

U.S. Highway Capital Programs: Elements of Dynamics and Innovation

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Methodologies for highway capital program management vary widely among state departments of transportation in the United States despite common funding sources and functional disciplines. Capital program management consists of measuring current highway physical and operating conditions, estimating future conditions, determining deficient sections, identifying cost-effective treatments, ordering projects according to established goals and policies, and developing program strategies that create and exploit opportunities for system improvement. State practices diverge to the greatest extent in the areas of establishing and implementing dynamic program strategies. The well-documented decline in infrastructure investment in the United States, coupled with various institutional changes under way, demands that the capital program management strategies become more dynamic and innovative. An overview of the changing transportation environment in the United States and how this has affected capital program management is presented. A 7-element framework to explore and understand this management process is developed. Results from an analysis of practices in eight states in the United States are described. This analysis reveals how various external factors as well as self-imposed conditions hold back or promote the dynamics of the programming process. Fifteen factors were found to be critical in this analysis. These factors ranged from obvious ones such as leadership, focus, and institutional relations to less obvious ones such as structured flow in program development, relief valves in the program structure, and real-time objective data for information analyses and program control.

Highway capital improvements have been a principal *raison d'être* and have provided the earliest justification for society's creation and support of highway and successor transportation agencies. Although this is now true to a lesser degree than when the highway systems were being newly built in the United States, nevertheless, the highway capital program management process remains highly visible and the delivery of high-quality, high-priority capital projects is perhaps the most readily measurable indicator of transportation agency performance.

The key activities in highway capital program management are as follows:

- Assessing current and projected highway system physical and operating conditions using quantitative measures whenever possible;
- Determining within some framework for categorization where and in what priority improvements should be effected, consistent with overall state and transportation agency strategy and goals;

- Developing a range of technically feasible options for the priority improvements sites and testing these against transportation, fiscal, political, environmental, and other impacts;
- Developing strategies that are creative to the point of being exploitive with respect to identification and application of resources to the array of ordered system improvements; and
- Budgeting, scheduling, letting to contract, and controlling these capital investments to completion.

The well-documented decline in infrastructure investment in the United States and the massive changes occurring in the transportation environment demand that the above capital program management activities become more dynamic and innovative. Analysis of several case studies reveals how various external as well as self-imposed factors can hold back or promote the dynamics in the programming process. A full description of these case studies is available in *NCHRP Synthesis of Highway Practice 151 (I)*.

An overview of the changing transportation environment and how this has affected capital program management is presented. This is followed by a conceptual view of the program management process and a discussion of the major factors affecting dynamics and innovation. Finally, some concluding observations are offered.

THE CHANGING TRANSPORTATION ENVIRONMENT

Even a casual observer may perceive significant changes in the highway transportation business during recent times. Following are some dimensions to and reasons for that change:

- The system is mature both geographically and physically. There is a growing maintenance and rehabilitation backlog as first life cycles are lived out and exceeded. The rapid early 20th century initial system construction period makes this, in economic terms, a "lumpy" phenomenon. For example, a large number of Federal-Aid primary system bridges are due or past due for replacement.
- The old institutional management and fiscal frameworks are vanishing and their replacements are only dimly perceived. For instance, the federal presence is being reduced, and the federal funding framework could change dramatically in 1991 when current legislation expires. As another example, chief administrators (at both state and federal levels) serve shorter terms, and so "institutional memory" is lost.

- Transportation is rapidly becoming more than transportation—society is redefining what it means by infrastructure in general and transportation in particular (2). For example, more than just freight haulers, highway transport companies are now components of manufacturing production, competing in a global marketplace. They are responsible for accommodating just-in-time (JIT) inventory and the consequent opportunity for cost containment and quality improvement. In some states, the planning process for highways is changing, with a growing emphasis on a strategic view of transportation. With this redefinition, transportation infrastructure will come under more public and legislative scrutiny, and there will be increasing pressure for system performance. This improved performance will be gained at the margin rather than through grand increments (i.e., the Interstate system) as in the past.

