Abridgment

ECONS: Case Study in Program Development Through an Integrated, Organizational Approach

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This paper describes how the new management philosophy in the Pennsylvania Department of Transportation has been linked with existing technical expertise within the Department to create a major new program aimed specifically at saving lives and reducing congestion. Despite an inauspicious beginning, the ECONS program is now finally understood and embraced by local officials. With local officials more involved in project selection and evaluation, differences of opinion that previously led to the best projects (from a technical perspective) being rejected are now resolved jointly by the Department and local officials. Although the result is a more modest program than originally conceived, the long run will no doubt demonstrate an overall greater cost effectiveness in conserving energy, reducing congestion, and improving safety. As efforts to restore existing highways and bridges take hold and the Interstate and Appalachian construction programs wind down, it may well be that this evolving program to conserve energy, reduce congestion, and improve safety becomes the state's highway program of the future.

In the early 1970s, Pennsylvania had one of the most ambitious highway construction programs in the country. Toward the mid-1970s, things started to fall apart. While literally billions of dollars in bond money were being spent for 100 percent state financing of expressway-type highways, the federal-aid program was being ignored. By 1978, Pennsylvania had fallen approximately three years behind in its use of federal aid and had accrued the largest unobligated balance in the country--more than $800 million. By 1979, in addition to the enormous unobligated balance, almost half a billion dollars had been reallocated to other states.

An expressed goal of the new management was to avoid additional loss of federal aid. A first step was to analyze the extent that limited state dollars could be leveraged with federal aid. During this exercise it was discovered that Pennsylvania had access to nearly $200 million in federal aid that required no state matching funds at all. This was through the so-called Federal-Aid "G" Fund established through the 1973 Federal-Aid Highway Act and broadened in the 1978 Act. This legislation provides that up to 10 percent of all Interstate, primary, secondary, and urban apportionments may be used for 100 percent federal financing for projects to eliminate the hazards of railway-highway crossings and to install traffic control signalization.

A NEW INITIATIVE

A new initiative to save lives and reduce congestion evolved from the discovery that $200 million was available to Pennsylvania for 100 percent federal financing of certain projects. Another $75 million in regular federal aid was added to create an overall $300 million program.

The objective in developing the new initiative was quite simple. Given the lowest-cost but most effective ways feasible, identify the 30 most hazardous railway-highway crossings in the state, the 350 most critical intersections, and the 50 most congested urban corridors. The overall goal was to develop and implement a program that would, by 1985, save 300 lives and 4 million hours of both personal and equipment time.

Although the objectives of the new initiative were quite straightforward, program development and implementation proved to be an elusive exercise. Not the least of the hurdles was the name of the program. The New Initiative Program to Save Lives and Reduce Congestion eventually became ECONS--an acronym for ENERGY CONSERVATION, CONGESTION REDUCTION, AND SAFETY IMPROVEMENT.

Other hurdles also had to be overcome. Perhaps the greatest was the notion that $300 million in new federal funds had been found that required no matching funds. What the Department had great difficulty in articulating was that the $300 million was not new money. Rather it was hoped by the Department that state and local governments working together could creatively innovate a new program to actually save lives and reduce congestion. Because of the poor fiscal situation, it was imperative that the program require a minimum of nonfederal matching funds. By taking full advantage of so-called federal-aid "G" funding, a program requiring only $25 million in non-federal matching funds was possible. Such a program could leverage each state-local dollar more than nine times. At a time when Pennsylvania was turning back half a billion dollars in federal aid for lack of state matching dollars this was an exciting proposition.

Another very difficult hurdle resulted from the way the new initiative cut across the traditional federal-aid Interstate, primary, secondary and urban system programs. Funding for the new initiative had to come from these categories. Local planning agencies felt as though these funds had already been earmarked for projects that, in their minds, had a very high priority. The fact that the state could not match federal aid and was otherwise incapable of carrying out "their" priority programs fell (at first) on deaf ears.

Another hurdle came soon after the first round of technical evaluations was completed. The Carter Administration, in an anti-inflation move, placed ceilings on how much federal aid each state could obligate. In effect, the $800 million balance of unobligated federal aid that had accrued to Pennsylvania was inaccessible. Some $200 million, which could have been used for 100 percent federal funding of projects to save lives and reduce congestion, now had to compete with closed bridges and Interstate completion deadlines for priority use of federal aid.

Project Selection

The Department's goal to have $300 million worth of ECONS projects implemented within four years led to an extremely tight timetable for project submission. The first step was to develop candidate projects. All county planning commissions, metropolitan planning organizations, and highway engineering districts, as well as the larger municipalities, were asked to submit candidate projects.

