus areas include but are not limited to: transportation infrastructure, school repair and construction, information technology, and water surety. However, this promising initiative has not been fully implemented due to lack of political support.

7. Human Resource Development Programs

There is no significant government wide human resource development program targeting R&D workforce in construction. There are some training programs supporting general workforce training for the construction industry, but no coordinated effort that addresses R&D workforce issues for the industry specifically.

For example, the Building and Fire Research Laboratory at the National Institute of Standards and Technology offers a 12-week Summer Undergraduate Research Fellowship Program (SURF). The SURF program is designed to provide hands-on research experience in building and fire research technologies for undergraduate students from diverse disciplines. The SURF program itself is small, but there are many other summer institute programs in the U.S. designed to provide hands-on research experiences for undergraduates. Together these programs have been shown to be very successful in attracting students to graduate school and later to careers in research. SRI recommends that the Korean government to implement a similar program.

Industry and trade association such as the American Society of Civil Engineers have their own summer internship programs for undergraduate students. The Building Futures Council program rewards doctoral engineering students for conducting research and development work on issues pertinent to the current or future construction environment. There are many other small programs like these, but they are rather sporadic and small scale activities.

U.S. TRANSPORTATION R&D

B. Transportation

1. Introduction

National expenditures on transportation represent the equivalent of 11% of the gross domestic product (GDP), and transportation accounts for 19% of total household spending. In 2000, about 11 million people, or 8% of the U.S. labor force, worked in transportation industries or provided transportation services.

In 2005, government support for transportation research and development was only 0.015% of the GDP. This tiny share is much lower than the nearly 0.07% of the early 1970s (Figure 6). Coupled with the declining support is the growth in earmarking of research budgets (the designation of funds to specific institutions to carry out research). Earmarking bypasses the role of merit review and competition in ensuring scientific quality and reduces the ability of funding agencies to carry out a coherent research investment strategy. The declining level of public funding for R&D and earmarking are the two most frequently mentioned issues in U.S. transportation R&D.

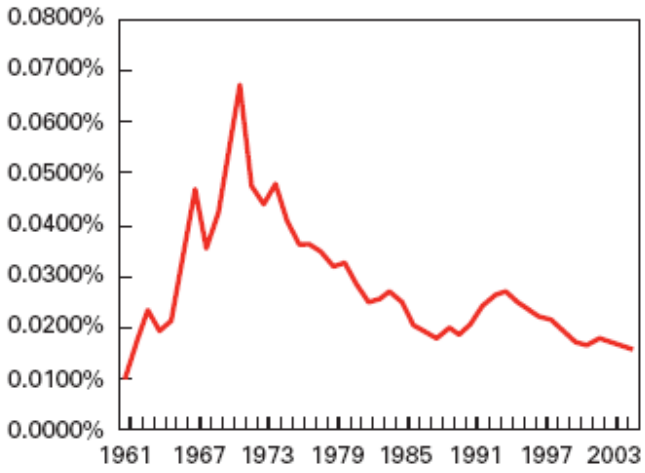

FIGURE 6: Public-sector transportation research and development as a percentage of gross domestic product.

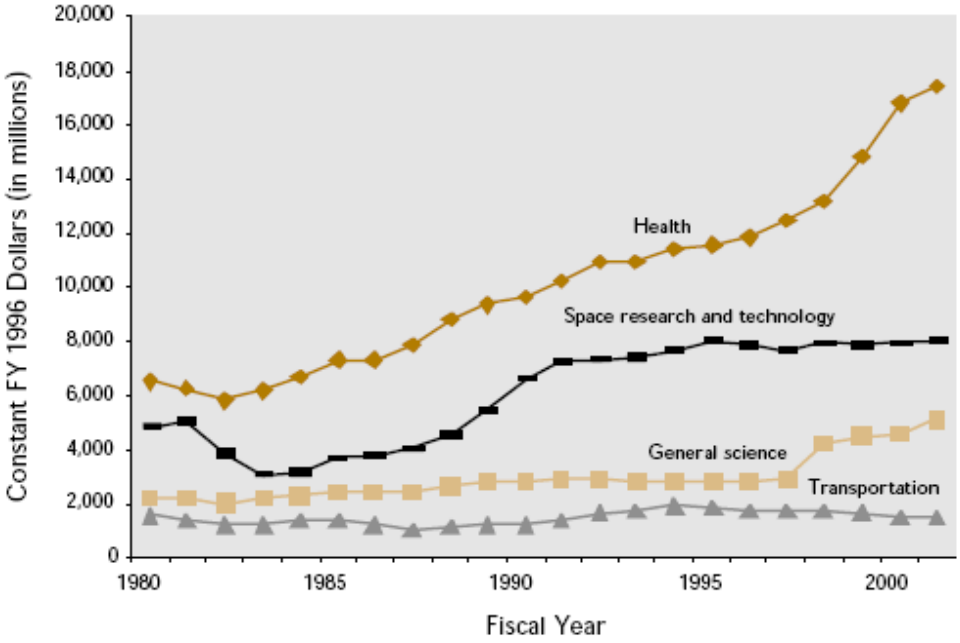

FIGURE 5 Total federal R&D by selected budget function, fiscal years 1980–2001. (SOURCES: Federal R&D Funding by Budget Function, Fiscal Years 1999–2001; Historical Tables, National Science Foundation, 2000.)

There is a clear market failure and disincentive for innovation in the transportation sector. Government is the biggest owner of transportation facilities. There is little incentive for the private sector to invest in transportation R&D areas, with the exception of the manufacturers of transportation equipment such as automobiles or airplanes. Private manufacturers of new vehicles, for example, work in an environment that rewards innovation and can respond accordingly. The public sector must meet multiple social goals, the most prominent of which is the concern for safety, which makes the public agencies risk-averse. Often, it takes much longer for the public sector to respond to changing environments and emerging technologies.

Federal, state, and local government agencies are all involved in building highways and roads. R&D is vital to the promising advances that can help solve the challenges facing the transportation sector including safety, congestion, environmental issues, etc. However, the decentralized structure of the transportation industry makes it hard to invest in long-term high-risk research, even if the potential return on investment is high. For example, the Federal Highway Administration has to work with state and local governments to build and maintain the nation's highway system.

Similar to the construction sector, government is a major owner of much of the transportation infrastructure. Public procurement practices require detailed specifications and typically award the contract to the lowest bidder, which in turn makes it more difficult to introduce innovative technologies and practices. For these reasons, the classic federal model of investing in basic research and assuming that the private sector will draw on the fruits of these efforts to innovate does not work well in the largely public-sector environment of transportation systems. In transportation infrastructure, government must therefore be more involved in the funding of applied research in addition to basic research. Reflecting its focus on applied research and technology development, DOT uses the name "Research, Development and Technology (RD&T)" to describe its research activities. The federal

government also supports applied research, demonstrations, and open standards needed to facilitate the procurement of those products and services by public agencies.

Applied transportation research programs have historically been modally oriented. Each mode of transportation is characterized by a different level of public and private involvement, and different degrees of federal responsibility and focus. So for example, the federal government owns and operates the air traffic control system and is the major, but not exclusive, provider of harbor vessel management; however, it does not own or operate highways, transit, railroads, or pipelines. Highway and transit infrastructure is owned and operated by the 50 states, hundreds of major cities, and tens of thousands of counties and towns. Research programs, like the modes, are also decentralized; none more so than in the case of highways, where the federal program is one among many.

2. Laws and Regulations

The Transportation Equity Act for the 21st Century (TEA-21), passed in 2003, calls on USDOT to carry out a program of strategic planning for surface transportation R&D in a manner consistent with the requirements of the Government Performance and Results Act of 1993.

In November 2004, Congress passed the *Norman Y. Mineta Research and Special Programs Improvement Act.* The Act creates two new organizations out of the existing Research and Special Programs Administration: (1) the Pipeline and Hazardous Materials Safety Administration (PHMSA) to further the highest degree of safety in pipeline and hazardous materials transportation; and (2) the Research and Innovative Technology Administration (RITA) to coordinate research and advance innovative technologies. In particular, RITA will review RD&T programs; conduct research on and analysis and reporting of transportation statistics; and support transportation-related education and training.

Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) was signed into law in 2005 and authorizes $2.3 billion for FY 2005 to 2009 for transportation research programs. This is less than the amount authorized in TEA-21. SAFETEA-LU's research title, Title V. SAFETEA-LU discusses the critical nature of research and development for transportation and acknowledges the meager funding provided for research. However, in contrast to TEA-21's research flexibility, SAFETEA-LU's Surface Transportation Research, Development, and Deployment Program (STRDD) directs all research funds to designated projects and initiatives with earmarking. http://www.tfhrc.gov/pubrds/06mar/01.htm

3. Government Organizations Responsible for R&D Policy

The Department of Transportation (and its operating administrations) is the lead federal government agency responsible for transportation activities and transportation R&D coordination. Although the Department of Transportation is the central agency in charge of transportation R&D, many other government agencies are involved. State governments usually have their own R&D programs whose focus is not the same as federal agency. Partnership is a key in this decentralized environment.

- Primary (lead) agency
  - Department of Transportation

        - Federal Aviation Administration (FAA)
        - Federal Highway Administration
            - Office of Advanced Research
            - Office of Technology Applications
        - Federal Motor Carrier Administration
        - Federal Railroad Administration
        - Federal Transit Administration
        - Maritime Administration
        - National Highway Traffic Safety Administration
        - Pipeline and Hazardous Materials Safety Administration
        - Research and Innovative Technology Administration
            - Volpe National Transportation Systems Center
- Other agencies conducting transportation-related R&D
    - Department of Commerce
        - National Oceanographic and Atmospheric Administration
        - National Weather Service
        - National Institute of Standards and Technology
    - Department of Defense
        - Including Defense Advanced Research Projects Agency
    - Department of Energy
        - Including National laboratories
    - Department of Homeland Security
        - Transportation Safety Administration
        - US Coast Guard
    - Environmental Protection Agency
    - National Aeronautics and Space Administration
    - National Science Foundation
- Inter-agency planning/ coordination organizations
    - Joint Planning Development Office for Air Transportation
        - FAA, National Aeronautics and Space Administration (NASA), Department of Commerce, Department of Defense, Department of Homeland Security
    - FAA-NASA Executive Committee
    - Interagency Air Traffic Management Integrated Product Team
    - FAA-NASA Aviation Safety Program
- Quasi-governmental organizations
    - Transportation Research Board of National Research Council
        - Technical Activities Division
        - Studies and Special Programs Division
        - Cooperative Research Programs Division
            - National Cooperative Highway Research Program
            - Transit Cooperative Research Program
            - Airport Cooperative Research Program
            - National Cooperative Freight Research Program
            - Hazardous Materials Cooperative Research Program
        - Strategic Highway Research Program II

Established in 1967, DOT sets Federal transportation policy and works with federal, state, and local governments and private sector partners to promote a safe, secure, efficient, and interconnected national transportation system. DOT's RD&T program leverages the research

investments of its partners to stimulate transportation improvements through targeted research, development, and technology implementation. All DOT modes embrace the objectives identified in the *DOT Strategic Plan 2003-2008*: safety, mobility, global connectivity, environmental stewardship, security, and organizational excellence. These objectives provide the framework for the Department's diverse RD&T activities.

DOT Operating Administration Roles and Responsibilities

In addition to supporting broad DOT goals, RD&T strategies, and emerging research priorities, the Department's operating administrations conduct RD&T to advance modal priorities based on their mission requirements, interactions with stakeholders, and understanding of transportation challenges, technologies, and operations. The following DOT administrations and offices have missions that involve supporting RD&T programs:

Federal Aviation Administration (FAA)

FAA's overall mission is to provide safe and efficient aviation and commercial space transportation systems by operating the air traffic control system, increasing commercial and general aviation safety through regulation and inspection, and working to improve the capacity and safety of the Nation's airports. This broad mission requires an extensive RD&T program carried out in cooperation with industry and other federal agencies. Components of this program include research in space and air traffic system technology, aviation weather products, airport technology, aircraft safety, commercial space transportation safety, human factors, and mitigation of aircraft emissions and noise.

Federal Highway Administration (FHWA)

FHWA's mission is to enhance mobility through innovation, leadership, and public service. One of the agency's key roles is to be an innovator for a better future. Toward this end, FHWA provides leadership, expertise, and resources to continually improve the quality of the highway system and its intermodal connections. Cooperating with state governments and other partners, the agency coordinates federal highway programs and conducts supporting research in highway safety, pavement and structures, congestion relief, planning, and the environment. Among the agency's major highway programs are the Federal-Aid Highway Program, which provides financial assistance to the States to construct and improve the National Highway System, urban and rural roads and bridges, and the Federal Lands Highway Program, which provides access to and within national forests, national parks, Indian reservations, and other public lands.

Federal Motor Carrier Safety Administration (FMCSA)

The mission of the FMCSA is to reduce the number and severity of commercial motor vehicle crashes. The agency's research and technology (R&T) program supports this mission through the discovery, application, and dissemination of new knowledge, and the assessment, development, and promotion of new technologies. FMCSA R&T addresses the safety performance of drivers, carriers, and vehicles and also includes crosscutting projects related to crash problem assessment and program support.

Federal Railroad Administration (FRA)

FRA promulgates and enforces railroad safety regulations; administers financial assistance programs to railroads, including Amtrak, conducts research in support of improved railroad safety, operational

efficiency, asset utilization, and capacity; fosters the development of high-speed-rail passenger service; and consolidates government support of rail transportation activities. FRA RD&T covers railroad system issues (safety, security, environment); human factors; rolling stock and components; track and structures; track/train interaction; train control; grade crossings; hazardous materials; train occupant protection; and research and development facilities and equipment.

Federal Transit Administration (FTA)

The mission of FTA is to ensure personal mobility and community vitality by supporting high-quality public transportation. FTA accomplishes its mission through leadership, financial resources, and technical assistance. Research is focused on analyzing potential solutions to transit challenges, developing research projects to evaluate and test best practices and technologies, and working with the transit industry to implement those research solutions that are found to have significant return on investment. Conducted in partnership with the broader transit community, FTA research focuses on increasing transit ridership, improving safety and emergency preparedness, improving capital and operating efficiencies, protecting the environment, and promoting energy independence.

Maritime Administration (MARAD)

MARAD is responsible for developing and maintaining a U.S. merchant marine capable of moving the Nation's waterborne commerce and serving as a military auxiliary in time of war or national emergency. MARAD has programs to improve the efficiency and productivity of the U.S. maritime industry, including ports and intermodal transportation systems. While MARAD currently has no directly funded RD&T, the agency actively facilitates several industry-wide cooperative programs to advance innovations in marine operations. In addition, MARAD works with other Federal agencies, stakeholders, and academic researchers to highlight potential maritime solutions for transportation system problems.

National Highway Traffic Safety Administration (NHTSA)

NHTSA's mission is to save lives, prevent injuries, and reduce economic costs due to road traffic crashes through education, research, safety standards, and enforcement activities. In the behavioral area, NHTSA focuses on the delivery of data-driven programs and countermeasures aimed at increasing occupant protection use, reducing alcohol-related fatalities, reducing motorcycle fatalities, promoting effective speed management, prolonging older driver mobility as long as medically practicable, promoting parental roles in effective driver education curricula, and maintaining the integrity of driver licensing processes. With respect to vehicle safety, in addition to NHTSA's traditional vehicle research, rulemaking, enforcement, and safety defect investigations, the agency assesses the lifesaving benefits of emerging technologies as they enter the vehicle fleet. NHTSA supports research programs in several critical areas: crash data trends, the safety impact of innovative technologies, injury causation and mitigation countermeasures, integrated safety from crash prevention to severity reduction, and driver behavioral safety.

Office of the Secretary of Transportation (OST)

OST has responsibility for formulating national transportation policies that affect various modes and help ensure achievement of Department-wide goals. OST research supports the development, evaluation, and improvement of these policies and comprises work in economic and strategic analysis;

safety, energy, and environments; freight and logistics; navigation and spectrum policy; aviation and international policy; and security. Key priorities include:

- improving the economic efficiency of the operation of, and investments in, the transportation system
- encouraging diffusion of best practices in transportation safety
- improving the sustainability of transportation through market-based solutions and new technologies that improve fuel economy and reduce greenhouse gases and air pollutant emissions
- illuminating the economic relationship of freight investments to the national economy and developing financial strategies to accelerate economic investment in freight capacity
- encouraging the development of civilian Global Positioning System and other positioning, navigation, and timing applications

Pipeline and Hazardous Materials Safety Administration (PHMSA)

PHMSA's mission is to ensure the safe and secure transportation of hazardous materials by all modes. The agency has two major safety offices: the Office of Pipeline Safety, which ensures the safe, reliable, and environmentally sound operation of pipeline transportation, and the Office of Hazardous Materials Safety, which identifies, evaluates, and mitigates risks to the safe and secure transportation of hazardous materials. PHMSA RD&T includes work in mission-critical areas including pipeline operations, control, and monitoring; pipeline damage prevention; improved pipeline materials; hazardous materials packaging and shipping, including packaging design; hazmat emergency response, hazard identification, risk assessment, and risk management; hazmat consequence modeling; and hazardous materials transportation security.

Research and Innovative Technology Administration (RITA)

RITA's mission is to enable, facilitate, and expedite innovation in the transportation system to advance the transportation and economic objectives of the United States. RITA accomplishes the RD&T components of this mission by leading crossmodal research; planning, reviewing, and coordinating RD&T Department-wide; leading the RD&T Planning Council and Planning Team; and managing the Department's University Transportation Centers Program. In addition, RITA's Bureau of Transportation Statistics (BTS) plays a key role in gathering and improving the quality of the aviation, freight, and passenger flow data upon which much of the Department's research relies.

4. Planning and priority setting

Current federal government-level plan for transportation R&D

- Most recent: *Transportation Research, Development and Technology Strategic Plan, 2006-2010* (2006), by Research and Innovative Technology Administration, Department of Transportation (DOT)
  - Responds to the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, which requires a five-year plan to guide transportation R&D
  - DOT agency-wide plan
  - Note that many individual operating administrations have their own R&D plans
- Aligns with broader *Department of Transportation Strategic Plan, 2006-2011* (2005)

        - Goals: safety; reduced congestion; global connectivity; environmental stewardship; security/ preparedness/response; organizational excellence

Transportation Research, Development and Technology Strategic Plan (2006)

- Federal strategy for R&D and technology (RD&T) in support of the transportation industry has been a yearly exercise since 1999; the strategy was reformatted in 2006.
- Developed by the Research and Innovative Technology Administration, DOT
    - Input from DOT's operating administrations
        - RD&T Planning Council (heads of operating administrations, DOT Under Secretary for Policy, other senior officials)
        - RD&T Planning Team (operating administrations' associate administrators for RD&T)
            - Planning process involves multi-year RD&T planning (framework for the plan); annual program planning (sets priorities for each fiscal year that are included in budget guidance to operating administrations and in funding reports to Congress); and budget and performance planning (supports the budgeting and program assessment through annual reviews and budget submissions).
    - Stakeholder input: The strategic plans are required to incorporate both primary and secondary input from a broad range of department stakeholders, including state and local transportation agencies, not-for-profit institutions, academia, and the private sector.
    - Most of transportation RD&T is conducted by the Department's operating administrations for modal-specific purposes. Each operating administration has its own set of research strategies. Research advisory committees, public meetings, and forums ensure that RD&T programs are validated through external stakeholder review and participation.

- DOT's RD&T Mission: Foster innovations leading to effective, integrated, inter-modal transportation solutions. The research activities are a basic federal responsibility when they are of national significance, when there is clear public benefit and private sector investment is less than optimal, when they support a stewardship role in assuring the efficient use of federal resources, and when they present the best means to support national policy goals.

- Strategic plan framework:
    - Six emerging research priority areas guide the Department's RD&T investments. These priority areas meet the following criteria: (1) they support identified Departmental goals and priorities; (2) they offer the greatest potential return on investment; and (3) they are areas where Federal RD&T is most appropriate and not likely to be duplicated by other efforts.

    - The plan lists specific research topic areas for each DOT operating administration in support of agency goals and RD&T strategies

- Note that in this agency-wide plan, emerging research priorities/research areas are "generic" in nature; individual administration plans differ in specificity

Table E-1. DOT Goals, RD&T Strategies, and Emerging Research Priorities

DOT Goal	RD&T Strategies	Emerging Research Priorities
Safety	Understand and Address Causal Factors and Risks	Human-Automation Interaction Enhanced Safety Data
	Mitigate Accidents and Incidents	
	Assess New Technologies, Vehicles, Concepts, Designs, and Procedures	
Reduced Congestion	Reduce Passenger and Freight Congestion in Air and Surface Modes	Congestion Reduction Policy Research and Technologies
	Extend System Life and Improve Durability	
	Advance Use of Next Generation Technologies and Combinations of Modes	System Resilience and Global Logistics Next Generation Air Transportation System
	Improve Planning, Operations, and Management	
	Improve Services for Underserved Areas and Populations	
	Advance the Nation's Transportation Research Capability	
Global Connectivity	Harmonize Standards and Support Leadership for U.S. Transportation Providers	
Environmental Stewardship	Understand and Mitigate Transportation Impacts	Energy Efficiency and Alternative Fuels
	Improve the Environmental Review Process	
Security, Preparedness and Response	Reduce Vulnerability and Improve Preparedness and Recovery	
	Secure Hazardous Materials Shipments and Assess Risks	
Organizational Excellence	Consistently Apply the R&D Investment Criteria	

A Transportation Research Board (TRB) committee reviewed USDOT's strategic plan for research and technology (R&T), its performance plan, and its performance reports. The committee recommended a sharper alignment and clearer articulation between USDOT's R&T activities and strategic goals. It also urged the department to identify the budgetary resources required to carry out the R&T activities identified in the plan. In addition, the committee encouraged USDOT to identify and articulate more clearly the appropriate federal role in research, to undertake more coordination with other public agencies that have transportation missions and also conduct research, and to seek more stakeholder involvement in the various agency R&T programs.

Evaluation and Assessment of RD&T:
The current Bush administration emphasizes evaluation and strategic planning of government programs. Therefore, evaluation is an important part of the RD&T programs. The Department continually assesses its research programs using three primary mechanisms:

(1) assesses RD&T relevance, quality, and performance; evaluates processes for RD&T program planning, budgeting, and management
(2) annually assesses implementation of investment criteria and PART; ensures that RD&T is evaluated according to best practices; identifies opportunities for crossmodal initiatives; prevents unnecessary duplication
(3) ensures that RD&T addresses critical needs; identifies RD&T priorities and programmatic direction; upholds technical quality of RD&T; provides basis for developing effective performance metrics

5&6. R&D Funding Organizations and Programs and Institutions Conducting R&D

Due to the decentralized nature of the transportation agencies, partnership is essential for the Department of Transportation. DOT collaborates with other government agencies, universities, industry, and other organizations. For a more detailed breakdown of the RD&T funding plan for 2006-2010 by agency and by RD&T strategy, see appendix C of *Transportation Research, Development and Technology Strategic Plan, 2006-2010*.
http://www.rita.dot.gov/publications/transportation_rd_t_strategic_plan/

- University-based programs
  In addition to coordinating research with other Federal agencies, the Department actively pursues partnerships with the Nation's academic institutions. The Department's largest university program supports the University Transportation Centers, which conduct basic and applied research to advance the body of knowledge in transportation; conduct education programs to expand the transportation workforce; and provide capacity building programs to existing transportation professionals.

    - Center for Commercial Deployment of Transportation Technologies
      MARAD and the U.S. Transportation Command provides coordinated support to the Center for the Commercial Deployment of Transportation Technologies (CCDOTT), a chartered university center at California State University in Long Beach. The center is congressionally sponsored, with funding provided from DOD. The CCDOTT functions as a partnership of academic institutions, government agencies, and private companies. It has three purposes: leverage advanced transportation technologies—including emerging high-speed ship systems, decision support tools, tagging and tracking, and agile port and terminal systems—to solve defense and commercial infrastructure problems; sponsor applied research in support of defense and commercial infrastructure initiatives; and provide a bilateral technology transfer/dual-use bridge between DOD and industry.

    - FAA Transportation Centers of Excellence (60+ universities and 200+ industry/government affiliates)

Centers of Excellence (COEs) are unique consortia of federal, university, and industry researchers working to improve aviation through shared resources, leveraged funding, and pooled talent. Following an extensive selection process, university core members enter into cooperative agreements with FAA. Subsequently, research scientists are funded through matching grants and cost-share contracts. COE members are required to provide matching funds from non-Federal sources, solidifying their partnership with FAA and enabling the centers to strive to be an independent national resource. Through these partnerships between government, academia, and industry, all parties maximize and strengthen their technological capabilities.

- Federal Railroad Administration University Research Program

This FRA program awards competitive research grants to universities for work on challenging priority areas identified in the FRA Strategic Plan. Efforts are supported using discretionary funds or in accordance with congressional mandates. When the work progresses to the prototype stage, cooperating railroads or FRA technical support contractors provide field testing support as necessary. Current studies include work at Marshall University and the University of Nebraska on human factors, infrastructure durability, and a high-precision differential global positioning system (GPS), and research at Ohio University on the development of high-performance nationwide differential GPS services and related user equipment.

- Global Maritime and Transportation School

Located at the U.S. Merchant Marine Academy (USMMA) in Kings Point, New York, the Global Maritime and Transportation School (GMATS) is designated as a National Maritime Enhancement Institute, recognizing its expertise, capabilities, and industry affiliations contributing to the advancement of safe, secure, economically viable, and environmentally sensible marine and intermodal transportation systems. The GMATS Division of Research and Special Projects conducts applied research in a number of areas, including maritime security; modal and intermodal freight systems; marine and intermodal terminal operations; maritime training and education; industry leadership and business ethics; port and waterway design and traffic management; maritime business and economics; communication and information systems; shipboard operations; and marine engineering, shipbuilding, and naval architecture.

- Joint University Program

Jointly sponsored by FAA and NASA, the Joint University Program seeks to materially improve the efficiency, performance, and safety of air transportation in the United States by identifying promising targets for development, by conducting associated long-term research, and by educating technological leaders. Through the program, leading academic researchers and their students are involved in solving critical aeronautical problems, particularly those related to aircraft guidance, navigation, and control; meteorological hazards; and human factors. The program currently provides research grants to the Massachusetts Institute of Technology, Ohio University, and Princeton University.

- Maritime Research and Education

The USMMA is one of five Federal service academies. Its four-year program provides the broad college education required for a Bachelor of Science degree, with the specialized training for licensing as a merchant marine officer and the military

knowledge for commissioning in a reserve component of the Armed Forces. USMMA laboratories and research contribute to maritime innovation and to building a talented and skilled maritime workforce.

- Renewable Energy Transportation Laboratory

Located at the USMMA, the Renewable Energy Transportation Laboratory acts as a test bed for a full range of alternative energy technologies. It facilitates advancements in renewable technologies, gives students a hands-on aspect to their studies, and promotes interest in the application of alternative energy systems. Currently receiving financial and technical support from the Long Island Power Authority and from Plug Power (in Latham, New York), the laboratory features integrated and fully operational wind, solar photovoltaic, and hydrogen fuel cell generators (which develop nonpolluting power for hydrogen production and the operation of two electric work carts); an "Electrathon" endurance race car; and a fuel-cell-powered boat.

- University Transportation Centers Program

The Department's largest university research program, the University Transportation Centers (UTC) Program conducts basic and applied research to advance the body of knowledge in transportation; conducts education programs to expand the transportation workforce; and provides capacity building programs to transportation professionals. The UTC Program is managed by RITA and funded by FHWA and FTA. The program has a multimodal focus and is supportive of the Department's strategic goals. SAFETEA-LU authorized the most significant expansion of the UTC Program to date, increasing the annual funding for UTCs and the number of UTCs to 60 from the 33 established in the Transportation Equity Act for the 21st Century. In 2006, DOT will competitively select 20 UTCs and fund an additional 40 named in SAFETEA-LU. Competitively selected centers receive $1 million per year, while congressionally designated centers receive either $500,000 or $750,000 per year. Federal funding is matched by state funding.

7. R&D Collaboration Programs

Inter-agency collaboration:

DOT leads transportation RD&T in the federal government. At the Cabinet level, the Department coordinates transportation research through the White House Office of Science and Technology Policy and the National Science and Technology Council. In addition, the Department's operating administrations work directly with agencies in areas of mutual interest to avoid duplication and leverage research investments. Among the agencies with which the Department actively cooperates are:

- Department of Agriculture
- Department of Commerce
- Department of Defense
- Department of Energy
- Department of Homeland Security
- Department of the Interior

- Department of State
- Environmental Protection Agency
- National Aeronautics and Space Administration
- National Science Foundation

All DOT funding programs are in a way collaboration programs since they all involve collaboration with partners in other federal agencies, local and state agencies, universities, industry, not-for-profit institutions, and other key stakeholders. Below is a list of representative collaborative programs that are explicitly designed for collaboration with external DOT organizations except for university funding programs, described previously:

- Airport Cooperative Research Program (with TRB at the National Research Council (NRC))
- Cargo Handling Cooperative Program
- Commercial Remote Sensing and Spatial Technologies Program
- Hazardous Materials Transportation Cooperative Research Program (with TRB at NRC)
- Marine Environmental Research Program
- Marine Transportation Systems Initiative
- Maritime Standards Coordination
- National Cooperative Freight Transportation Research Program (with TRB at NRC)
- National Cooperative Highway Research Program (with AASHTO)
- Ship Operations Cooperative Program
- Ship Structure Committee
- Short Sea Shipping Cooperative Program
- Transit Cooperative Research Program (with TRB at NRC)
- Transportation Pooled-Fund Program

8. Human resource development programs

There are many human resource development program coordinated by DOT covering a wide range of students and professionals interested in transportation related study and training. Below is a brief description of each of DOT human resource development programs.

Garrett A. Morgan Transportation and Technology Futures Program
Since 1997, the U.S. Department of Transportation has supported a career-oriented outreach program for K-12 students, community college students, graduate students, and transportation agency employees, called the Garrett A. Morgan Transportation and Technology Futures Program. Funding for the program stopped in 2000 but was re-authorized in 2005 at $1.25 million per year.

Dwight D. Eisenhower Transportation Fellowship Program(DDETFP)
DDETFP awards fellowships to students pursuing degrees in transportation-related disciplines. This program advances transportation education, research, and workforce development, and encompasses all modes of transportation. More specifically, there are seven program areas that support each of the following categories: graduate study, research experience for undergraduate and graduate students, Historically Black Colleges and Universities, Hispanic Serving Institutions, Tribal Colleges and

Universities, people with disabilities, and internship. Approximately 100-150 fellowships are awarded each year out of approximately $2 million in annual funding.

Local Technical Assistance Program (LTAP)/Tribal Technical Assistance Program (TTAP)
These programs work to advance partnerships with professional associations, provide outreach to local transportation agencies, industry, and academia, and further professional development. There are 58 LTAP/TTAP centers: one in each state, one in Puerto Rico, and seven regional tribal centers serving Native American tribal governments. Averaging around three full-time employees per center, the LTAP/TTAP staff work to foster a safe, efficient, and environmentally sound transportation system by improving the skills and knowledge of the local transportation workforce and decision makers.

Transportation Education Development Pilot Program
This pilot program establishes funding to develop training and education curriculums for surface transportation workers. Funding is $1.875 million per year

Transportation Scholarship Opportunities Program
This program provides authority for the USDOT Operating Administrations and for "non-governmental institutions" to establish scholarship and mentoring programs. Most USDOT Operating Administrations did not have statutory authority in this area prior to SAFTEA-LU. Operating Administration participation is discretionary, funding is not provided.

University Transportation Centers (UTC)
UTCs are the university based research centers on transportation related topics, but include education components and support their own graduate students as a part of the center activities.

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10. Department of Housing and Urban Development, Office of Policy Development and Research., Affordable Housing Research and Technology Division. Website: http://www.huduser.org/research/tech.html
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Directorate of Civil Works
Directorate of Research and Development
Engineering and Research Development Center
http://www.erdc.usace.army.mil/
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Naval Facilities Engineering Service Center
Air Force Laboratories

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JAPAN CONSTRUCTION & TANSPORTATION R&D

A. Construction

1. Introduction

S&T Policy Context

The Council for Science and Technology Policy, Cabinet Office (CSTP) is positioned at the top in the administrative hierarchy in Science and Technology (S&T) in Japan. CSPT was established in January, 2001 by the Law for Establishing Cabinet Office (Public Law 09-89). The law calls for CSTP to serve as a source of scientific and technological analysis and judgment for the Prime Minister with respect to major policies, plans, and programs of the Government of Japan. The Act authorizes CSTP to:

- Advise the Prime Minister and others cabinet members on the impacts of science and technology on domestic and international affairs;
- Lead an interagency effort to develop and implement sound science and technology policies and budgets;
- Work with the private sector to ensure that government investments in science and technology contribute to economic prosperity, environmental quality, and national security;
- Build strong partnerships among central and local governments, other countries, and the scientific community; and
- Evaluate the scale, quality, and effectiveness of the government effort in science and technology.

2. Laws and regulations

Science and Technology Basic Law and Plan

The National Diet of Japan passed the Science and Technology Basic Law in 1995, and the law lays down the fundamental principles of S&T policy for the Government of Japan. The Law calls for CSTP to develop the Science and Technology Basic Plan every five years. The Science and Technology Basic Plan is a comprehensive plan for the Government of Japan to promote S&T policy strategically and effectively. The current S&T Basic Plan, which started in their Fiscal Year (FY) 2006[1], is the third one and covers the primary and secondary priority fields. These priority fields were selected based on three criteria; national needs; Japan's competitive power; and contribution to the national innovation system. The primary priorities are:

- Life Science
- Information and Communication Technology
- Environmental Science
- Nanotechnology and Materials Science

The secondary priorities are:

[1] The Government of Japan's fiscal year starts April 1st and ends March 31st of the next year.

- Energy
- Manufacturing Technology
- Social Infrastructure (Construction and Transportation Technology)
- Frontier Science (Ocean science and aerospace technology)

These primary and secondary priority fields were also emphasized as primary and secondary priority fields, respectively, in the previous (second) S&T Basic Plan.

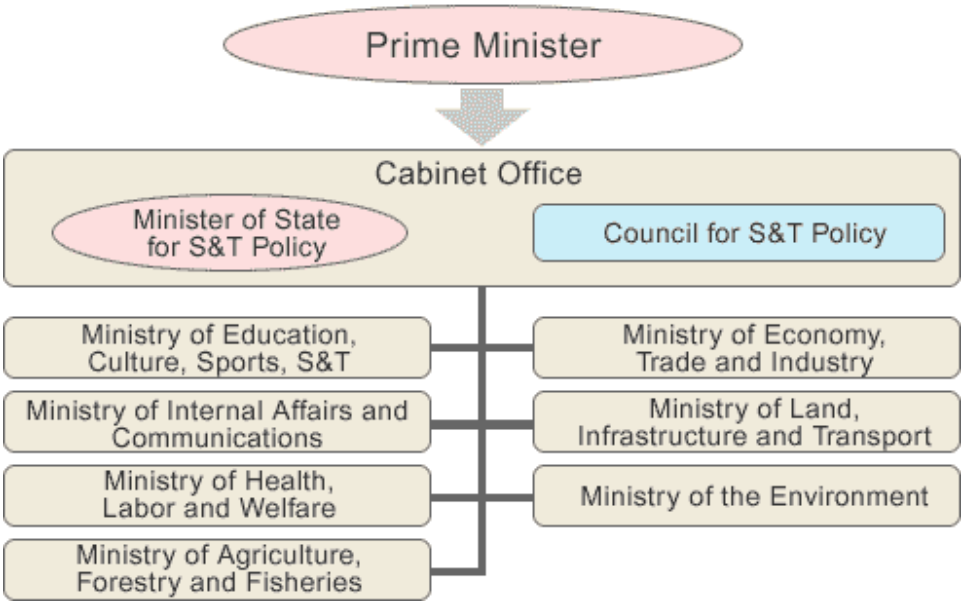
3. Government Organization Responsible for R&D Policy

1) S&T Policy Context

CSTP is the supreme decision-making body of Science and Technology (S&T) policy within the Government of Japan. CSTP is chaired by the Prime Minister and consists of several other cabinet members including the chief cabinet secretary, the Minister for Science and Technology, the Finance Minister, the Minister of Education and Science, the Minister of Economy, Trade and Industry, and the Minister of Internal Affairs and Communications. CSTP members also include several leaders in business and academic sectors.

Figure 1 shows the organizational structure for S&T policy at the Government of Japan.

Figure 1 Organization Chart of S&T Policy at the Government of Japan



Source: CSTP website, www8.cao.go.jp/cstp

The Ministry of Land, Infrastructure and Transport Government of Japan (MLIT) is the primary agency (ministry?) which addresses Research and Development (R&D) in both construction and transportation technologies.

2) R&D efforts at MLIT

MLIT was established in 2001 by consolidating:

- Former Ministry of Construction
- Former Ministry of Transport
- Former National Land Agency
- Former Hokkaido Development Agency

For the legacy of this consolidation, R&D programs in construction and transportation areas were decentralized over several bureaus which inherited the structure of their former ministries and agencies; there is no bureau or division with the single mission of R&D.

Figure 2 shows the organizational chart of MLIT. The Policy Division at the Policy Bureau takes responsibility for both planning and coordination of R&D programs for construction and transportation areas. Two MLIT affiliated institutes; the Policy Research Institute for Land, Infrastructure and Transport, and the National Institute for Land and Infrastructure Management assist the Policy Division in the planning and coordination of the R&D programs. The Policy Division cooperates with other bureaus and funds both intramural and extramural programs.

Figure 2 MLIT Organizational Chart

Source: MLIT Organization Chart, MILT, April 1, 2007

The Geographical Survey Institute, which is affiliated with MLIT, carries out research for the geodetic and geological survey and mapping. Recently, the Institute placed emphasis on the development of methods for measurement and mapping with data by satellite observation. Also, the Institute promotes

research to predict earthquake and volcanic explosion, and develops the monitoring methods of the Earth's environment.