- The highway program is increasingly used to achieve other societal goals. Some examples follow:

- Attract and accommodate economic development
- Enhance environmental quality
- Manage growth and land use
- Promote minority employment
- Preserve cultural heritage
- Reduce alcohol abuse
- Promote agricultural production
- Conserve energy
- Balance the federal budget

- With some localized exceptions, the U.S. highway network during most of its history has enjoyed comfortable margins of overcapacity. As a prudent society dictates narrowing these margins, the professionals, generally risk averse as a group, become increasingly uncomfortable.

- Modal variety is narrowing. Of the more than \$700 billion per year private and public U.S. transportation expenditure, highway transportation accounts for more than 90 percent. When there are fewer modal options, expectations of those remaining are inevitably higher.

- The resource pool is shrinking, in part from inflation and higher standards (which cost more) but even more from national budget constraints and competition from other sectors for public funds.

- Traditional highway tax revenue sources are being eroded due to the fixed nature of the levies (which are generally not responsive to inflation, unlike sales and income taxes), through exemptions of agriculturally derived fuels, and through marked improvements in fuel efficiency for both trucks and automobiles. Meanwhile, the deficit in the federal general fund creates pressure to maintain a surplus in user fee trust funds such as those for highways.

- Private and local governments' share of highway financing is increasing with a consequent blurring of accountability and with some loss of ability to forge programmatic consensus.

- Loss of sovereign immunity and rising tort claims demand aggressive preventive measures focused on targets for these claims.

- The sophistication of instrumentation and devices for measurement, and in computer hardware and software for data management and analysis, is growing at such a rapid pace that maintaining currency is difficult and expensive, yet absolutely essential.

- There is increasing sophistication and analytical capability among congressional and state legislative members and

staffers. To match this capability, departments of transportation must develop similar resources.

- The cadre of professionals brought to highway agencies by expanding programs (e.g., the Interstate system), and the attendant opportunity for personal growth, is now retiring or otherwise leaving this industry. In some states, 30 to 40 percent of the professional engineering staff is eligible to retire. A more productive use of fewer professionals must evolve.

The conclusion from this overview is that highway transportation, in all its systemic ramifications (i.e., physical extent, user mix, intergovernmental relationships, technology, etc.) is undergoing massive change in the United States. The capital program management process is at the center of this change, and thus experiences both the threats and pressures, as well as the opportunities, they represent.

7-S CONCEPTUAL FRAMEWORK

Given the complex set of functions, and the highly diverse milieu in which they are embedded, it seems intuitively correct to assume that there is no single best model or methodology for highway capital program management. The 50 states, with strong individuality, continuously seek to develop their resources and apply them to their option set, recognizing, albeit too dimly in some cases, the circularity between option identification, delivery effectiveness, and resource availability. The dynamics involved in the capital program management process can be better understood, however, by a conceptual framework of the key interacting elements of the process.

Well-executed highway capital program management represents a fine balance between art and science. This balance is necessary in listening to citizen needs and political priorities, forging a manageable consensus, and then empowering the organization to carry out the mission. The technical contributions—the science part—in this process should not be overlooked, both in objectively measuring needs (and informing the constituents thereof) and in carrying out a program of improvements; but the process is by no means completely scientific.

The 7-S framework described here is a variation of the so-called Seven S management model described by Waterman (3). The management concepts of the model have been modified to make the framework relevant to prevailing management practices in U.S. state transportation organizations.

Figure 1 is a schematic view of the 7-S framework as adapted to highway capital program management. The six external circles represent elements that interact in shaping the last element (the internal circle) resulting in skills and success in capital program management.

