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.

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

JAMES F. McMANUS

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 occurs and as long as all levels of management understand where they are at any point in time, the impacts of the change can be measured to minimize organizational trauma and establish a new goal for accomplishment.

Such a system must be comprehensive and yet relatively simple. The system must be responsive to management needs and be capable of providing information incrementally or collectively on the basis of the total transportation program, modal element, modal component, organizational function, project, or activity/task. The system must provide information for each part of the full management cycle: planning, programming, scheduling, staffing, budgeting, monitoring, evaluation, and a feedback loop to planning (see Figure 1). To handle effectively the myriad of demands for structured and timely information, manipulated in various formats, most often requires a system employing computerization.

Computerized management systems abound. Most are described as such incorrectly because many are basically administrative systems that allow people to watch things happen, usually after they have happened, while others forecast resources in pieces--people separate from time, time and people separate from dollars. Many are incomplete, leaving out important elements of a complete project. What has been needed is a comprehensive system with all resource needs tied together that points the way--a system that can respond to changing processes as they occur and can provide managers with complete, timely, and comprehensive information and options to enable them to make informed decisions that make things happen. Such a system has been developed in California and is the subject of this paper.

Figure 1. Transportation program management cycle.

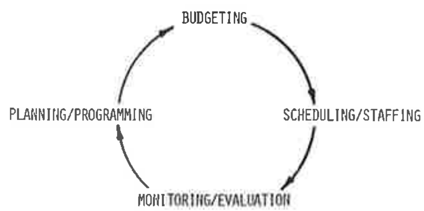
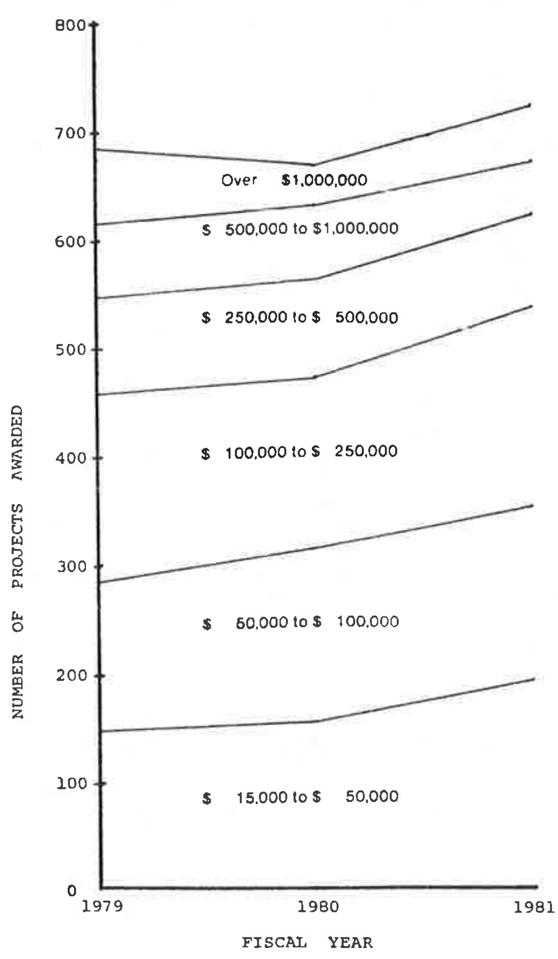


Figure 2. Number and size of capital projects awarded in California between June 1978 and July 1981.



PRIOR MANAGEMENT SYSTEMS DEFICIENT

California, like many states, has had project-specific work plans loaded into its computerized data base for at least the past 12 years. The loading had to be done manually, project by project, utilizing data separately calculated from a large array of complex manpower management systems that became notoriously out-of-date with processes. Manually calculated supplements were then added. None of the management systems had direct interfacing with project schedules. Project schedules were manually cranked into the system by each project manager.

Usually, once a year, a gigantic manpower-intensive effort was launched statewide lasting from one to two months when all manpower resource needs were tied to project schedules. Under the decentralized management of that time, this effort was undertaken in 11 district offices and numerous headquarter units. Between redundancy on the one hand and omissions on the other, the whole exercise was suspect. Nonetheless, it became the base for the Governor's Budget. Manpower allocations were transmitted six months later and were pitifully out-of-date with everything. When all of this was loaded into the computer, we were able to produce beautiful management reports fraught with incredible information leading to total management frustration. Program scheduling was done independently by using this information and then management wondered why program delivery was so far out of synchronization with programming.

Overoptimism in project scheduling was rampant, and there was no backlog of completed projects to bring in to fill the breach when programmed projects were not deliverable. Obviously, capital programming was out of synchronization with delivery schedules at a time when project cost inflation was galloping out of control. With the deficiencies of the existing loosely controlled manpower systems, resultant organizational imbalances were not being identified in a timely manner and were also contributing to the problem.

As was the national trend, California was and still is being faced with an increasing number of low-cost, manpower-intensive projects. The trend during the past three years of contract awards shows that approximately 80 percent of the number awarded (about 575 per year) were less than $500 000 in size (see Figure 2). Conversely, the small slice of projects more than $1 million in size during this same period were approximately 85 percent of the total capital dollars awarded (not shown in Figure 2).