The Regional Development Bureau has regional offices in Hokkaido, Tohoku, Kanto, Hokuriku, Chubu, Kinki, Chugoku, Shikoku and Kyusyu. The regional offices promote research, development, testing, and application of new technologies, which are necessary to their jurisdictions, and promote technology transfer by cooperating with local companies and universities in their jurisdictions. They also collect technical information from their jurisdictions and provide the information to the Policy Division for its R&D planning. The Policy Division also uses the information for standardization of new technologies.

The independent administration institutions, including the Public Works Research Institute; the Building Research Institute, the National Traffic Safety and Environment Laboratory; the National Maritime Research Institute; the Port and Airport Research Institute; and the Electronic Navigation Research Institute became independent from MLIT in 2001. However, most of their revenues still come from MLIT. Commissioned by MLIT, these institutions carry out R&D projects by cooperating with private companies and universities.

4. Planning and Priority Setting

1) CSTP strategic R&D plan in social infrastructure field

The current S&T Basic Plan calls for CSTP to establish Strategic R&D Plans by the priority fields. In the social infrastructure field, CSTP established the Social Infrastructure Task Force (SITF) and commissioned SITF to develop the Strategic R&D Plan in the field.

First, SITF set the following goals of the Strategic R&D Plan in the social infrastructure field:

- Make Japan the safest country in the world with full-scale countermeasures against natural disasters; and
- Develop social infrastructure that is environmentally friendly and suited for an advanced information society in the 21st Century by both addressing urgent social needs and revitalizing the aging infrastructure.

In order to achieve the goals, SITF called for government agencies to:

- Promote interagency cooperation to protect the nation from disasters;
- Develop R&D systems which secure the nation; and
- Promote on-site demonstration and practical use of new technologies developed by R&D projects funded by government agencies

Furthermore, SITF set seven R&D agenda areas and forty critical technologies under the agenda. The R&D agenda and the critical technologies were selected partly based on findings of the eighth Delphi

survey[2] and other studies. In the selection process, SITF also considered other criteria, including contribution to national goals and the public benefit; and Japan's R&D competitive power in the world.

Table 1 R&D agenda and critical technologies in social infrastructure field

R&D agenda	Critical technologies
Disaster prevention	1. Observation/monitoring/prediction of earthquakes 2. Geological survey and research 3. Damage alleviation technology (quakeproof engineering, disaster management and reconstruction, etc.) 4. Prediction technology of volcanic explosion 5. Observation/monitoring/alleviation technology against natural disasters including gale, flood, mudslide, and heavy snow 6. Technology for satellite observation/monitoring of natural disasters 7. Technology for warning, communication, and damage prediction against natural disasters 8. Technology for initial and quick response to natural disasters 9. Research for building the disaster-resistant society 10. Technology for risk-free and accident-free facility/building
Counterterrorism and national security	11. Technology for identification and treatment of toxic and hazardous materials 12. Technology for detection of any unlawful entries to the homeland 13. Technology for identification and prediction of vulnerability 14. Technology for prevention and investigation of crimes
Urban revitalization and protection of life environment	15. Technology for alleviation of urban heat island problem 16. Reconstruction of the urban infrastructure corresponding to social changes 17. Low-cost recycling technology for transportation and housing 18. Energy efficiency in the urban development 19. Resource management systems with conservation of the environment in rural areas
Management of social capital	20. Maintenance-renewal optimization of social capital and constructions 21. Construction technology for the comfortable and safe living environment 22. Creation of the recycling society with limited resource and little waste
Land conservation and management	23. Land conservation and management of sediment injury 24. Integrated management of the water and material circulation 25. Conservation and revitalization of the healthy ecosystem

[2] See the attached documents:
"The Eighth Technology Foresight Study in Construction Technology", National Institute for Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology, Tokyo, 2005.

"The Eighth Technology Foresight Study in Transportation Technology", National Institute for Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology, Tokyo, 2005.

	26. Design and prediction for the ideal national land
Transportation	27. Improvement of safety and reliability of the transportation system 28. Prevention of accidents by human errors 29. Development of the mobile transportation system suited for local transportation 30. Land/sea/air seamless logistics 31. Integration of aircraft systems 32. Development of a supersonic aircraft 33. Development of an aircraft for short distance transportation 34. Cutting-edge technology for aircraft systems 35. Technology to prevent air and marine pollution by vessels 36. Advanced technology to develop an environmentally-friendly aircrafts
Universal society	37. Adoption and diffusion of the universally-friendly design 38. Development of the society where people can lead safe and healthy lives 39. Development of the social infrastructure to increase people's mobility 40. Development of multifunctional methods to assure people's quality of life in rural areas

Source: "The R&D Strategy Plan in Social Infrastructure", Council for Science and Technology Policy, Cabinet Office, Tokyo, 2006.

Disaster prevention

Japan has strong R&D capabilities in seismic investigation, earthquake proofing construction, and quick precipitation forecast. Based on the capabilities, SITF set the following critical technologies to protect the nation against natural disasters, including earthquake, tsunami, volcanic explosion, gale, flood and heavy snow:

1. Observation/monitoring/prediction of earthquakes
2. Geological survey and research
3. Damage alleviation technology (quakeproof engineering, disaster management and reconstruction, etc.)
4. Prediction technology of volcanic explosion
5. Observation/monitoring/alleviation technology against natural disasters including gale, flood, mudslide, and heavy snow

The satellite observation/monitoring system and the warning communication system are especially important for disaster prevention. These systems are for the public benefit, rather than for commercial benefit, and government agencies should play a major role to promote the R&D of these systems. SITF emphasizes the following critical technologies in the current S&T Basic Plan:

6. Technology for satellite observation/monitoring of natural disasters
7. Technology for warning, communication, and damage prediction against natural disasters

SITF has selected the following critical technologies which are necessary to build the disaster-resistant society:

8. Technology for initial and quick response to natural disasters
9. Research for building the disaster-resistant society
10. Technology for risk-free and accident-free facility/building

Counterterrorism and national security

Homeland security is one of the top national priorities of the Government of Japan, and social needs for counterterrorism and anticrime measures are increasing in Japan. Most of the technologies for homeland security are for the public benefit, and procurements by government agencies could encourage vendors to develop these technologies. The eighth Delphi survey indicated the technologies that government agencies should address for a homeland security purpose. Partly based on the technologies identified by the eighth Delphi survey, but additionally based on national priorities and Japan's R&D capabilities in homeland security, SITF set the following critical technologies:

11. Technology for identification and treatment of toxic and hazardous materials
12. Technology for detection of any unlawful entries to the homeland
13. Technology for identification and prediction of vulnerability
14. Technology for prevention and investigation of crimes

Urban revitalization and protection of life environment

There are growing social needs for the urban revitalization and the high quality of life. Based on the findings of the eight Delphi survey and Japan's R&D capabilities, SITF set the following critical technologies that government agencies should promote for the public benefit:

15. Technology for alleviation of urban heat island problem
16. Reconstruction of the urban infrastructure corresponding to social changes
17. Low-cost recycling technology for transportation and housing
18. Energy efficiency in the urban development
19. Resource management systems with conservation of the environment in rural areas

Management of social stocks

The social infrastructure developed in the period of the high economic growth, late 1950s to early 1970s, is becoming old, and there is a high demand to maintain, manage, and reconstruct the infrastructure by utilizing the fundamental functions of the aging infrastructure. SITF set the following critical technologies that government agencies should support to meet the demand:

20. Maintenance-renewal optimization of social capital and constructions
21. Construction technology for the comfortable and safe living environment
22. Creation of the recycling society with limited resource and little waste

Land conservation and management

In the environmentally friendly society, there is a high demand for R&D to maintain and manage the ecosystem, and SITF set the following critical technologies that are especially important for government agencies to address for the public benefit:

23. Land conservation and management of sediment injury
24. Integrated management of the water and material circulation
25. Conservation and revitalization of the healthy ecosystem
26. Design and prediction for the ideal national land

Transportation

Highway and railway accidents cause a great number of casualties every year, and there is a high demand for the safe transportation system and infrastructure. SITF selected the following critical technologies which government agencies should promote by integrating Japan's world-leading information and communications technologies:

27. Improvement of safety and reliability of the transportation system
28. Prevention of accidents by human errors
29. Development of the mobile transportation system suited for local transportation
30. Land/sea/air seamless logistics
31. Integration of aircraft systems
32. Development of a supersonic aircraft
33. Development of an aircraft for short distance transportation
34. Cutting-edge technology for aircraft systems
35. Technology to prevent air and marine pollution by vessels
36. Advanced technology to develop an environmentally-friendly aircrafts

Universal society

The universal society means the society where people can lead safe and health lives. SITF set the following critical technologies to realize the universal society:

37. Adoption and diffusion of the universally-friendly design
38. Development of the society where people can lead safe and healthy lives
39. Development of the social infrastructure to increase people's mobility
40. Development of multifunctional methods to assure people's quality of life in rural areas

2) MLIT R&D plans

MLIT master plan for R&D

When MLIT was established in 2001, there was no mechanism to coordinate the R&D programs that MLIT took over from its former ministries and agencies. MLIT established the Strategic Technology Council for Research and Development of Land, Infrastructure and Transport in 2002, and called for the Council to develop a comprehensive R&D plan by coordinating all of the R&D programs. This

Council's effort led to the "MLIT Technology Basic Plan[3]" which was published by MLIT in November 2003. This Basic Plan incorporated findings of the two reports published before the Basic Plan; "Construction R&D Plan," published by the Council for Transport Technology in December 2000; and "Transportation R&D Plan," published by the Technology Development Council for Social Infrastructure in July 2002. The MLIT Technology Basic Plan provided the groundwork for R&D efforts by MLIT during the following five years (2003 to 2007).

The "MLIT Technology Basic Plan" is consistent at a high level with the Strategic R&D Plans in the social infrastructure field in the third S&T Basic Plan.

R&D Agenda and Priorities in Social Infrastructure Field in the Third S&T Basic Plan

MLIT established the Joint Subcommittee of Technology under the Panel on Infrastructure Development and the Council of Transport Policy in 2005, which was charged with developing an R&D agenda in the social infrastructure field to be covered in the third S&T Basic Plan. The Subcommittee subsequently published the report, "R&D Agenda and Priorities in Social Infrastructure Field – For Preparing the Strategic R&D plan in social infrastructure field in the Third Science and Technology Basic Plan[4]" on December 27, 2005. This report provided the groundwork for the SITF's Strategic R&D Plan for the social infrastructure field.

5. R&D Funding Organizations and Programs

MLIT has three major R&D programs; the Integrated Technology Development Program; the R&D Grant Program for Construction Technology; and the R&D Program for Road Transportation Technology.

Integrated Technology Development Program

The former Ministry of Construction started the Integrated Technology Development Program[5] in 1972, and MILT took over this program in 2001 when MLIT consolidated the Ministry of Construction. This program funds large scale (multimillions of U.S. dollars) projects where research institutions inside and outside of MLIT, universities, and private companies work together to address important problems for the nation. Past and current projects include the project for technology development to predict earthquake disasters in metropolitan areas, the project for development of the remote-controlled robotic technology for distant construction, etc.

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[3] See R-11 "MLIT Technology Basic Plan", Ministry of Land, Infrastructure and Transport, Tokyo, November, 2003

[4] See "R-12 R&D Agenda and Priorities in Social Infrastructure Field: For Preparing the Strategic R&D plan in social and infrastructure field in the Third Science and Technology Basic Plan", Joint Subcommittee of Technology under the Panel on Infrastructure Development and the Council of Transport Policy, Tokyo, December 27, 2005"

[5] The Engineering Affairs Division at the Minister's Secretariat Bureau, MLIT provides the list of the past and current projects of the Integrated Technology Development Program at http://www.mlit.go.jp/tec/gijutu/kaihatu/soupro.html

R&D Grant Program for Construction Technology

The Engineering Affairs Division of the Minister's Secretariat Bureau at MLIT started the R&D Grant Program for Construction Technology in 2001 and has provided universities and research institutions with grants to support a broad range of R&D in the construction area. This program covers both basic and applied research for construction technologies[6], and also supports the investigation application of new construction technologies in the practical use[7].

R&D Program for Road Transportation Technology

The Road Bureau of MLIT established the New Council for Road Transportation Technology in 2004, and called for the Council to provide technical advice on road transportation for the Road Bureau. The Council cooperates with the National Institute for Land and Infrastructure Management and sets the guideline for R&D in road transportation every year. Based on the guideline, the Road Bureau provides contracts and grants for research institutions inside and outside of MLIT, universities, and private companies[8].

6. Institutions Conducting R&D

Figure 3 shows how MLIT contributes to the national R&D system in the construction and transportation areas.

MLIT cooperates with the independent administrative agencies (formally its affiliations) and private companies, and financially supports their R&D efforts. MLIT provides R&D contracts for the private sector, and R&D grants for the academic sector. Furthermore, MLIT promotes standardization of new technologies and technology transfer to the construction and transportation industries.

The Regional Development Bureaus at MLIT collect information on construction and transportation technologies, including the policy/users needs; trends in the new technologies; and assessments of new technologies. The Bureaus compile the findings into databases and provide the databases for the further demonstration and pilot projects of new technologies.

Based on the findings of the demonstrations and the pilot projects, the Bureaus promote application of the new technologies with private companies and academic researchers in their jurisdictions. These findings are also used for technical design, cost estimation, and technology standardization.

R&D efforts in the private sector can be financed by non-MLIT investments and loans, too. The tax incentive program is another channel to encourage R&D efforts in the private sector.

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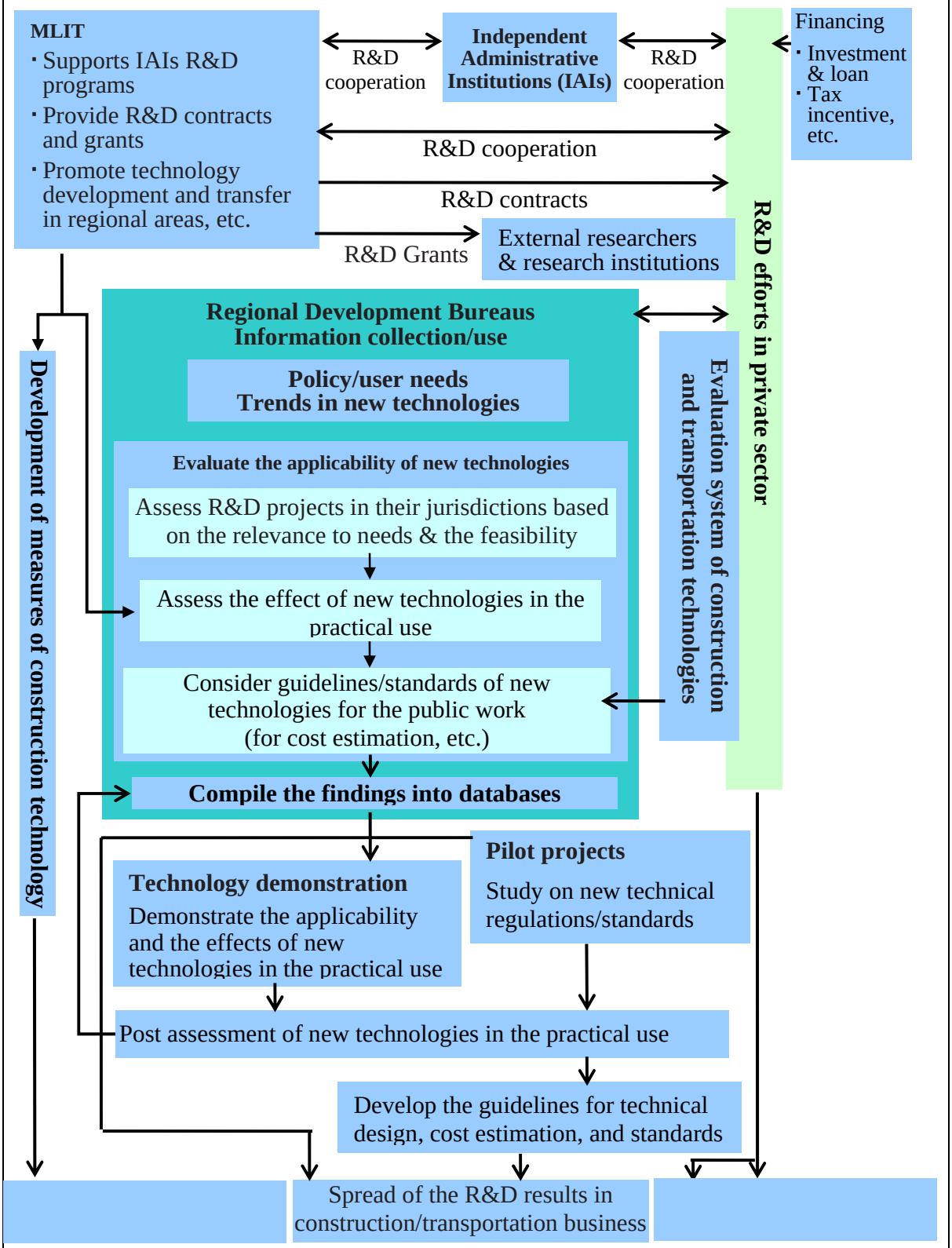
6 For more detail, see www.mlit.go.jp/tec/gijutu/kaihatu/01kiso.html

7 For more detail, see www.mlit.go.jp/tec/gijutu/kaihatu/02jitsuyo.html

8 For more detail, see www.mlit.go.jp/road/tech/gijutu/outline.html

Figure 3 MILT's role in the national R&D system in construction and transportation areas



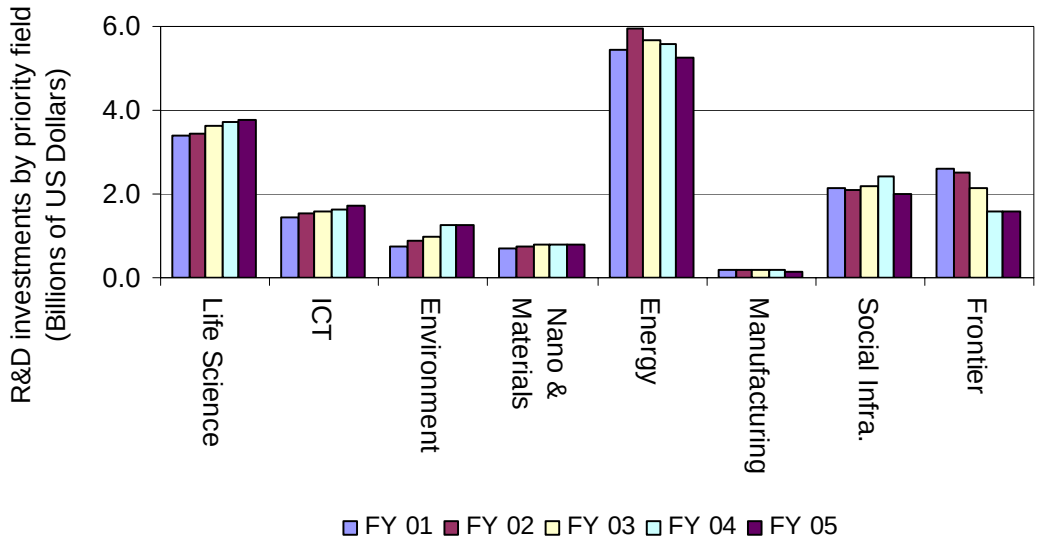
Source: The Office for Technology Study at MLIT www.mlit.go.jp/tec/gijutu/

7. R&D Collaboration Programs

Funding Priorities

오류! 참조 원본을 찾을 수 없습니다. shows R&D budgets of the Government of Japan by the eight priority fields in the second and third S&T Basic Plans.

Figure 4 R&D Budgets by the eight priority fields (FY 01-05)



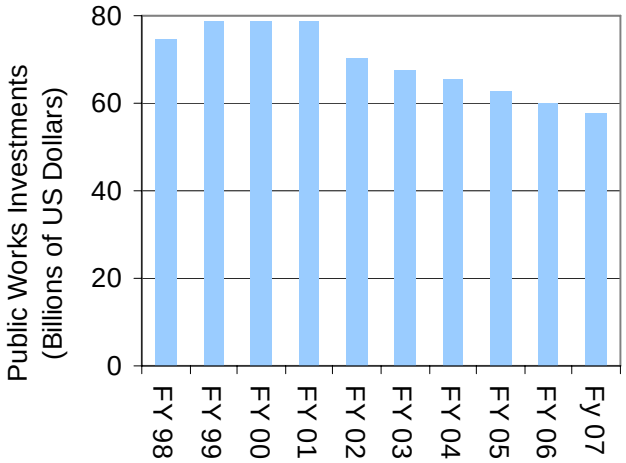
Note: Exchange rate: 1.00 USD = 120 JPY
Source: CSTP website at www8.cao.go.jp/cstp/siryo/haihu43/siryo2-1.pdf

The Government of Japan has increased R&D investments in the primary priority fields (life science, ICT, environment, and nanotechnology and materials science). On the other hand, R&D investments in the secondary priority fields have been up and down. R&D investments in social infrastructure had increased for FY 2002 and FY 2004. This is partly because one of the national goals is for Japan to be the safest and securest country in the world, and the Government of Japan emphasized R&D to predict and cope with natural disasters in social infrastructure field.

Figure 5 indicates investments in the public work by the Government of Japan during the past decade (FY 1998 to FY 2007). Public work here means the projects funded by the government agencies to maintain and develop the social infrastructure in Japan. Because of soaring national debt and financial deficit, the Government of Japan has decreased investments in the public work since FY 2002. However, the Government of Japan still places a high value on the public work to encourage the local economy, and has tried to keep the same level of outcomes from the public work. The Government of Japan has encouraged contractors to increase performance of their public work projects by reducing costs with cutting-edge technologies.

It is notable that the Government of Japan has been changing investment targets of the public work from conventional construction work (construction of highways or dams, etc.) to the next generation systems (the Intelligence Transportation System (ITS), advanced systems for disaster prediction and measures, etc.).

Figure 5 Public Work Investments by the Government of Japan



Note: The public work represents projects funded by the government agencies to maintain and develop social infrastructure in Japan

Source: FY 2007 Budget, the Ministry of Finance, Japan, December, 2006

8. Human Resource Development Programs

The Geographical Survey Institute, which is affiliated with MLIT, and the independent administration institutions, which spun off from MLIT, have provided training opportunities for graduate and undergraduate students and postdocs. As part of the technology transfer program, the Regional Development Bureaus have supported students and young researchers to gain experience in working at the construction and production sites and to learn how new technologies can be applied to real problems.

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has various programs to support undergraduate and graduate students and young researchers, including postdocs, not only in construction and transportation areas but also in all science and technology fields. For example, MEXT provides undergraduate and graduate students with scholarships. Also, MEXT has a specific R&D grants dedicated to young researchers.

Since the Science and Technology Basic Law was enacted in 1995, MEXT and its predecessor have encouraged universities to increase the number of students in their PhD courses in all science and technology fields. Before MEXT started encouraging universities to increase the number of PhD students, most of the PhD students assumed they would pursue their professional careers in the academic community. As the number of PhD students increased, it became more and more difficult for PhD students and postdocs to obtain academic positions. The result has been an increasing number of jobless postdocs ,prompting MEXT to start a new program. This program provides PhD students and postdocs with opportunities to build networks with people from the private sector, non profit organizations, and professional associations and encourages PhD students and postdocs to consider career opportunities outside of the academic community.

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   http://www8.cao.go.jp/cstp/kihon3/bunyabetu1.pdf
5. “The R&D Strategy Plan in Social Infrastructure”, Council for Science and Technology Policy, Cabinet Office, Tokyo, 2006.
6. “Important R&D Themes and Areas in Social Infrastructure which Need to Be Emphasized in The Third Science and Technology Basic Plan”, Technology Task Force of the Joint Committee with the Panel on Infrastructure Development and the Council of Transport Policy, Tokyo, 2005
   Note: This report became a draft of The R&D Strategy Plan in Social Infrastructure
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U.K. CONSTRUCTION R&D

A. Construction

1. Introduction

1) The Impacts of Rethinking Construction on the UK Construction R&D

Rethinking Construction, the report prepared by John Egan in 1998 brought fundamental changes to the overall paradigm of the UK Construction industry. In this report, Egan made key recommendations to improve the efficiency and quality of UK construction. Most of them were accepted by the Government through the strategy for sustainable construction presented in *Building a Better Quality of Life*, published in 2000. The two publications mandate that all new research projects within Government programs show clear evidence of meeting priorities. These documents continue to drive competitiveness and client value agendas for the UK construction industry.

John Fairclough, the former Government Chief Scientific Advisor, was commissioned to review the role government should play in supporting construction research. His report, *Rethinking Construction Innovation and Research*, was published in 2002 and made several key recommendations with respect to investment in R&D, strategic vision, mechanisms for change, and other aspects of construction innovation and research.

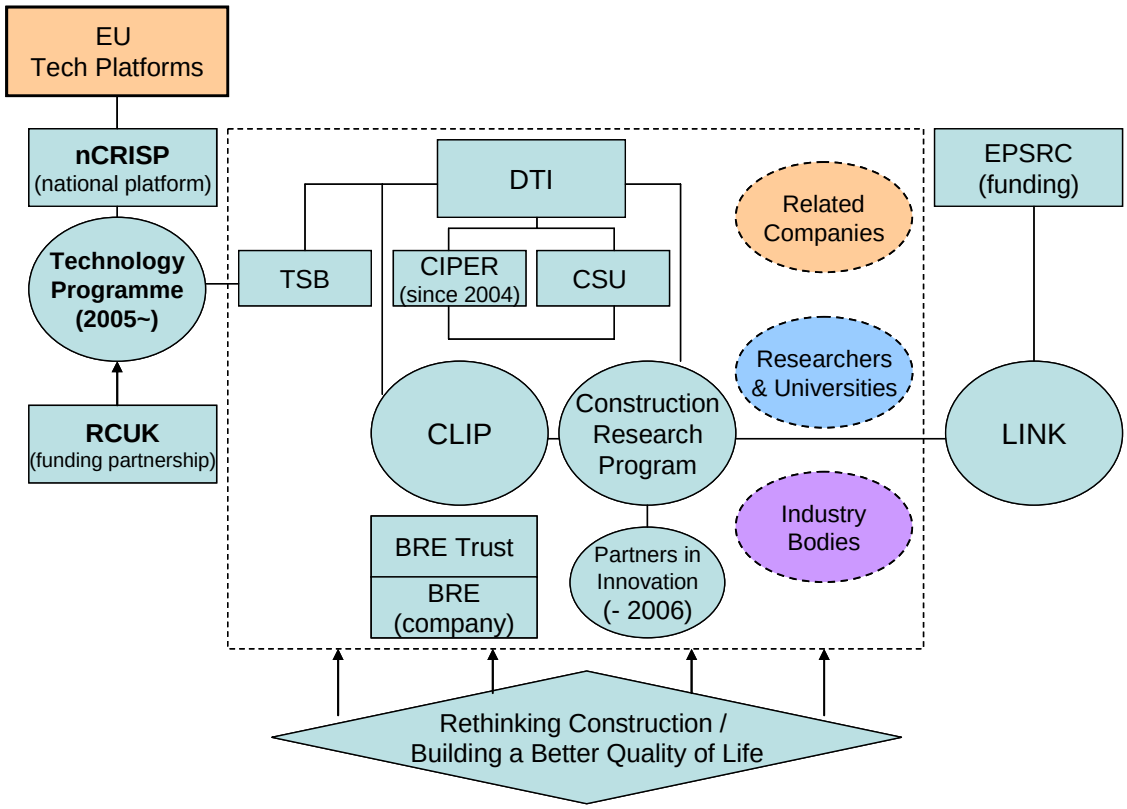
2) UK Construction R&D System

Since the advent of *Rethinking Construction* and the increased recognition of innovations within the Government, the UK construction R&D system has been experiencing rapid transition. Throughout the whole industry, the Department of Trade and Industry (DTI) plays a key role in promoting industrial R&D activities. Technology Strategy Board (TSB) was launched as an executive body to develop the government technology strategy. The Technology Programme was established to encourage innovation. Together, TSB and the Technology Programme drove rapid changes in the construction R&D sector. All the related programs and organizations are managed based on the two fundamental frameworks: *Building A Better Quality of Life*, established under the Government Sustainable Development Movement, and *Rethinking Construction Innovation and Research*.

A diverse group working closely performs UK construction R&D activities. Figure 1 shows the current focus of the construction R&D system, the Technology Programme, as a comprehensive framework within the Government and the previous main programs managed by individual agencies under DTI, such as the Construction Lean Improvement Programme (CLIP), the Construction Research Program (CRP), and Partners in Innovation within the CRP framework. In the construction sector, DTI and New Construction Research and Innovation Strategy Panel (nCRISP) play a key role in developing strategies for the industry. BRE Trust, which was privatized from a public fund for the construction industry, provides R&D funding for the management and implementation of related programs. In the broader context, nCRISP is cooperating with as well as being applied to the EU authorities under the scheme of the EU Technology Platform Program. The Engineering and Physical Sciences Research Council (EPSRC), which is the major R&D funding organization in the UK, provides money to the industry related programs.

Currently, DTI is trying to centralize its technology innovation activities. Accordingly, almost all programs implemented by individual teams or groups within the DTI have been or will be eliminated. Instead, each division will increase its role in establishing strategies as well as collaboration with other stakeholders in the industry.

<Figure 1> UK Construction R&D System



2. Laws and Regulations

1) Housing Grants Construction and Regeneration Act 1996
2) Scheme for Construction Contracts (England and Wales) Regulations 1998

3. Governmental Organizations Responsible for R&D Policy

1) Department of Trade & Industry (DTI)

(a) Technology Strategy Board (TSB)

The TSB was established in 2005 following the recommendation made in the *Rethinking Construction Innovation and Research* (DTI, 2002) encouraging the formation of a business-led organization to reflect business needs. The main work of the Board is to help inform the Government's Technology

Strategy as it applies to the whole industry sector, especially in translating knowledge into innovation and new and improved products and services. TSB also takes a key role in overseeing the DTI-led Technology Programme, which has a budget of approximately £ 200 million per year.

(b) Construction Sector Unit (CSU)

Within the DTI, CSU is a main actor working closely with the construction industry. The Unit aims to cooperate with the industry as well as stakeholders to improve business performance by focusing on productivity, profitability, and competitiveness. To do so, the Unit's work covers the following areas (from the DTI webpage http://www.dti.gov.uk):

- Policy and Regulation
  - Improving payment practices in the construction industry
  - Engaging industry in regulation and policy development via Construction Industry Policy and Regulatory Group (CIPER)
  - Coordinating responses to Government on issues impacting the Construction Products sector

- Industry Performance
  - People issues: covering health and safety, training and diversity in the industry
  - Leading on sustainability in construction
  - Supporting the national Key Performance Indicators; enabling companies and projects to benchmark their performances

- Innovation
  - Promoting R&D in the industry to increase innovation, competitiveness and more sustainable construction
  - Involvement in the Construction Lean Improvement Program (CLIP) to improve efficiency in construction processes
  - Overseeing the implementation of the Rethinking Construction initiative with Constructing Excellence

(c) Construction Industry Policy and Regulatory Group (CIPER)

CIPER, the forum established in 2004 by the announcement of the 2004 Budget, aims to encourage the construction industry inputs to emerging policy and regulatory proposals from the UK and Europe. For the UK Government especially, it helps to provide appreciation of the potential impact of the prospective regulations on the competitiveness of the industry. The members of CIPER, who met four times a year, are representatives of industry.

2) New Construction Research and Innovation Strategy Panel (nCRISP)

nCRISP, originally named "CRISP," began in 1995 as a small joint panel between the government and the construction industry, was re-established to develop priorities of research funding and help set the agenda for construction research and innovation. However, based on the suggestion in the report, *Rethinking Construction Innovation and Research,* nCRISP has been transformed as a formal joint government-industry panel supported by the Strategic Forum. After the National Platform (NP) for the Built Environment under the European Construction Technology Platform was launched in 2005, an industry-led initiative to encourage wider participation from the key stakeholders has became an additional function of nCRISP.

nCRISP also focuses on strategic and collaborative research in the areas of reduced resource consumption; a client-driven, knowledge-based construction sector; and ICT & automation.

4. Planning and Priority Setting

There are two fundamental frameworks that focus on construction innovation in the UK. The first one, *Rethinking Construction Innovation and Research: A Review of Government R&D Policy and Practices*, published in 2002, based on the same framework suggested in *Rethinking Construction Movement*, reviews the current framework of governmental policies and regulations and provides some suggestions for the improvements. The second, *Building a Better Quality of Life: A Strategy for more Sustainable Construction*, published in April 2000 by the Department of the Environment, Transport, and the Regions, investigates an environmentally-friendly strategy for the construction sector under the national sustainable development framework started in May 1999.

1) DTI (Feb. 2002), *Rethinking Construction Innovation and Research: A Review of Government R&D Policy and Practices*

Assuming that the innovative capacity of industry determines its long-term competitiveness and effectiveness, the author, John Fairclough argues that R&D in individual industry is the most important factor for future success. To encourage R&D and innovation in the construction sector, he reviews the ongoing status of construction R&D and the policy framework, and then provides a new strategic framework encouraging the role of the Strategic Forum and nCRISP, as well as the linkages between the government and the industry. He gives specific recommendations for the areas below:

- Investment:
  - The current level of government investment towards construction R&D should be maintained
  - Increasing investment is also needed to support productivity, public sector clients' values, and strategic issues

- Strategic Vision
  - The importance of construction industry should be recognized especially in relation to quality of life issues
  - In the process of setting strategic vision, industry sector participation should be encouraged
  - R&D priorities should be determined by strategic-analysis of the issues faced by the industry sector

- Mechanisms for Change
  - The roles of Strategic Forum and CRISP should be increased

- Commissioning Research
  - Long-term R&D programs should be developed based on the analysis of current problems
  - Collaboration with the industry sector, research reflecting industrial needs, and strong quality control mechanisms should be secured
  - Dissemination should be improved, impact evaluated, and return on Government investment assessed

- Government Focus
    - Government R&D investment should reflect diverse aspects of government's role in construction R&D (government as a regulator, sponsor, client, and a policy maker)

- Responding to Unforeseen Events
    - All R&D should be enacted based not on the uncertainty of the future but on merit

- Skills and Recruitment
    - Excite researchers by relating R&D programs to the quality of life and sustainability issues
    - Encourage the activities and applications of Center of Excellence
    - There should be an effort made to develop a high profile generalist construction qualification to attract outstanding young researchers to a career in the construction industry

- Research Base Structure
    - Closer relationships among already-established research organizations should be encouraged.

- Innovative Capacity
    - Supportive actions for the best innovators should be made
    - Innovation should be encouraged by providing guidance and encouraging participation in the Teaching Company Scheme

2) Department of the Environment, Transport and the Regions (DETR) (April 2000), *Building a Better Quality of Life: A Strategy for More Sustainable Construction*"

The former organization (DETR) for the multiple functions of environment, transport, and local government and regions published this strategy in 2000 in response to the Governmental Sustainable Development Framework, *A Better Quality of Life - A Strategy for Sustainable Development for the United Kingdom*. As a strategy for construction, it suggests key themes for action by the industry and clarifies key elements of sustainable construction in the UK:

- Key 10 Action Themes:
    - Re-use existing built assets
    - Design for minimum waste
    - Aim for lean construction
    - Minimize energy in construction
    - Minimize energy in use
    - Do not pollute
    - Preserve and enhance bio-diversity
    - Conserve water resources
    - Respect people and their local environment
    - Set targets

- Key Elements:
    - Environmental responsibility
    - Social awareness
    - Economic profitability

5. R&D Funding Organizations and Programs

1) Research Councils UK (RCUK)

- Introduction
RCUK is a strategic partnership launched in May 2002 in relation to the Technology Programme among the UK seven Research Councils: Arts & Humanities Research Council (AHRC), Biotechnology & Biological Sciences Research Council (BBSRC), Engineering & Physical Sciences Research Council (EPSRC), Economic & Social Research Council (ESRC), Medical Research Council (MRC), Natural Environment Research Council (NERC), and Science and Technology Facilities Council (STFC). The number of employees working in the membership Councils is around 12,000 and the number of researchers supported by the seven Councils is approximately 30,000, including 15,500 doctoral students in UK universities and in their own Research Institutes.

- Main Activities (http://www.rcuk.ac.uk/)
The main objectives of the RCUK activities are to:

- Fund basic, strategic, and applied research
- Support postgraduate training PhD and master's students, as well as fellows
- Advance knowledge and technology and provide researchers in science and engineering to increase national economic competitiveness, the effectiveness of public services and policy, and quality of life
- Support science in society activities

- Funding
The seven UK Research Councils have a combined budget of around £2.8 billion for 2005-06, most of which they receive from the Government's Science Budget. The Science Budget is administered through the Office of Science and Innovation (OSI), which is part of the Department for Trade and Industry (DTI). In addition, some RCs as members of RCUK are additionally funded from other related Government Departments, commercialized products of research, and other research funders in related areas. Each member of RCUK is under the control of Parliament (via the Office of Science and Innovation).

2) Engineering and Physical Science Research Council (EPSRC)

EPSRC, like the National Science Foundation in the U.S., is the UK Government's prime funding agency for research and training in engineering and the physical sciences. It is also a member of RCUK.

3) BRE Trust

BRE Trust is a charitable company owned by BRE in collaboration with stakeholders in the construction industry. It aims to advance knowledge, innovation, and communication within the industry through research and education. The Trust also conducts independent research.