Vision, leadership—is first. What does the state, through its highway agency, through leadership, want to accomplish? The highway function is derivative. Only as highway programs serve social, economic, and political purposes will they be perceived as successful. Thus, a proper vision for capital program management is not simply of more highways and bridges; such a small vision will surely fail to garner support in an increasingly competitive environment. The vision must be to help the state and the nation in global economic competition



FIGURE 1 Seven interrelated elements.

through improved transportation. Aschauer has given substance to such a vision by noting parallel movement between indicators of infrastructure investment and productivity growth (4). The vision must also include worthy social and environmental goals, such as reducing carbon dioxide emissions and so the “greenhouse effect” by searching out new fuels and new propulsion systems and by reducing congestion. The vision must now offer more than getting farmers out of the mud, the catch phrase during the first half of the century. It must help them in all aspects of their enterprise, certainly providing a system of non-weight-restricted roads and bridges.

Finally, the vision must deal with equity as well as efficiency issues. Transportation professionals may indeed have a priority set that is optimal from a transportation efficiency perspective. But government will always be constrained by equity considerations. And nowhere is this more critically true than in highway transportation. In its redefined role, transportation in the United States is an essential good for social and economic reasons; a fundamental right to young and old, to rich and poor, and to urban, suburban, exurban, and rural citizens. Any vision of a highway capital improvement process less encompassing than suggested by these few thoughts will not succeed.

Why it will not succeed relates to all the affected constituencies. This is the subject of the second element, the *political, cultural, and economic environment*, or more simply, the *authorizing environment*. Government exists, in the United States context, by the consent of the governed. They, the governed, authorize all programs, including the highway program. For the highway system, this authorizing environment is very extensive. Indeed, it is difficult to define out any individual function, group, or institution. How does this authorizing environment speak? Concerning the need for highways,

it spoke in a 1916 congressional action. It—mostly the farm society of the day—said, “Get us out of the mud and ensure regular mail delivery with a system of federally aided roads.” Later, in 1944, it—then an increasingly urban population—said, “Look after some of the major urban highways in essentially the same fashion as rural highways were looked after.” Still later, in 1956, again through congressional action, the authorizing environment—then a more dispersed population, one recently exposed to two world wars and facing burgeoning economic growth—said, “Connect all major economic and political centers with a national network of freeflowing, defense-supportive highways.” The 1982 Surface Transportation Assistance Act said, “Let us increase spending for preservation and restoration of existing roads and bridges.”

More recently, the voice of the highway authorizing environment seems, to those conditioned by previous clarion-clear calls to action, to be muted and confused. Some may say it is like viewing a rich tapestry backward and in dim light. This implies in no way, however, that the authorizing environment has gone awry. It only means that listening is more difficult, more important. A major note to be made here is to the role of leadership vis-à-vis this authorizing environment. Must highway agencies only wait for the clear voice? By no means. Pro-active listening requires knowledge, sharing of ideas, discipline, courage, and respect, respect for all the authorizing environment. These, in turn, are more likely to be found in an agency under empowering leadership.

Finally, there is *organizational capacity*. It is no good selecting, prioritizing, and promising capital programs that will not be delivered. Indeed, it is counterproductive to do so. The long-range urban planning process of the 1960s and 1970s that simultaneously raised expectations and alarms, without adequate attention to delivery, proved this point. In many regions of the country, a public exposed to undeliverable, unrealistic, threatening plans rapidly lost faith in the agency proffering them.

Organizational capacity rests in part on particular skills and numbers. But in the highway capital program arena, it rests even more on creativity, a fact noted earlier. In terms of the 7-S framework, four elements make up the organizational capacity.

Organizational goals and objectives—Organizations come to grips with something more specific than a vision. Leadership must provide manageable packages set in realistic time frames. Only then can they become part of the driving force, the empowerment for the agency.

Organizational structure, culture, and motivation—How well the internal resources are utilized is the issue here. No one structure or culture is uniquely right for capital program management. However, a “directed autonomy” is more likely to produce the necessary culture, motivation, and creativity to move the process forward and reflect the constant stream of change that is the environment. Robert Waterman in *The Renewal Factor* (3), says,

“In a directed autonomy, people in every nook and cranny of the company are empowered—encouraged in fact—to do things their way . . . but this all takes place within a context of direction. The highway arena is indeed characterized by this directed autonomy.”