A list of 1061 candidate projects was developed. Preliminary estimates totaled $580 million--almost twice the $300 million program target. In addition, projects on the federal-aid primary system exceeded target values by a factor of three. This was an insurmountable problem since primary funds available to Pennsylvania were already four times oversubscribed.

Technical Evaluation

Concurrently with developing candidate projects, the Department hired a consultant to develop a methodology for evaluating projects. Factors to be considered were benefit/cost ratios, number of deaths and injuries reduced, amount of delay reduced, fuel saved, and qualitative factors such as economic growth. The basic aim was to establish a group of common measures of effectiveness. The measures of effectiveness established were delay, fuel consumption, and injury and fatal accident occurrences. Four categories of problems were identified: (a) spot locations with high accident experience, (b) congestion problems at isolated intersections, (c) congestion problems along urban arterials, and (d) congestion problems within urban grids. Delay, fuel consumption, and accident impacts could be identified and measured for each candidate project within these categories.

Limited manpower with expertise in traffic safety and operational improvements led the Department to hire four consultants to analyze and evaluate candidate projects. Because each consultant was responsible for a certain geographic area of the state, it was extremely important that the values of delay, fuel consumption, and accident reduction could be comparatively applied.

High Accident Locations

Analysis of high-accident locations was based on the state's Location Priority Report. High-accident locations were analyzed through collision diagrams, accident patterns, and substandard design features. Improvements to upgrade substandard design features were then determined and estimates made of the savings that could be achieved.

Congested Intersections

Information required for intersection analysis included turning volumes during the peak hour, average daily traffic, physical characteristics, and existing signal timing and phasing. The existing condition was then optimized by using Webster's method of determining effective green time and cycle length (1). Saturation flow rates needed for computing cycle lengths and effective green times were initially determined by using intersection capacity charts with demand volumes. Delays during the peak hour were then computed for each approach lane based on computed effective green times and actual saturation flow rates with delay being a function of degree of saturation for unsaturated intersections and the size for queues of oversaturated intersections. The next step was to determine how to reduce intersection delay. The Highway Capacity Manual provided the basis for determining critical approaches and turning movements (2).

Once a hypothetical package of improvements was identified, the "improved" condition was analyzed to determine delay. Delay values were then compared with delay values for the "optimized" existing intersection to determine how effective improvements would be.

Next, off-peak delays were analyzed. The average off-peak hour was determined by summing the approach volumes occurring from 6:00 a.m. to 12 midnight, deducting the peak-hour volumes, and then dividing by the number of off-peak hours. The same procedures described for the peak-hour analysis were then followed to determine delay savings during the off peak. It was found that the delay savings during the accumulated off-peak hours varied between 90 and 140 percent of the peak-hour delay savings.

Fuel consumption saving was based solely on delay. It was determined by taking the product of the delay saving and average vehicle fuel consumption at idling rates (0.63 gal/h).

Accident analysis procedures for congested intersections depended on whether the intersection appeared in the state's Location-Priority Report. For those intersections listed in the report, analysis was the same as for high-accident locations described previously. If an intersection did not appear in the report, appropriate accident reduction factors were applied to proposed improvements based on the site's accident history.

Congested Arterial Corridors

By using speed and delay runs, critical intersections were identified. Each intersection was then analyzed by using the same methodology as for isolated congested intersections. If the geometry of the roadway and the spacing of signals were favorable for interconnection, each signal was retimed by using the optimum cycle length of the critical signal(s). The delay difference of offset computer program was then used to determine arterial delay during the peak hour with interconnected signals (3). Arterial approaches to the main arterial were assumed to operate at level-of-service D or better. The values derived from the delay difference of off-set program were then compared with the approach delays for optimized but nonconnected signals to determine the net savings from interconnection during the peak hour. By using the same concept as the average off-peak hour in the congested intersection discussion, the average and total off-peak savings due to interconnection were determined.

Congested Urban Grids

Conceptually, grid-system analysis was an extension of urban arterial analysis. Speed and delay runs were performed during peak and average off-peak hours. Critical intersections were identified and each intersection analyzed as described previously. Delay savings were based on various signal system improvements. The total stopped delays were summed for all links, then percentages were applied for various types of improvements to determine annual savings for each type of improvement.

Comparative Analysis

For comparative analysis, benefits from potential improvements were expressed in terms of number of vehicle hours, gallons of gasoline, property damage, and injury and fatal accidents that could be saved each year. Values were then converted to dollars and compared with project costs.