- Members of the BRE Trust
Members of the Trust are grouped by seven areas: built environment professionals, contractors, suppliers of materials and products, housing, academic institutions (universities), building owners and

managers, and building users. A diverse range of membership makes it possible to cover comprehensive interests across the whole built environment sector.

- Research Projects managed by the BRE Trust in 2005/2006:
  - BREEAM- next generation
  - A BRE Design Tool for Effectively Designing Buildings in Polluted Urban Areas
  - Quality and Performance Scheme for Waste Management Facilities
  - Innovative Timber Scanning Techniques
  - Integrated Fire Resistance Test Methodology-Structural Fire Engineering
  - Internet Protocol (IP) based Communication Systems for Wired and Wireless Fire Detection, Security and Other Services
  - Sustainable Refurbishment of Victorian Houses
  - An Environmental Map for Learning
  - FM Toolkit-A Sustainable Occupation Assessment Tool
  - BRE Creating Safe and Secure Town Centers at Night Model
  - Development of New Methods of Investigating Air Quality and Indoor Pollution Problems
  - Fire Performance of Structural Connections
  - Fire and Modern Materials
  - Application of CHP and Heat Pump Technology with a New Renewable Energy Resource
  - Assessment of Fire Damaged Concrete Structures: Incorporation of 'Whole Building Behavior' Aspects
  - Sustainable House Building: New Build and Refurbishment in the Sustainable Communities Plan

6. Institutions Conducting R&D

Almost all kinds of public and private sector stakeholders are related R&D activities through diverse programs and projects. Some examples of construction R&D related organizations and companies are below:

- In the area of Sustainable Development:
  - Sustainable Development Commission (SDC) (www.sd-commission.gov.uk)
  - Sustainability Forum (www.constructingexcellence.org.uk)
  - Strategic Forum for Construction (www.strategicforum.org.uk)
  - WWF-UK (a global environment network) (www.wwf-uk.org)
  - Business in the Environment (www.business-in-environment.org.uk)
  - Carbon Trust (www.thecarbontrust.co.uk)
  - Energy Savings Trust (www.est.org.uk)

7. R&D Collaboration Programs

1) The Technology Programme (New Framework since 2007)

The UK Government's ten-year Science and Innovation Investment Framework, Technology Programme provides two types of support mechanisms: Collaborative Research and Development and

Knowledge Transfer Networks. From 2005 to 2008, £ 320 million is available to businesses to support research in the key technology areas identified by TSB.

- Collaborative R&D
The goal of collaborative R&D is to assist the industry and related research communities to work together in important technology areas. The applicant who wants to get support through the collaborative R&D mechanism should establish R&D projects involving two or more collaborators, with at least one being from industry.

- Knowledge Transfer Networks (KTNs)
A KTN is a single national overarching network in each specific field of technology based on the participation of diverse organizational inputs. The Technology Programme requires the Network to develop strong links among the participants to maximize the benefits of knowledge transfer effects. It is required for the KTN members to provide their inputs to develop a national Technology Strategy in each technology area.

2) Foresight

A recommendation in William Waldegrave's Government White Paper, "Realizing our Potential-A Strategy for Science, Engineering and Technology" (May 1993), was the impetus for Foresight. Foresight was started in 1994 to identify the key technologies and to guide national science and technology policy.

The first round of Foresight was maintained from 1994 to 1999 in 15 sectors to explore opportunities in different sectors of the economy. The second round of Foresight began in April 1999 and was continued until 2002. In that period, a combination of 3 thematic and 10 sector panels worked to identify the future for a particular area of the economy.

The current phase of Foresight began in 2002 and is ongoing. In regard to the construction industry, "Sustainable Energy Management and the Built Environment" is in progress. This project, launched in 2006 as one of the products from the Government's Energy Review, aims to explore how the UK built environment could evolve to help manage the transition over the next five decades to secure, sustainable, low carbon energy systems that would correspond to future society needs. The scope of the project is currently being developed and will be followed by specific research projects as well as the exploration of future uncertainties, challenges, and opportunities during 2007. The outputs and findings will be published in 2008.

3) Construction Lean Improvement Program (CLIP)

CLIP was established in 2003 to support the UK construction industry, encouraged by the report, *Rethinking Construction*. It aims to improve the industry's financial performance, to provide a better product and service to its customers, and to deal with a skills shortage problem within the sector.

- The main products of CLIP include
- Product and process benchmarking and recommendations
- Strategy development program – leadership, business planning tools, policy development
- Process improvement master class
- Supply chain and supplier development program
- Communications, teamwork and team-leader training

- Lean assessment
- Company and project team roll-out programs

Currently, BRE and the CSU in the DTI are closely working to monitor the program implementation. According to the DTI website, the budget assigned for CLIP is £2.5 M for 5 years until 2008.

4) DTI Construction Research Program (CRP) (completed)

As opposed to the previous three governmental research programs, CRP has been completed or is in the termination phase. CRP encompassed two different types of research programs: Partners in Innovation (PII) and LINK.

(a) Partners in Innovation (PII)

PII was the CRP's prime collaborative research scheme and provided up to half the costs of research and innovation (R&I) projects. It was closed to new applications in September 2002 but still has about 70 projects in the portfolio. It was open to all UK companies, industry bodies, institutions, research and technology organizations, and universities. Run as an annual competition, new money available for the scheme each year was about £ 7M, with around £ 21 million of research projects in the portfolio at any one time.

- Two representative programs having £ 750,000 as the budget for each program are below:
  - Avanti (ICT enabled collaborative working)
  - Build Offsite (Offsite Manufacture)

- Other examples of programs under the PII are below (*Construction Research Programme*, published in 2007):
  - Building Down Barriers (construction supply networks)
  - ISC Project (advancing the Integration of the Supply Chain)
  - IMMPREST (Measuring the value of off-site)
  - BSRIA Series (Technical Design Quality Control)
  - ECBP (Learning from the European concrete building Project)
  - COMIT (Mobile Technology)
  - RFID Tagging Technology
  - STRATRISK (Managing Strategic Risk)
  - VALiD (Value Added Design)
  - Specifying Timber
  - NGCC (Composites in Construction)
  - Dynamic Compaction

(b) LINK

The LINK Scheme as a research funding mechanism, co-funded by DTI and EPSRC as a part of Meeting Clients' Needs through Standardization (MCNS) and Integration in Design And Construction (IDAC), existed to encourage collaborative R&D and knowledge transfer. However, due to the attempt to rationalize the government funding paradigm, LINK as related to the construction sector no longer exists.

Under the LINK program, over 1400 projects were funded. The detailed names and profiles of each project are available at http://www.constructionresearch.info/dti/projects.asp

5) Construction Excellence (http://www.constructingexcellence.org.uk/)

In response to Sir Michael Latham's 1994 report 'Constructing the Team' and Sir John Egan's 1998 report 'Rethinking Construction' ten cross industry bodies were formed to drive change. Significant progress has been made in driving these initiatives into the practicing industry with many examples of projects that have been run in accordance with the fundamental principles. In order to streamline the effort involved, all the above cross industry bodies have now been united as Constructing Excellence to form a coherent, influential voice for improvement in the built environment sector.

8. Human Resource Development Programs

Currently, there is no specific program focused on the construction industry. Rather, each Research Council takes on the training of students and researchers in the related field. In addition, information and guidance specifically for small and medium-sized enterprises (SMEs) in the construction industry are available in the webpages of Businesslink, CITB-ConstructionSkills and SummitSkills. Lastly, the Construction Skills Certification Scheme (CSCS), issues a CSCS card to provide the related industry stakeholders the way to prove that they are competent in their fields and have health and safety awareness. Although the CSCS card is not a training program, it is still meaningful in the sense of providing an industrial standard and a certain type of training course is needed to get the card.

1) CSCS and CSCS card (www.cscs.uk.com)

CSCS has been in existence for over 10 years and was started to help the construction industry get quality up, accidents down, and cowboy builders out. Currently, it is supported by organizations in the construction related fields such as the Major Contractors Group (MCG), National Contractors Federation (NCF), Major Home Builders Group (MHBG) and Civil Engineering Contractors Association (CECA). In addition, the Department of Trade and Industry and the Health and Safety Executive are participated as observer members.

As of October 2005, CSCS had 809,136 cardholders or affiliated cardholders in 230 occupations. A CSCS card lists the cardholder's qualifications and is valid for either three or five years depending on the industry the cardholder is related to.

CSCS exists to meet industry needs, is administered by the CITB-ConstructionSkills, and is managed by CSCS Limited whose board members come from the following groups within the construction industry:

- Construction Confederation
- Federation of Master Builders
- GMB Union
- National Specialist Contractors Council
- Transport & General Workers Union (Building Crafts Section)
- Union of Construction
- Allied Trades and Technicians

- CITB-Construction Skills, Construction Industry Council
- the Construction Clients Group

2) EPSRC's Funding for Postgraduate Training

EPSRC provides students at the doctoral and master's level funding through the universities (rather than directly funding the students). Two kinds of accounts cover postgraduate training:

- Doctoral Training Accounts (DTAs)
  - Targeted at the academic end of the student spectrum
  - Awarded to universities
  - Allow awarded universities to the maximum level of flexibility to manage their research studentship population

- Collaborative Training Accounts (CTAs)
  - Designed to provide a single, flexible mechanism for funding all the EPSRC schemes related to the role of postgraduate training including Masters Training Packages, Engineering Doctorates, Knowledge Transfer Partnerships, Research Assistants into Industry, Industrial CASE, and CASE for New Academics

U.K. TRANSPORTATION R&D

B. Transportation

1. Introduction

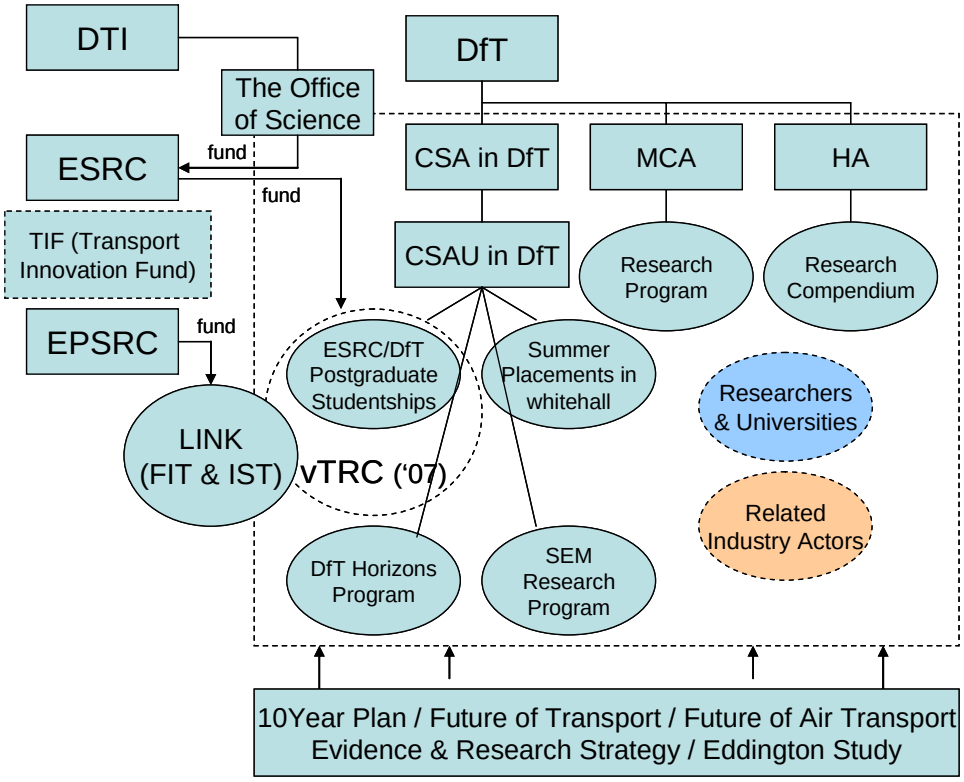
Because the transport sector has many sub-industries, the British transport R&D framework is very fragmented. While the Department for Transportation (DfT) is in charge of developing and implementing the main R&D plans and programs, many related departments and funding organizations are also involved throughout the process.

The decentralization can be seen by examining the DfT's various master plans for each area. Since the publication of the Ten Year Plan, several documents on the transport sector have been published: *The Future of Air Transport* in December 2003 and the *Future of Rail Transport* in July 2004.

Because of the need for an integrated national transport plan, DfT and HM Treasury asked Rod Eddington to examine the long-term links between transport and the economic growth of the U.K., resulting in the *Eddington Transport Study* published in December 2006. Currently, the Government is reviewing the strategies and delivery methods presented in the study, and it is expected that there will be a paradigm change based on the results of the review.

Figure 1 shows the overall structure of British transport R&D. First of all, the Chief Scientific Adviser (CSA) and his/her support Unit, Chief Scientific Adviser's Unit CASU), play a key role in providing long-term transport and investment plans, as well as setting up strategic priorities. In addition, various agencies within the DfT implement the plans and research programs using diverse cooperative relationships with external organizations. Governmental funding organizations such as the Economic and Social Research Council (ESRC) and the Engineering and Physical Sciences Research Council (EPSRC) participate in the programs by providing funding.

<Figure 1> UK Transport R&D Policy Framework



2. Laws and Regulations

1) The Civil Aviation Act (in relation to the *Future of Air Transport*, announced in 2003)

The Future of Air Transport White Paper suggested improvements in the areas of sustainable aviation and the protection of passenger interests. The Civil Aviation Act was passed to implement these suggestions. The Act clarifies and strengthens the measures airports can take to deal with aircraft noise. For example, the Act allows for the enforcement of noise amelioration measures beyond airport boundaries and for economic measures to be taken to prevent aircraft from straying from routes designed to minimize noise.

To provide the required budget, the Act also established the Air Travel Trust Fund. It also meets the obligations under EU law.

3. Governmental Organizations Responsible for R&D Policy

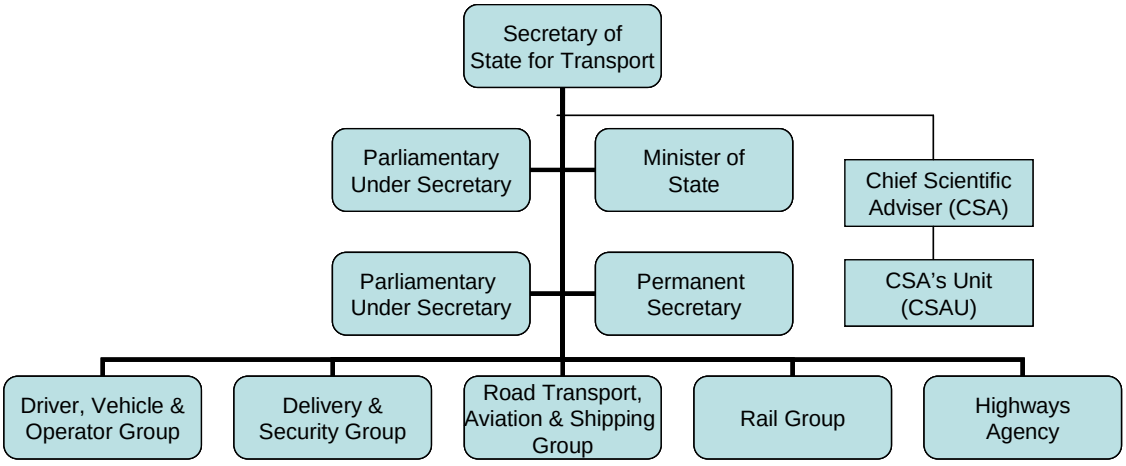
1) Department for Transportation (DfT)
DfT plays a key role in developing transport-related plans and priorities, including R&D. It also cooperates with other departments to deliver the programs and projects stated in the plans.

As shown in its webpage (http://www.dft.gov.uk), DfT's strategic objectives and key tasks are as follows:

- Strategic objectives
  - To sustain economic growth and improved productivity through reliable and efficient transport networks
  - To improve the environmental performance of transport
  - To strengthen the safety and security of transport
  - To enhance access to jobs, services and social networks

- Key tasks
  - Improving the current operation and capacity of transport networks and services, and providing better information for travelers
  - Shaping the future pattern of demand for transport, including through land –use planning and appropriate pricing
  - Tackling the environmental impacts of transport through pricing, regulation, technology, consumer information and promoting efficient use of resources
  - Planning and managing investment programs for the long-term
  - Regulating and licensing certain transport services and operators
  - Managing information and delivering services to support wider Government objectives

<Figure 2> DfT Organization Chart (October 2006)



Among the agencies included in the DfT, the Chief Scientific Advisor (CSA) and its staff organization, Chief Scientific Advisor's Unit (CSAU), are especially important in regard to R&D planning and management.

(a) CSA (Chief Scientific Adviser)

Supported by CSAU, the duties of the CSA are to ensure that the DfT's scientific activities are well-directed and its policy development is based on sound science. Some of the CSA's activities include:

- Encouraging the Department to consider science issues affecting policy at an appropriately senior level by meeting regularly with the DfT Board and Ministers

- Assisting the DfT's Units with the development, presentation, and implementation of the scientific and technical aspects of their policies
- Working with the Government Chef Scientific Adviser, other Government research advisers, and departmental CSAs to ensure the overall quality of science and research in government
- Working with staff in advising Ministers, the DfT Board and senior officials to enhance the science and research evidence base on policy development
- Ensuring that the DfT uses the research it commissions properly and has the right balance and quality of internal expertise by providing advice on training, development, and deployment of science and research professional staff
- Ensuring that the DfT has effective horizon scanning arrangements so that issues involving science, or issues where science could be of benefit, are identified in advance
- Assisting the DfT in publicly explaining the science and research evidence base of policies to strengthen the DfT's scientific links with the outside world

(b) CSAU (Chief Scientific Adviser's Unit)

CSAU supports CSA and its activities. To do that, CSAU conducts analysis and research related activities. To help with the policy development of the Department, CSAU prepares budgets and regulatory impact assessments. Some specific organizational objectives of CSAU follow:

- Support the improvement of Evidence and Research Strategy (ERS) through the Strategy Economics and Mobility (SEM) Research Program
- Support the CSA as the Secretariat by managing the policy support and challenges functions
- Assure the Department's scientific activities by developing and implementing central and strategic guidance for research managers
- Organize scientific advice in new policy areas and on new techniques including future methodologies; manage the DfT's role for the Data Grand Challenge; and manage the DfT Horizons Program
- Participate in the DfT's attempts to increase transport technology and innovation capacities, such as the Transport Innovation Fund (TIF), the Investment Assurance Framework (IAF), the *Eddington Transport Study*, and the SI Ministerial Committee
- Support the CSA to improve research and professional skills by balancing internal and external expertise
- Link research programs with national and international programs to improve the research base for policy support
- Maintain and develop the DfT Research Database (RD) to support evidence management across DfT and the external audiences

4. Planning and Priority Setting

The milestone plan for the U.K. transport sector was the DfT's *Transport Ten Year Plan 2000*. Subsequently, many plans have emanated from the sub-sector of the transport industry, the most recent being the *Eddington Transport Study*, published in December 2006.

1) DfT (July 2000), *Transport Ten Year Plan 2000*

Known as the general master plan of the U.K. transport industry, the *Transport Ten Year Plan* was the first plan to clarify the challenges and investigate solutions. It marked the beginning of a more strategic approach to transport and resulted in a long term government commitment to sustained increases in transport spending, ending stop-start funding and short term planning. It mainly covers the road transport system and does not focus on transport R&D.

Specifically, the *Ten Year Plan* examines the overarching issues facing the U.K. road transport system, including cutting congestion, reducing pollution, and boosting choice through investing, modernizing, and integrating. It also deals with the rail and freight industries, motorists and road haulage issues, and people's accessibility issues.

Under the control of this Plan, over 80 schemes have been designed to deliver new capacity on the U.K. road network.

2) DfT (December 2003), *The Future of Air Transport*

The White Paper, *The Future of Air Transport*, published on 16 December 2003, sets out a strategic framework for the development of airport capacity in the U.K. over the next 30 years. The Paper provides a strategic framework for the development of aviation and it seeks the opportunity to extend an equivalent long term framework across the rest of transport. Accordingly, *The Future of Transport* was prepared in 2004.

This paper deals with critical air transport issues and sets goals related to noise, blight, safety and security, support for regional air services, and airport development. However, it does not formally authorize any development; as a result, the goals laid out in the paper must be met through the Civil Aviation Act.

3) DfT (July 2004), *The Future of Transport: A Network for 2030*

The Government White Paper, *The Future of Transport: A Network for 2030* is the basis for the current U.K. transport R&D framework. This document sets out the U.K. Government's vision for transport for the next 30 years with a funding commitment, at record levels, until 2015.

4) DfT (2006), *Evidence and Research Strategy*

This plan differs from most in that it is updated nearly every two years by the DfT to reflect the rapidly changing technology trends in the transport industry.

The plan is Department-wide and covers a whole range of economic, technological, social, and environmental factors. Through this plan, DfT pursues a certain type of R&D based on more integrated evidence – monitoring and data collection, analysis (of internal and external information), policy evaluation, and commissioned research – and ensures quality by adopting best practices.

An attractive aspect of this plan is that it shows the most recent version of the planned R&D budget for the period 2005-2006 (see Table 1):

<Table 1> DfT's Research Budget (2005-2006)

Program (or Organization)	Budget Amount £M)
Chief Scientific Advisor	1.5
Civil Aviation	2.6
Freight Logistics	1.6
Local and Regional Transport	3.0
Rail	5.1
Road Safety	4.3
Strategy, Economics and Mobility	4.5
Cleaner Fuels and Vehicles	1.3
Transport Security and Contingencies	2.1
Transport Technology and Standards	9.0
Driver Vehicle and Operator	0.5
Highways Agency	14.2
Maritime and Coastguard Industry	1.1
Commission for Integrated Transport	0.6
TOTAL	**51.4**

5) The *Eddington Transport Study*

In 2005, Rod Eddington was jointly commissioned by the Chancellor of the Exchequer and the Secretary of State for Transport to examine the long-term links between transport and the U.K.'s economic productivity, growth, and stability within the context of the Government's broader commitment to sustainable development. The resulting report was published in December 2006 to accompany the 2006 Pre-Budget Report.

In the study, Eddington highlights the pivotal role that transport plays in supporting the U.K.'s economy and productivity and recommends how it can do so more effectively. In addition, the study concludes that to sustain future productivity, transport policy must reflect the economic and structural changes that are shaping the U.K.'s transport needs. Finally, the study argues that the strategic economic priorities for long term transport policy should be a national priority.

During 2007, the Government will review the strategies, processes, and delivery systems on transport provided by the Eddington study, along with the information from another study by Nicholas Stern, *Review on the Economics of Climate Change*, to develop recommendations based on the review. It is expected that this will lead to another paradigm transition in the transport sector.

5. R&D Funding Organizations and Programs

As with the construction industry, transport R&D is supported by the related Research Councils in general. In regard to the transport industry directly, the Transport Innovation Fund will be launched in 2008 within the DfT.

1) Transport Innovation Fund (TIF)

The concept of TIF was initially introduced in the White Paper, *The Future of Transport*. Activities to launch TIF have been underway and the money will become available 2008-2009.

The goal of TIF is:
- To support the costs of smarter, innovative local transport packages that combine demand management measures, such as road pricing, with measures to encourage modal shift, and better bus services
- To support local mechanisms which raise new funding for transport schemes
- To support regional, inter-regional and local schemes that are beneficial to national productivity

The Fund would be operated as a rolling process, and the available budget is initially expected to be £ 290 M in 2008/09 and increase to over £ 2 billion by 2014/15.

This Fund is designed especially for research related to congestion and improving productivity; funding would be provided based on how effectively the objectives of a proposal meet the purposes of TIF.

2) Economic and Social Research Council (ESRC) – partially involved in transport R&D

ESRC, one of the research councils in the UK, is the funding organization for research and training mainly in social and economic issues. Its legal basis comes from the Royal Charter; however, it receives most of its funding through the Office of Science and Innovation within the DTI.

On average, the overall budget of ESRC is approximately £ 100M per year; it currently supports 2,500 researchers in academic institutions and policy research institutes throughout the U.K. and more than 2,000 postgraduate students.

6. Institutions Conducting R&D

Research centers in academic institutions, companies, and foundations work closely with DfT to deliver the planned programs, research projects, or other related activities.

- Academia/research centers
  - Center for Ecology and Hydrology (www.ceh.ac.uk)
  - EPSRC (www.epsrc.ac.uk)
  - ESRC (www.esrc.ac.uk)
  - Rail Research UK (www.railresearchuk.org.uk)
  - NERC (www.nerc.ac.uk)
  - Tyndall Centre (www.tyndall.ac.uk)
  - Joseph Rowntree Foundation (www.jrf.org.uk)
  - University departments and research centers (various)
  - Transport Research Laboratory (www.trl.co.uk)

7. R&D Collaboration Programs

The DfT, as a key player in the transport R&D sector, is collaborating with other government departments and local authorities, as well as research councils and universities, in the areas of data collection, analysis, and research. DfT cooperates with others in several ways:

- By working with local authorities for the issues like road safety or traffic management
- By participating in consortia partially-funded by the research councils and the EU Framework Programme
- By jointly funding research projects and programs
- By jointly sponsoring dissemination events
- By participating in advisory and steering groups.

According to the DfT's report, *Evidence and Research Strategy*, there are numerous examples of DfT research partners by sector. Some of organizations have their own transport research programs:

- Central government
  - Department for Communities and Local Government (www.communities.gov.uk)
  - Department for Education and Skills (www.dfes.gov.uk/research)
  - Department for Environment, Food and Rural Affairs (www.defra.gov.uk/science/default.asp)
  - Department for Work and Pensions (www.dwp.gov.uk/asd)
  - Department of Health (www.doh.gov.uk/research/index.htm)
  - Department of Trade and Industry (www.dti.gov.uk/industries_science_technology.html)
  - Health and Safety Executive (www.hse.gov.uk/index.htm)
  - HM Customs and Excise (www.hmrc.gov.uk)
  - HM Treasury (www.hm-treasury.gov.uk)
  - Home Office (www.homeoffice.gov.uk/rds/index.htm)
  - Neighbourhood Renewal Unit (www.neighbourhood.gov.uk/)
  - E-Government Unit (www.cabinetoffice.gov.uk/e-government/)
  - Social Exclusion Unit (www.socialexclusionunit.gov.uk)
  - Office for National Statistics (www.statistics.gov.uk)

- DfT agencies and Non-departmental Public Bodies
  - Driver and Vehicle Licensing Agency (www.dvla.gov.uk)
  - Driving Standards Agency (www.dsa.gov.uk)
  - Highways Agency (www.highways.gov.uk)
  - Maritime and Coastguard Agency (www.mcga.gov.uk)
  - Vehicle Certification Agency (www.vca.gov.uk)
  - Vehicle and Operator Services Agency (www.vosa.gov.uk/vosa)
  - Strategic Rail Authority (www.sra.gov.uk)

- Devolved administrations
  - Scottish Executive (www.scotland.gov.uk)
  - Welsh Assembly (www.wales.gov.uk)
  - Northern Ireland Office (www.nio.gov.uk)

- Transport operators
  - Bus operators (various)
  - National Air Traffic Services (www.nats.co.uk)

- Statutory/regulatory bodies
  - Civil Aviation Authority (www.caa.co.uk)
  - Disabled Persons Transport Advisory Committee (www.dptac.gov.uk/access.htm)
  - Rail Passengers Council (www.railpassengers.org.uk)

- Other government bodies
  - British Transport Police (www.btp.police.uk)
  - Health Development Agency (www.hda-online.org.uk)

- Local government
  - County Surveyors Society (www.cssnet.org.uk)
  - Local Government Association (www.lga.gov.uk)
  - Local Authorities (various)
  - Passenger Transport Executives
    - www.centro.org.uk/
    - www.gmpte.gov.uk/
    - www.merseytravel.gov.uk/
    - www.nexus.org.uk/
    - www.sypte.co.uk/
    - www.wymetro.com/
  - Transport for London (www.tfl.gov.uk/tfl)
  - London Underground (http://tube.tfl.gov.uk)

- Independent advisers
  - Commission for Integrated Transport (www.cfit.gov.uk)
  - Sustainable Government Commission (www.sd-commission.org.uk/)

- Academia/research centers
  - Center for Ecology and Hydrology (www.ceh.ac.uk)
  - EPSRC (www.epsrc.ac.uk)
  - ESRC (www.esrc.ac.uk)
  - Rail Research UK (www.railresearchuk.org.uk)
  - NERC (www.nerc.ac.uk)
  - Tyndall Centre (www.tyndall.ac.uk)
  - Joseph Rowntree Foundation (www.jrf.org.uk)
  - University departments and research centers (various)
  - Transport Research Laboratory (www.trl.co.uk)
- European/international forums
  - Advisory Council for Aeronautics Research in Europe (www.acare4europe.com)
  - COST Transport (www.cost.esf.org/index.php?id=238)
  - European Framework Programs (www.cordis.lu/en/home.html)
  - European Organization for the Safety of Air Navigation (EUROCONTROL) (www.eurocontrol.int)
  - European Platform for Coordination and Cooperation in Transport Research (under the EU 6th Framework Programme)

- OECD (www.oecd.org/)
- International Civil Aviation Organization (www.icao.int/)
- International Maritime Organization (www.imo.org/index.htm)
- OECD/ECMT Joint Transport Research Center (www.oece.org/)
- United Nations Economic Commission for Europe (www.unece.org/trans/Welcome.html)
- UNECE/WHO Pan-European Programme on Transport, Health and the Environment (www.thepep.org/en/welcome.htm)
- European Rail Research Advisory Council (www.errac.org)

- Commercial organizations
  - Technology companies (various)
  - Vehicle Manufacturers (various)
  - Network Rail (www.networkrail.co.uk)
  - Rail Safety and Standards Board (www.rssb.co.uk)

- Interest groups and associations
  - Association of Train Operating Companies (www.atoc.org/)
  - The Health and Safety Commission's Railway Industry Advisory Committee (www.hse.gov.uk/aboutus/hsc/iacs/riac/)
  - Bus Partnership Forum
  - Confederation for Passenger Transport (www.cpt-uk.org/)
  - Energy Saving Trust (www.est.org.uk/)
  - Freight Transport Association (www.fta.co.uk/)
  - Institution of Civil Engineers (www.ice.org.uk)
  - Institute of Logistics and Transport (www.iolt.org.uk/)
  - Light Rail Transit Association (www.lrta.org/)
  - Low Carbon Vehicle Partnership (www.lowcvp.org.uk/)
  - Road Haulage Association (www.rha.net/index.shtml)
  - Road Haulage Forum (Secretariat in Logistics Policy, DfT)
  - Roads Liaison Group (Secretariat in Roads Policy Division, DfT)
  - Royal Society for the Prevention of Accidents (www.rospa.com)
  - SUSTRANS (www.sustrans.org.uk)
  - The Carbon Trust (www.thecarbontrust.co.uk)
  - Transport 2000 (www.transport2000.org.uk/)
  - Transport Planning Society (www.tps.org.uk)

There are several kinds of collaborative programs such as the Virtual Transport Research Center (vTRC), scheduled to begin mid 2007. In addition, some divisions under DfT have their own research programs; examples include CSAU, Highways Agency, and Maritime and Coastguard Agency. Further, as is the case for construction R&D, the Foresight paradigm includes a specific project for transport.

1) Virtual Transport Research Center (vTRC) (forthcoming)

The planned vTRC, which will begin operation in 2007, will be based on the partnership with the Economic and Social Research Council (ESRC) and others if possible. It will take a key role as a multi-disciplinary center of excellence for independent, high quality, innovative, and strategic research and will focus on enhancing the evidence base to inform the key transport policy issues facing the UK.

2) Under the CSAU of DfT

(a) Summer Placements in Whitehall

The summer Placement in Whitehall program aims to strengthen links between the Government and the research community. Under the program, applicants are invited to submit research project proposals, both theoretical and/or applied, that are relevant to the aims and objectives of the DfT. Proposals may be submitted that identify emerging policy issues or that aim to increase the DfT's understanding about current issues in related fields.

Applicants whose proposals are accepted will be funded for two months, of which at least four weeks should be spent within the DfT during the summer sharing knowledge with DfT officials.

(b) DfT Horizons Programme

The DfT Horizons Programme was launched in 2003 as a successor to the Department for Environment, Transport, and the Regions (DETR) New Horizons Programme. Between 2000 and 2002, the New Horizons Programme provided funding to 23 projects, 3 fellowships, and 17 studentships.

The current Horizons Programme aims to support innovative research proposals on the challenges and opportunities DfT might face over the next decade and beyond. It provides researchers opportunities to conduct innovative research in the area of policy, policy framework development, or government operation but does not aim to boost transport R&D itself.

Each year the Programme has special topics. For example, the Second Call in February 2005 sought to find efficient solutions for managing and analyzing large datasets. The Third Call in January 2006 focused on the infrastructure requirements of hydrogen-fuelled transport; currently this Programme supports five projects.

(c) Strategy Economics and Mobility (SEM) Research Program

Under the direct control of CSAU, the SEM Research Program seeks to improve the overall level of DfT Evidence and Research Strategy, which is newly developed every two years in lieu of a direct research program for the transport sector.

3) Other DfT Agencies' research programs

(a) Highways Agency (HA)'s Research Compendium

The HA Research Compendium was started in 1994 to conduct research committed to highway-related transport research issues, including relieving congestion, improving safety, reducing environmental impact, and providing value for money spent on England's motorway and trunk road network.

The Compendium focuses on the dissemination of the research results funded under the program, and has been supported by Government funding of approximately £ 12 million per year.

(b) Maritime and Coastguard Agency (MCA) Research Program

The MCA Research Program aims to support MCA's organizational purposes, which are to promote safe, efficient, and environmentally friendly shipping. The program's aims and objectives are differentiated depending on the MCA's annual Business Plan and Forward Look, which in turn informs the MCA's research strategy. However, in most cases, the Program focuses on priority areas such as accident prevention, vessel safety, navigation safety, environmental protection, seafarer/fisherman safety, and search and rescue.

In determining the content of the program, the MCA takes into account the needs of relevant units of DfT that have no specific research programs of their own. These units may voice their research priorities through the Shipping Policy representative responsible for liaising with MCA or the Maritime Policy Group (MPG) on maritime research issues.

The program is managed by Maritime Projects Branch, which is made up of two committees. Activities like discussing financial and administrative matters and finalizing the program are handled by the MCA Research Steering Committee. The MCA Research Advisory Committee's responsibilities include assessing new proposals and evaluating the quality of the outcomes of projects.

4) Foresight: Intelligent Infrastructure Systems (IIS) project

The current phase of Foresight, which is the third round, was started in 2002 and has ongoing projects in specific areas. In regard to the transport sector, the "Intelligent Infrastructure Systems (IIS) Project" is in progress.

The IIS Project was launched in January 2006 to explore how science and technology can be applied over the next 50 years, particularly in the area of design and implementation of intelligent infrastructure systems.

The official webpage (http://www.foresight.gov.uk) of the IIS Project under the Foresight Scheme states that intelligent infrastructure systems
- Are aware of their environment, responsive and adaptive
- Collect and transmit relevant data to and from intelligent nodes to provide some or all of: critical information to responsible operator(s); feedback that results in local automated response; relevant and useful information to users

The Project was divide into five phases (Scope, Review, Synthesis, Engagement and Launch & Action), and is currently in the final, or Launch & Action, phase. The project outputs provide evidence based reviews of development process of Intelligent Infrastructure Systems, but do not give recommendations for action. A one-year review is scheduled for the first quarter of 2007, with the results about the outputs and impacts of the Project to be reported to the U.K. Prime Minister.

5) LINK Program: FIT and IST (Completed)

(a) LINK Future Integrated Transport (FIT)
LINK FIT was established by the DfT and the EPSRC to promote high quality scientific research and increased competitiveness of the UK transport industry. It was maintained from September 1999 to March 2002 with funding from the sponsors under the LINK scheme, which was the Government's principal mechanism for that period to encourage partnerships in pre-competitive research between

industry and the research base. In addition, EPSRC also provided money for certain types of proposal through its standard research grant mechanism.

(b) LINK Inland Surface Transport (IST)

Under the same LINK paradigm, IST was launched and conducted between March 1996 and April 1999. It aimed to support research contributing to the development of the inland surface transport system that would be efficient, safe and both environmentally and socially acceptable while contributing to the competitiveness of the U.K. transport industry. Like FIT, IST was managed and sponsored by DfT and EPSRC, with additional sponsorship from the Department of Trade and Industry (DTI) and ESRC.

8. Human Resource Development Programs

Education and training for researchers and students in the transport sector are conducted in two ways: directly within DfT and through the Government, which implements programs for all fields of science.

1) DfT Direct Program (Under the CSAU)

(a) ESRC / DfT Postgraduate Studentships
This program had selected four postgraduate studentships every year with support from the ESRC. The goal of the program was to fund research corresponding to the DfT's objective of providing for everyone reliable, safe, secure transport that respects the environment. This program has not been carried out since 2005 and is going to be merged into the newly developed Transport Research Center, leaving no directly-managed program in education within the DfT.