While state program managers strive, with strong encouragement from all sides, for creative new approaches in the capital

program management process, the federal government, governors, cabinet secretaries, and commissioners provide the context of direction. Using another of Waterman's terms, the frequent "renewal" from legislative input, gubernatorial change, federal program reauthorization, professional skill enhancement, and others have benefited the capital management process.

Technical and support staff capability—Along with much art, the capital program management process has strong elements of science, as already noted. People who know federal programs well, who understand political and organizational processes, who are facile in data management and analysis, and finally people who are willing to work long, very hard, and with complete integrity, these kinds of people are absolutely essential to success in this arena.

Systems for information, analyses, and control—The data volume is too great, the required analyses too extensive, and the requirements for control too pressing to operate without benefit of state-of-the-art systems. As an obvious example of element interaction, these systems must be authorized by a forward-looking leadership, one that sees improved systems as part of the overall strategy, and as further interaction, these systems become the tools whereby the support staff meets its obligation in creative ways.

The last element, the derivative element, in the 7-S framework is *skill and success* in improving and recapitalizing highway transportation systems. Lack of this success, this skill, will not be hidden. Indeed, the ability to move projects through the pipeline is perhaps the most common, most readily identifiable measure of transportation agencies' success. It relies on skill and success in all contributory elements. An important final note on this 7-S framework is that the process itself, the way in which the elements are carried out and how they interact, is important in its own right, perhaps almost as important as the product. Indeed there will not be a continuing stream of good product without a good process.

FACTORS AFFECTING DYNAMICS OF CAPITAL PROGRAM MANAGEMENT

Case studies of capital program management processes in eight states (California, Colorado, Connecticut, Florida, New York, Pennsylvania, Texas, and Washington) suggest that the 7-S framework is useful for gaining an understanding of the dynamics of the process. The case analyses revealed 15 dynamic factors or elements, factors with the potential to contribute or detract from the effectiveness of the capital management process. These factors are summarily shown in Table 1, grouped according to 7-S elements (although in some cases they could be put under more than one element) and example manifestations in state practices. The 15 factors are discussed below by 7-S element.

Vision and Leadership

In the eight states examined, three factors were observed to have a significant effect in advancing a meaningful vision for transportation. The first, an obvious one, is the nature of leadership. Strong executives can bring drama and excitement

to the programming process. An example of this at the gubernatorial level is Colorado where the current governor has taken a strong role in the process, personally chairing project hearings throughout the state to build a transportation program consensus. This leadership can offset or transcend institutionalized weaknesses in the power structure resulting from constitutional separation of powers or political partisanship. A well-thought-out, goal-oriented approach also marks leadership. In Colorado, the governor's highway proposals focused on 42 critical major projects throughout the state. In New York, the department of transportation (DOT) launched its goal-oriented programming process as a way to make the agency more responsive and supportive to statewide social, economic, and transportation goals.

Another important facet of leadership is top management stability or lack thereof. Nationwide, transportation executive positions are increasingly short term and often filled from outside the agency. In contrast, the top positions in Texas are filled with people of considerable experience in the agency serving on a professional career basis. This stability is particularly important to long-term, publicly sensitive programs such as highway capital investments.

A second important factor is division of effort between or focus on building versus slicing the pie. The General Assembly of California has dealt with the resource allocation issue, north versus south, urban versus rural, by putting in place mandated distribution formulas. Due to various program limitations, this political solution is a major constraint to the program management process. The Texas Department of Highways and Public Transportation has attempted to deal with the allocation issue by using ranking indices of cost-effectiveness and accounting for equity in part through population distribution. This approach has permitted the agency to focus the attention of its constituencies on long-term goals, addressed on a statewide basis, to building and enlarging the pie. The Colorado DOT has also developed a decision tree process (called Resource Allocation and Project Prioritization or RAPP) to rationalize its allocation of road expenditures for selected programs.