Lessons Learned

As would be expected in developing any new program, a number of problems emerged. In retrospect, a lot of time and effort was wasted because of inadequate prescreening of projects. Another problem occurred when it was discovered that the four consultants were not consistent in their application of procedures for project analysis and evaluation.

Initial Results

Of the 1061 candidate projects generated initially, 109 projects survived the first-round technical evaluation. These projects were then further evaluated to ensure they met the basic goals and objectives of the ECONS program. Finally, projects

Table 1. Federal-aid categorical splits.

Item	Total	Federal Funds ($000 000s) FAP	FAS	FAU	Total	Matching Funds
Initial targets	300.0	85.5	22.5	162.0	270.0	30.0
First round	7.7	4.4	0.2	1.6	6.2	1.5
Second effort	24.7	10.3	0.0	10.1	20.4	4.3

Table 2. Estimated annual benefits.

Item	Lives Saved	Hours Saved	Fuel Saved (gal)
Initial targets	300.0	4 000 000	-
First round	2.2	1 162 100	750 000
Second effort	4.5	1 427 300	900 000

were prioritized on a statewide basis. Of the 109 projects submitted, 50 projects clearly did not meet the goals and objectives of the program and were dropped from further consideration.

The first-round submission had a cutoff benefit/cost criterion of 3.0. Some 28 projects met this criteria. Annual benefits totaled $5 754 000 compared with annual costs of $1 687 000 that yielded an overall benefit/cost ratio of 3.4. Collectively, the 28 projects annually would save 1.1 million h of stopped delay during the peak hour, 750 000 gal of gasoline, 53 serious injuries, and 2 lives. Estimated cost of the 28 projects was $7 669 000, but federal funds only made up 80 percent.

Management was disappointed in the first-round submission. First, a 90 percent federal participation rate had been set as an overall program objective. Second, the ECONS program requires a combination of primary, secondary, and urban system funding. Since Pennsylvania's anticipated primary apportionment was already four times oversubscribed, federal-aid primary funds required by the ECONS program had to be strictly limited. Finally, the 28 projects submitted for the first round were not nearly as effective in saving lives as originally hoped.

Management directed staff to review the original submission. The first-round resubmission consisted of 20 projects costing $3.3 million. While federal-aid primary funding required was reduced to $1.6 million, the federal participation rate remained at 80 percent and lives saved at 6 within 4 years. Nevertheless, because of the significant time and fuel savings, the 20 projects were authorized for construction.

A SECOND EFFORT

The disappointing results of the first round led to a reassessment of the entire program. Management decided that in spite of federal obligation ceilings, a modest ECONS program would be pursued.

For second-round projects both qualitative and quantitative factors were considered. Qualitative factors included (a) local priority, (b) local participation in funding, and (c) impact on the local economy. Quantitative factors included (a) the overall benefit/cost ratio, (b) the energy benefit/cost ratio, (c) the safety benefit/cost ratio, (d) fatal accidents saved, (e) average daily traffic, (f) share of federal funding, and (g) share of local funding.

Second-round projects had to meet the following criteria: (a) overall benefit/cost ratio-->3.0, (b) safety benefit/cost ratio-->2.0, (c) fatal accidents saved-->1 in three years, (d) average daily traffic-->15 000 vehicles, and (e) federal participation rate-->90 percent.

In all, 161 projects were submitted costing $43.8 million. This was narrowed to 70 projects totaling $24.7 million. Nevertheless, even with stricter criteria for federal participation rates and the use of federal-aid primary funds, the two problems still persisted. Table 1 shows the federal-aid categorical splits. In this case, management decided to authorize the 70 projects provided that metropolitan planning organizations endorse them. All 70 projects were subsequently endorsed. Table 2 provides an estimate of annual benefits.

AN ESTABLISHED PROGRAM

Now, after almost two years of starts, reassessments, and restarts, ECONS has become an established program. Energy conservation, which was considered more a byproduct of the new initiative to save lives and reduce congestion, has now become a basic element of the ECONS program.

While a great deal was learned from initial efforts to develop the program, the basic lesson learned was that the metropolitan planning organizations must be brought into the program from the very beginning. During negotiations with metropolitan planning organizations in developing their respective unified planning work programs, corridors were selected for ECONS examination. In all, 66 corridors were evaluated during FY 1981-1982.

SUMMARY AND CONCLUSIONS

Despite its inauspicious beginning, the ECONS program is now finally understood and embraced by local officials. With local officials more involved in project selection and evaluation, differences of opinion that previously led to the best projects (from a technical perspective) being rejected are now resolved jointly by the Department and local officials. While the result is a more modest program than originally conceived, the long run will no doubt demonstrate an overall greater cost effectiveness in conserving energy, reducing congestion, and improving safety.