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<Construction>

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6. DTI (January 2006), Sustainable Construction Strategy Report 2006 (draft), from http://www.dti.gov.uk/files/file21332.pdf
7. DTI Construction Research Program (Feb 2007), from http://www.dti.gov.uk/files/file37735.pdf
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   - the UK government's leading funding agency for research and training in engineering and the physical sciences
3. BRE Trust (http://www.bretrust.org.uk/)
   - supporting education and research in the built environment (funding organization)
   - the organization including universities, governments, and industrial companies

4. BRE (http://www.bre.co.uk/index.jsp)
   - a firm providing research and technology consulting (also assessment and training courses)

<Transportation>

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EU CONTRUCTION R&D

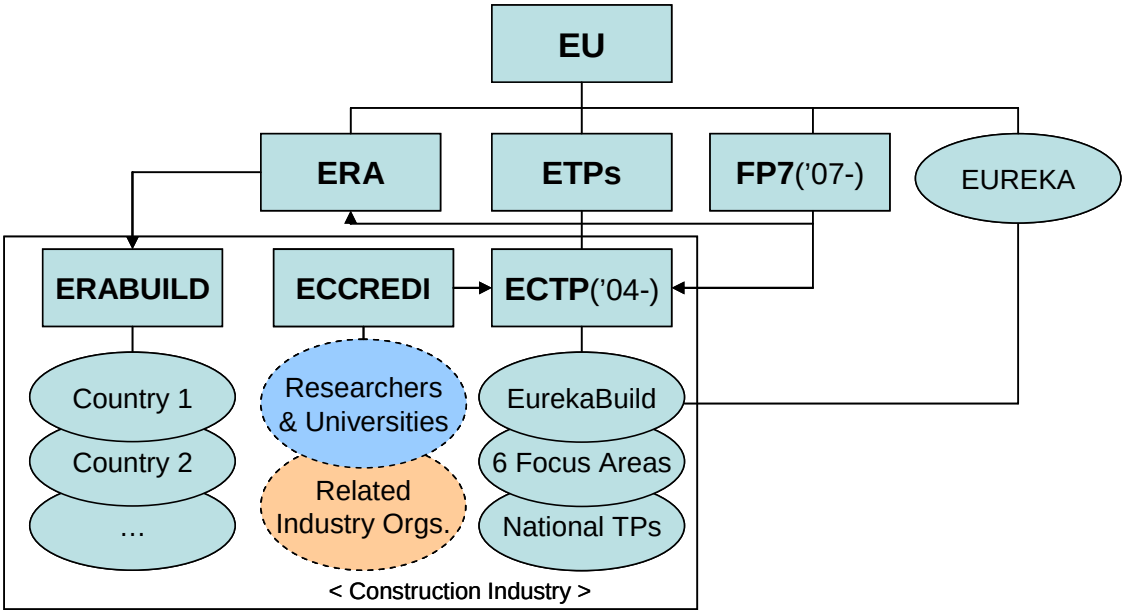
A. Construction

1. Introduction

The establishment of European Construction Technology Platform (ECTP) in July 2004 centralized European construction R&D. Prior to the ECTP, although the European Construction Research Network (E-CORE) was the center of the construction sector, all R&D activities were done by individual EU research programs in fragmented ways.

Currently, most European construction R&D is delivered by each membership country and managed by ECTP, based on financial support from the just started framework, FP 7. Additionally, some other organizations beneath the EU umbrella, like Erabuild of European Research Area (ERA) or EUREKA, contribute to the development of the European construction industry, along with numerous associations and research networks.

<Figure 1> EU Construction R&D System



2. Laws and Regulations

1) European Commission (2003), (COM (2003) 226 final) *Communication from the Commission-Investing in Research: an Action Plan for Europe*

2) European Commission (2003), (38 final) *Communication from the Commission-Stimulating Technologies for Sustainable Development: an Environmental Technologies Action Plan for the European Union*

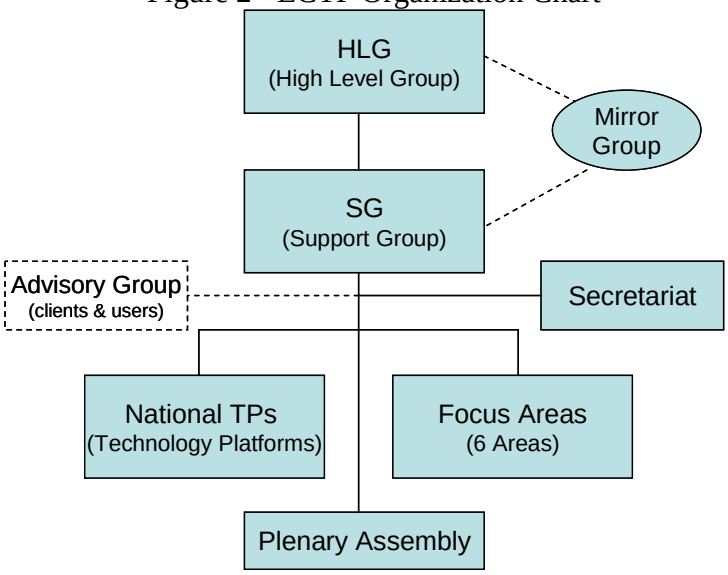
3. Government Organization Responsible for R&D Policy

1) European Construction Technology Platform (ECTP)

ECTP was launched at Maastricht, Netherlands in July 2004, initiated by the close cooperation between the EC Directorate General Research and the European Council for Construction Research, Development and Innovation (ECCREDI), with the support of construction industry stakeholders and the European Commission (EC) officers. Prior to ECTP, E-CORE was the main organization developing strategies for European construction and the built environment industries based on substantial input from ECCREDI. However, the actual R&D activities done at the national level were not affected by the E-CORE to merge all the RYD efforts and interests of the European construction sector. ECTP was established as a part of the European Technology Platform (ETP).

ECTP aims to analyze the sector's challenges in terms of society, sustainability, and technological development, with input from the construction sector stakeholders. It was instrumental in developing the European construction plan, "Challenging and Changing Europe's Built Environment: A Vision for a Sustainable and Competitive Construction Sector by 2030." Currently, ECTP is supported by over 30 national organizations including the UK National Platform.

<Figure 2> ECTP Organization Chart



Source: (ECTP, 2005c)

As shown in Figure 2, ECTP functions are delivered by several divisions: High Level Group (HLG), Support Group (SG), Advisory Group, Mirror Group, ECTP Secretariat, and Plenary Assembly. The function of each part is below:

(1) High Level Group (HLG)

HLG is a senior decision group composed of the stakeholders, member states, and EC officers. Its main tasks are:

- To identify challenges to the sector
- To develop and to sign a vision for 2030 and a strategic research agenda (SRA) to decide on setting-up of focus areas

- To develop action plans for the ECTP.

Currently, 13 EU member countries and related groups participate in the activities of the HLG. Some specific companies, universities, and other related organizations in the EU construction industry are below (ECTP, 2005c):

- Construction companies: Bam, Besix, Bouygues, FCC, Dragados, Hochtief, NCC, Necso, Soletanche-Bachy, Taylor Woodrow, Vinci, Züblin
- Suppliers: Consolis, Corus, EdF, Herrenknecht, Lafarge, Lohja Rudus, Saint-Gobain
- Designers: Arup, Arcadis, Egis, Ian Ritchie
- Operators: Autostrade, Banverket
- Researchers: BAM, CSTB, Czech Technical University, Salford University, TNO, Vilnius University, VTT, ZAG
- Clients: Danish Broadcasting Coop., Dutch Building Agency, GERG
- User Organizations: EDF, AGE, Euro cities
- Financial Organizations: European Investment Bank

(2) Support Group (SG)

The role of the SG is to assist the HLG in developing vision, SRA, and other documents based on HLG discussions, to receive inputs from Focus Areas (FAs) and National Technology Platforms (NTPs), to disseminate strategy, and to develop terms of reference for the ECTP. Currently, various actors from 12 European countries participate in the SG (ECTP, 2005c):

- Construction companies: Bouygues, Dragados, FCC, Hochtief, Necso, NCC, Soletanche Bachy, Vinci
- Suppliers: Corus, EdF, Heidelberg, Saint-Gobain
- Designers: Arup, Evata
- Operators: Autostrade
- Researchers: BBRI, CSTB, FEHRL, SBi, University of Ljubljana, University of P. Marche
- End users/clients: EDF, ASM, Deltaneth, Tekes
- European Commission (EC): DG Research, DG Enterprise, and other related DGs

(3) Advisory Group (AG)

AGs report to the Support Group. They are set up by the ECTP to provide advice on strategy in well identified fields. AGs revise ECTP activities and strategies and assure that the actions of the ECTP fit the needs of the stakeholders.

(4) Mirror Group (MG)

Representatives from the Member States and DG research make up the MG. Its goal is to strengthen the link between the ECTP and member states. Members of MG are DG Research from European Commission, ECTP, and EU membership countries. The Chairman of the Support Group, the Secretariat, and other SG members are invited to meetings of the Mirror Group

(5) Secretariat

The ECTP Secretariat is the organization that provides administrative and financial support for the ECTP. Its main tasks are to organize HLG and SG meetings, to assist the Chairman of HLG, SG, and Working Groups in preparing documents, and to disseminate ECTP activities.

(6) Plenary Assembly

The assembly is consisted of all European stakeholders who are interested in joining the ECTP so that they have access to the relevant working papers through the website, and are able to make contributions to ECTP through the FAs.

4. Planning and Priority Setting

1) ECTP, *Challenging and Changing Europe's Built Environment: A Vision for a Sustainable and Competitive Construction Sector by 2030*

Signed and committed to by major stakeholder groups in the European construction industry, ECTP's long-term vision was published in 2005. The vision of ECTP for the construction and built environment industry in Europe of 2030 is:

"In the year 2030, Europe's built environment is designed, built and maintained by a successful knowledge- and demand- driven sector, well known for its ability to satisfy all the needs of its clients and society, providing a high quality of life and demonstrating its long-term responsibility to the mankind's environment. Diversity in age, ability and culture is embraced. Equalization of opportunities for all is an overarching principle; construction has a good reputation as an attractive sector to work in, is deeply involved in research and development, and whose companies are well known for their competitiveness on the local and regional as well as global levels (ECTP, 2005a: 7)."

In order to cooperate with the vision, ECTP has clarified that meeting client requirements and reaching sustainability would be the two key areas of European construction R&D (ECTP, 2005a).

(1) Vision 1: Meeting client requirements

- Objectives: provides a variety of attractive, healthy, safe, accessible, useable and sustainable environments in which a diversity of social and cultural values are welcomed and fostered
- Corresponding research targets:
    - Process
    - Product
    - Infrastructure
    - Cultural heritage & collective memory
    - Hazards
    - Social sustainability

(2) Vision 2: Becoming sustainable

- Objectives: combine 'high tech' with 'high culture' and be a natural leader in creating a sustainable built environment which links nature and citizens in a sustainable way
- Corresponding research targets:
    - Interaction of built and natural environments
    - Interaction of built environment with citizens
    - Production
    - Existing buildings and infrastructure

Moreover, ECTP recommends some specific research topics under the three strategic R&D themes related to achieving the vision: materials and technology, industry transformation, and service (ECTP, 2005a):

- Materials and technology
  - New materials and construction, maintenance and demolition techniques
  - Efficient materials and technologies
  - Methods of inspection, maintenance, repairs and renewals of infrastructure at minimal cost and with minimum disruption
  - Nanotechnologies, biotechnologies, and ITs as drivers of change in the construction industry and the built environment

- Industry transformation
  - Link the value and supply chains in construction together
  - Reengineer construction into a safe, knowledge-based and high-tech industrialized process
  - Develop new sustainable models, design and building techniques, materials and ICT helping to increase design possibilities, efficiency and safety, and reduce risks from hazards
  - Develop performance based standards
  - Develop tools for improving the general public's, particularly young people's, perceptions of the construction sector
  - Build a more human-friendly construction work environment
  - Address the mechanisms of change needed for business procedures
  - Develop and implement the architectural knowledge-base
  - Develop robust technologies connecting human behavior and requirements for safety, energy-efficiency, etc.

- Service
  - Methods for management, life-extension, assessment, monitoring, diagnosis, improving energy performance, shortening payback time and reducing the environmental impact of infrastructure, networks and buildings
  - Specific methods and materials to preserve and rehabilitate existing buildings and transport and services infrastructure
  - Ways to integrate buildings and networks in the urban and natural environment (including social innovation and risk-sharing)
  - Methods for incorporating alternative energy resources into the built environment

2) ECTP, *Strategic Research Agenda for the European Construction Sector: Achieving a Sustainable and Competitive Construction Sector by 2030*

The strategic research agendas (SRAs) are established to clarify Vision 2030. Although the vision has two parts, the SRAs cover three different themes, including two directly drawn from the vision (ECTP, 2005b).

(1) Meeting client/user requirements
- Healthy, safe, accessible, and stimulating indoor environments for all
- A new image of cities
- Efficient use of underground city space
- Mobility and supply through efficient networks

(2) Becoming sustainable
- Reduce resource consumption (energy, water, materials)
- Reduce environmental and man-made impacts
- Develop sustainable management of transport and utilities networks
- Establish a living cultural heritage for an attractive Europe
- Improve safety and security

(3) Transformation of the construction sector
- A new client-driven, knowledge-based construction process
- ICT and automation
- High added-value construction materials
- Attractive workplaces

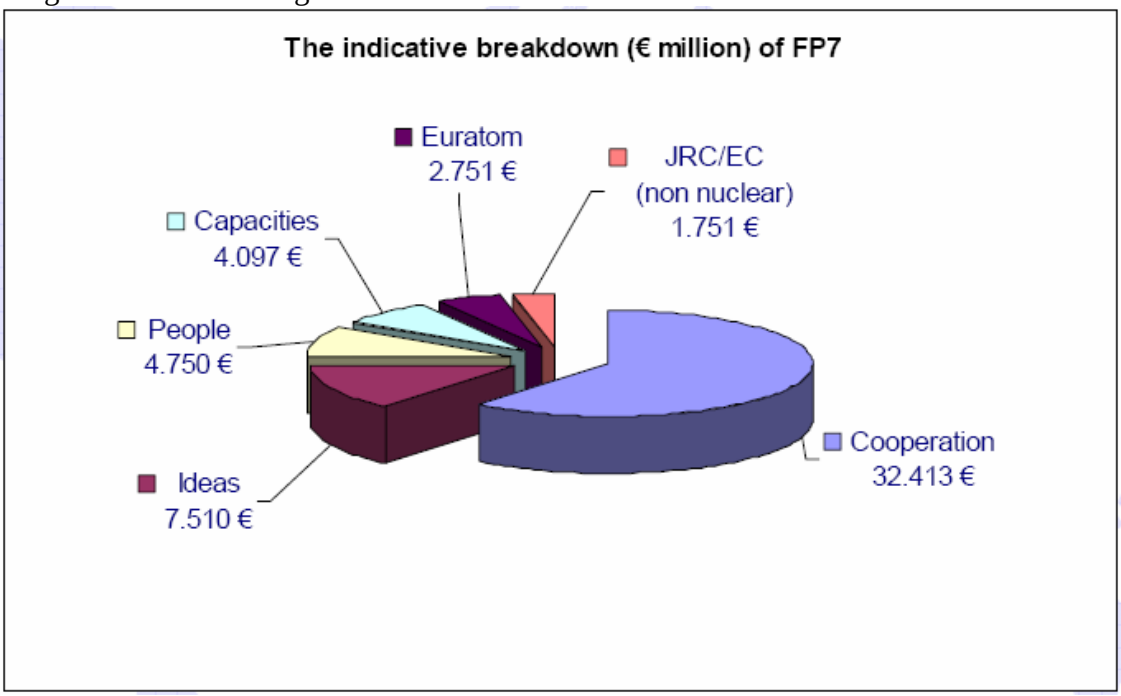
5. R&D Funding Organizations and Programs

In most cases, European R&D activities are funded by the EU Framework Programme (FP). In 2007, FP7 was launched to provide funding for the period from January 2007 to 2013.

According to the EU, FP7 will be delivered through (ECRDG, 2007):
- Cooperation (fostering collaboration between industry and academia)
- Ideas (supporting basic research at the scientific frontiers)
- People (supporting mobility and career development for researchers)
- Capacities (helping development of capacities that EU needs to become a knowledge-based economy)
- Nuclear Research (Euratom Programme)

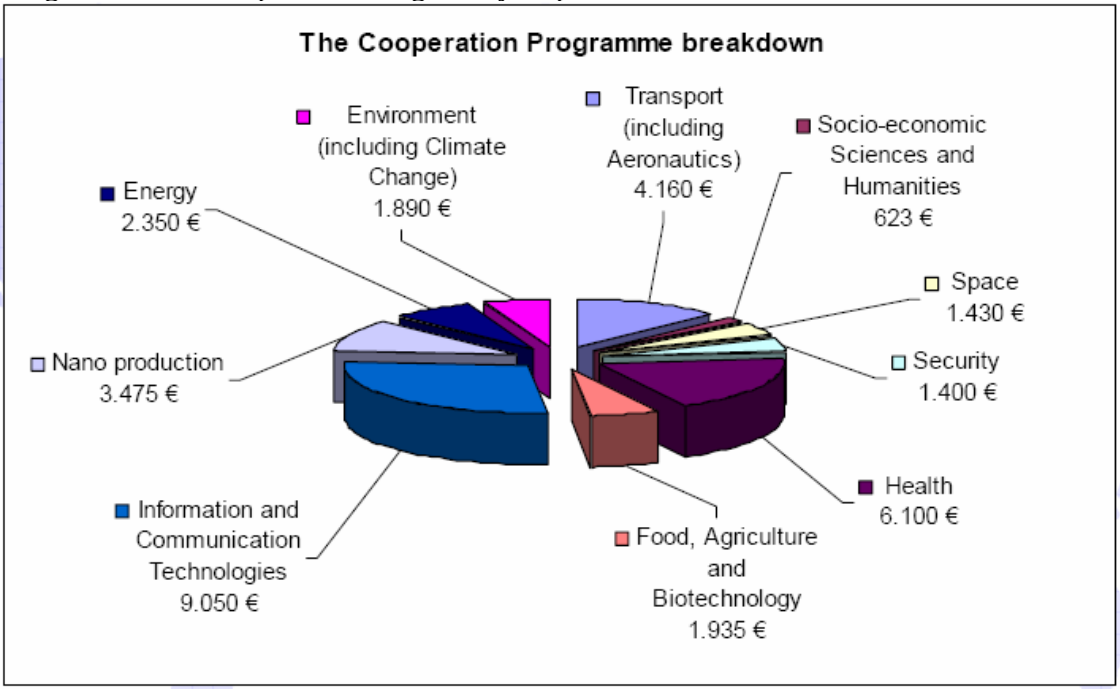
Under the FP 7, total budget of € 50 billion will be made available over 7 years, including € 9 billion for ICT research, € 3.5 billion for nanotechnology, materials and processes, € 1.8 billion for environmental issues and € 4.1 billion for transport research. The overall budget distribution by research topic, detailed information of R&D cooperation by area, and the historical funding amount change from FP1 to FP7 are shown in Figure 3, 4, and 5, respectively:

<Figure 3> FP7 Funding Overview



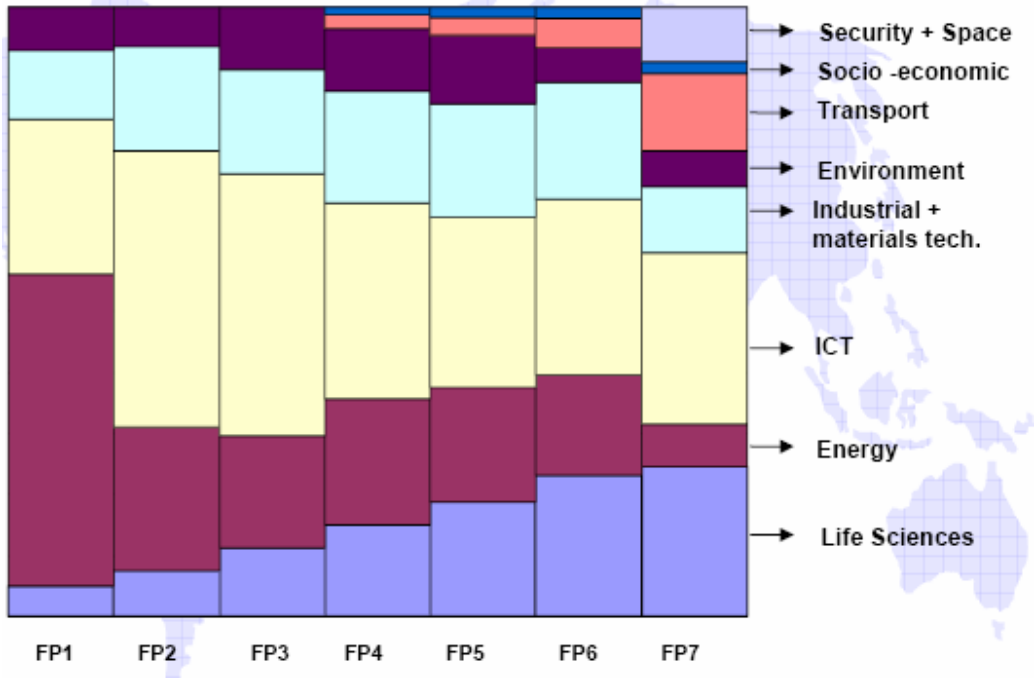
* Source: http://www.feast.org/fp7/documents/2006-12_Damiani.pdf

<Figure 4> FP7 Cooperation Program by Topic



* Source: http://www.feast.org/fp7/documents/2006-12_Damiani.pdf

<Figure 5> Priority Changes from FP1 to FP7



* Source: http://www.feast.org/fp7/documents/2006-12_Damiani.pdf

In addition to the funding by the FP 7, the countries and core participants involved in individual R&D projects in the construction industry also provide funding for their research projects.

6. Institutions Conducting R&D

Some examples of key actors in EU's collaboration programs, such as NTPs, FAs, Erabuild, and EUREKA Build, are below:

- Finland
  - Tekes – National Technology Agency (www.tekes.fi/eng)

- Austria
  - BMVIT – Federal Ministry of Transport, Innovation and Technology (www.bmvit.gv.at)
  - FFG – Austrian Research Promotion Agency Ltd. (www.ffg.at)
  - ÖGUT – Austrian Society for Environment and Technology (www.oegut.at)

- Denmark
  - EBST – National Agency for Enterprise and Construction (www.naec.dk)

- France
  - Ministry of Transport, Building and Housing (www.equipment.gouv.fr)
  - CSTB – Centre Scientifique et Technique du Bâtiment (http://international.cstb.fr/)

- Germany
  - BMBF – German Federal Ministry of Education and Research (www.bmbf.de/en)
  - TÜV – Akademie Rheinland Gmbh (www.tuv.com)

- Netherlands
  - Ministry of Spatial Planning, Housing and Environment (http://www.international.vrom.nl)
  - SenterNovem – Netherlands Agency for Energy and Environment (www.senternovem.org)

- Sweden
  - Formas – The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (www.formas.se)
  - BIC – The Swedish Construction Sector Innovation Centre (www.bic.nu)

- United Kingdom
  - Department of Trade and Industry (www.dti.gov.uk)

7. R&D Collaboration Programs

There are two types of EU collaboration programs that promote cooperation among various stakeholders in the EU construction industry. The first type, NTPs and FAs, fall under the umbrella of ECTP; the second type includes programs such as Erabuild or EUREKA build, which are outside the boundaries of ECTP.

1) National Technology Platforms (NTPs) of each EU member country

Many European countries have established National Technology Platforms (NTP) addressing the future needs of the built environment, and particularly the challenge of innovation and industry transformation in the construction sector. In all cases, these national platforms are being led by industry with the endorsement of their respective governments. They include many common elements, such as involvement of all stakeholders and the aim of identifying technological, regulatory, and financial challenges to improving the performance of the industry in terms of productivity and environmental impact. Some of these platforms may also be established at the regional level (such as in Flanders in Belgium).

Currently, many EU member countries have their own NTPs; some examples of NTPs by country are below:

- ACTP (Austrian Construction Technology Platform) (http://www.actp.at/)
- NTP (Belgium) (http://www.cstc.be/homepage/index.cfm?cat=services&sub=vision2030&pag=intro)
- CCTP (Czech Construction Technology Platform) (http://www.czctp.cz/)
- ECTP (Denmark / Dansk teknologiplatform for byggeriet) (http://www.ectp-denmark.dk/)
- GCTP (German Construction Technology Platform) (http://www.gctp.de/GCTP-Info.88.0.html?&L=1)
- HCTP (Hellenic Construction Technology Platform) (http://www.hctp.tee.gr/)
- PTIC (Italian Construction Technology Platform) (http://www.ptic.it/)
- DeltaNeth (The Netherlands Technology Platform) (http://www.deltaneth.nl/)
- Norsk teknologiplattform (Norwegian National Construction Technology Platform) (http://www.sintef.no/content/page12____9296.aspx)
- PCTP (Polish Construction Technology Platform) (http://www.pptb.pl/)
- RCTP (Romanian Construction Technology Platform) (http://www.rctp.ro/)

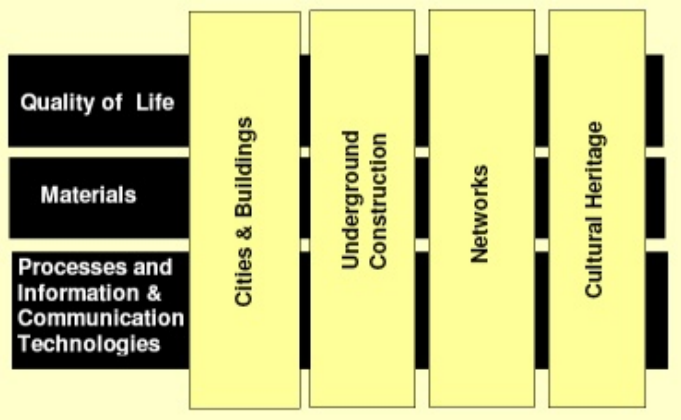
- SGTP (Slovenian Construction Technology Platform) (http://www.sgtp.si/index.php)
- PTEC (Spanish Technology Construction Platform) (http://www.construccion2030.org/ptec.php)

2) Focus Areas (FAs)

Under the ECTP, there are seven FAs to meet the needs of the European construction industry. Main tasks of FAS are:
- To arrange discussion forums, workshops, etc.
- To formulate visions and strategies in coordination with HLG and SG
- To report to the Support Group
- To disseminate all deliverables
- To encourage and support proposals for projects and Joint European Technology Initiatives.

Currently, seven FAs are in progress. Among them, four of the FAs cover specific aspects of the construction sector; the other three focus on overarching themes of the whole construction industry.

<Figure 6> Structure of Seven Focus Areas



* Source: from ECTP webpage (http://www.ectp.org/presentation.asp#Focus%20areas)

The leaders of each FA define the group's topics, organizational structure, and meeting frequency. The outputs of FAs include research proposals to the SG, support for establishing the Vision 2030 and SRAs, and setting priorities for Joint European Technology Initiatives. FAs can be defined as the coordinating organization for each defined topic based on the inputs from a broad range of participants, rather than as programs doing research directly.

3) ERABUILD under the European Research Area (ERA)

ERABUILD is included in another research framework of EU, the European Research Area.

(1) European Research Area (ERA)

ERA is a system of scientific research programme integrating the European Union's scientific resources. Since its creation in 1984, the system has concentrated on multi-national cooperation in the fields of medical, environmental, industrial, and socio-economic research. The overall purpose of ERA is to increase the competitiveness of European research institutions by bringing them together and encouraging a more inclusive way of work and by identifying European research areas to support.

In 2002, EU announced the following focus areas to be supported:
- Genomics and biotechnology for health
- Information Society Technologies
- Nanotechnologies, intelligent materials, and new production processes
- Aeronautics and space
- Food safety and health risks
- Sustainable development
- Citizens and governance in the European knowledge-based society

(2) ERABUILD (http://www.erabuild.net/)

The aim of ERABUILD is the creation of the ERA in research on sustainable construction and operation of buildings. It aims to increase networking and coordination among EU member countries, efficiency in research, and sharing resources. At this time, more than 200 projects are in progress or just initiated, and specific projects are delivered by eight broader program frameworks in member countries. Details about participant countries and their projects are below:
- Austria
  - Building of Tomorrow (http://www.hausderzukunft.at/english.htm%C2%A0)
- Denmark
  - Digital Construction
- Finland
  - SARA – Value Networks in Construction (www.tekes.fi/english/programmes/sara/)
  - CUBE – Building Services Technology Programme (www.tekes.fi/english/programmes/cube/)
- France
  - CSTB Programme on "Sustainable Buildings" (www.cstb.fr)
- Germany
  - Building and Housing in the 21st Century (www.baufo.net)
- Netherlands
  - Compass – towards Energy Efficient Building (www.senternovem.nl/compass)
- Sweden
  - Formas-BIC: Sustainable Buildings (www.formas.se/sustainablebuildings)
- United Kingdom
  - Avanti (www.avanti-construction.org)

4) EurekaBuild under the EUREKA

As with ERABUILD, EurekaBuild is based on another EU research framework, EUREKA, which is focused on doing market-oriented research and development activities, especially.

(1) EUREKA (http://www.eureka.be/home.do)

EUREKA is one of the European Commission's research related initiative. It seeks to be a Europe-wide network for market-oriented industrial R&D and innovation. Currently, numerous researchers and institutes coming from 35 EU member countries are involved in the activities of EUREKA.

(2) EurekaBuild (http://www.ectp.org/eurekabuild_about.asp)

EurekaBuild is a European research program to encourage European innovative R&D with national funding. Its purposes are to create a sustainable and demand-driven construction sector. It was created in mid 2006 by ECTP under the EUREKA framework to improve the communication and cooperation between European researchers and industry, as well as to deliver R&D projects responding to the needs of key stakeholders. Its detailed projects are not defined yet.

Currently, it seeks to launch R&D projects in some specific areas:
- Technologies for Healthy, Safe, Accessible and Stimulating Indoor Environments for All
- Innovative Use of Underground Space
- New Technologies, Concepts and High Tech Materials for Efficient and Clean Buildings
- Reduce Environmental and Man-made Impacts of Built Environment and Cities
- Sustainable Management of Transports and Utilities Networks
- A Living Cultural Heritage for an Attractive Europe
- Improve Safety and Security within the Construction Sector
- New Integrated Processes for the Construction Sector
- High Added Value Construction Materials

EU TRANSPORTATION R&D

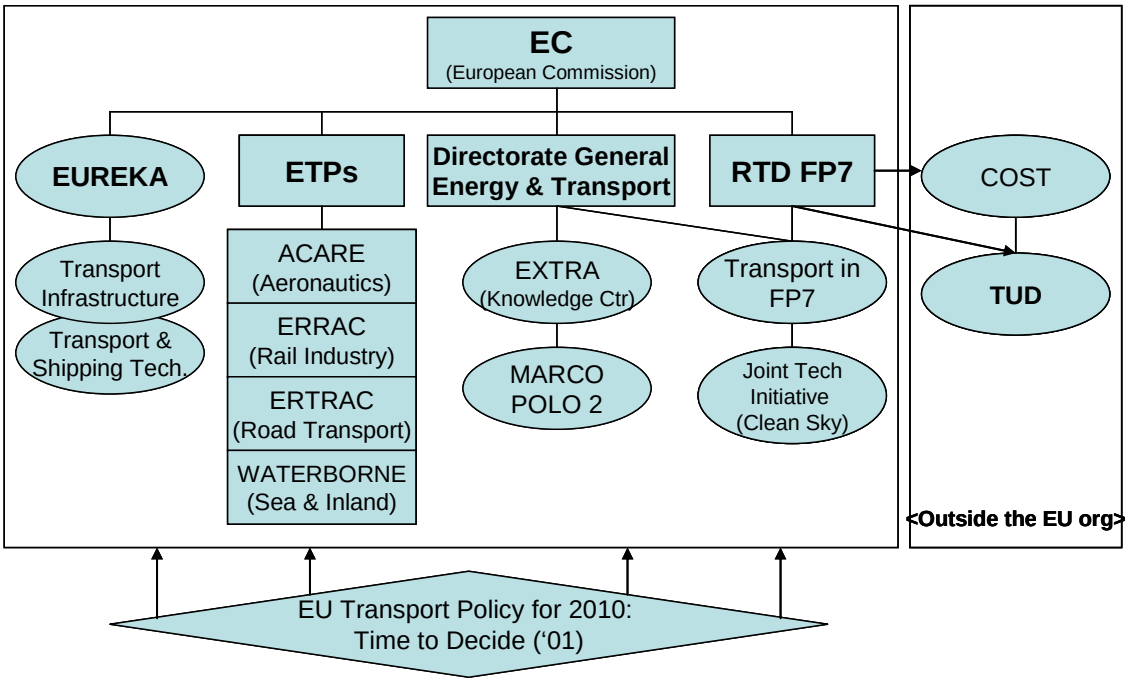
B. Transportation

1. Introduction

Compared to European construction R&D, transport R&D in Europe is more centralized by the specific Directorate, Directorate General for Energy and Transport (DGET), which is in charge of European transport and energy related issues. Rather than performing R&D activities directly, the Directorate plays a key role in identifying key issues and planning programs and sets priorities in transport areas. It owns a couple of small programs like EXTRA or Marco Polo. Major programs are delivered through projects under the EUREKA or European Technology Programs by sector, such as aeronautics, rail, road, and sea & inland as shown in Figure 1. Further, under the FP7, which is the European Commission's funding framework, there are several specific programs for transport area including aeronautics. Also, within the Joint Technology Initiative of FP7, there is the opportunity to launch transport-related initiatives like the "Clean Sky" program.

Outside the European Commission, there have been active efforts to stimulate transport research among European researchers without considering national boundaries. The initiative, European Cooperation in the field of Science and Technology Research (COST), symbolizes the vigorous efforts of European researchers for cooperation in the transport sector. Some of projects under the COST framework are also funded by FP7.

<Figure 1> EU Transport R&D System



2. Government Organizations Responsible for R&D Policy

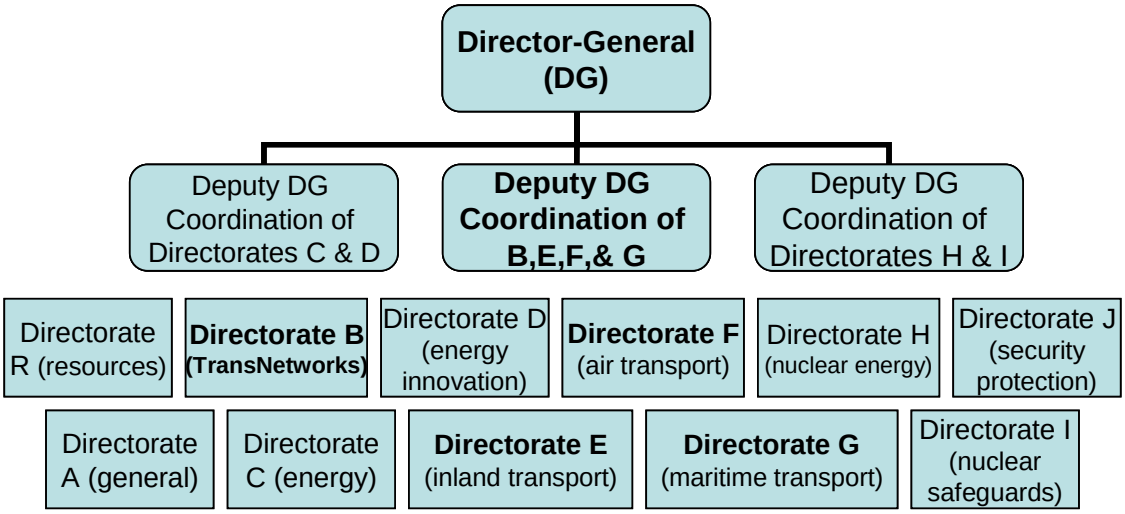
1) Directorate-General for Energy and Transport (DGET)

Headed by Matthias Ruete, the current Directorate-General for Energy and Transport (DGET) is a key actor in European transport areas. Its main roles are:

- To develop community transport and energy policies, including dealing with State aid
- To manage the financial support programs for the trans-European networks, technological development, and innovation, (totaling on average €1 billion per annum for the period 2000-2006)

As shown in Figure 2, among the diverse Directorates under the DGET, Directorate B, E, F, and G cover the transport sector.

<Figure 2> Directorate-General for Energy and Transport Organization Chart



* Source: created by the DGET webpage
(http://ec.europa.eu/dgs/energy_transport/matthias_ruete/doc/dg_tren_organisation_chart_en.pdf)

3. Planning and Priority Setting

1) EU (2001), *European Transport Policy for 2010: Time to Decide*

Published in 2001, the White Paper, "European Transport Policy for 2010," is the planning document for providing policy guidelines to the European transport sector for the future. Although it covers not only transport R&D but also the whole area of transport, it still works as the fundamental policy framework for EU transport R&D policy.

There are four main parts to the report (EU, 2001):

(1) Part one: shifting the balance between modes of transport

- Regulated competition: improving quality in the road sector, revitalizing the railways, and controlling the growth in air transport
- Linking up the modes of transport: linking among the different sectors in the transport areas, helping to start up intermodal services, and creating favorable technical conditions to support the linkages

(2) Part two: eliminating bottlenecks

- Unblocking the major routes: realizing multimodal corridors with given importance to freight, establishing a high-speed passenger network, delivering major infrastructure projects
- Considering funding problems: investigating the limit of public funding, finding an innovative approach to pool fundings from private investors

(3) Part three: placing users at the heart of transport policy

- Securing road safety
- Finding a EU Community framework
- Establishing a harmonized taxation system
- Investigating human problems: rights and obligations of users, high-quality guaranteed public services
- Rationalizing urban transport: diversifying energy sources, promoting good practice

(4) Part four: managing the globalization of transport

- Changing the “rule of game”
- Strengthening international cooperation in transport areas

Especially in Annex IV, the report deals with technological development, According to the report, the EU focuses on the three issues below (EU, 2001:114-115):

- Aeronautics and space
    - Lessening the environmental impacts of engine emission and noise and improving aircraft safety
    - Increasing the capacity and operating safety of the air traffic management system so as to facilitate the achievement of the single European sky initiative
    - Creating safer and less polluting aircraft: reducing CO_2 emissions by 50% and NO_x by 80%, and reducing aircraft noise by 10dB
- Sustainable development and global change
    - Reducing greenhouse gases and pollutant emissions
    - Securing energy supply and balanced use of the various transport modes
    - Promoting clean urban transport
    - Exploring railway interoperability: focusing on the technologies which will help improve the capacity of means of transport and traffic management systems and introduce more competitive services
    - Developing new sources of renewable energy such as hydrogen technologies and fuel cells (long-term research objective)

- Anticipating the EU's scientific and technological needs
    - Covering all the thematic areas mentioned above in support of policies of EU interest, such as the common transport policy presented in the remaining part of the report

2) EU (2006), *Keep Europe Moving: the Mid-term review of the 2001 Transport White Paper*

As a mid-term review report, *Keep Europe Moving* investigates the changes in the European transport environment presented after the publication of the 2001 EU White Paper. It also includes actions to make the European railway network more competitive through liberalization, technological innovation, interoperability of equipment, investment in infrastructure and better market monitoring. The review places particular emphasis on intelligent transport systems.