A third factor is simply the time dimension of the programming process. In Pennsylvania the dimension is 12 years, divided into three 4-year segments. Projects in the first 4-year segment are approved for final design and construction; in the second segment, projects are approved for preliminary plans and clearances only; in the third segment, years 9 through 12, projects are in the distant planning stage with no dollar commitments. Texas uses a 20-year horizon for its mobility plan, with actual project development narrowing to 10 years and then differing by program in project specificity. In California, the State Transportation Improvement Program (STIP) with a 5-year horizon is specified in law with specific milestone dates in terms of program development. Until a recent legislative amendment, no funds could be expended outside the 5-year period. This time frame appears inadequate for early phase project preparation because an overall time frame of 10 years is not unusual for major projects.

Authorizing Environment

Two major factors affecting the ability to constructively work with the authorizing environment are fragmentation of authority

TABLE 1 FACTORS AFFECTING THE CAPITAL MANAGEMENT PROCESS

7-S ELEMENT	DYNAMIC FACTOR	MANIFESTATION
VISION	LEADERSHIP	*STRONG EXECUTIVES *GOAL-ORIENTED MANAGEMENT
	FOCUS ON BUILDING/ SLICING THE PIE	*MANDATED FORMULAS
	TIME DIMENSION	*SHORT TIME FRAME
AUTHORIZING ENVIRONMENT	FRAGMENTATION OF AUTHORITY	*WEAK POWER STRUCTURE *LARGE LOCAL/PRIVATE ROLE *DIFFUSED RESPONSIBILITY *LOWER VISIBILITY
	PROCESS AS TOOL FOR BUILDING CONSENSUS	*STRUCTURED INPUT *WIDE PARTICIPATION
GOALS & OBJECTIVES	DERIVATIVE CONTEXT	*LINKAGE *DISAGGREGATION
	PRIORITY SETTING/ FOCUS	*PROJECT CATEGORIES *PROGRAMMING THEMES
	STRUCTURED, MULTI-DIRECTIONAL FLOW	*JUST ENOUGH CHAOS *EXTENSIVE COMMUNICATION
STAFF	CAPACITY LIMITATIONS	*ARBITRARY CUTBACKS *CONSULTANT POLICY
	COORDINATION	*PROGRAM CENTER
STRUCTURE, CULTURE	INSTITUTIONAL RELATIONSHIPS	*INSULATION *POWER RELATIONSHIPS
	PROFESSIONAL SKILLS & VALUES	*VALUE SYSTEM *SKILLS TRAINING
	RELIEF VALVES	*DISCRETIONARY ALLOCATION *POLITICAL BALANCE
SYSTEMS	REAL-TIME OBJECTIVE DATA	*NEW TECHNOLOGY *EXPERIMENTATION
	INFORMATION MANAGEMENT	*MANAGEMENT CONTROL

and use of the programming process as a tool for building consensus.

Fragmentation of authority can occur because of too much weakness in a state's power structure, which diffuses authority between the executive and legislative branches of government, or within the executive branch among various departments. In California, the legislature established an independent California Transportation Commission, which is charged with approving and adopting the STIP, but which is without resources for implementation, which are in the hands of CalTrans (the state DOT). Furthermore, the director of CalTrans is subordinate to a cabinet officer in charge of a "Super-Cabinet" agency with oversight of transportation, commerce, and housing. This means that transportation is one layer removed from the governor. Also, in California, as

in many other states including Florida and Colorado, there has developed a large local government and private sector contribution to transportation capital improvements using so-called "innovative financing methods," including public-private partnerships (5,6). Do these developments create checks and balances in the programming process or are they fragmenting transportation authority? Though judgment may be premature, the experience seems to point to the latter, with great effort being required to build political consensus at the statewide level for any broad improvement thrust.

In terms of building consensus, the program development process itself can be a valuable tool for transportation executives. Both Pennsylvania and Colorado, among others, use the structure of the process, coupled with statewide input, including several public hearings, to develop project priorities

and support for the program. Frequent, periodic updating of the capital program provides an opportunity to build credibility with the program's constituencies.