In the lessons-learned category, it can be concluded that

1. Traditional safety programs do not lend themselves to programs that also include congestion reduction and energy conservation;
2. Narrow federal categories (primary, secondary, and urban systems) restrict a systems approach to intersection improvements that have a mix of federal-aid system designations;
3. The gauntlet of federal regulations and bureaucratic reviews inherent in federal-aid programs makes it difficult for low-cost operational/safety improvements to survive the process;
4. The state of the art does not lend itself to the development of a broad, statewide goal-directed program;
5. Overly rigorous analytical methods become unwieldy when applied by a variety of individuals to an array of improvement categories;
6. A great deal of cross-education is required to achieve agreement on what is "best" in the minds of technical evaluators and what is "best" in the minds of local officials; and
7. It takes both strong, articulate leadership and willing local cooperation to develop and carry

out a goal-oriented program that cuts across traditional funding sources.

Finally, worthwhile goals and objectives simply do not come easily. Nevertheless, despite the constraints of restrictive federal funding categories, overly narrow analytical procedures, general resistance to change, and the inability to articulate the potential benefits of doing things a little differently, reducing congestion and saving lives remain worthwhile goals. Now, after two years of cross-education, the state's transportation department is pleased to join with local officials in the continuing identification and selection of cost-effective projects that actually do conserve energy, reduce congestion, and save lives.

REFERENCES

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California's Engineered Systems Approach to Project Delivery and Capital Resource Management

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The California Department of Transportation's development of an engineered systems approach to project delivery and capital resource management is discussed. Effective management of productivity is the important key to the successful delivery of a transportation program. The California system focuses directly on the effective management of productivity through informed and timely decisionmaking in order to make things happen. This approach is used in resource management planning and then to measure the effectiveness of carrying out that plan.

Problems that face the professional transportation manager today are well documented. What was once a pure technical process now involves a multidisciplinary team approach to problem solving with a mixture of agendas and understandings of the real problems to be solved. Add to this an increasing number of uncontrollable external barriers, as well as inordinately long required process times, and it has become more and more difficult to forecast and maintain program delivery. The manager is confronted with constant change in program direction and composition due to a limited money supply or revenue base, while at the same time facing up to a basic responsibility to preserve an aging system and keep it operational. Continuing cost inflation spirals are resulting in rescoping and/or downscoping engineering designs to keep costs within allocation limits that result in a dichotomy of additional costs in time and effort thrust on an already limited staff. The number of smaller-sized, manpower-intensive projects is increasing in logarithmic proportions in an attempt to stretch a diminishing constant-worth dollar.

It would seem that in the purview of today's professional transportation manager, the only certainty is continuing uncertainty and limits. It has been said that the 1980s will more than likely be an era of limits for transportation. Money, staff, and time are limited, but demands for meeting broadening transportation needs will be unlimited. These limits and demands to a transportation manager mean just one thing--increase productivity.

Additional complexities surfaced during the 1970s when there was a national change in cultural climate, a new energy awareness, and the awakening of the era of limits. Highway departments had been highballing the development of a national network of highways as "the transportation system" for about 20 years and suddenly became "transportation departments." New responsibilities and requirements surfaced along with new technologies aimed at interfacing multiple air, land, and water modes into an integrated system. The transition is beginning to move forward aggressively with the highway corridor still the dominant surface facility for moving goods and people. The highway corridor has been expanded to a transportation corridor and now may include exclusive lanes and even tracks for high-occupancy vehicles at one end of the spectrum to lanes for bicyclists at the other end, in addition to cars and trucks normally found in a highway corridor. To keep all of these responsibilities in focus and balance, the transportation manager has had to slice the total program into elements and components that have varying goals and objectives, thus adding further complexities to managing in the world of limits.

To bring order to all of the disorder, a manager obviously needs a resource utilization plan. In this type of environment, a systems approach to resource planning and decisionmaking becomes an important element in the successful management of productivity. Therefore, effective management of productivity is the important key to successful delivery of a transportation program.

A comprehensive and integrated information system can be used by the manager to establish a plan of program delivery to meet long- and/or short-term goals and objectives set for the program. The quality of information provided from this systems approach can affect the quality of the plan and ultimately affect productivity. The manager then can establish a mutual understanding and balance with staff between rates of productivity and the capability to accomplish the program. Placing this information into a systems context also enables all levels of management and staff to individually and/or collectively plan for rates of productivity to accomplish the established program goals. An essential element of the system then becomes maintaining information credibility in order to have a base for the exchange, communication, and measurement of accomplishments. As the inevitable change