4. R&D Funding Organizations and Programs

1) RTD FP (Framework Programme) 7 (2007-2013)

(1) FP7 Cooperation Work Program: Transport

<Table 1> Minimum Conditions of Each Funding Scheme

Funding Scheme	Minimum conditions
Collaborative project	At least 3 independent legal entities, each of which is established in a MS or AC, and no two of which are established in the same MS or AC
Network of Excellence	At least 3 independent legal entities, each of which is established in a MS or AC, and no two of which are established in the same MS or AC
Coordination & support action (Coordinating)	At least 3 independent legal entities, each of which is established in a MS or AC, and no two of which are established in the same MS or AC
Coordination & support action (Supporting)	At least 1 independent legal entity
Research for the benefit of specific groups, such as SMEs	At least 3 independent legal entities, each of which is established in a MS or AC, and no two of which are established in the same MS or AC

* Source: http://www.technion.ac.il/~liaison/fp7/WorkPrograms/Transport.pdf

FP7, which is the seventh Framework Programme (FP) for Research and Technological Development in Europe, is the EU's main instrument for funding research in Europe between 2007 and 2013. With its 41% budget increase over FP6, FP7 plans to support research in selected priority areas including transport. Table 1 provides an overview of FP7's main funding schemes and their requirements.

<Table 2> Indicative Budget for Transport Theme for the 2007 Work Programme-DG Research

European Commission's DG Research	**2007***
FP7- Aeronautics and Air Transport (AAT)- 2007-RTD-1**	153.48M€**
FP7-Sustainable Surface Transport (SST)-2007-RTD-1**	153.48M€**/***
FP7-Transport (TPT)-2007-RTD-1	12M€
Total for RTD calls	318.96M€
General activities	25.788M€
Other activities - Evaluations (1M€) - Programme impact assessment - Information / communication - Joint Technology Initiative (JTI) preparatory activities	3M€
Estimated total budget allocation	**347.75M€**

* Source: http://www.technion.ac.il/~liaison/fp7/WorkPrograms/Transport.pdf

<Table 3> Indicative Budget for Transport Theme for the 2007 Work Programme-DGET

European Commission's DGET	**2007***
FP7- Aeronautics and Air Transport (AAT)-2007-TREN-1	4M€
FP7-Sustainable Surface Transport (SST)-2007-TREN-1	60M€
Total for RTD calls	64M€
General activities	6.99M€
Other activities - Galileo (40M€) - Sesar (10M€) - Evaluations and monitoring (0.7M€) - Programme impact assessment - Information /communication	40M€ 10M€ 0.7M€
Estimated total budget allocation	**121.69M€**

* Source: http://www.technion.ac.il/~liaison/fp7/WorkPrograms/Transport.pdf

According to the FP7 framework, funding for European transport R&D activities can take two different forms: funding can come from the Directorate General Research or from DGET, which is the research directorate designed for the transport industry. Under the FP7, Table 2 shows the expected amount of budget supported by the DG Research, and Table 3 investigates the DGET's planned budget for its energy and transport R&D activities.

5. Institutions Conducting R&D

Transport R&D activities in EU are performed by each membership country through numerous types of R&D projects. The projects can be organized at the national or the international level.

6. R&D Collaboration Programs

European countries have a broad range of collaboration programs. The current programs for the transport sector are of one of two types; the first type, which includes EUREKA, European Technology Platform (ETP), EXTRA, Marco Polo2, Transport in FP7, and Joint Technology Initiative (JTI), is delivered under control of the European Commission; the second type Transport and Urban Development (TUD), covered by the COST framework, is a voluntary cooperation among European researchers.

1) EUREKA (http://www.eureka.be/home.do)

Established in 1985 by 17 European countries and the EU, EUREKA is a pan-European network focusing on market-oriented, industrial R&D, ultimately aimed at improving the quality of life. Currently, about 2,231 (149 transport-related) R&D projects have been undertaken; 651 (52 transport-related) projects are ongoing; 1,279 (91 transport-related) projects have been finished; and 101 (6 transport-related) projects are expected to be delivered.

All the projects are divided by technology areas. Currently, EUREKA covers ten technology areas:

- Electronics, IT and Telecommunication Technology
- Energy Technology
- Agriculture and Marine Resources
- Technology for Protecting Humankind and the Environment
- Industrial Manufacturing, Material and Transport
- Chemistry, Physical and Exact Sciences
- Agrofood Technology (food industry, nutrition and health)
- Biological Sciences
- Other Industrial Technologies
- Measurement and Standards

Among the areas above, transport R&D is delivered under the Industrial Manufacturing, Material and Transport technology by two different programs: Transport Infrastructure and Transport and Shipping Technologies.

Some examples of EUREKA members are shown below:

- Bureau for International Research and Technology Cooperation, Austria
- Services Federaux des Affaires Scientifiques, Techniques et Culturelles, Belgium
- Ministry of Science and Technology, Croatia
- Research Promotion Foundation, Cyprus
- Ministry of Education, Youth and Sports, Czech Republic
- Ministry of Science, Technology & Innovation, Denmark

- ESTAG - Estonian Technology Agency, Estonia
- National Technology Agency, Finland
- ANVAR - National Research Valorization Agency, France
- DLR - German Aerospace Center
- Ministry of Development (General Secretariat for Research and Technology), Greece
- Ministry of Education (Research and Development Division), Hungary
- The Icelandic Research Council
- Enterprise Ireland
- MATIMOP - Israeli Industry Center for R & D
- MIUR - Ministry of Education, Universities and Research, Italy
- Consulting and Information Bureau BIK Ltd, Latvia
- National Information Office of Lithuania
- Luxinnovation Gie National Agency for Innovation and Research,
- SENTER Netherlands
- The Research Council of Norway
- KBN - State Committee for Scientific Research, Poland
- Agencia de Inovacao S.A.,
- Ministerului Educatiei si Cercetarii (Ministry of Education and Research), Romania
- Ministry of Industry, Science & Technology of the Russian Federation
- Ministry of Science, Technology and Development of the Republic of Serbia, Serbia & Montenegro
- SARC Centre for Advancement, Science and Technology, Slovakia
- Ministry of the Economy (Sector for technological development and innovation), Slovenia
- CDTI - Centre for the Development of Industrial Technology, Spain
- VINNOVA, Sweden
- OPET - Federal Office for Professional Education and Technology, Switzerland
- TUBITAK - Scientific and Technical Research Council of Turkey
- Department of Trade and Industry, United Kingdom
- European Commission - DG Research

(1) Transport Infrastructure (http://www.eureka.be/thematic/showPrjThematic.do?area=2.8)

Under the Transport Infrastructure, the list of ongoing research projects is below:

- DEFOE (Detection Of Fog In Motorway Environments)
- UMT-CYPWD-CVOLOS (Establishment Of A Prototype Dta-Based Universal Transport Model For The Cyprus Public Works Dept. And The City Of Volos)
- SPIN-ALP (Scanning The Potential For Intermodal Transport On Alpine Corridors)
- ATMS (Automatic Pneumatic Tube System (P.T.S.) With Carrier Storage For Systems With An Air Column Free Of Bacteria/Viruses)
- HYDROMAN (A New Methodology For Sustainable, Integrated Water Management)
- ICARO (Image Controlled Adaptive Regulation Optimization)
-SAFE DRIVE (Monitoring System For Airport Vehicles)
- INCOWATRANS (Environmentally Friendly Inland And Coastal Ships For Polish East-West Waterways)
- LOGCHAIN POLCORRIDOR (Exploring A Freight Supply Connection Between Nordic Region Region/S.E. Europe. Development Of Intermodal Corridor)
- ONE - (ECO-POWER) (One - (Eco Power) Optimized New Engines)
- TRAIN-TRANS (Adaptation Of Train Protection Transmission Receiver And Signal Converter To Local Conditions)

(2) Transport & Shipping Technologies
(http://www.eureka.be/thematic/showPrjThematic.do?area=2.9)

Under the EUREKA project of Transport & Shipping Technologies, the list of ongoing research projects is below:

- GEOTRAC 4 (Geotrac 4 - Development Of Motor, Gearbox, Electronic Circuit, Cabin)
- ECO MIDI BUS (New Generation Of Ecological Midi Buses)
- SHIPSENSE (Ship Sensor Technology For Better Operational Efficiency And Performance Control)
- I-STARS (Integrated Starter Alternator Reversible System)
- 4 SAVE (Development Of A Transporter Construction For Use In Case Of Disaster With A New Type Of 4 Stretcher Bearing)
- KB I ELECTRIC-HYBRID (Kb I Electric-Hybrid)
- ALTAIR (New Bearing With Load Sensors)
- LOGCHAIN CARGOROROWAGON (The Development And Production Of An Intermodal High Speed Ro-Ro Wagon)
- SAFEPASEA (Safe Passenger Transport At Sea)
- GOENGINE (The Development Of Goengine Demonstrators)
- NEPH INDUSTRIAL (New Electrical Postman Helper: Industrial Part)
- HINCA (Development And Validation Of A Hybrid Instrument Panel Concept)
- SAVE (Light Bag For Soft Airbags)
- LOGCHAIN MODLOC (Modernisation Of Diesel Traction Vehicles For East-West Transit Services On The Wide-Gauge Metallurgic Railway Line)
- ESPIRE (Environmentally Friendly Cutting Technologies For The Restoration Of Mountain Forest Stands In Spain And Ireland)
- TWO (Two Wheels Optimization)
- BALTECOLOGICALSHIP (Environment Friendly Ships For Baltic Area)
- EUROENVIRON DIECO (Development Of A Diesel Mine Locomotive)
- ULTRA-LIGHT (Lightweight Hull With Integrated Propulsion)
- TRUS (Zero Emission Public Transport For Urban Areas)
- EUROBOGIE (Advanced Rail Suspension Using Fibre-Reinforced Plastics)

2) European Technology Platform (ETP)
The ETP is a EU framework that focuses on strategic issues where achieving competitiveness and sustainable growth depends upon important technological advances. Led by industry, ETP brings together all stakeholders within a given sector to define medium- and long-term research and technological development objectives.

The primary mission for the ETPs has been to define Strategic Research Agendas (SRAs), addressing the challenges facing the particular sectors they represent. The ETP activities are divided by technology area; currently, ETP in the transport sector includes four different organizations: the Advisory Council for Aeronautics Research in Europe (ACARE) in the Aeronautics industry, European Rail Research Advisory Council (ERRAC) in the rail industry, European Road Transport Research Advisory Council (ERTRAC) in the road transport industry, and WATERBORNE in the sea and inland industry.

(1) ACARE (http://www.acare4europe.org/)

Launched in 2001 by then European Research Commissioner Philippe Busquin, ACARE is one of the oldest ETPs in the EU. Currently, it has 39 members, including representatives from EU Member States, the European Commission, the European aeronautics industry, and air transport operators.

According to its webpage, ACARE establishes its own mission and strategic research agendas by discussions among the participants. In 2002, the first edition of the SRA was published to address the challenges facing the European aeronautics industry. In March 2005, ACARE presented the second edition of its SRA, looking 20 years into the future. This SRA presents expected or potential technology requirements in the air transport sector based on a series of possible scenarios for the coming decades. The two SRA documents still serve as the key guiding force in the planning of research under public, private, national, and EU programs in the aeronautics industry. The specific projects supported by FP7 are designed by the SRA publications.

The main activities of ACARE, including the establishment of the SRA, are below:

- Launch and approve the SRA and update it periodically
- Make strategic and operational recommendations as well as commission studies for implementing the SRA and achieving the 2020 Vision prepared by the ACARE
- Evaluate the overall results and benefits of the SRA for Member States, the Commission, and stakeholders groups
- Recommend measures for optimizing the use of existing research infrastructures and achieving cost-effective investments
- Recommend measures for improving educational policies to attract the scientists, engineers and other skills that the sector needs
- Develop and implement a communications strategy to promote awareness of the SRA
- Disseminate information on stakeholders' research programs for facilitating consensus on priorities

(2) ERRAC (http://www.errac.org/)

Established in 2001, ERRAC aims to create a single European body with both the competence and capability to help revitalize the European rail sector and make it more competitive by fostering increased innovation and guiding research efforts at the European level.

According to its webpage, ERRAC’s organizational goals are:

- Defining and implementing steps to achieve a joint European rail research strategy for the next 20 years through the Strategic Rain Research Agenda 2020 (SRRA)
- Enhancing collaborative European rail research by:
    - Building consensus among stakeholders
    - Improving synergies between EU, national, and private rail research
    - Strengthening and reorganizing research and development efforts
    - Facilitating effective pooling of human and material resources

Currently, ERRAC’s activities cover five technology areas in the rail industry:

- Railway interoperability
- Intelligent mobility

- Safety and security
- Environment
- Innovative materials and production methods.

(3) ERTRAC (http://www.ertrac.org/)

Established in 2003, ERTRAC aims to mobilize all stakeholders, develop a shared vision, and ensure timely, coordinated and efficient application of research resources to meet the continuing challenges of road transport and European competitiveness.

The mission of ERTRAC is below:

- Define strategies and roadmaps to achieve this vision through the formulation and maintenance of a Strategic Research Agenda (SRA) and Strategic Research Recommendations (SRR)
- Stimulate increased effective public and private investment in road transport research and development
- Contribute to improving coordination between the European, national, regional, and private research and development actions on road transport
- Enhance the networking and clustering of Europe's research and development capacity;
- Promote European commitment to research and technological development ensuring that Europe remains an attractive region for researchers and competitive industries

Further, it covers the following research areas in the road transport sector:

- Environment, Energy and Resources
- Safety and Security
- Transport, Mobility and Infrastructure
- Design and Production Systems

(4) WATERBORNE^{TP} (http://www.waterborne-tp.org/bal_ims_controler.php?menu=NDFhMmphPjY7NDBlN240ZQ===&page=1&reset=search)

Established at Jan. 25, 2005 as a forum for all stakeholders from the waterborne (sea and inland) sector, WATERBORNE develops a long-term vision, assesses the key challenges, and formulates R&D activities to meet the vision and SRAs for the related industries.

3) Joint Technology Initiative (JTI): Clean Sky (http://ec.europa.eu/research/transport/info/jti_en.html)

Joint Technology Initiatives (JTIs) are a new concept launched under the FP7 to involve long-term public-private partnerships (PPPs) that can carry out large-scale technological R&D programs and support strong, continuous, European-level industrial research.

Clean Sky, as the first JTI, will work to develop various technology demonstrators, including flight test vehicles that will be essential for successful market introduction. It will also deliver technologies enabling drastic reduction of fuel consumption, noxious emissions, and noise for the next generation of air transport systems.

4) Marco Polo (Intermodal Freight Transport) 2
(http://ec.europa.eu/transport/marcopolo/index_en.htm)

Initiated in 2003 and continued until 2006, the original purpose of the previous Marco Polo Programme was to unite segmented European freight systems into a single European freight transport system as recommended by the White Paper in 2001. The Programme aimed to reduce road congestion and to improve the environmental performance as well as intermodality of the freight transport system within the EU. To achieve these goals, it delivered three R&D projects, mainly in the freight transport, logistics, and other relevant markets.

The newly launched Marco Polo 2 under the FP7, which is planned to continue from 2007 to 2013, will cover broader areas than the previous program, such as motorways of the sea and traffic avoidance measures. Currently, a €400 million budget for 2007-2013 has been confirmed, and the DGET, which manages the Programme, predicts that every €1 in grants to Marco Polo will generate at least €6 in social and environmental benefits.

The Programme plans to support the following actions:

- Modal shift actions, which focus on shifting as much freight as economically meaningful under current market conditions from road to short sea shipping, rail, and inland waterways.
- Catalyst actions that change the way non-road freight transport
- Motorways of the sea actions achieving a door-to-door service, which shift freight from long road distances to a combination of short sea shipping and other modes of transport
- Traffic avoidance actions that integrate transport into production logistics, reducing freight transport demand by road with a direct impact on emissions
- Common learning actions that enhance knowledge in the freight logistics sector and foster advanced methods and procedures of cooperation in the freight market

5) EXTRA: Transport Research Knowledge Centre (http://ec.europa.eu/transport/extra/web/index.cfm)

Rather than a research framework or program, EXTRA is a search engine designed to raise awareness of the outputs of transport research at the European and national levels and to explain how these outputs can be utilized to shape the European transport policy for sustainable mobility. With EXTRA, it is possible to get some detailed information about previous and current programs undertaken in Europe.

6) Outside EU Organization: Transport and Urban Development (TUD) under the COST

(1) COST: European Cooperation in the field of Science and Technology Research
(http://www.cost.esf.org/index.php)

Founded in 1971, COST is an intergovernmental framework supporting European R&D cooperation. It is also the oldest European networking system among researchers. Non-European countries are allowed to join the COST framework. In 2006, 58 countries participated in the COST, including 34 EU member countries as well as 1 associate country, Israel. Further, more than 30,000 researchers are involved in 230 or more running actions.

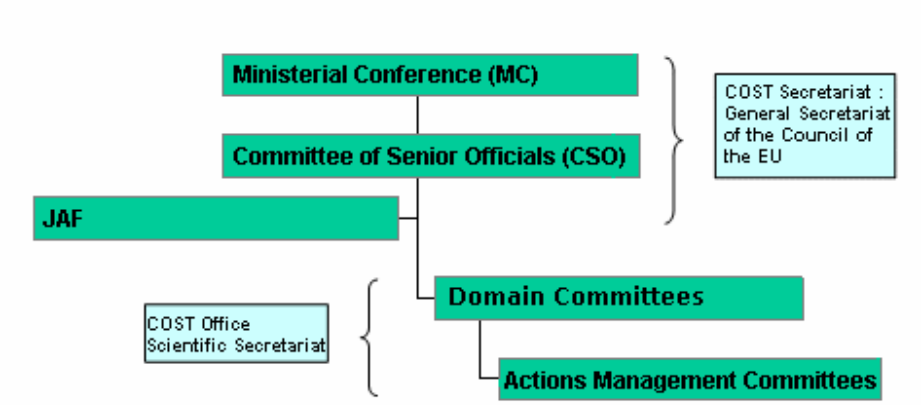
Although COST is not an official branch of the EU organization, the EU R&D related frameworks apply to it and the EU Council provides administrative support. to the COST Secretariat. Rather than

funding research itself, COST brings together research teams in different countries working on specific topics and supports networking, conferences, and short-term scientific exchanges, and produces publications.

COST includes 9 Domain Committees and several Interdisciplinary Ad Hoc Working Groups. Figure 3 shows the overall structure of COST:

- BMBS - Biomedicine and Molecular Biosciences
- CMST - Chemistry and Molecular Sciences and Technologies
- ESSEM - Earth System Science and Environmental Management
- FA - Food and Agriculture
- FPS - Forests, their Products and Services
- ISCH - Individuals, Societies, Cultures and Health
- ICT - Information and Communication Technologies
- MPNS - Materials, Physical and Nanosciences
- TUD - Transport and Urban Development
- Interdisciplinary Ad Hoc Working Groups in Cultural Heritage, Biomaterials, and Nanosciences

<Figure 3> COST organization chart



* Source: http://www.consilium.europa.eu/cms3_fo/showPage.asp?id=702&lang=en&mode=g

(2) Transport and Urban Development (TUD) (http://www.cost.esf.org/index.php?id=238)

TUD is one of the nine Domains under the COST framework. It aims to foster international research networking activities of scientists and experts dealing with transport systems and infrastructures, urban land use and development, architecture and design, and civil engineering issues. The following illustrate areas of actual research in this Domain:

- Sustainable transport and urban planning policy
  - Environmental and socio-economic impacts of transport, traffic safety, security and energy consumption
  - Modal diversion and modal re-equilibrium, intermodal solutions and interoperability among the different systems
- Design of transport systems and development of urban infrastructures
  - Transport infrastructures (building, development, maintenance, rehabilitation)
  - Development of new technologies both for infrastructures (materials, etc.) and for vehicles (alternative fuels, etc.)

- Urban architecture and civil constructions
    - Planning and design, covering urban design and architecture, urban constructions, reconstruction and rehabilitation of structures and buildings, including cultural heritage areas, green structures as well as issues of quality of life.

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AUSTRALIA CONTRUCTION R&D

A. Construction

1. Introduction

Since 1990, most R&D activities in Australia have been performed by the Cooperative Research Center (CRC). The CRC program is based on the partnerships among industry, business, educational institutions, Government, and Australian researchers. The program aims to enhance Australia's industrial, commercial, and economic growth through the development of sustained, user-driven, cooperative public-private research centers achieving high levels of outcomes in adoption and commercialization (DEST, 2006a). Currently, there are 71 CRCs in 6 industry areas. Table 1 shows the CRCs in Australia by industry:

<Table 1> Australia CRCs by Industry (technology)

Manufacturing Technology	CAST CRC
	CRC for Advanced Automotive Tech.
	CRC for Advanced Composite Structures
	CRC for Bioproducts
	CRC for Construction Innovation
	CRC for Functional Coomunication Surfaces
	CRC for Intelligent Manufacturing Systems and Techs
	CRC for microTech.
	CRC for Polymers
	CRC for Railway Engineering & Tech.
	CRC for Welded Structures
	CRC for Wood Innovations
ICT	Australasian CRC for Interaction Design
	Australian Photonics CRC
	Australian Telecommunications CRC
	Capital Markets CRC
	CRC for Enterprise Distributed Sustems Tech.
	CRC for Integrated Engineering Asset Management
	CRC for Sensor Signal and Information Processing
	CRC for Smart Internet Tech.
	CRC for Spatial Information
Mining & Energy	CRC for Clean Power from Lignite
	CRC for Coal in Sustainable Development
	CRC for Greenhouse Gas Techs
	CRC for Landscape Environments and Mineral Exploration
	CRC for Predictive Mineral Discovery
	CRC for Sustainable Resource Processing
	CRC Mining

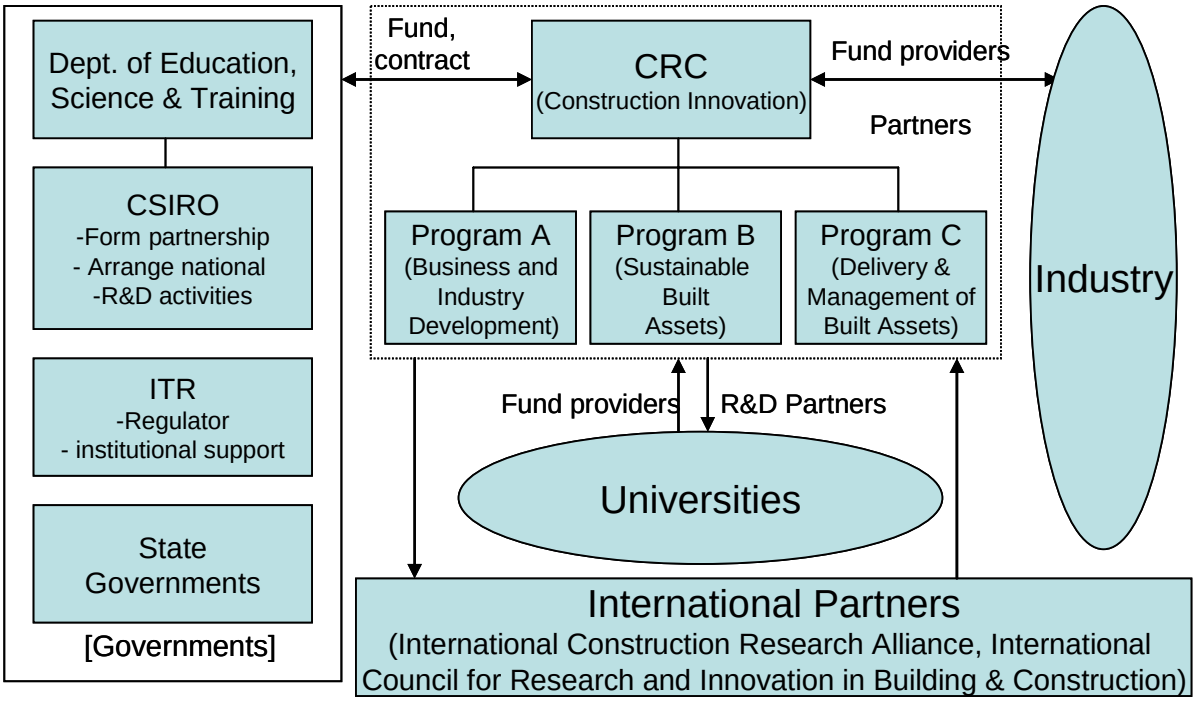
	Parker CRC for Integrated Hydrometallurgy Solutions
Agriculture & Rural Based Manufacturing	Australian Biosecurity CRC for Emerging Infectious Diseases
	Australian Sheep Industry CRC
	Cotton Catchment Communities CRC
	CRC for Internationally Competitive Pork Industry
	CRC for Beef Genetic Techs
	CRC for Forestry
	CRC for Innovative Dairy Products
	CRC for Innovative Grain Food Products
	CRC for National Plant Biosecurity
	CRC for Sugar Industry Innovation through Biotech
	CRC for Sustainable Aquaculture of Finfish
	CRC for the Australian Poultry Industries
	CRC for Tropical Plant Protection
	CRC for Value Added Wheat
	CRC for Viticulture
	Molecular Plant Breeding CRC
Environment	Bushfire CRC
	CRC for Antarctic Climate & Ecosystems
	CRC for Australian Weed Management
	CRC for Coastal Zone, Estuary & Waterway Management
	CRC for Contamination Assessment & Remediation of the Environment
	CRC for Greenhouse Accounting
	CRC for Irrigation Futures
	CRC for Plant-based Management of Dryland Salinity
	CRC for Sustainable Tourism
	CRC for the Great Barrier Reef World Heritage Area
	CRC for Tropical Rainforest Ecology & Management
	CRC for Tropical Savannas Management
	CRC for Water Quality & Treatment
	Desert Knowledge CRC
	Environmental Biotechnology CRC
	eWater CRC
	Invasive Animals CRC
Medical Science & Technology	CRC for Aboriginal Health
	CRC for Asthma & Airways
	CRC for Biomedical Imaging Development
	CRC for Chronic Inflammatory Diseases
	CRC for Cochlear Implant & Hearing Aid Innovation
	CRC for Diagnostics
	CRC for Oral Health Science
	CRC for Vaccine Technology
	The Vision CRC

* Source: (DEST 2006a)

All CRCs are funded from the Government as well as from the participants of each center; the relationship between CRCs and the Government is based on a formal agreement with the Commonwealth. The term of agreement can be continued up to seven years. The CRC for the construction industry, *CRC for Construction Innovation* (CRC CI), was established in July 2001 within the Manufacturing Technology area as shown in Table 1. CRC CI has 14 postgraduate researchers and 60 research staff involved in its activities. Its funding period from the Government is 7 years. The CRC CI's research expertise areas are business and industry development; sustainable built assets; and delivery and management of built assets underpinned with advanced ICT platforms.(DEST 2006a: 7).

Before the establishment of CRC CI, the Department of Industry, Tourism and Resources (ITR) had played a key role in developing plans and setting out priorities for each industry including the construction sector. However, after launching the CRC in the construction industry, the current Australian construction R&D function and related activities, such as developing plans or priorities, are handled by the CRC CI.

<Figure 1> Australia Construction R&D System



2. Laws and Regulations

There is no specific law or regulation in relation to the establishment or management of the CRCs. However, an organization which wants to participate in the CRC program should meet the requirements clarified in the CRC Funding Agreement between the Commonwealth and the CRC program. Regarding the Commonwealth Scientific and Industrial Research Organization (CSIRO) and related authorities, two laws can be considered: Science and Industry Research Act 1949 (SIR Act), and the Commonwealth Authorities and Companies Act 1997 (CAC Act).

3. Government Organizations Responsible for R&D Policy

Each CRC sets out individual strategic plans and priorities for its own industry; CRC CI is the main actor to make and implement strategy for construction industry.

1) Cooperative Research Center program for Construction Innovation (CRC CI)

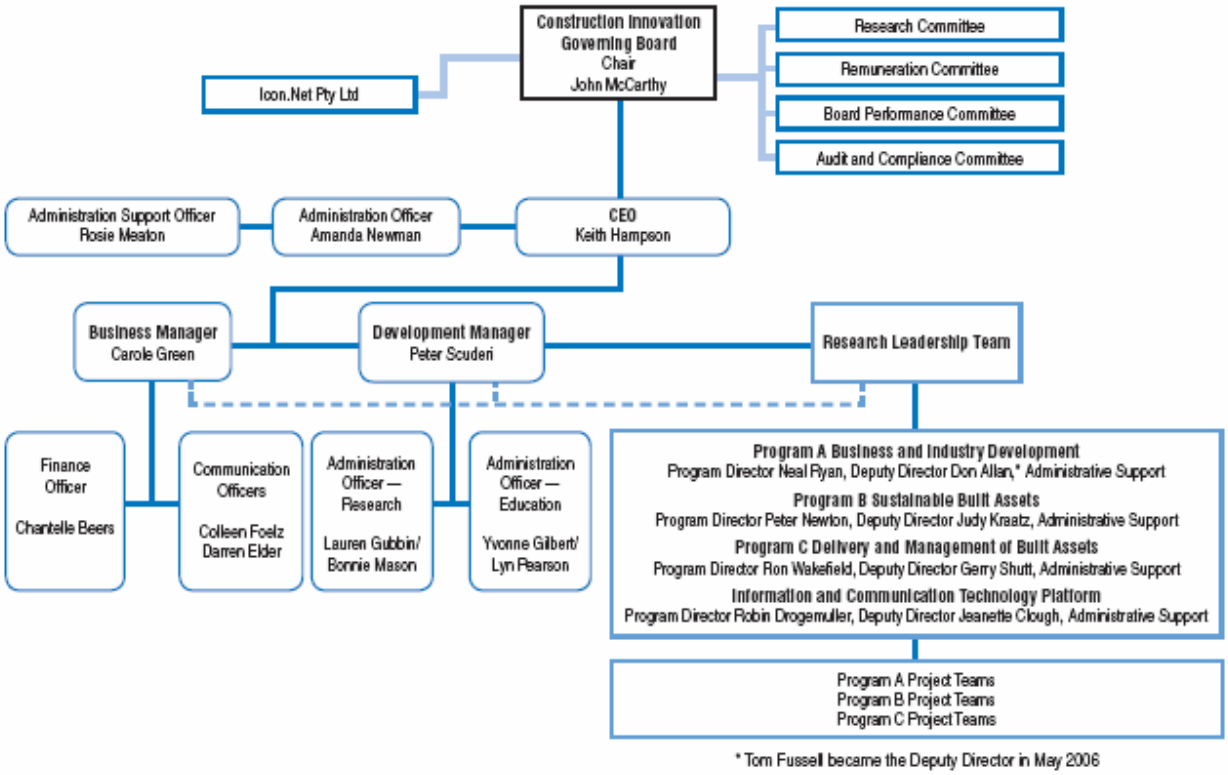
The CRC CI, headquartered at the Queensland University of Technology, was established in 2001 as a joint venture under the Australian Government's Cooperative Research Program. Its goal is to develop key technologies, tools, and management systems to improve the effectiveness and competitiveness of the construction industry in Australia. It aims to realize healthy and sustainable construction and optimize the environmental impact of built facilities. According to the CRC CI webpage (http://www.construction-innovation), its objectives are:

- To enhance the contribution of long-term scientific and technological research and innovation to Australia's sustainable economic and social development
- To enhance the collaboration between researchers, industry, and government, and to improve efficiency in the use of intellectual and research resources
- To create and commercially exploit tools, technologies and management systems to deliver innovative and sustainable constructed assets to further the financial, environmental and social benefit to the construction industry and the community

To realize its above organizational mission and objectivities, CRC CI is working mainly in areas such as building procurement, sustainability, 3D visualization, business innovation, facility management, and commercialization.

As shown in Figure 2, nine nominees selected from participant organizations comprise the Governing Board of CRC CI. Among the nominees, five should come from non-research institutions and four should come from research partners. The Governing Board holds responsibility for strategic and policy matters as they relate to the Center activities and for ensuring that the activities are carried out properly. The Icon.Net Pty Ltd holds intellectual properties from the all products of CRC CI. Decision making is facilitated by four different types of committees (Research Committee, Remuneration Committee, Board Performance Committee, and Audit & Compliance Committee).

<Figure 2> CRC CI Organization Chart



* Source: (CRC CI, 2006: 8)

4. Planning and Priority Setting

Although there are several planning documents created by the Center, the main plan based on the long-term prospective is the vision report, *Construction 2020: A Vision for Australia's Property and Construction Industry*, published in 2004. Another critical plan is the *Strategic Plan (2005-2008)*, which was prepared in 2005 to specifically convey the messages from the *Vision* report.

1) CRC CI (2004), *Construction 2020: A Vision for Australia's Property and Construction Industry*

This report was published in 2004 as the output of the *Construction 2020 Initiative*, carried out by the CRC CI. The Initiative aimed to present the current status of the Australian construction industry, provide guidance on ways to improve the status, identify the barriers to achieving the future directions, and to define the R&D activities needed to solve the challenges. This report was an agglomeration of the survey results (vision questionnaire) from the Australian property and construction industry, literature reviews, and expert opinions gathered from various workshops. It presents nine key visions of the Australian construction industry, the reasons for selecting each vision, the means to achieve individual visions considering the current status of the industry, and the barriers to achieving the visions.

The nine key visions are:

- Australian leadership in research and innovation (overarching vision)
- Environmentally sustainable construction
- Meeting client needs
- Improved business environment
-Welfare and improvement of the labor force
- Information and communication technologies for construction
- Virtual prototyping for design, manufacture and operation
- Off-site manufacture
- Improved process of manufacture of constructed products.

2) CRC CI (2005), *Executive Summary: CRC Strategic Plan (2005-2008)*

The CRC CI's strategic plan for the years from 2005 to 2008, *Strategic Plan (2005-2008)* was established in 2005. Although only the executive summary has been open to the public, it is possible to determine that the Center focuses on delivering its key values, including collaboration, integrity, research excellence, innovation and sustainability, and leadership responsibility, through numerous R&D projects. The Strategic Plan also shows how performance is measured by each factor. Table 2 outlines the main contents of goals and strategies presented in the Plan.

5. R&D Funding Organizations and Programs

1) Overall funding for CRC programs

In general, each CRC receives on average about $2.95 million in cash (ranging from $1.6 to 5.8 M) from the Government, mainly through the Department of Education, Science and Training (DEST). Centers also receive funding from their partner organizations. All participants have committed more than $11 billion to CRCs including $2.6 billion from the assigned funding for the CRC Program, $2.8 billion from involved universities, over $2 billion from industry, $1.2 billion from State Governments, $1.1 billion from the Commonwealth Scientific and Industrial Research Organization (CSIRO) and almost $0.5 billion from other Australian Government agencies.

2) Funding for CRC for Construction Innovation

According to the Commonwealth's CRC Directory 2006 (DEST, 2006a), the annual average funding for CRC for Construction Innovation is $ 9.2 million including $2.0 million from the Government's CRC Program funding. The total funding over the grant period is $64.5 million, including $14.0 M from CRC Program funding.