Organization Goals and Objectives

Three key factors were observed to drive successful, goal-oriented transportation agencies. The first of these, derivative context, refers to the fact noted earlier that society is defining transportation as more than just transportation; and successful organizations, recognizing this trend, set their transportation goals in a larger context. Florida has carried this thought a step further, embedding the transportation plan in a state-wide comprehensive planning process mandated of all state agencies by statute (7). In addition, Florida statutes require that the DOT's programs be driven by policies and program objectives explicitly stated in its "Work Program." There has to be disaggregation from the larger context to measurable targets.

A second dynamic factor is priority setting and focus. The Texas DOT divides its construction projects into nine categories with tailored goals, objectives, and allocation rules for each. Pennsylvania uses federal funding categories but also develops program themes of special interest: the agricultural access network (farmers), industrial and commercial access networks (industry), and priority commercial network (truckers). Projects on these networks get added preference. The Washington DOT has a tradition longer than most states in this area, rooted in a priority programming law passed in 1963. This law, with subsequent amendments, defines goals and procedures for functional classification, improvement categories and priorities, and long-term program and financial plans.

The third factor, structured and multidirectional process flow, is more elusive, but still an important source of dynamics and innovation in the program process. In successful organizations, the process of establishing goals and objectives and constantly updating them is carefully structured, with specification of roles and duties for all participants, time-phased milestones, and widespread communication. In addition, the flow is multidirectional, functioning both "top-down" and "bottom-up." Furthermore, both top executives and line officers, such as directors of regional engineering offices, get input "sideways," from legislators, media, special constituency groups, and the public. However, unless there is a carefully considered structure to the process, this can be chaotic. To maintain just enough chaos to stimulate change and innovation is an art that successful agencies have come to appreciate if not master.

Technical and Support Staff

State DOTs are by and large staffed by skilled, motivated, and professional personnel. However, two factors have notable effect on the capital programming process, capacity limitations and coordination.

Capacity limitations often take the form of arbitrary, across-the-board staff cutbacks, which result in loss of experienced

personnel, difficulties in recruiting bright young replacements, and a decline in morale. Where cutbacks are a necessity due to statewide budgetary difficulties, a goal-oriented approach that distinguishes the importance of various activities is much more productive. Judicious use of consultants can augment agency capabilities in needed areas.

The importance given to coordination of capital program activities varies according to the structure of responsibilities. In centrally managed agencies, a high degree of coordination is needed. The Pennsylvania DOT uses a Program Management Committee involving all senior managers meeting weekly for full program development and control. In contrast, Florida has a highly decentralized structure. Its seven district directors report directly to the agency head (state secretary of transportation) and have authority to make most capital program decisions, subject only to certain aggregate fiscal and administrative restrictions.

Structure, Culture, and Motivation

Three important factors have strong influence on the corporate culture and internal environment within transportation agencies. The first of these, institutional relationships, refers to the manner in which agency personnel relate to external bodies, such as legislative members and local government officials. The diffusion of responsibility in California places a great importance on cooperative relationships between the agencies involved to maintain effective program development and delivery.

In Colorado, there is another manifestation of this factor, resulting from the fact that the state constitution not only provides for earmarking of highway user fee revenues to the State Highway Fund, but also makes the revenues immediately available to the agency with no appropriation needed from the legislature. The lack of "purse-string control" makes it less attractive for legislators to vote for revenue increases. In contrast, in the state of Washington, the DOT has a very close interaction with the legislature, indeed is one of the agencies most tightly controlled by the legislature. This relationship has helped in some ways to address pressing transportation concerns. For example, in 1976, Washington was an early enactor of an innovative, variable fuel tax, with a floor and a ceiling to maintain revenue stability. Since then, even more responsive measures have been considered.