<Table 2> Main Contents of CRC CI Strategic Plan 2005-2008

Critical Success Factors		Goal	Strategies
	Quality Research	• Be positioned to provide ongoing research supports • Be recognized as the most essential source of relevant data and applied research in the industry • Be known as the lead developer • Be the focus for construction research in Australia and be recognized as the reference point for Australian research	• Maximize internal opportunities for collaboration with partner organizations through diverse initiatives • Coordinate research into and across the research programs to secure the strength of multi-disciplinary research and specialist expertise • Select and conduct excellent research • Leverage the CI funds through collaborating with key national and international partners • Map project achievements against "Construction 2020" • Engage industry early • Apply research outcomes through demonstration projects
	Education & Training	• Enhance the value of graduate researchers • Enhance the collaborative culture of construction • Partner with organizations developing educational & professional development courses	• Provide input to university curriculum development • Provide scholarship funds for qualified PhD and Master's students • Identify education and training opportunities from research projects • Provide opportunities to industry and researchers for continuous professional development • Work with existing professional development providers including professional associations
	External Communication	• Promote the benefits of collaboration and innovation in construction industry • Position the CI to achieve goals in research, education, and training	• Use simple, sharp messages to identify industry impacts • Target industry illuminaries • Develop robust and rigorous communication for government and industry
	Commercialization	• Enhance the research output and other outcome transfers into commercial to maximize the national economic, environmental, and social benefits	• Develop commercialization plan for targeted CI projects • Educate & train key personnel in the CI • Partner with others in the process of research outcome commercialization • Develop prototypes suitable for demonstration purposes • Ensure early involvement of potential commercialization partners
	Administration	• Provide effective management • Position the CI to response needs of the Australian construction industry	• Identify important drivers of the CI participants and response their needs better • Increase the CI's financial base • Leverage research activities to create a larger critical mass of research effort • Effective leadership and coordination among industry, government and research participants • Provide full administration support at the program level

* Source: CRC CI (2005), p.2

6. Institutions Conducting R&D

R&D activities in the CRC CI are mainly conducted by the partner institutions. Core participants of CRC CI are shown below:

- University: Queensland University of Technology, Royal Melbourne Institute of Technology, the University of Newcastle, the University of Sydney
- Australian Government: Australian Building Codes Board, CSIRO
- State Government: Building Commission (Victoria), QLD Department of State Development, Trade and Innovation, QLD Building Services Authority, QLD Department of Main Roads, QLD Department of Public Works
- Industry / Private Sector: Bovis Lend Lease Pty Ltd, DEM Architects, John Holland Pty Ltd, Ove Arup Pty Ltd, Rider Hunt Sydney Pty Ltd, Springfield Land Corporation Pty Ltd
- Other: Brisbane City Council

Further, some examples of the R&D performers in the CRC CI by sector are below (CRC CI, 2006):

1) Government sector

- Brisbane City Council
- Building Commission (Victoria)
- CSIRO
- Office of Federal Safety Commissioner
- Queensland Building Services Authority
- Queensland Department of Main roads
- Queensland Department of Public Works

2) Educational Institutions (Universities)

- RMIT University (in Melbourne)
- Queensland University of Technology
- University of Newcastle, University of Sydney
- University of Western Sydney

3) Industry

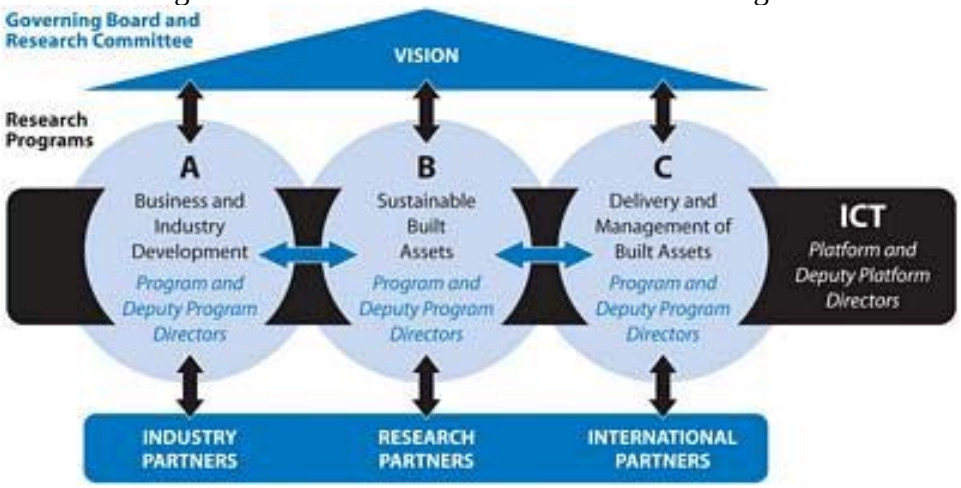
- Association of Consulting Engineers Australia
- Bovis Lend Lease
- Engineers Australia
- John Holland
- Leighton Holdings
- Master Builders Association

7. R&D Collaboration Programs

Within the CRC, three different types of collaboration program are available, depending on the focus area. Each program is closely related to other programs through ICT platforms and the interaction

among the program directors as shown in Figure 3. First, Program A, "Business and Industry Development," aims to improve the long-term effectiveness, competitiveness and dynamics of a viable property and construction industry in Australia; it includes three different themes. Second, Program B, "Sustainable Built Assets," seeks to drive healthy and sustainable constructed assets and optimize the environmental impact of built facilities with three different themes. Third, Program C, "Delivery and Management of Built Assets," is designed to deliver whole-of-life project value for stakeholders from business need, design, and construction, through to ownership, asset management, and reuse with three themes as well (CRC CI, 2006).

<Figure 3> CRC CI's Research Collaboration Programs



* Source: CRC CI homepage, from http://www.construction-innovation.info/index.php?id=49

1) Program A: Business and Industry Development

(a) Theme 1: Greater Innovation in Business Practice

- Building Research Innovation Technology and Environment (BRITE) (Jan. 2006~ Dec. 2007)

(b) Theme 2: More Effective Interactions between Industry and Clients

- e-Business Adoption (Aug. 2004~Jun. 2006)
- Supply Chain Sustainability (Jul. 2005~Jun. 2007)
- Construction Industry Business Environment (CIBE) (Jul. 2005~Jun. 2007)
- BSITE: Mobilizing Construction (Jul. 2005~Mar. 2006)
- Modeling Construction Business Performance (Feb. 2006~Jun. 2007)
- Electronic Contract Administration-Legal and Security Issues (Dec. 2005~Dec. 2006)

(c) Theme 3: Strengthened Human Relations and Ethical Practices

- Ethical Construction Procurement (Jun. 2003~Oct. 2005)
- Construction Site Safety Culture (Mar. 2005~Sep. 2006)
- Safer Construction (Feb. 2006~Jun. 2007)

2) Program B: Sustainable Built Assets

(a) Theme 1: A Sound Conceptual Basis for Economic, Social and Environmental Accounting of the Built Environment

- Sustainable Subdivisions–Ventilation (Oct. 2005~Jun. 2007)
- Sustainable Subdivisions–Energy and Water Efficient Design (Oct. 2003~Jun. 2006)
- Learning System for Life Prediction of Infrastructure (Oct. 2005~Jun. 2007)
- Your Building (Jul. 2005~Jun. 2007)

(b) Theme 2: Virtual Building Technology to Examine Design Performance prior to Documentation, Construction and Use

- SpecNotes and Viewer Extension (Jul. 2005~Jun. 2006)
- Team Collaboration in High-Bandwidth Virtual Environments (May 2003~Dec. 2005)
- Microclimate Impacts on the Built Environment (Feb. 2005~Oct. 2006)

(c) Theme 3: Assessment of Human Health and Productivity Benefits of Smart Indoor Environments

- Regenerating Construction to Enhance Sustainability (Jan. 2005~Dec. 2006)
- Right-sizing Air-conditioning Systems (Oct. 2004~Feb. 2006)
- Indoor Air Quality Estimator (Feb. 2006~Jan. 2007)

3) Program C: Delivery and Management of Built Assets

(a) Theme 1: Improved Communication and Use of Information

- Automated Estimating Civil Concrete Structures (Nov. 2005~Feb. 2006)
- Team Collaboration through Wireless Computing (Sep. 2004~Mar. 2007)
- Way-finding in the Built Environment Phase 2 and 3 (Dec. 2004~Jun. 2006)

(b) Theme 2: Increased Productivity and Value

- Off-site Manufacture in Australia (May 2006~Oct. 2006)
- Business Drivers for Building Information Models (May 2006~Jun. 2007)

(c) Theme 3: Effective Delivery and Management of Built Assets

- Sydney Opera House Facility Management Exemplar (Feb. 2005~Nov. 2006)
- Delivering a Re-life Project (Aug. 2004~Sep. 2006)
- Maintenance Cost Prediction for Roads (Aug. 2004~Jun. 2006)

8. Human Resource Development Programs

Education and Training is one of the key activities of CRCs. Currently, each CRC has its own education and training related programs, and in the case of CRC CI, there are two kinds of HR development programs: Construction Innovation's Education and Training Program and the Scholarship Program.

1) Construction Innovation's Education and Training Program
The purpose of the program is to enhance the value of Australian graduate researchers, to contribute to the collaborative culture of construction, and to partner with organizations to develop educational and professional development courses based on the outcomes from the CRC CI R&D activities. Table 3 shows the strategy for the CRC CI Education Program:

<Table 3> Program Management Strategy

Strategy 1 (Curriculum Development & Support)	**Strategy 2** (Student Support)	**Strategy 3** (Research Project Education Dispersion)	**Strategy 4** (Continuous Professional Development)
• Provide input to univ.	• Provide Scholarship funds and the industry reference for high quality PhD & Master's Students	• Identify education & training opportunities from research projects, • Develop greater appreciation & support from research teams for educational efforts	• Provide opportunities for continuous professional development for industry & research personnel
• Measure: the uptake of CI research outputs into univ. partners and related sectors	• Measure: the uptake of CI Research Scholarships by quality candidates, the amount of successful co-supervision of student by Industry Partners	• Measure: the uptake of CI inputs into curricula	• Measure: # of industry users using research outputs in their professional development programs

* Source: CRC CI homepage, from http://www.construction-innovation.info/index.php?id=372

In 2005-06, there were two kinds of education-related activities: Scholars' Workshops and Industry Forums. Two workshops were held in 2005-06, including the Construction Innovations' second international conference. Numerous industry forums were also held. Some examples by topic are presented below (CRC CI, 2006: 33):

- Sustainable Infrastructure in Aggressive Environments: workshops for industry partners at Queensland Department of Main Road (July 2005), workshop and technical evening at Queensland Department of Main Road (April 2006)
- Sustainability and Facility Management Forum, Sydney (August 2005)
- Innovation in the Building and Construction Industry, Road Systems and Engineering Forum, Department of Main Roads, Brisbane (August 2005)
- An Overview of CRC Major Research Findings/Results and Future Plans (August 2005)
- Presentation of Six Final BRITE Project case studies to industry, Brisbane (November 2005)
- Queensland Department of Main Roads Industry Partner Workshop (December 2005)
- *DesignCheck* Industry Information Session, Melbourne (November 2005)

- *LCADesign* Demonstrations to Help Industry Gain an Understanding of Its Capabilities, Sydney (February 2006)
- *Your Building* Workshops, Sydney and Perth (May 2006)

2) Scholarship Program

The Scholarship Program aims to produce impressive academic outcomes, well-informed young professionals, and a strengthened capacity to provide applied solutions to the Australian construction industry. The CRC CI's Scholarship Program supports 12 Ph.D. and Master's program students enrolled in the partner universities, such as the University of Sydney or Queensland University of Technology. The students supported by the program are working on diverse topics covering the full spectrum of the CRC CI activities.

AUSTRALIA TRANSPORTATION R&D

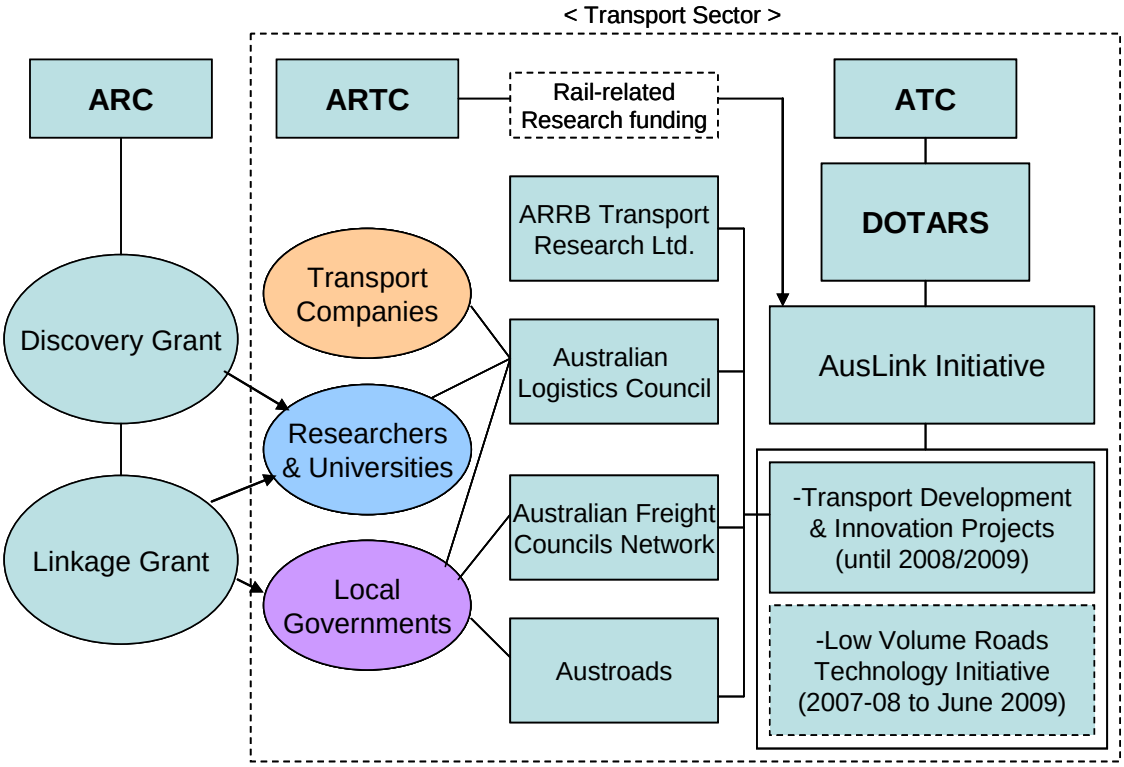
B. Transportation

1. Introduction

Like the construction industry, the Australian transport R&D system has been changing rapidly, especially in the land transport area. The changes are driven largely by the newly launched Governmental project, the AusLink Initiative, implemented in 2005 by the Department of Transport and Regional Services (DOTARS). The Initiative is based on the close relationships among the government sector, national industry associations, and transport sector; various players are involved in putting the initiative into practice. Although the Initiative covers all kinds of transportation related Government activities, its two R&D related projects play a key role in Australian transport R&D.

Figure 4 describes how the Australian transport R&D system is currently working. First, DOTARS plans and delivers the R&D related projects included in the AusLink Initiative, interacting with other institutions such as universities and industry associations. Separate from the Initiative, each organization also conducts research projects funded by the industry sector and Government research organizations, such as the Australian Research Council (ARC).

<Figure 4> Australian Transportation R&D System



2. Laws and Regulations

The AusLink Act 2005 was prepared to provide the legal basis for the AusLink Initiative, to assist national and regional economic and social development by delivering the Initiative, and to specify the six different funded programs under the Initiative. Particularly, Part 4 and 5 describes the transport R&D as well as the funding framework for the research entities in the AusLink Initiative (AG, 2005).

1) *The AusLink (National Land Transport) Act 2005*

Its six main programs are below:
- AusLink National Projects
- Transport Development and Innovation Program (or Projects)
- Land Transport Research Entities
- Strategic Regional Program
- Black Spot Program
- Roads to Recovery Program.

Among the six programs, the program directly related to transportation R&D is the Transport Development and Innovation Program, funding for which is covered under Part 4 of the Act. Part 4 clarifies the requirements for projects to be approved/funded and explains the process for acquiring funding and identifies the eligible projects for getting the Commonwealth funding through regulating sources, mandatory conditions, and determination of funding agreement. Part 5 of the Act explains the funding process for the Land Transport Research Entities Program.

(a) Part 4: AusLink Transport Development and Innovation Projects

- According to the definition of the Act, eligible projects for the Minister's approval are below:
    - Planning, research, investigation, studies or analysis of matters related to the present or future development or usage of the National Land Transport Network (NLTN)
    - R&D related to technology or practices that will, or could, be used in connection with transport operations on the NLTN

The Act directs that projects should be related to efficiency, security or safety of transport operations; should propose to increase the economic, environmental or social impact or performance of the National Land Transport Network; or should assist better-informed decision-making of the NLTN. The funding for the Projects comes from Commonwealth funding, and it is controlled by the funding agreement between the Australian Government and the recipients of each project.

(b) Part 5: AusLink funding for Land Transport Research Entities

- This section specifies the meaning of funded entity, funding approval instrument, funding period, and land transport research entity.

3. Government Organizations Responsible for R&D Policy

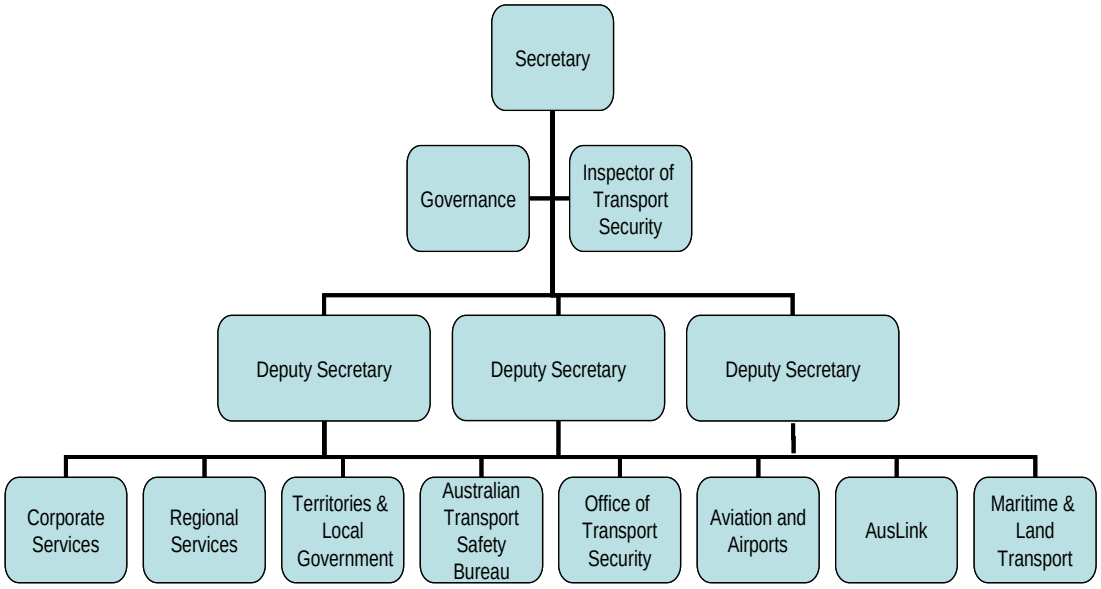
There are several Government organizations that establish plans or setup priorities for transport R&D. Although DOTARS is the main actor, the Australian Transport Council (ATC) is also important and functions as a forum having responsibilities in coordinating and integrating all transport and road policy issues.

1) Department of Transport and Regional Services (DOTARS)

As the Government department in charge of the whole transport area, DOTARS aims to provide safe, efficient, competitive, sustainable, and accessible transport systems to the nation. It also advises policy and provides support for the national Transport and Regional Services portfolio, as well as delivering diverse programs in relation to Australian transport. It also covers regulatory functions in the transport area. DOTARS prepared the White Paper for AusLink, "Building our National Transport Future," which is the fundamental plan for national transportation.

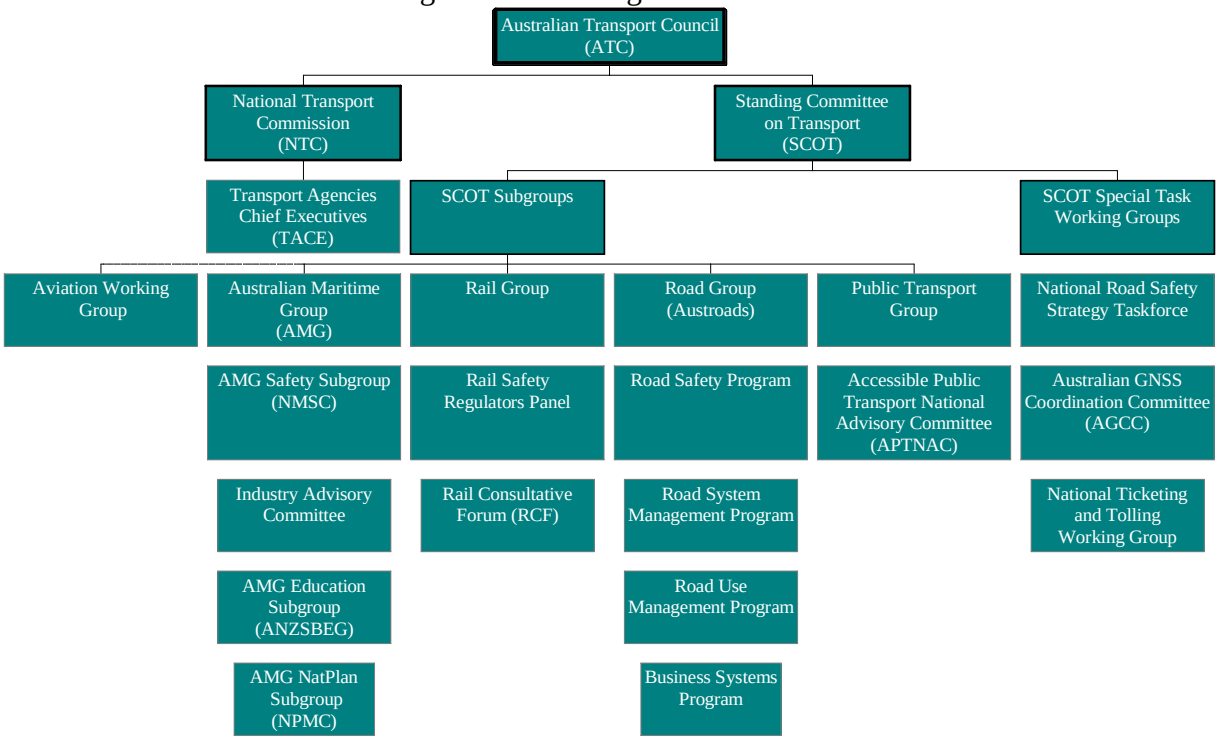
According to its webpage (http://www.dotars.gov.au), the key policy roles of DOTARS are:
- Promoting the integration of transport and regional development
- Promoting safe and secure transport solutions
- Providing a framework for competition between and within transport modes
- Promoting a transport system that is accessible, sustainable, and environmentally responsible
- Providing funding for transport infrastructure
- Ensuring that the legislative regimes and systems of governance of Australia's territories meet local and national needs
- Aligning conditions and standards in the territories with those of comparable communities in the rest of Australia
- Promoting efficient and effective local government which fosters a strong sense of community
- Providing policy advice on Government strategies to maximize the potential of Australia's regions
- Ensuring information about relevant Government policies and programs is disseminated effectively to regional Australia
- Maintaining and enhancing the significance of the national capital for all Australians

<Figure 5> DOTARS Organization Chart



* Source: Created based on the DOTARS homepage, from http://www.dotars.gov.au/department/dotars/structure.aspx

<Figure 6> ATC Organization Chart



* Source: ATC homepage, from http://www.atcouncil.gov.au/about_us/org_chart.aspx

2) Australian Transport Council (ATC)

The Australian Transport Council was established in June 1993 to provide a forum for Commonwealth, State, Territory and New Zealand Ministers to consult and provide advice to governments on the coordination and integration of all transport and road policy issues. Its vision is to maximize the contribution of effective transport to Australia's productivity, quality of life and equity; its objectives are to achieve an efficient, safe, sustainable, accessible and competitive transport system in Australia. The ATC's publication, "National Guidelines for Transport System Management in Australia" in 2006 provides a new policy framework to support transport-related decision making.

4. Planning and Priority Setting

There are two key Government documents related to Australian transport R&D. The first one, the AusLink White Paper *Building our National Transport Future* is important in designing a new paradigm for land transport planning, funding, and investment decision making. Its limitation is that it only focuses on land transportation, but it was instrumental in the creation of the AusLink Act. The second one, *National Guidelines for Transport System Management in Australia,* which was prepared by the ATC in 2006, discusses how the decision-making process could be managed efficiently, as well as how the performance of national-level initiatives could be measured.

1) DOTARS (2004), *Building our National Transport Future*

(a) Aims

- To promote sustainable national and regional economic growth, development, and connectivity by contributing to the development of an integrated National Network which:
    - Improves national and interregional connectivity for people, communities, regions, and industry
    - Improves national, interregional, and international logistics
    - Enhances national, interregional, and international trade
    - Enhances health, safety, and security
    - Is consistent with the obligation to current and future generations to sustain the environment
    - Is consistent with viable, long-term economic, and social outcomes
    - Is linked effectively to the broader transport network

(b) Core components

- AusLink National Network: defines important road and rail infrastructure links and their intermodal connections
- National Land Transport Plan: outlines the Government's approach to improve and integrate the National Network, and the investment to realize the Plan
- A single funding regime, under a new AusLink programme, for the National Network
- Separately-distributed funding for local and regional transport improvements
- New legislative, intergovernmental and institutional mechanisms

(c) Essential Characteristics of AusLink different from the previous plans

- Provides an integrated and systematic approach to planning
- Involves shared responsibility and funding for the National Network with state and territory governments
- Clarifies national focus on sustainable development and connectivity considering community health, safety, and security at the same time
- Encourages integrated land use and transport planning to protect vital national transport corridors and improve transport, urban development, and environmental outcomes
- Promotes a consistent approach to translate better planning into better solutions
- Encourages private sector involvement in land transport infrastructure planning, financing, operation, and ownership

(d) The National Land Transport Plan

- Overview:
    - The blueprint for improving the National Network into the future
    - Will be operated on a rolling five-year basis
    - Contains strategic directions developed by the Australian Government to guide its investment priorities
    - Sets out the projects that the Australian Government will fund in the period from 2004-05 to 2008-09 cooperating with state and territory governments and the private sector
- Funding overview:
    - AusLink is jointly funded by the Australian Government and the Australian Rail Track Corporation in the National Network over the five years
    - Total $8.6 billion
    - 78% will be invested in road projects ($6.7 billion)
    - 21% will be invested in rail projects ($1.8 billion)
    - 1% will be invested in research and technology
    - Components of the funding
- Strategic directions (2004-05 ~ 2008-09):
    - Planning on an integrated long-term basis: planning based on the negotiation between the Australian Government and the States/Territories
    - Improving the eastern seaboard north-south corridors: improving the capacity and performance of eastern seaboard north-south interstate corridors
    - Improving the capacity and reliability of other interstate and interregional corridors
    - Addressing congestion on key urban links
    - Utilizing technology: improving infrastructure performance by facilitating the development and application of appropriate and cost-effective new technologies
    - Improving safety and security: improving safety on the National Network along with the National Road Safety Strategy and through the Australian Rail Track Corporation
    - Protecting past investment
    - Supporting regional and local economic growth: improving the capacity of local government to address local transport infrastructure backlogs and to fund projects regionally important

<Table 4> Australian Government Land Transport Infrastructure Funding, 2005-06

	NSW $m	VIC $m	QLD $m	WA $m	SA $m	TAS $m	NT $m	ACT $m	Other $m	Total $m
AusLink National Network	480.8	291.2	248.3	96.4	92.2	27.2	31.0	0.5	6.9	1,274.4
AusLink National Projects (Rail, HML, research and technology)									46.0	46.0
AusLink Network Sub Total [1]	**480.8**	**291.2**	**248.3**	**96.4**	**92.2**	**27.2**	**31.0**	**0.5**	**52.9**	**1,320.4**
Roads to Recovery	85.0	62.5	62.5	45.0	25.0	10.0	5.0	5.0		300.0
Strategic Regional Programme (including unincorporated areas)	16.8	6.6	2.9	1.0	2.7	5.3	5.0		0.2	40.6
Roads to Recovery Sub Total	**101.8**	**69.1**	**65.4**	**46.0**	**27.7**	**15.3**	**10.0**	**5.0**	**0.2**	**340.6**
Black Spot Programme	14.3	10.4	8.9	5.0	3.5	1.1	0.7	0.6	0.5	45.0
Untied Local Road Grants	144.2	102.5	93.1	76.0	27.3	26.3	11.6	15.9		497.0
Supplementary funding to SA Councils					9.0					9.0
Federation Fund		9.5								9.5
Total	**741.1**	**482.8**	**415.7**	**223.4**	**159.7**	**70.0**	**53.3**	**22.0**	**53.5**	**2,221.5**

* Source: DOTARS homepage, from http://www.dotars.gov.au/department/statements/2005_2006/media/trs1.aspx
Note) Figures may not add precisely to totals due to rounding.

2) ATC (2006), *National Guidelines for Transport System Management in Australia*

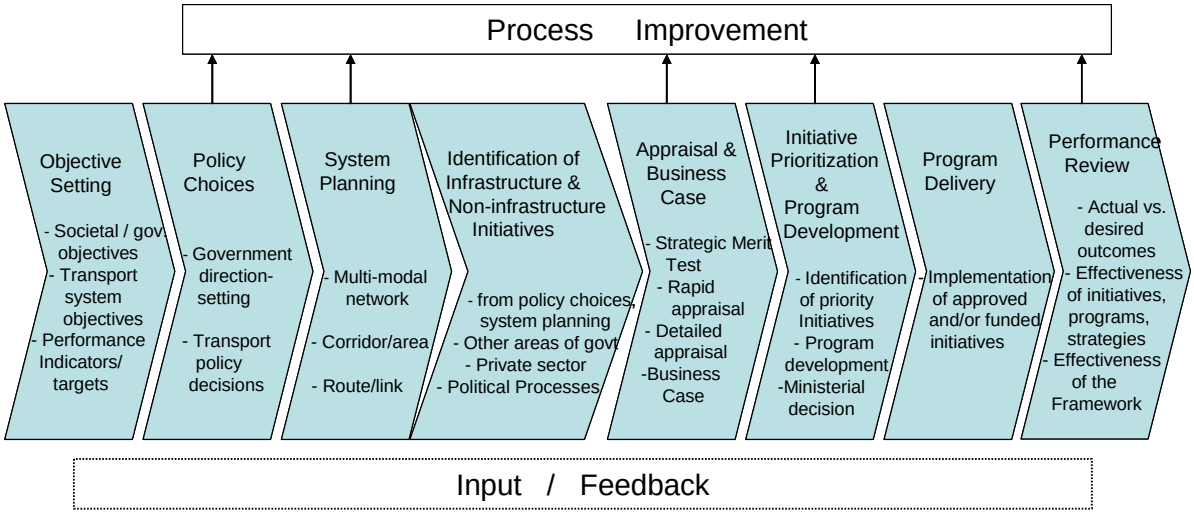
(a) Aims

- Support transport sector decision-making
- Provide an approach and national standard for all strategic planning and appraisal of transport initiatives
- Guide and complement existing practices
- Promote consistency, objectivity and transparency in the assessment of initiatives within and across modes, undertaken by different jurisdictions and analysts
- Move Australia towards a more holistic, multi-modal approach to transport policy, planning and assessment that compares all feasible solutions and takes full account of social, environmental and economic factors
- Provide a basis for integrating with, and implementing, related initiatives

(b) Composition: 5 volumes

- Volume 1: Introduction to the Guidelines and Framework
- Volume 2: Strategic Transport Planning and Development
- Volume 3: Appraisal of Initiatives
- Volume 4: Urban Transport
- Volume 5: Background Material (including detailed supporting materials)

<Figure 7> Transport System Management Framework provided by ATC



* Source: ATC (2006: 9)

5. R&D Funding Organizations and Programs

All the Government funding for the AusLink R&D Projects, which is managed and controlled by DOTARS, comes from the Commonwealth funding based on the funding agreement. Otherwise, Australian Research Council (ARC) provides its funding to the transport sector through the Discovery and/or Linkage Grants in the National Competitive Grants Program. Lastly, there is a special funding company for the Australian rail industry.

1) Commonwealth funding (DOTARS)

- DOTARS plays a key role in implementing the Commonwealth funding in the transport industry.

2) Australian Research Council (ARC) Grant Program: NCGP

(a) National Competitive Grants Program (NCGP)

- Funding Areas:
  - Support for the highest-quality research leading to the discovery of new ideas and the advancement of knowledge
  - Financial assistance towards facilities and equipment that researchers need to be internationally competitive
  - Support for the training and skills development of the next generation of researchers
  - Incentives for Australia's most talented researchers to work in partnership with leading researchers throughout the national innovation system and internationally, and to form alliances with Australian industry

- Overall fields of funding:
  - Biological Sciences and Biotechnology
  - Engineering and Environmental Science
  - Humanities and Creative Arts
  - Mathematics, Information and Communication Sciences
  - Physics, Chemistry, and Geoscience
  - Social, Behavioral and Economic Sciences

- Types of funding:
  - Discovery Grant:
    - Discovery Indigenous Researchers Development
    - Discovery Projects
    - Federation Fellowships
  - Linkage Grant:
    - ARC Research Networks
    - Linkage Infrastructure, Equipment and Facilities
    - Linkage International
    - Linkage LASP
    - Linkage Projects
  - Centers:
    - ARC Centers of Excellence (CE)
    - ARC Special Research Centers
    - Co-funded Centers of Excellence
  - Special Research Initiatives:
    - ARC Center of Excellence in Policing and Security (CEPS)
    - Australian and New Zealand Council for the Care of Animals in Research and Teaching (ANZCCART)
    - Anglo-Australian Observatory Fellowship (AAO Fellowships)
    - Thinking Systems

(b) ARC Grants related to transportation R&D: Discovery and Linkage Grants

- ARC Discovery Grant (Discovery Projects)
  - Derivation of Emissions Models for Commercial Vehicles (AU$ 225,000)
    - Institution: University of South Australia
    - To develop emissions models for commercial vehicles that are capable of modeling changes in driver behavior
  - Control Strategies for Idle Speed of Automotive Engines (AU$245,000)
    - Institution: The University of Melbourne
    - To realize higher level of fuel efficiency by reducing engine idle speed

- ARC Linkage Grants (Linkage Projects)
  - Emerging Futures: Transit-oriented Development as a Strategy for Dealing with Urban Sprawl and Congestion in South East Queensland (SEQ) (AU$297,000)
    - Partner organizations: The University of Queensland, Queensland Rail, Queensland Transport
    - Examine the phenomenon of urban sprawl in SEQ to understand how sprawl is impacting architectural and urban environments
  - Effectiveness and Appropriateness of Child Restraints (AU$360,000)

    - Partner organizations: The university of New South Wales, Motor Accidents Authority of NSW, NSW Roads and Traffic Authority
    - To provide a definitive picture of the use, misuse and inappropriate use of child restraints in motor vehicles
    - Evaluate the biomechanical and size deficiencies of current child restraints
- Developing Light Weight Automotive Structures (AU$596,000)
    - Partner organizations: Deakin University, Ford Motor Company of Australia Ltd
    - To develop a detailed understanding of the forming and post-forming properties of a range of high-strength formable steels and to design and produce new lighter-weight automotive structures

3) Australian Rail Track Corporation (ARTC)

<Table 5> ARTC Investment Program in the Melbourne-Sydney-Brisbane corridor, 04-05 to 08-09

Works	Melbourne - Sydney ($m)	Sydney - Brisbane ($m)	Hunter Valley ($m)	Total ($m)
Passing lanes and other crossing facilities	274.6	89.7	38.0	**402.3**
Works to increase speed through curves	40.6	12.1	9.9	**62.6**
Southern Sydney Freight Line	192.0	0.0	0.0	**192.0**
Train control consolidation and upgrade	40.3	7.2	12.5	**60.0**
Renewal investment	100.8	32.4	325.5	**458.7**
Contingency and unallocated	41.5	11.8	16.0	**69.3**
Tottenham Bypass	15.0	0.0	0.0	**15.0**
Concrete sleepers	287.0	113.0	0.0	**400.0**
Increase clearance to allow for larger containers and car transporters	20.0	20.0	0.0	**40.0**
Investment Program Total	**1011.8**	**286.2**	**401.9**	**1699.9**

*Source: DOTARS homepage, from http://www.auslink.gov.au/funding/projects/rail.aspx

The Australian Rail Track Corporation is one of the main funding organizations in the Australian rail industry. It was established in 1998 by the Australian Government to manage and develop Australia's interstate track infrastructure as a single entity. Currently, ARTC takes the form of a public company whose shares are wholly owned by the Australian Government and it owns or leases the interstate track from Kalgoorlie to the NSW/QLD border. It is financed by fees charged to commercial operators to access the track that it maintains, revenue received from maintenance contracts, Australian Government equity, commercial borrowings, and direct grants from the Australian Government. Table 5 shows individual project and funding size in the plan for the innovation of the Melbourne-Sydney-Brisbane corridor.

6. Institutions Conducting R&D

Core R&D performers in the Australian transport industry can be divided by the type of R&D programs or funding source. Currently, there are four different types of R&D performers. First, the institutions that are clearly mentioned in the Act are: Austroads, ARRB Transport Research Ltd, Australian Logistics Council, and Australian Freight Councils Network (AFCN). Second are the core participants (not yet determined) of the second AusLink R&D Initiative, Low Volume Road Technology Initiative. Third, there are some universities, local governmental authorities, and private actors who are funded by the governmental grants. Last, there are some other Australian institutions, which are famous for its R&D capacities: these are mentioned in the book introducing Australian transport R&D, *Transport Innovation: A New Era for Australia.*

1) Legally authorized participants of the AusLink Transport Development and Innovation Projects

(a) Austroads (http://www.austroads.com.au/)

- Association of Australian and New Zealand road transport and traffic authorities
- Membership: six Australian State and two territory road transport and traffic authorities, DOTARS, the Australian Local Government Association (ALGA), and Transit New Zealnd
- Purpose: undertake nationally strategic research, promote improved practice by Australasian road agencies, facilitate collaboration between road agencies to remove redundancy, promote harmonization and uniformity in road and related operations, provide expert advice to the ATC and SCOT (under the ATC)

(b) ARRB Group Ltd. (http://www.arrb.com.au/)

- A private company doing research, delivering technology (or software) products, and holding related industrial conferences

(c) Australian Logistics Council (http://www.austlogistics.com.au/)

- A partnership between Australian Governments and senior leaders in the logistics field including logistic users, suppliers, peak bodies and academics
- Purposes: to lead the development of logistics in Australia and to create competitive advantage for Australian companies and the Australian economy

(d) Australian Freight Councils Network (AFCN) (http://www.freightcouncils.com.au/)

- The network of 11 Air and Sea Freight Councils in each State of Australia with a Freight Working Group operating in the Northern Territory
- The councils were established to be a help in improving logistics chains for the export of perishable products as well as non-perishable logistics chains

2) Participants of the Low Volume Road Technology Initiative

The participants of the Low Volume Road Technology Initiative will be specified in 2007.

3) Participants of the Australian Research Council (ARC) Grants

The R&D performers supported by the ARC Grants are divided by the type of grant.

- ARC Discovery Grants
  - University of South Australia, Univ. of Melbourne

- ARC Linkage Grants
  - University of Queensland
  - University of New South Wales
  - Deakin University
  - Queensland Rail (local governmental authority)
  - Queensland Transport, Motor Accidents Authority of NS
  - NSW roads and Traffic Authority
  - Ford Motor Company of Australia Ltd (private sector company)

4) Others: Major Australian Centers doing transport research and their focus areas

(a) ARRB Transport Research Ltd (http://www.arrb.com.au/)

This company is also one of the main participants of the AusLink Transport Development and Innovation Project.

(b) Bureau of Transport and Regional Economics (BTRE) (http://www.btre.gov.au/index.aspx)

- Based in Canberra
- Operates with DOTARS to provide information and analysis for the Government and the community
- Main Research Themes:
  - Useful facts and statistics about transport
  - Rail, road and air transport reform: issues in regulatory and technical harmonization of rail's regulatory, operational, and technical frameworks

(c) Manufacturing and Infrastructure Technology (CMIT) within the Commonwealth Scientific and Industrial Research Organization (CSIRO) (http://www.csiro.au/)

- Provides new methods for transport forecasting and analysis to local, state, and Australian Governments
- Carries out logistics research for industry

(d) Planning and Transport Research Center (PATREC) (http://www.patrec.org/)

- Areas of educational and research focus:
  - Integrated transport and land use planning
  - Transport economics
  - Logistics management and business logistics systems and tools

- Transport modeling and data management
- Transport sustainability
- Transport safety and risk management

(e) Institute of Transport Studies in Monash University (http://civil.eng.monash.edu.au/its)

- Focused research areas:
  - Travel demand including mobility management and travel behavior change
  - Transport operations
  - Transport and traffic management
  - Public transport planning and management

(f) The Australian Center for Integrated Freight Systems Management in the University of Melbourne (http://www.soe.unimelb.edu.au/Content.aspx?topicID=326)

- Focuses on research and teaching in freight systems design and management

(g) Transport Systems Center (TSC) in the University of South Australia (http://www.unisa.edu.au/tsc/)

- Addresses major issues of contemporary transport and logistics including:
  - Transport planning and policy
  - Logistics
  - Energy and emissions
  - Transport management and control
  - Spatial information technology
  - Sustainable transport

(h) School of Civil and Environmental Engineering in the University of New South Wales (http://www.civeng.unsw.edu.au/)

- Main research areas:
  - Micro-simulation modeling of road-based urban transport systems
  - Simulation and animation models for light rail systems and bus services
  - Facility location
  - Intelligent Transport Systems: analysis of route guidance systems and modeling of traffic information delivery systems

(i) Queensland University of Technology (http://www.qut.edu.au/)

- School of Urban Management
  - Multi-combination vehicles
  - Adoption of e-business systems in the Australian freight rail industry
  - An integrated system to optimize container transfers at multi-modal terminals

- The Centre for Eye Research
  - Developed a system based on photogrammetric principles to measure the distance between drivers and road signs or pedestrians accurately
  - Develops technologies to assess driving performance under low light levels

- The International Laboratory for Air Quality and health (ILAQH)
  - A World Health Organization Collaborating Center on Global Burden of Disease Due to Air Pollution
  - Research areas: vehicle emissions and their impacts of urban air quality and human health risk

(j) The University of Queensland (http://www.uq.edu.au/)

- The Centre for Transport Strategy
  - A partnership between the University of Queensland and Queensland's transport agencies
  - Undertakes cross-disciplinary research and provides professional development and services
  - Leadership in transport strategy and advanced transportation technology
  - Focus areas: transport policy & institutional development, integrated transport planning, intelligent transport systems, transport management and operations, passenger transport, transport economics, travel demand management, sustainability of transport and stakeholder & community interaction

- The ITS Research Laboratory
  - Provides high-end computing and communications servers and wide range of software tools

7. R&D Collaboration Programs

DOTARS currently operatesns two Governmental R&D projects based on the collaborations among the Government, transportation industry, and educational institutions under the AusLink framework. In addition, the Australian transport industry and universities are actively interacting through numerous kinds of other Government funding programs such as ARC's NCGP and Discovery Grant as already mentioned in the section of funding.

1) AusLink Transport Development and Innovation Projects

Although the Projects are not initiated, according to the *AusLink (National Land Transport) Act 2005*, the projects should meet either or both of the purposes below:
- Planning, research, investigations, studies or analysis of matters related to the present or future development or usage of the National Land Transport Network
- and/or research or development related to technology or practices that will, or may, be used in connection with transport operations on the National Land Transport Network. For achieving the purposes of the Projects, $38 million-funding for the year of 2008-2009 is available.

The core participants specified by the Act are:
- Austroads
- ARRB Transport Research Ltd
- Australian Logistics Council
- Australian Freight Council Network.

In addition, some examples of Transport Development and Innovation Projects are:
- National Traveler Information Service
- Transport Logistics Track and Trace Systems

- Variable Speed Limits Trial
- Corridor Studies to Support the Development of Long-term Investment Strategies for Each of the 24 Corridors of the AusLink Network

2) Low Volume Road Technology Initiative

Not implemented yet, the Low Volume Road Technology Initiative aims to promote the investigation and development of new technology or the new application of existing technology to enhance the efficiency and effectiveness of low volume roads. Currently, funding of $ 2.5 million from 2007-08 to June 2009 has been confirmed, and the process of colleting applications and selecting proposals is in progress. Approximately five projects are available under this Initiative.

8. Human Resource Development Programs

Compared to the construction industry, in which the CRC CI manages several training and education programs especially for the construction industry, there is no specific program in the transport industry. However, the Australian Research Council (ARC) is delivering some training and skill development programs for the next generation of researchers in general.

There are two different types of training programs under the ARC's Discovery Scheme. The first program is to provide salary support to native researchers; and the other one is given as awards.

1) Discovery Indigenous Researchers Development (http://www.arc.gov.au/ncgp/dird/dird_default.htm)

This program provides salary support to native Australian researchers and postgraduate research students to develop research expertise and experience to a level that is competitive with applicants for mainstream funding.

2) Discovery Federation Fellowships (http://www.arc.gov.au/ncgp/fedfellows/ff_default.htm)

It provides awards to attract and retain outstanding researchers to Australia, to build and strengthen Australia's world-class research capacity, to support ground-breaking internationally competitive research, and to develop strong links among researchers, industry, and the international research community. Up to 25 fellowships are available on an annual basis; the awardees get a specified salary and a standard tenure for five years.

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7. Austroads, from http://www.austroads.com.au/
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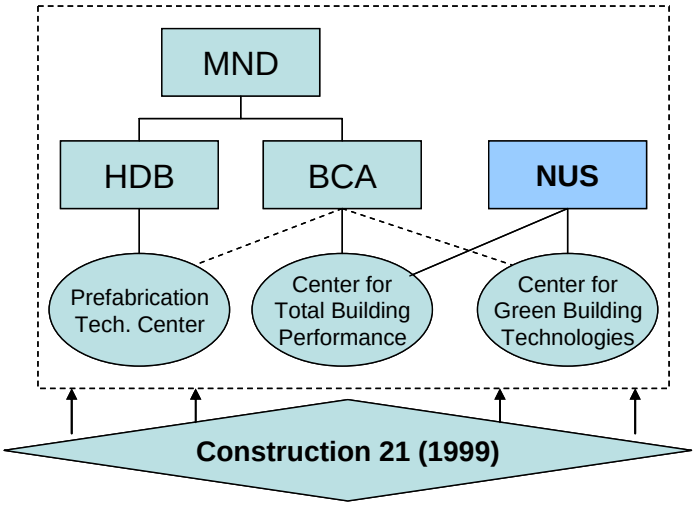
SINGAPORE CONSTRUCTION R&D

A. Construction

1. Introduction

<Figure 1> Singapore Construction R&D System



In general, the current construction R&D system of Singapore follows the main recommendations developed by the Construction 21 report, which was published in 1999. Although the report was a cooperative effort between the Ministry of National Development (MND) and the Ministry of Manpower (MOM), currently, efforts to improve the construction industry performance are made by the Building and Construction Authority (BCA) under the MND. It appears that Singapore adopted the UK model for reforming their construction R&D effort.

2. Laws and Regulations

The *Building and Construction Authority Act (Cap. 30A)* defines the responsibilities of the Authority, allows for the establishment, incorporation, and constitution of Authority and the function of, provision for, and funding of the BCA within the MND.

3. Government Organizations Responsible for R&D Policy

Although the fundamental plan supporting Singapore construction R&D, Construction 21, was developed by the MND and MOM, the current key actor in construction R&D sector is BCA under the MND.

1) Building & Construction Authority (BCA) in MND (http://www.bca.gov.sg/index.html)

BCA is an agency under the Ministry of National Development (MND) whose organizational mission is to shape a safe, high quality, sustainable, and friendly built environment. BCA's four key areas are safety, quality, sustainability, and user-friendliness, it also values "iCARE," which means innovative spirit, cohesiveness, advancement, responsibility, and excellence, respectively. In addition, its strategic goals are:

- To be a caring and progressive organization that values its people, the innovative spirit, integrity, and service excellence;
- To ensure high safety standards and promote quality excellence in the built environment;
- To champion barrier-free accessibility and sustainability of the built environment;
- To lead and transform the building and construction industry by enhancing skills and professionalism, improving design and construction capabilities, developing niche expertise, and promoting export of construction related services;
- To forge effective partnerships with the stakeholders and the community to achieve its vision.

BCA is divided into seven functional divisions as shown below.

(a) Building engineering division
- Approval of structural plans
- Construction site inspections
- Permit for building works
- Review building regulations
- Registration of Accredited Checkers

(b) Building plan and management division
- Approval of building plans
- Issuance of TOC and CSC
- Outdoor advertisement licensing
- Management & maintenance of private buildings by owners

(c) Special functions division
- Engineering services for CD shelters & key installations
- Periodic structural inspections
- Dealing with unauthorized construction

(d) Business development division
- Procurement policies, Contractors registry, Panels of consultants
- Export promotion
- Construction economics and resource planning
- Management of aggregate terminals
- Land for supporting industries

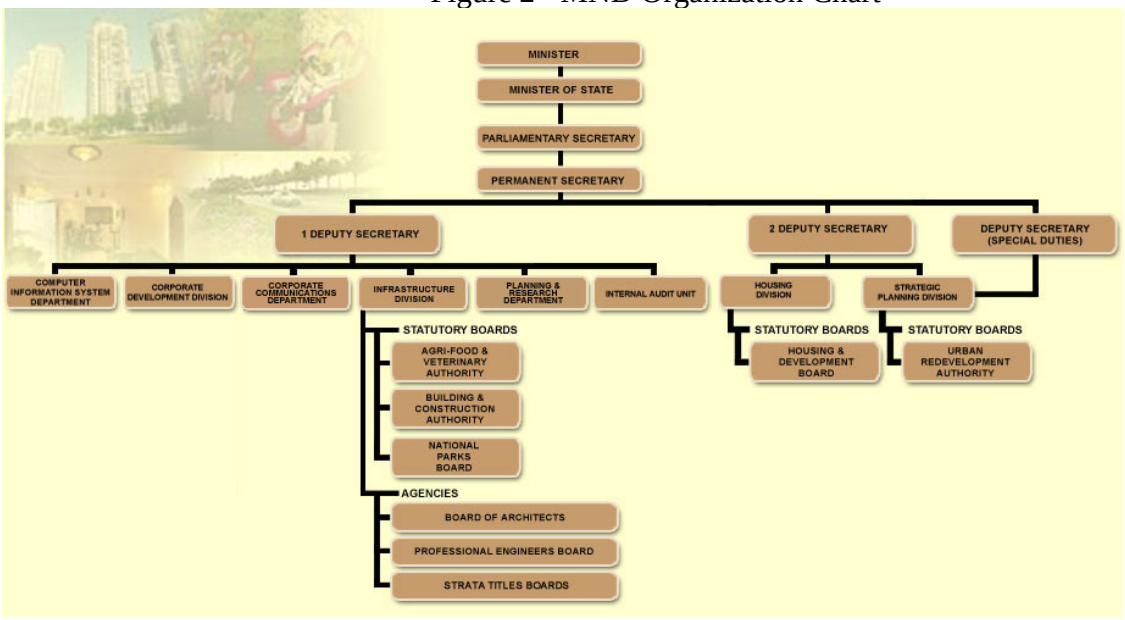
(e) Manpower development division
- Manpower policies and career promotion
- Technical, supervisory and management training
- Trade skills training and certification

(f) Technology Development Division
- CONQUAS & Quality Mark program
- ISO 9000, ISO 14000, OHSAS 18000 certification
- Green Mark for Buildings scheme
- Buildability and productivity promotion
- Good industry practices promotion

(g) Corporate development division
- Administration
- Corporate communications
- Financial management
- Human resource
- Information systems
- CORENET e-Submission system implementation

2) Ministry of National Development (MND) (http://www.mnd.gov.sg/content.htm)

<Figure 2> MND Organization Chart



MND is a department of the Singapore Government, the goals of which are to develop world-class national infrastructure, to create a vibrant and sustainable living environment, and to build rooted and cohesive communities. Among its divisions, BCA is included as one of the statutory boards under the Infrastructure Division.

4. Planning and Priority Setting

Singapore construction R&D is famous for its establishment of national plan, “Construction 21,” in 1999. However, no follow-up national plan has been developed.

1) MOM and MND (1999), *Construction 21*

In May 1998, MOM initiated the Construction Manpower 21 Study. The study sought to address the problems of an over-reliance on unskilled foreign workers and the low-level productivity of the construction industry. This study team was later merged with the "Committee on Practices in the Construction Industry" convened by MND, and expanded to become the Construction 21 (C21) Study.

The C21 aimed to address the current inefficiencies in the industry and to transform it into a knowledge industry. Given that upstream decisions have an impact on downstream construction processes, the C21 Study addressed issues across the whole construction value chain from design to construction and to maintenance.

Under its vision, "to be a World Class Builder in the Knowledge Age," the Study provides 6 strategies and key recommendations for each category (MOM and MND, 1999):

(a) Enhance the Professionalism of the Industry
- Continuing Professional Development (CPD)
- Develop Individual Codes of Conduct (followed by a National Code of Conduct)

(b) Raise the Skills Level of the Construction Workforce
- Reducing the Man-Year Entitlement (MYE) Formula
- Set skills level for construction workforce

(c) Improve Industry Practices and Techniques
- Legislation and emphasis on buildability
- Improve safety awareness in the industry
- Increase the R&D efforts of the industry

(d) Adopt an Integrated Approach to Construction
- Encourage the use of design and build methods through promotion
- Review the various Acts that restrict partnerships

(e) Develop an External Wing
- For construction and/or design companies to venture abroad

(f) Adopt a Collective Championing Effort for the Construction Industry
- Building and construction authority- the Industry Champion
- Construction Industry Joint Committee – the private sector involvement

Following the key strategies and recommendations of the Study, one of the main organizational goals of the MND is to develop a progressive construction industry. Accordingly, three broad efforts have been made, mainly by the BCA within the Department (MND homepage http://www.mnd.gov):

(a) Developing a modern construction industry

- Raising construction quality:
    - CONQUAS (Construction Quality Assessment System) since 1989, and now changed into CONQUAS 21 in 1998 assesses public and private projects and sets the standard for construction quality. Contractors undertaking government projects are given bonuses if they

achieve a high CONQUAS score. To recognize quality contractors, BCA gives out Construction Excellence Awards annually.
- ISO 9000 requirement: All BCA-registered contractors in the top grades of G6-G8 and consultants who undertake public-sector projects above $30M are required to be certified to the ISO 9000 standards. ISO 9000 training is also provided to assist firms to achieve the certification

- Improving buildability
- BDAS (Buildable Design Appraisal System): BDAS was introduced to help designers assess the buildability–or ease of construction–of their projects. Best Buildable Design Awards are conferred annually as recognition for designers who achieve highly buildable designs. As of January 2001, buildable design became a mandatory requirement for building plans.

- Maximizing the benefits of technology
- BCA's Architecture, Engineering and Construction Center assists consultants and contractors in maximizing the benefits of IT. The Center plays a key role in facilitating IT interoperability, developing common national IT standards for construction data exchange and enhancing the use of advanced IT applications in the industry.

- Upgrading skills of construction personnel
- BCA conducts training and skills testing to achieve higher productivity, promotes the construction industry to attract new talents, and offers scholarships for degree studies.
- CITI (Construction Industry Training Institute) offers a comprehensive range of training and trade testing programs as well as supervisory, technical and management courses. Further, to raise the skills of foreign workers in Singapore, CITI provides certification support to overseas test centers established by the private sector to ensure that foreign workers entering Singapore have basic construction skills.

- Improving the business environment
- BCA provides information on the prospects and performance of the construction industry to support policy formulation. It also plays a key role in developing effective strategic support industries for the construction sector. These include the development and management of aggregate terminals and land for concrete-related industries.
- The BCA Contractors Registry registers contractors to support the procurement needs of the public sector. Contractors are registered under five major categories and eight financial grades which limit the size of projects they can tender for.

(b) Ensuring safe building and infrastructure

- Ensuring safe building works
- BCA's principal regulatory functions include the approval of building and structural plans and the issuance of building statutory completion.

- Ensuring proper maintenance of buildings
- Existing buildings are periodically inspected and maintained throughout their economic life to ensure public safety under the Building Control Act.

- Providing engineering support
    - BCA provides engineering support services to the Ministry of Home Affairs on the technical requirements for the design and construction of Civil Defense (CD) shelters. It also regulates the design and construction of CD shelters.

(c) Future directions: the re-invention of the industry

- Preparing industry for buildable design
    - BCA will help ensure that the industry has a thorough understanding of the code of practice on buildable designs and is prepared to meet buildability requirements for projects in Singapore.

- Enhancing skills and professionalism
    - Increase the proportion of skilled workers in the construction industry
    - Strengthen supervisory and management training
    - Emphasize on raising the level of professionalism in the industry

- Promoting innovation
    - Build up a culture of innovation in the construction industry to raise the level of productivity and quality standards
    - Launch some IT projects, including BP Expert, which will automate the process of checking plans for compliance with building regulations
    - Develop a One-Stop-Submission-Center to enable building applications to be submitted through the Internet

- Establishing standards
    - Widen the scope of building management and maintenance to cover total building performance
    - Develop an Energy Efficiency Index to benchmark the performance of buildings

5. R&D Funding Organizations and Programs

The funding for construction R&D has been distributed by the Ministry of Finance in Singapore Government. In addition, the "MND Research Fund," especially for the construction industry, will be operational in 2007.

1) General funding from the Ministry of Finance (MOF)

According to the budget announcement of MOF, in FY 2007, BCA got up to $ 70 million R&D related funding for the next five years. Among the funding amount, $ 50 million is for the newly launched MND Research Fund to intensify R&D efforts focusing on green building technologies and energy efficiency. Another $ 20 million is assigned to promote the design and construction of more green buildings in Singapore through an incentive scheme for the next three years.

2) MND Research Fund for the Built Environment

The MND Research Fund, beginning in 2007, aims to intensify R&D efforts in green building technologies and energy efficiency as an integral part of the BCA's Green Building Masterplan. The

Fund is meaningful in that it is the first dedicated R&D fund especially for the construction and real estate sectors.

The fund will provide monetary support covering 30-75% of each project's expenses under the limitation of $2 million per proposal. Distribution of the Fund would be based on its priority areas; for the first round, topics related to sustainable development and distinctive global city will be highlighted. Some examples of topics are:

- Energy efficiency in buildings and indoor environment quality
- Increasing land supply and land use optimization
- Tropical green architecture
- Greenery and Ecology/biodiversity studies

The MND Research Fund requested proposals from all Singapore based stakeholders, and the first call for collecting research proposals closed March, 2007. As the result of the first call, 62 proposals were submitted.

6. Institutions Conducting R&D

The main R&D performer is BCA; however, by contracts with BCA, many research institutes and universities such as BCA-CITI, BCA-NUS, and the NTU's Center for Green Building Technologies are participated in joint research and training programs.

7. R&D Collaboration Programs

According to the BCA's annual report in 2006, BCA planned to intensify its efforts to work closely with key industry players and research institutes to improve energy efficiency and to build up the industry's capability in green building technologies. In 2007, BCA will be collaborating with the BCA-NUS Center for Total Building Performance, NTU's Center for Green Building Technologies, and HDB's Precast Technology Center (BCA, 2006).

1) BCA-NUS Center for Total Building Performance (CTBP)

(a) BCA-NUS

- Joint research center of the BCA and the National University of Singapore (NUS).
- Hosted by the Department of Building, School of Design and Environment
- Focuses on Building Performance research, aims to underpin the R&D needs of the construction industry as envisioned by the BCA, and aims to engage in relevant cutting edge research with other national and international institutions and centers to deliver world class research valued by academic institutions

(b) Research Roadmaps

- Vision: to champion Total Building Performance R&D and support the quest towards a quality and productivity driven construction industry
- Research Roadmaps
  - Green and Energy Efficient Building Research Program
  - Indoor Environmental Quality Research Program
  - Building Performance Integration and Innovation Research Program
  - Building Maintainability Research Program
  - IT Design Support Systems Research Program

- Research areas
  - Energy performance of buildings
  - Development of a maintainability index for buildings
  - Development of a framework for building performance assessment
  - Development of computer based design decision support tools
  - Indoor environmental quality
  - Sustainable built system
  - Total building performance and diagnostics
  - Maintainability of building façade systems

(c) Partnerships

- Industry Partnership
  - CTBP supports industry based joint R&D with public and private agencies as well as individual companies. This is organized on a project basis, or through a wider tie-up within the framework of a MOU.
  - Some examples of CTBP's research partners: National Parks Board, PREMAS International (total asset management company), and Halton Group Ltd (one of the world's leading indoor climate management companies; recently launched an indoor climate technology development project with CTBP)
- International Partnership
  - Denmark Technology University (DTU)

2) Center for Green Building Technologies (CGBT)

(a) About CGBT
- Established under the School of Mechanical and Aerospace Engineering, NTU, in collaboration with the College of Environmental and Energy Engineering of Beijing University of Technology (BJUT) to address the problems related to resource depletion and to develop innovative ways of conserving resources
- Mission: to promote the research, development and application of technologies for energy efficient and environmental-friendly buildings
- Activities: consultancy services, design audits, project technical appraisal, contracted investigation, joint funded research, and in-house training

(b) Main Research Interests and ongoing projects
- Research interests
  - Central Air Conditioning System (CACS)

- Indoor Air Quality
- Water Treatment of Cooling Towers
- Clean rooms
- Thermal Performance of Building Materials
- Equipment performance appraisal
- Fuel cell applications

- Some ongoing projects
  - Energy management of Chiller Plant
  - AHU Control Strategy
  - Photocatalytic Process for Cooling Tower Water Treatment
  - Photocatalytic Process for Indoor Air Sterilization
  - Cooling Storage for Central Air Conditioning Plant

3) HDB Prefabrication Technology Center (PTC)

- To enable it to reap the benefits of higher productivity and quality while maintaining the cost effectiveness of its public housing, HDB under the MND has embarked on an industrialization program using innovative construction technologies. These technologies have enabled the construction industry to break new inroads into productivity and quality. These initiatives are the incorporation of modular co-ordination of public housing designs, design standardization and customization, prefabrication, and the mechanization of site operations.

- Main activities:
  - To design, develop and produce prefabricated building products
  - To conduct research and development of advanced and innovative construction materials and systems
  - To manage and supply prefabricated building products; conduct training and license its intellectual property rights.

8. Human Resource Development Programs

BCA manages a training program through the Construction Industry Training Institute (CITI) within the construction sector. It also provides some career information as well as research information including articles and statistics on its webpage. In addition, BCA has its own scholarship programs for undergraduate students and for professionals in the industry, respectively. All of the government programs related to construction careers are managed or organized by BCA.

1) BCA-CITI

Construction Industry Training Institute (CITI), which is the Building and Construction Authority's training arm, provides technical, supervisory, professional, and management training as well as skills training, testing, and certification programs for construction personnel.

Since founded in 1984, CITI has been expanding and enhancing its role as the major construction training provider for Singapore's Construction Industry. Currently, it provides three different types of diploma curriculums:

- Diploma in Construction Engineering course
- Diploma in Design (interior and landscape) course
- Diploma in real estate and facility management course

2) BCA Building Careers webpage (http://www.bca.gov.sg/BuildingCareers/)

It provides some information about construction careers and job opportunities.

3) Construction Info Net
- Maintained by BCA on the BCA webpage (subscription necessary)
- Provides some articles, statistics, and project information related to the construction industry

4) Job Search Service

BCA also provides the job search services on its webpage.

5) BCA Scholarship Program
(a) BCA Undergraduate Scholarships (http://www.bca.gov.sg/BuildingCareers/scholarships_bca.html)
(b) BCA Construction Industry Scholarships
(http://www.bca.gov.sg/BuildingCareers/scholarships_bca_industry.html)

SINGAPORE TANSPOTATION R&D

B. Transportation

1. Laws and regulations

1) *Land Transport Authority of Singapore Act*
- An Act to establish and incorporate the Land Transport Authority of Singapore, to provide for its functions and powers and matters connected to it. This Act was first established on September 1, 1995.
- Some functions and duties of the Authority by the Act:

(a) To plan, design, construct, manage and maintain roads in Singapore in accordance with this Act and the Street Works Act
(b) To promote better understanding of land transport policies and programs, whether solely or jointly with other authorities or organizations
(c) to conduct, or engage persons to conduct research and demonstration projects in respect of land transport and associated matters, and to encourage, advise, and otherwise assist (whether financially or otherwise) any such research or project
(d) To advise the Government in respect of the land transport system in Singapore, including, but not limited to:
- Its adequacy to meet national and community needs in an efficient, viable and safe manner
- Changes considered advisable in the provision of finance for the control, construction, management or maintenance of the land transport system
- Changes considered advisable in the levying and collection of land transport taxation, including the granting or withdrawing of exemptions or partial exemptions from any form of land transport taxation

2. Government Organizations Responsible for R&D Policy

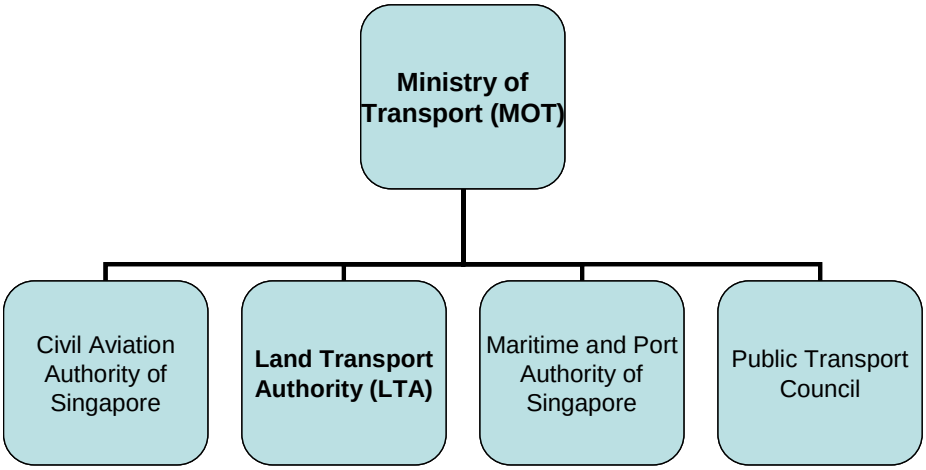
In general, the Ministry of Transport plays the key role in the transport sector, but there is currently no central body to plan, coordinate, or fund transport R&D.

1) Ministry of Transport (MOT)

(a) Mission
- To develop Singapore's land, sea and air transport sectors so as to enhance the nation’s economic competitiveness and quality of life in a knowledge-based economy

(b) Vision
- In achieving the mission, MOT aims to be a pro-active and forward-looking organization, anticipatory and responsive to the needs of its customers and changes in the environment, both domestically and internationally.

<Figure 3> MOT Organization Chart

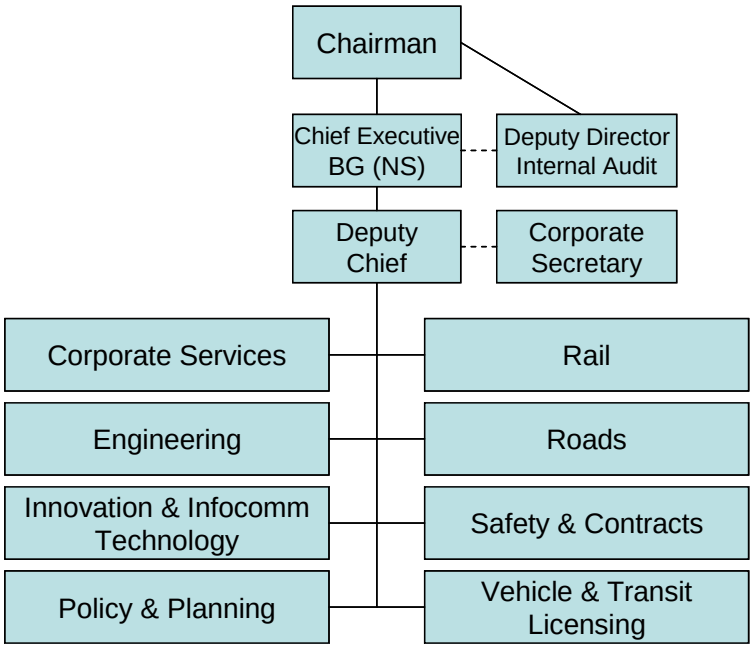


* Source: Created by the MOT webpage (http://www.mot.gov.sg/about/organisation.htm)

- Land Transport Authority (LTA): oversees land policies which strive to maintain a quality and efficient land transport system - one which is affordable, efficient and accessible to the public, and one which ensures smooth flowing traffic on the roads

1) LTA in MOT

<Figure 4> LTA Organization Chart



(a) Vision of LTA
- To build a world-class land transport system

(b) Mission of LTA
- To provide an efficient and cost-effective land transport system to meet different needs

(c) Values of LTA
- Commitment to goals, teamwork, competence, customer focus, integrity, and care and concern

(d) Strategic thrusts of LTA
- Make public transport a choice mode: to promote the use of public transport as well as make public transport safe, secure, convenient, affordable, and accessible to people with different needs
- Optimize the road network and enhance its accessibility: to keep our roads smooth-flowing as well as provide a conductive walking environment for different groups of people
- Excel in service quality: to provide delightful traveling experiences to commuters and service experiences to the customers, along with being pro-enterprise
- Create value and instill pride in the work of the Authority: to encourage staff to come up with innovative solutions to create value for the organizations as well as develop a pool of committed and motivated staff who are proud of their work

(e) Core functions of each divisions in the LTA
- Corporate Services: introduces and manages welfare schemes to create a more conducive environment and provides staff with necessary training to enhance their personal effectiveness and career prospects. This group also provides logistical and administrative support as well as essential and value-added support to the other groups in the areas of finance and legal advice
- Engineering: focuses on system integration and intricate technical design details of every road, tunnel, pedestrian overhead bridge, and other structures that support a safe, well-connected and efficient transport system. It also ensures that commuter facilities are designed and integrated with transport nodes and developments to give commuters a seamless journey
- Innovation & Infocomm Technology: oversees the formulation and implementation of e-transformation strategies and development initiatives to achieve total organizational excellence. It also spearheads e-government initiatives through value innovation in process re-design, product development, and service delivery
- Policy & Planning: carries out careful planning and analysis to help set the direction and develop plans to meet Singapore's medium and long-term transportation needs. It also formulates policies to achieve the mission of providing a premier land transport system and implements communications programs to secure the public's understanding and support
- Rail: manages the construction of new Rapid Transit System (RTS) projects, and the extension as well as upgrading of existing rail lines
- Roads: Enhances the road network and provides motorists with a greater choice of travel routes by carrying out projects to widen, upgrade, and build new roads. It also manages and maintains road structures and facilities so that they are operational at all times
- Safety & Contracts: conducts project safety review to ensure that the rail and road systems delivered are safe for use. It also sets up the framework and oversees the implementation of the Occupational Safety and Health Management System during project construction to ensure a "Safe-To-Build" environment for the public, staff and contractors
- Vehicle & Transit Learning: takes care of the needs of vehicle owners and public transport commuters, implements policies related to vehicle ownership and usage control, enforces

vehicle safety, and regulates public transport services to ensure that they are safe, efficient and meet quality service standards

- Currently, 3,500 staff (including 1,200 professionals) are working in the LTA

3. Planning and Priority Setting

- There is no specific plan for transport R&D so far.

4. R&D Funding Organizations and Programs

- There is no specific organization for transport R&D so far. However, for most R&D projects, LTA provides financial support.

5. Institutions Conduction R&D

LTA conduct research or commissions the third parties, including academic institutions or consulting firms, to do research activities in various aspects of transport R&D, including passenger behavior, road/rail construction engineering, safety engineering and others. In addition, the Center for Transportation Research (CTR) in the National University of Singapore (NUS) and the Center for Infrastructure Systems (CIS) in Nanyang Technological University (NTU) conduct research independent from the LTA, although their projects might be fully or partially funded from LTA through contracts or collaboration on an ad hoc basis.

6. Human Resource Development Programs

LTA and some universities offer further training in transport related subjects.

1) LTA Academy

2) National University of Singapore (NUS)

3) Nanyang Technological University (NTU)

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3. Land Transport Authority (LTA), from http://www.lta.gov.sg/
4. Ministry of Transport (MOT): http://app.mot.gov.sg/default.asp

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IV. INTERNATIONAL INDICATORS OF R&D IN CONSTRUCTION AND TRANSPORTATION

1. NSF Science and Engineering Indicators 2006

1) Appendix table 4-19: Total (federal + company & other) funds for R&D performance in the U.S., by industry and size of company: 1999-2003 (Millions of dollars)

		Funds					
Industry and size of company	**NAICS code**	***1999[a]***	***2000***	***2001[b]***	***2002***	***2003***	***2004***
All industries	21–23, 31–33, 42, 44–81	184,129	201,962	202,017	193,868	204,004	208,301
Manufacturing industries	31–33	118,339	126,501	124,217	112,089	123,384	147,288
Transportation equipment	336	33,965	30,085	25,965	26,145	34,273	D
Motor vehicles, trailers, and parts	3361–63	D	D	D	D	D	15,677
Aerospace products and parts	3364	14,425	10,319	7,868	9,654	15,731	13,086
Other transportation equipment	Other 336	D	D	D	D	D	D
Non-manufacturing industries	21–23, 42, 44–81	65,790	75,461	77,799	81,779	80,620	4,865
Construction	23	691	D	320	164	333	15
Transportation and warehousing	48, 49	460	D	1,848	D	272	D

* D=data withheld to avoid disclosing operations of individual companies; S=imputation of>50%; NA=not available; na=not applicable
* NAICS = North American Industry Classification System
* Some statistics for 1999 were revised since originally published.
* Beginning with 2001, statistics for total and federally funded industrial R&D exclude data for federally funded research and development centers

Notes: R&D is industrial R&D performed within company facilities funded from all sources. Funds are company's own; funds from outside organizations, such as other companies, research institutions, universities and colleges, nonprofit organizations, and state governments; and funds from federal government. Excluded are R&D not performed within the company (e.g., R&D contracted out to other organizations) and R&D not performed within the 50 United States or District of Columbia (e.g., R&D performed outside the United States by foreign subsidiaries or other foreign organizations).

* Source: NSF, *Science and Engineering Indicators 2006*

* 2004 data came from: National Science Foundation, *U.S. Industrial R&D Performances Report Increased Expenditures for 2004, NSF 07-304, Infobrief*, December 2006

2) Appendix table 4-20: company and other nonfederal funds for industrial R&D performance in the U.S., by industry and size of company: 1999-2003

Industry and size of company	**NAICS code**	***1999[a]***	***2000***	***2001***	***2002***	***2003***	***2004***
All industries	21–23, 31–33, 42, 44–81	161,594	182,844	185,118	177,467	183,305	188,035
Manufacturing industries	31–33	101,283	113,173	112,733	101,344	108,079	131,887
Transportation equipment	336	23,928	22,917	21,004	21,452	26,111	26,019
Motor vehicles, trailers, and parts	3361–63	17,987	18,306	16,089	15,199	16,874	15,610
Aerospace products and parts	3364	5,309	3,895	4,083	5,349	8,203	9,224
Other transportation equipment	Other 336	632	716	832	905	1,034	1,185
Non-manufacturing industries	21–23, 42, 44–81	60,311	69,671	72,384	76,123	75,226	56,168
Construction	23	690	222	320	164	254	1,466
Transportation and warehousing	48, 49	460	277	1,776	339	272	D

* D=data withheld to avoid disclosing operations of individual companies; S=imputation of>50%; NA=not available; NA= not applicable
* NAICS = North American Industry Classification System
* Some statistics for 1999 were revised since originally published.
* Beginning with 2001, statistics for total and federally funded industrial R&D exclude data for federally funded research and development centers

Notes: R&D is industrial R&D performed within company facilities funded from all sources. Funds are company's own; funds from outside organizations, such as other companies, research institutions, universities and colleges, nonprofit organizations, and state governments; and funds from federal government. Excluded are R&D not performed within the company (e.g., R&D contracted out to other organizations) and R&D not performed within the 50 United States or District of Columbia (e.g., R&D performed outside the United States by foreign subsidiaries or other foreign organizations).