The high degree of urbanization in Connecticut gives local Metropolitan Planning Organizations (MPOs) a strong voice in transportation decisions in their regions. Indeed, as a unique feature of their organizational structure and culture, the state DOT has chosen not to be represented in the MPOs. Nevertheless, Connecticut's cooperative process is such that all its major expressway improvements during the 10-year program have been endorsed by the appropriate MPOs.

A second factor affecting culture and motivation is professional skills and values. CalTrans, for example, remains a leader in many aspects of highway technology and program development, including benefit-cost analyses, because of the high professionalism and skills of its personnel. Similarly, the California Transportation Commission has developed a small but highly qualified staff, expert in transportation policy and

program development. These staffs use modern information, analysis, and control systems in their highway capital improvement related work, similar to their counterparts in other leading state DOTs.

A third factor affecting delivery capability of an agency is the presence of relief valves in the programming process. Just as valves in a pipeline can provide escape when too much pressure builds up, mechanisms are needed in the capital program management process to deal with uncertainty, new or changing political preferences, unresolved equity issues, and "just enough chaos." Texas provides two relief valves: first, a group of projects identified in its long-term plan as "tentative Commission commitments." This permits real input from the small but active Texas Transportation Commission, insures their "ownership" of the program, while not permitting uncontrolled expenditure. As explicitly noted in its plan, these projects are approved for planning only, not land acquisition or construction, for which they must go through the normal ranking process. The other relief valve is a discretionary allocation to the districts to address relatively low-cost needs (traffic signal, spot safety project, etc.) for which there may be significant community clamor.

Systems for Information, Analyses, and Control

Two major factors affecting innovation in the use of information systems in transportation agencies are the desire for real-time objective data and for information management. The former is reflected in the increasing use by state DOTs (e.g., Texas) of video-imaging equipment to capture and analyze road profiles, and of pavement management systems for optimizing surface treatments.

Information management is the response to too much data, much of it often too late or not usable to management. Initial computerization efforts in state agencies often led to stand-alone automated systems. The next generation of software used linkages or integration, utilizing large data bases, and providing wide access to central office and field personnel with the need. For instance, Florida DOT's Work Program Administration (WPA) permits a "gaming" or what-if analysis approach to capital program development. The WPA also tracks performance and aids in program implementation. For example, WPA aids districts in performing allocation swaps

to balance fund surpluses and shortages. As legislative and public inquiries become more sophisticated, transportation agencies will need to develop executive information systems (sometimes referred to as decision-support systems) that can extract summary data from a large pool of real-time transaction data bases.

CONCLUSION

This paper has described a framework for understanding the very creative processes used for managing capital programs in state DOTs in the United States, and the major factors observed to affect dynamics and innovation in these programs. What of the future? Clearly, the growing congestion will increase pressure on program delivery and for shorter project cycle times. At the same time, building consensus for broad programmatic initiatives may be difficult. To succeed in this competitive environment, the capital programming process must focus on broad goals, and be responsive, through better technology, analysis, and communication, to legislative and other external concerns.

REFERENCES

1. T. Larson and K. Rao. *NCHRP Synthesis of Highway Practice 151: Process for Recapitalizing Highway Transportation Systems*. TRB, National Research Council, Washington, D.C., 1989.
2. *Special Report 220: A Look Ahead: Year 2020*. TRB, National Research Council, Washington, D.C., 1988.
3. R. H. Waterman, Jr. *The Renewal Factor*. Bantam Books, New York, N.Y., 1987.
4. D. Aschauer. *Is Public Expenditure Productive?* Federal Reserve Board of Chicago, 1988.
5. R. R. Mudge and S. Jakubiak. *Financing Infrastructure, Innovations at the Local Level*. National League of Cities, Washington, D.C., 1987.
6. K. Rao. Highway Funding Trends in the US: Innovations Amidst Turbulence. *PTRC Europe Proceedings*, Vol. P303, 1988, pp. 193-204.
7. G. L. Reed. Changing Roles for State Transportation Planning: The Florida Case. In *Transportation Research Record 1124*, TRB, National Research Council, Washington, D.C., 1987, pp. 76-80.

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