* Source: NSF, *Science and Engineering Indicators 2006*

* 2004 data came from: National Science Foundation, *U.S. Industrial R&D Performances Report Increased Expenditures for 2004, NSF 07-304, Infobrief*, December 2006

3) Appendix table 4-21: federal funds for industrial R&D performance in the U.S., by industry and size of company: 1999-2003

Industry and size of company	**NAICS code**	***1999[a]***	***2000***	***2001[b]***	***2002***	***2003***	***2004***
All industries	21–23, 31–33, 42, 44–81	22,535	19,118	16,899	16,401	20,699	20,266
Manufacturing industries	31–33	17,055	13,328	11,484	10,745	15,305	15,401
Transportation equipment	336	10,037	7,168	4,961	4,692	8,162	D
Motor vehicles, trailers, and parts	3361–63	D	D	D	D	D	67
Aerospace products and parts	3364	9,117	6,424	3,785	4,306	7,528	3,862
Other transportation equipment	Other 336	D	D	D	D	D	D
Non-manufacturing industries	21–23, 42, 44–81	5,479	5,790	5,415	5,656	5,394	4,865
Construction	23	2	D	1	*	79	15
Transportation and warehousing	48, 49	0	D	72	D	*	D

* *=data< $500,000; D=data withheld to avoid disclosing operations of individual companies; S=imputation of>50%; NA=not available; na=not applicable
* NAICS = North American Industry Classification System
* Some statistics for 1999 were revised since originally published.
* Beginning with 2001, statistics for total and federally funded industrial R&D exclude data for federally funded research and development centers.

Notes: R&D is industrial R&D performed within company facilities funded by the federal government. Excluded are R&D not performed within the company (e.g., R&D contracted out to other organizations) and R&D not performed within the 50 United States or District of Columbia (e.g., R&D performed outside the United States by foreign subsidiaries or other foreign organizations).

* Source: NSF, *Science and Engineering Indicators 2006*
* 2004 data came from: National Science Foundation, *U.S. Industrial R&D Performances Report Increased Expenditures for 2004, NSF 07-304, Infobrief*, December 2006

4) Appendix table 4-22: company and other (nonfederal) R&D fund share of net sales in R&D-performing companies, by industry and company size: 1999-2003

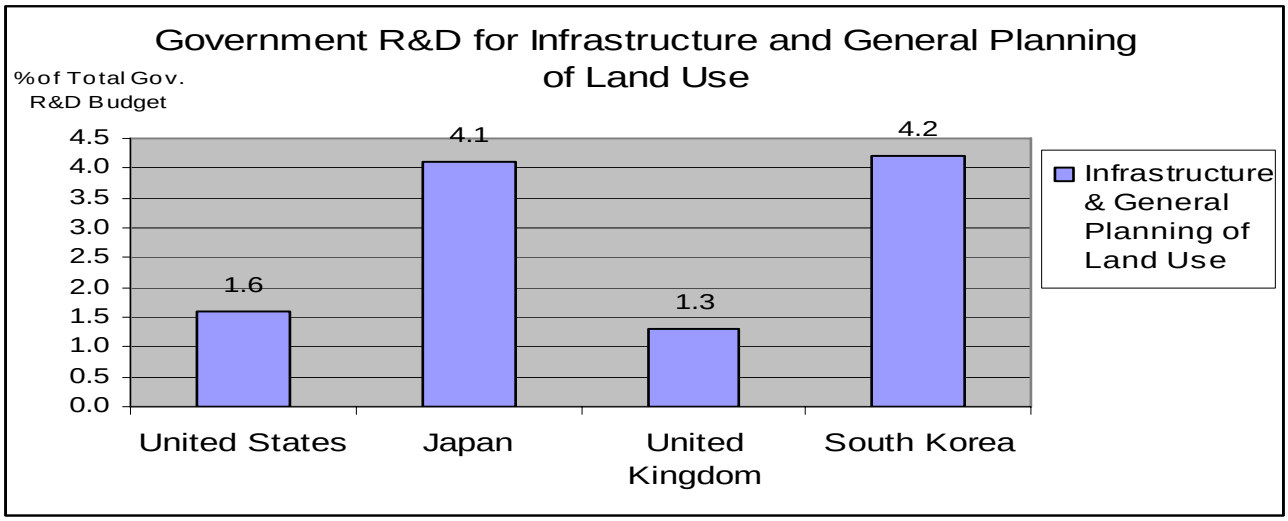
Industry and size of company	**NAICS code**	***1999[a]***	***2000***	***2001***	***2002***	***2003***
All industries	21–23, 31–33, 42, 44–81	2.8	3.4	3.8	3.6	3.2
Manufacturing industries	31–33	3.2	3.2	3.7	3.3	3.1
Transportation equipment	336	2.9	3.1	3.4	2.8	2.7

Motor vehicles, trailers, and parts	3361–63	2.9	3.2	3.5	3.1	2.4
Aerospace products and parts	3364	3.2	2.8	3.0	2.3	3.5
Other transportation equipment	Other 336	1.6	1.8	2.5	2.9	2.7
Non-manufacturing industries	21–23, 42, 44–81	3.4	3.8	4.0	4.1	3.3
Construction	23	3.1	1.9	1.4	0.6	1.2
Transportation and warehousing	48, 49	0.5	0.3	2.4	0.5	0.4

D=data withheld to avoid disclosing operations of individual companies; S=imputation of>50%
NA=not available; na=not applicable
* NAICS = North American Industry Classification System
* Some statistics for 1999 were revised since originally published.
* Source: NSF, *Science and Engineering Indicators 2006*

5) Appendix table 4-47: government R&D budget appropriation, by selected country and socioeconomic objective (%): Selected years, 2001-04

Socioeconomic objective (2002)	**United States** ***(2004)***	**Japan** ***(2003)***	**United Kingdom** ***(2002)***	**South Korea** ***(2004)***
Total (2000 US $ millions)	116,889	24,525	12,041	7,275
Exploration and exploitation of Earth	0.8	1.7	1.7	1.4
Infrastructure and general planning of land use	**1.6**	**4.1**	**1.3**	**4.2**
Control and care of environment	0.5	0.9	1.6	4.5
Protection and improvement of human health	23.1	4.0	13.2	7.9
Energy	1.2	17.2	0.5	5.2
Agriculture production and technology	2.0	3.3	3.3	8.3
Industrial production and technology	0.4	7.2	4.7	27.4
Social structures and relationships	1.1	0.7	3.6	2.7
Exploration and exploitation of space	7.8	6.7	1.9	3.0
GUF	NA	34.4	20.2	NA
Non-oriented research	5.7	15.3	13.3	22.1
Other civil research	0.0	0.0	0.4	NA
Defense	55.8	4.5	34.1	13.4



* Source: NSF (2006), Appendix table 4-47
Note: US in 2004, Japan in 2003, UK in 2002, Korea in 2004

6) Appendix table 4-58: share of business expenditures for R&D, by industry and selected country/economy: 2001-03

Industry	ISIC	EU *(2002)*	Australia *(2002)*	Japan *(2002)*	Korea *(2003)*	United Kingdom *(2002)*	United States *(2002)*[a]
Total business enterprise		100.0	100.0	100.0	100.0	100.0	100.0
Manufacturing	15–37	82.9	47.3	91.1	85.5	77.3	70.9
Motor vehicles	34	15.9	10.6	14.3	13.7	7.1	7.9
Other transportation equipment	35	7.9	1.7	1.1	2.5	12.7	5.6
Building and repairing ships and boats	351	0.3	1.0	0.1	1.7	0.7	NA
Aircraft and spacecraft	353	6.8	0.0	0.8	0.6	10.3	5.0
Railroad and other transportation equipment, NEC	352+359	0.8	0.7	0.2	0.3	1.7	0.6
Services	50–99	14.8	42.2	6.8	9.0	20.2	27.4
Construction	45	0.4	1.1	1.2	4.4	0.3	0.1
Transport and storage	60–63	NA	0.5	0.2	0.0	NA	0.2

* NA = not available
* EU = European Union; ISIC = International Standard Industrial Classification; NEC = not elsewhere classified

* Data for United States adjusted to reclassify some wholesale trade R&D as manufacturing R&D.

Notes: Data are for years in parentheses. Because Organization for OECD and NSF analysts adjust country data to achieve internationally comparable estimates, these data may differ from individual countries' survey estimates. Detail may not add to total because of rounding.

* Source: NSF, *Science and Engineering Indicators 2006*
* Appendix Table 4-58
* Source: NSF, 2006

Note: Korean R&D expenditure is based on the measure of 2003.

TABLE 34. Federal research and development and R&D plant budget authority for transportation (400): FY 2005–07
(Millions of dollars)

Funding category and agency	2005 actual	2006 preliminary	2007 proposed	2006–07 (% change)
Total	1,866	1,741	1,507	-13.5
Air transportation (402)	1,403	1,194	960	-19.6
National Aeronautics and Space Administration, aeronautics[a]	962	884	724	-18.1
Federal Aviation Administration (DOT)	263	310	235	-24.1
Transportation Security Administration (DHS)	178	0	0	na
Ground transportation (401) (DOT)	410	499	507	1.4
Federal Highway Administration	304	380	397	4.6
National Highway Traffic Safety Administration	61	58	51	-12.0
Federal Railroad Administration	32	48	38	-20.5
Federal Motor Carrier Safety Administration	8	9	12	43.2
Federal Transit Administration	4	6	8	45.9
Water transportation (403)	19	19	15	-21.1
U.S. Coast Guard (DHS)	19	19	15	-21.1
Other transportation (407)[b] (DOT)	34	29	26	-12.3

na = not applicable.

DHS = Department of Homeland Security.
DOT = Department of Transportation.

[a] Includes funds for research and research program management.
[b] Includes Office of the Secretary, Pipeline and Hazardous Materials Safety Administration, and the Research and Innovative Technology Administration.

NOTES: Detail may not add to total because of rounding. Percent change derived from unrounded data.

SOURCES: Agencies' submissions to Office of Management and Budget per MAX Schedule C and supplemental data obtained from agencies' budget offices.

TABLE 1. Federal research and development and R&D plant budget authority, by budget function: FY 2005–07

2007 rank	Budget function	2005 actual	2006 preliminary	2007 proposed	2005–06	2006–07
		$ millions			% change	
	All functions conducting R&D	131,259	135,205	136,850	3.0	1.2
1	National defense	74,641	77,630	78,388	4.0	1.0
2	Health	29,129	29,088	29,025	-0.1	-0.2
3	Space research and technology	9,656	10,411	11,478	7.8	10.2
4	General science and basic research	7,477	7,495	8,321	0.2	11.0
5	Natural resources and environment	2,245	2,202	2,043	-1.9	-7.2
6	Agriculture	2,094	2,128	1,711	1.6	-19.6
7	Transportation	1,866	1,741	1,507	-6.7	-13.5
8	Energy	1,324	1,419	1,363	7.2	-3.9
9	Administration of justice	779	1,011	895	29.8	-11.5
10	Veterans benefits and services	742	765	765	3.1	0.0
11	Education, training, employment, and social services	495	522	519	5.5	-0.6
12	Commerce and housing credit	475	457	486	-3.9	6.4
13	International affairs	255	255	255	0.0	0.0
14	Community and regional development	45	55	68	22.2	23.6
15	Income security	35	27	27	-22.9	0.0

NOTES: Detail may not add to total because of rounding. Percent change derived from unrounded data.

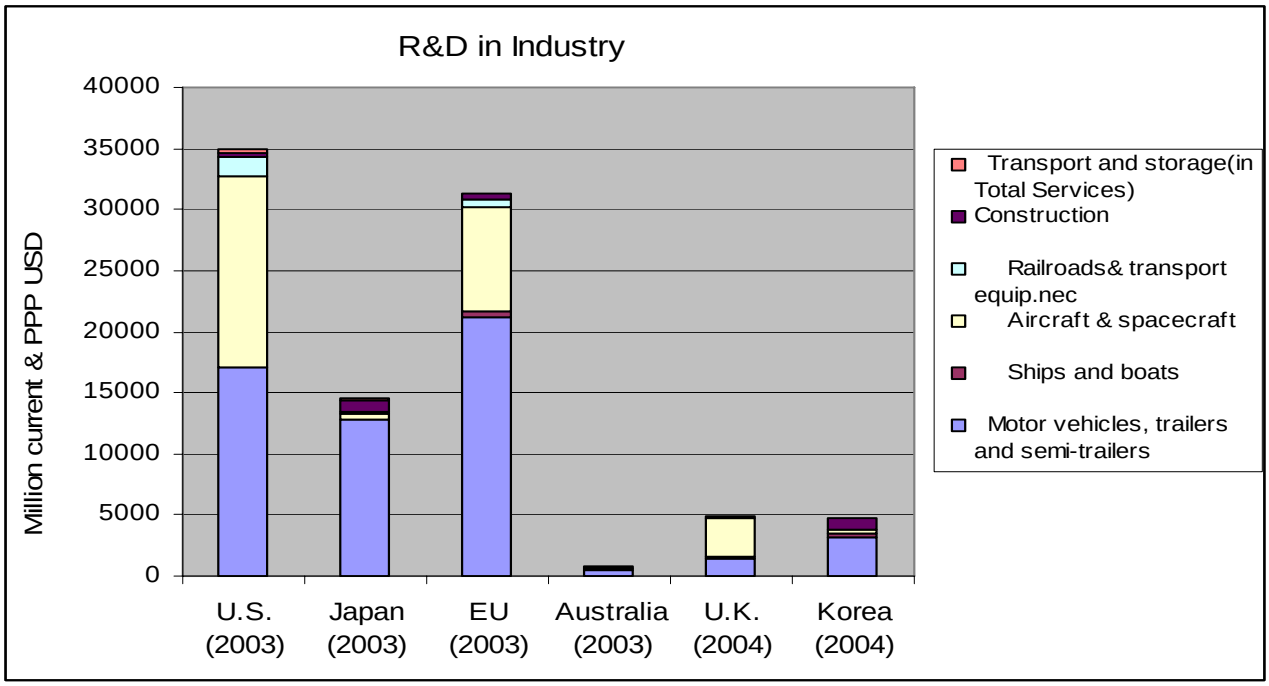
SOURCES: Agencies' submissions to Office of Management and Budget per MAX Schedule C, agencies' budget justification documents, and supplemental data obtained from agencies' budget offices.

2. OECD RDEI (R&D Expenditure in Industry) (ANBERD)

(Million current & PPP USD)

Industry	**U.S.** *(2003)*	**Japan** *(2003)*	**EU** *(2003)*	**Australia** *(2003)*	**U.K.** *(2004)*	**Korea** *(2004)*
Motor vehicles, trailers and semi-trailers	17033.7	12765.5	21257.7	534.5	1390.3	3185.3
Other transport equipment	17239.3	618.7	9506.9	109.1	3350.8	625.8
Ships and boats	NA	70.9	375.2	65.2	148.9	315.4
Aircraft & spacecraft	15731	384.6	8517.8	4.8	3167.1	251.1
Railroads& transport equip.nec	1508.3	163.2	613.9	39.2	34.8	59.4
Construction	333	982.3	506.5	95.2	63.3	859.1
Transport and storage(in Total Services)	272	173.8	NA	28.5	20.6	0

* nec = not elsewhere classified; na = not available
* Ships and boats; Aircraft & spacecraft; railroad & transport equipment.nec are included in other transport equipment.
* Source: OECD, Research and Development in Industry 2006



* Source: OECD, Research and Development in Industry 2006

3. OECD Structural Analysis (STAN) Database (2006)

1) Distribution of R&D expenditures across industries for the total economy (RDS) (2002)

Industry	Australia	Japan	Korea	United Kingdom	United States
Motor vehicles, trailers and semi-trailers	10.6	14.3	12.7	7.1	7.9
Other Transport Equipment	1.7	1.1	3.2	12.7	5.6
Building and repairing of ships and boats	1	0.1	1.4	0.7	0
Aircraft and spacecraft	0	0.8	1.8	10.3	5
Railroad equipment and transport equipment n.e.c.	0.7	0.2	0.5	1.7	0.6
CONSTRUCTION	1.1	1.2	4.2	0.3	0.1
Transport and storage (in total services)	0.5	0.2	0	-	0.2

* nec = not elsewhere classified; na = not available
* Ships and boats; Aircraft & spacecraft; railroad & transport equipment.nec are included in other transport equipment.
* Source: OECD STAN Database, 2006

2) Distribution of R&D expenditures across industries for total manufacturing (RDSMAN) (2002)

Industry	Australia	Japan	Korea	United Kingdom	United States
TOTAL MANUFACTURING	100	100	100	100	100
Transport equipment	25.9	16.8	19.2	25.6	22.9
Motor vehicles, trailers and semi-trailers	22.3	15.7	14.8	9.2	13.4
Other transport equipment	3.5	1.2	4.4	16.4	9.5
Building and repairing of ships and boats	2.1	0.1	1.7	0.9	0
Aircraft and spacecraft	0.1	0.9	2.2	13.3	8.4
Railroad equipment and transport equipment n.e.c.	1.4	0.2	0.6	2.2	1

* Source: OECD STAN Database, 2006

3) R&D intensity using value added (RDIV) (2002)

Industry	Japan	Korea	United Kingdom	United States
TOTAL MANUFACTURING	10.4	6.9	6.9	7.8
Transport equipment	12.9	10.6	16.2	14.2
Motor vehicles, trailers and semi-trailers	13.5	12	10.9	13.4
Other transport equipment	8.2	7.7	22.3	15.5
Building and repairing of ships and boats	1.3	-	8.6	-
Aircraft and spacecraft	21.6	-	23.8	18.5
Railroad equipment and transport equipment n.e.c.	6.8	-	30.5	15.3
TOTAL SERVICES	0.2	0.3	0.4	0.9
CONSTRUCTION	0.4	1.1	0.1	0
Transport and storage (in total services)	0.1	0	-	0.1

* Source: OECD STAN Database, 2006

4) R&D intensity using production (RDIP) (2002)

Industry	Japan	Korea	United Kingdom	United States
TOTAL MANUFACTURING	3.8	1.7	2.5	2.8
Transport equipment	3.9	2.3	4.8	4.3
Motor vehicles, trailers and semi-trailers	4	2.4	2.6	3.5
Other transport equipment	3.2	2.1	8.9	6.4
Building and repairing of ships and boats	0.5	-	3.6	-
Aircraft and spacecraft	9.3	-	9.7	7.6
Railroad equipment and transport equipment n.e.c.	2.6	-	10.1	5.5
CONSTRUCTION	0.2	0.5	0	0
TOTAL SERVICES	0.2	0.2	0.2	0.6
Transport and storage (in total services)	-	0	-	0.1

* Source: OECD STAN Database, 2006

5) Employment shares in the total economy (EMPSH) (2002)

Industry	Japan	Korea	United Kingdom	United States	EU15
GRAND TOTAL	100	100	100	100	100
TOTAL MANUFACTURING	17.7	19.1	13.6	11.3	17.3
Transport equipment	1.7	-	1.4	1.2	1.6
Motor vehicles, trailers and semi-trailers	1.5	-	0.8	0.8	-
Other transport equipment	0.2	-	0.6	0.5	-
Building and repairing of ships and boats	0.1	-	0.1	0.1	-
Aircraft and spacecraft	0.1	-	0.4	0.3	-
Railroad equipment and transport equipment n.e.c.	0.1	-	0.1	0.1	-
TOTAL SERVICES	65.4	63.3	80.2	80.4	7.9
CONSTRUCTION	9.9	7.9	4.5	5.8	6.9
Transport and storage (in total services)	-	-	3.9	3.1	-

* Source: OECD STAN Database, 2006

6) Employment shares in the total economy (EMPSH) (2003)

Industry	Japan	Korea	United Kingdom	United States	EU15
TOTAL MANUFACTURING	17.4	19	12.9	10.8	-
Transport equipment	1.7	-	1.4	1.2	-
Motor vehicles, trailers and semi-trailers	1.4	-	0.8	0.8	-
Other transport equipment	0.2	-	0.6	0.4	-
Building and repairing of ships and boats	0.1	-	-	0.1	-
Aircraft and spacecraft	0.1	-	-	0.3	-
Railroad equipment and transport equipment n.e.c.	0.1	-	-	0	-
TOTAL SERVICES	66	63.5	80.9	80.9	-
CONSTRUCTION	9.7	8.2	4.7	5.9	7
Transport and storage (in total services)	-	-	3.9	3.1	-

* Source: OECD STAN Database, 2006

7) Employment shares in total manufacturing (EMPSHM) (2002)

Industry	Japan	United Kingdom	United States	EU15
TOTAL MANUFACTURING	100	100	100	100
Transport equipment	9.6	10.4	11.1	9.3
Motor vehicles, trailers and semi-trailers	8.3	5.9	7	-
Other transport equipment	1.3	4.5	4.1	-
Building and repairing of ships and boats	0.6	1	0.9	-
Aircraft and spacecraft	0.3	3	2.7	-
Railroad equipment and transport equipment n.e.c.	0.4	0.6	0.5	-

* Source: OECD STAN Database, 2006

8) Employment shares in total manufacturing (EMPSHM) (2003)

Industry	Japan	United Kingdom	United States
TOTAL MANUFACTURING	100	100	100
Transport equipment	9.7	10.5	11.1
Motor vehicles, trailers and semi-trailers	8.3	6	7
Other transport equipment	1.4	4.5	4.1
Building and repairing of ships and boats	0.6	-	1
Aircraft and spacecraft	0.4	-	2.7
Railroad equipment and transport equipment n.e.c.	0.4	-	0.5

* Source: OECD STAN Database, 2006

9) Labor compensation per employee relative to the total economy (LABEMP) (2002)

Industry	Japan	Korea	United Kingdom	United States	EU15
GRAND TOTAL	100	100	100	100	100
TOTAL MANUFACTURING	117.8	138.2	136.4	137.3	125.5
Transport equipment	156.4	-	158.1	183.2	164.2
Motor vehicles, trailers and semi-trailers	160.6	-	157.7	184.9	-
Other transport equipment	129.5	-	158.7	180.4	-
Building and repairing of ships and boats	130	-	123.5	123	-
Aircraft and spacecraft	161.1	-	176.5	203.1	-
Railroad equipment and transport equipment n.e.c.	102.4	-	126.2	140.9	-
TOTAL SERVICES	102.5	94.5	93.3	95.7	98.8
CONSTRUCTION	97.5	148.1	104.2	94	83.6
Transport and storage (in total services)	-	-	140.5	106.9	-

* Source: OECD STAN Database, 2006

10) Labor compensation per employee relative to the total economy (LABEMP) (2003)

Industry	Japan	Korea	United Kingdom	United States
GRAND TOTAL	100	100	100	100
TOTAL MANUFACTURING	120.3	135.1	136.9	142.5
Transport equipment	159.6	-	155.9	211.7
Motor vehicles, trailers and semi-trailers	164.3	-	152.2	224.6
Other transport equipment	131	-	161	189.5
Building and repairing of ships and boats	127.2	-	-	132.2
Aircraft and spacecraft	165.3	-	-	216.4
Railroad equipment and transport equipment n.e.c.	100.2	-	-	149
TOTAL SERVICES	102	93.6	93.5	95.6

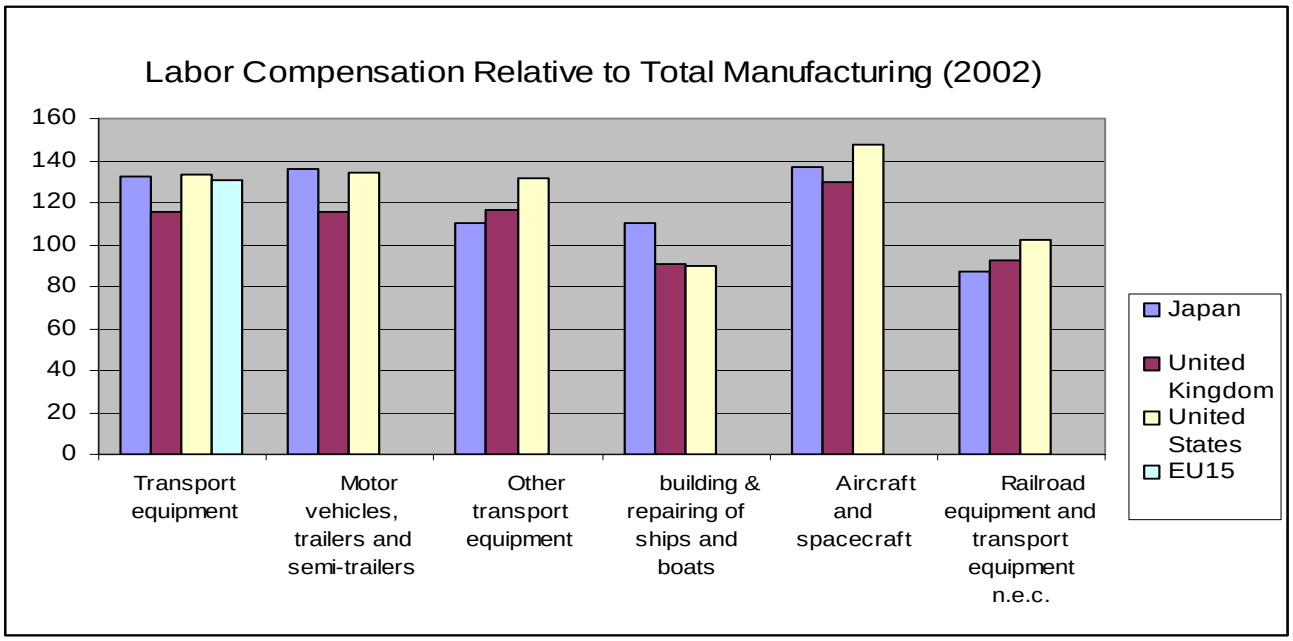
CONSTRUCTION	97.1	155.5	105.7	90.7
Transport and storage (in total services)	-	-	139.4	105.5

* Source: OECD STAN Database, 2006

11) Labor compensation per employee relative to total manufacturing (LABEMPM) (2002)

Industry	Japan	United Kingdom	United States	EU15
TOTAL MANUFACTURING	100	100	100	100
Transport equipment	132.8	115.9	133.4	130.8
Motor vehicles, trailers and semi-trailers	136.4	115.6	134.6	-
Other transport equipment	109.9	116.3	131.4	-
Building and repairing of ships and boats	110.4	90.6	89.6	-
Aircraft and spacecraft	136.8	129.5	147.9	-
Railroad equipment and transport equipment n.e.c.	86.9	92.5	102.6	-

* Source: OECD STAN Database, 2006

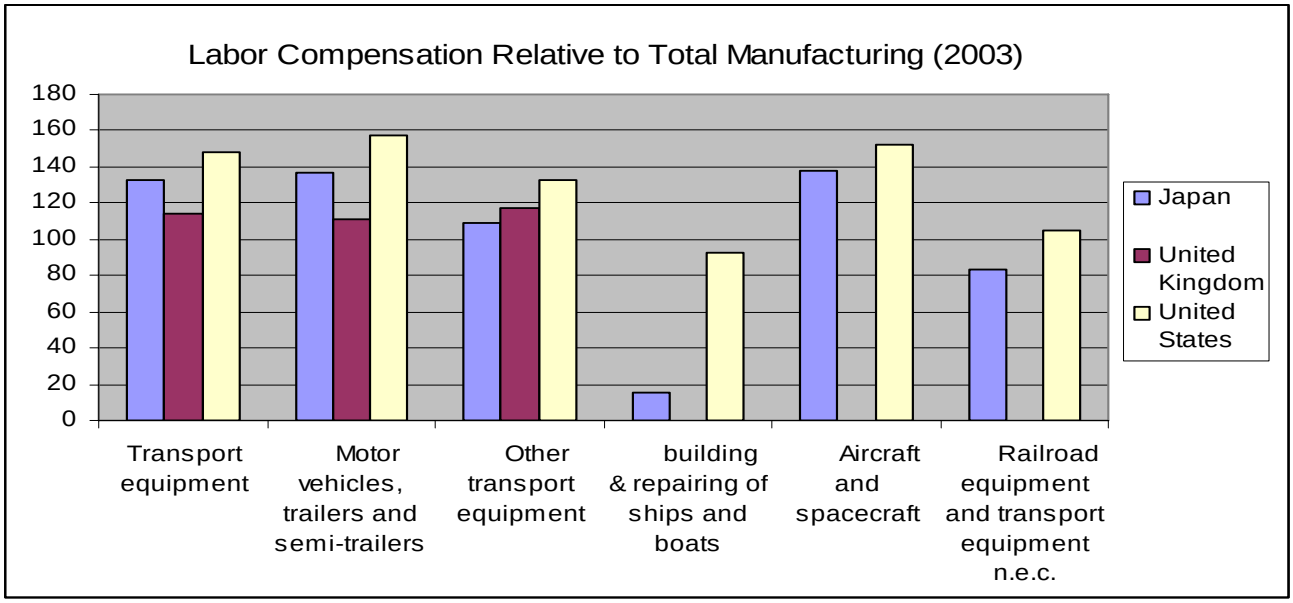


* Source: OECD STAN Database, 2006

12) Labor compensation per employee relative to total manufacturing (LABEMPM) (2003)

Industry	Japan	United Kingdom	United States
TOTAL MANUFACTURING	100	100	100
Transport equipment	132.6	113.9	148.6
Motor vehicles, trailers and semi-trailers	136.5	111.2	157.6
Other transport equipment	108.9	117.7	133
Building and repairing of ships and boats	105.7	-	92.8
Aircraft and spacecraft	137.4	-	151.9
Railroad equipment and transport equipment n.e.c.	83.3	-	104.5

* Source: OECD STAN Database, 2006



* Source: OECD STAN Database, 2006

13) Labor productivity (LPDTY) (2002)

Industry	Japan	Korea	United Kingdom	United States
GRAND TOTAL	110.45	105.89	102.45	103.65
TOTAL MANUFACTURING	123.54	111.27	105.32	109.48
Transport equipment	128.33	-	101.24	113.52
Motor vehicles, trailers and semi-trailers	-	-	109.75	116.49
Other transport equipment	-	-	91.59	109.21
Building and repairing of ships and boats	-	-	90.79	-
Aircraft and spacecraft	-	-	91.81	-
Railroad equipment and transport equipment n.e.c.	-	-	99.78	-
TOTAL SERVICES	106.08	104.3	102.07	103.77
CONSTRUCTION	93.08	98.09	104.99	99.15
Transport and storage (in total services)	-	-	103.18	103.14

* Source: OECD STAN Database, 2006

14) Labor productivity (LPDTY) (2003)

Industry	Japan	Korea	United Kingdom	United States
GRAND TOTAL	113.66	109.32	104.95	106.78
TOTAL MANUFACTURING	138.34	118.42	111.07	120.23
Transport equipment	132.08	-	111.37	121.61
Motor vehicles, trailers and semi-trailers	-	-	117.09	131.47
Other transport equipment	-	-	104.54	107
Building and repairing of ships and boats	-	-	-	-
Aircraft and spacecraft	-	-	-	-
Railroad equipment and transport equipment n.e.c.	-	-	-	-
TOTAL SERVICES	106.72	105.71	103.52	105.93
CONSTRUCTION	93.26	102.46	106.16	97.71
Transport and storage (in total services)	-	-	102.91	109.89

* Source: OECD STAN Database, 2006

15) Value added shares relative to the total economy (VASH) (2003)

Industry	Japan	Korea	United Kingdom	United States	EU15
GRAND TOTAL	100	100	100	100	100
TOTAL MANUFACTURING	20	26.4	14.2	13.8	17.9
Transport equipment	2.6	3.3	1.5	1.7	-
Motor vehicles, trailers and semi-trailers	2.4	2.2	0.8	1.1	-
Other transport equipment	0.3	1	0.7	0.6	-
Building and repairing of ships and boats	0.1	-	0.1	0.1	-
Aircraft and spacecraft	0.1	-	0.5	0.5	-
Railroad equipment and transport equipment n.e.c.	0.1	-	0.1	0.1	-
TOTAL SERVICES	68.6	57.2	75	77.4	71.6
CONSTRUCTION	6.5	9.6	5.9	4.6	5.7
Transport and storage (in total services)	4.5	4.6	4.6	2.9	-

* Source: OECD STAN Database, 2006

16) Value added shares relative to total manufacturing (VASHMAN) (2003)

Industry	Japan	Korea	United Kingdom	United States
TOTAL MANUFACTURING	100	100	100	100
Transport equipment	13.3	12.3	10.6	12.4
Motor vehicles, trailers and semi-trailers	11.9	8.5	5.7	8
Other transport equipment	1.4	3.8	4.9	4.4
Building and repairing of ships and boats	0.7	-	0.7	0.6
Aircraft and spacecraft	0.4	-	3.6	3.4
Railroad equipment and transport equipment n.e.c.	0.3	-	0.7	0.4

* Source: OECD STAN Database, 2006

V. POLICY IMPLICATIONS FOR THE KOREAN GOVERNMENT

After reviewing R&D policy in construction and transportation in target countries, SRI identified several common themes. What follows is a list of lessons learned and best practices that may help the Korean government in designing its own policy instruments, with necessary modification to fit the local culture and political economy.

1. Keep in mind that R&D is a high risk activity. By definition, truly innovative change will have a higher probability of failure than incremental change. If government R&D policy does not recognize the high risk nature of R&D activity, it is highly unlikely that transformative, radically new ideas will be nurtured and supported. Political pressure for a higher success rate for R&D funding programs exists in all countries reviewed. Furthermore, R&D funding programs that support incremental change are also important. However, there should be a separate funding mechanism that can support high-risk research projects. The goal is to have a balanced portfolio of transformative and incremental R&D funding programs for any sector.

2. The UK Rethinking Construction movement and the U.S. National Construction Goal share many characteristics and were both developed with active industry participation. The UK efforts have been more successful; the U.S. initiative faltered over time due to the lack of political support. In discussing how to best achieve the National Construction Goal, many of the ideas proposed been very innovative. Even though these ideas were not fully implemented, many lessons can be learned from the U.S. endeavor. Korea appears to have strong consensus, not only within the government but also among the general public, about the need for its industry to innovate to stay competitive. However, even though current political support may be strong for construction and transportation R&D, policy makers should exercise caution, continue to engage the public, and constantly strive to build consensus.

3. Instead of focusing solely on new cutting edge R&D, consider drawing on existing knowledge sources or adopting off-the-shelf technology already developed in other industry sectors or other countries. For example, Korea has relative competitive strength in the IT integration and interoperability area and this strength should be cultivated. Product oriented processes in the ship building industry may provide insights for the construction industry as there are many similarities between these two activities. It is an innovation if it is new for the construction or transportation sector.

4. In the context of the nation’s physical infrastructure, innovation pertains to methods and processes as well as materials and technologies. For example, new and more efficient design methods, performance standards, or procurement practices may be as beneficial as advanced materials or structural systems.

5. Collaboration with industry, university, local government and other government ministries is the key. In most countries reviewed, government funded construction research institutes are seeing their positions weakened and are experiencing budget cuts. These government institutes are moving toward more collaboration, especially with industry but also with academia, either out of necessity or by policy directives. There appears to be a general agreement that collaboration is now a given and the focus has shifted to developing the best mechanism for collaboration.

6. Create centers of excellence for construction and transportation in universities whose research topics are clearly aligned with industry interest, and whose training program for students are designed with industry input. There already exist many examples of centers of excellence in Korea: Engineering Research Centers (ERC), Science Research Centers (SRC), and Regional Research Centers (RRC).

   One major difference between the U.S. and Korean centers of excellence is that the U.S. centers include outreach programs for K-12 (elementary, middle school and high school) students via schools and science museums. Nanoscale Science and Engineering Centers (NSEC) in the U.S. provide a best practice model for exemplary outreach efforts.

   Considering the applied nature of construction and transportation research, ERC and NSEC in the U.S. may provide the best model for benchmarking. The centers of excellence should be required to conduct interdisciplinary research. It is widely accepted wisdom that an interdisciplinary team approach is the effective mechanism for generating new ideas.

7. Establish summer institutes for undergraduate research experience, modeled after the Research Experience for Undergraduate program (REU) in the U.S., to excite and encourage science and engineering students in construction and transportation related research. Undergraduate students in related fields of science and engineering should have an opportunity to experience hands on research in the construction and transportation sector, either during the summer or throughout the academic year. Studies show that the REU program is effective for motivating undergraduate students to move on to graduate school in the fields where they have experienced hands on research during undergraduate study.

   It should be emphasized that the experience should be “real” research in the sense that the students participate in the research design and have the freedom to choose the research topic. Just spending a summer in the lab entering data, for example, is not hands on research experience. It is preferable that the REU program should be affiliated with, and managed by university centers of excellence, such as Engineering Research Centers, Science Research Centers, or Regional Research Centers, already established in Korea.

8. Reform the government bidding process from the “low cost” model to “best value” model. In both construction and transportation (highway building, bridge building, etc), companies will not adopt innovative technology if it does not provide them with a competitive edge. The construction companies compete on cost and the profit margin is tight. If the initial cost for innovation is higher, even though it may reduce the life-cycle cost in the long run and deliver higher value, the industry has a disincentive to adopt innovation. It will require serious government action to address this disincentive to innovation.

   As a client that procures large construction projects, government can and should provide incentives for the construction sector to innovate by awarding contracts to companies with innovative approaches. Of course, it is easier said than done as large government construction contracts are closely scrutinized and can provoke political pressure, but many countries are moving toward the “best value” approach with incentives for innovation. The Korean government can not continue to stay with the low-cost approach. While the adopting the “best value” approach is one of the most effective ways to stimulate innovation, it is recognized that it will require consensus building and careful implementation.

9. Cost sharing and tax credit are two preferred mechanisms employed by most countries reviewed, especially Japan. Countries are moving away from the research grant mechanism and the government research institute model to cost sharing with industry and tax credits. The shift came from understanding that industry initiated projects may have a better chance of success than projects chosen by intellectual curiosity. However, it should be noted that the two types of projects are not mutually exclusive and there are plenty of interesting problems that are important. However, in many countries, industry did not respond well and was not enthusiastic about taking advantage of the cost sharing type of government programs. The major barriers for industry participation in collaborative cost sharing programs are the cost and the government grant management system. If compliance with government regulatory requirements in exchange for cost sharing projects is too cumbersome for companies, it will outweigh the cost savings. However, government funding programs have to follow the rules that are not always designed with research in mind and conflicting needs for accountability exist. Striking a balance will be crucial for the successful cost sharing research program.