The deficiencies of the old procedures became apparent to top levels of departmental management and a proposal for an integrated systems approach to resource management was developed.

1978-1979--A NEW DIRECTION

During the 1978-1979 period, the California Director of Transportation launched a number of steps directed toward correcting resource management deficiencies:

1. Centralized all capital related resources management activities into headquarters with districts relegated to pure line responsibilities for implementation of centralized directions and decisions;
2. Redefined a role for the Deputy Director for Engineering to be responsible for statewide project preparation and delivery;
3. Approved formation of a central design unit in headquarters to supplement design units in the 11 districts (the central unit absorbs overflow work load resulting from any imbalances between program and staffing in the districts, and this unit also began work to develop a backlog of ready projects);
4. Commissioned a number of studies to find and recommend methods and/or opportunities to improve resources management in the department.

SYSTEMS APPROACH PROPOSED

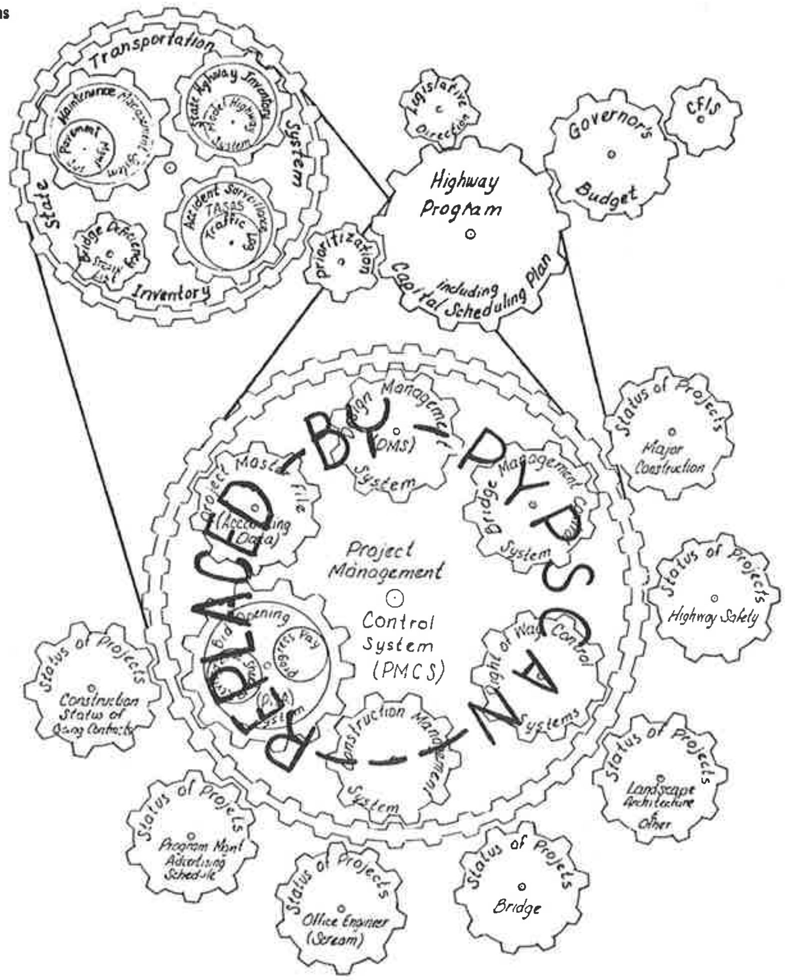
In April 1979, a special task force of district and headquarters technical experts and management staff was commissioned by the director to develop a centralized capital outlay and technical support budget process for the department. This process was to compliment the decision to centralize capital program management in headquarters with implementation of the capital decisions at the project level in the districts. Six weeks later, the task force presented a conceptual proposal to the directorate (Director and four Deputy Directors) for an automated capital scheduling plan (ACSP). The proposal, rather than limiting the focus to just a narrow budgeting process, envisioned development of a comprehensive, computerized, on-line management information system. The system would fully automate multiyear scheduling of all resources (money, time, and people) for the department's capital-related transportation program.

System output would include mutliyear assignments for about one-third of the department's 15 000-person work force. It would schedule all of the resources in an annual capital-related budget of $500-$600 million (including right-of-way and technical support), and provide project delivery scheduling that need only be limited to the extent desired by the department--5 years, 10 years, 20 years, forever. The initial plan would be based on the department's five-year program and would contain approximately 3000 projects. Finally, it would be dynamically responsive to change and provide current information on which to base resource management decisions. The task force specified that the design of the ACSP would

1. Be project specific. This concept expanded detailed resource management from an orientation that had been strictly highway to include all proposed transportation facilities undertaken by the department. The task force reasoned that a project required essentially the same elements for resource management purposes whether it be a traditional highway facility or a facility specifically for buses, intermodal transfer, rail, or aviation. The task force further reasoned that all capital projects went through the same basic development steps of planning, design, and construction regardless of whether the project was reconstruction, rehabilitation, operational improvement, or a total new facility and that transportation projects undertaken by the department require the same general types of resources to manage--namely, time, dollars, and people.
2. Be integrated into an existing project data base known as the Project Management Control System (PMCS). PMCS was designed 12 years earlier as the department's primary automated project data base system. PMCS, as originally designed, accommodates a multiple purpose system with capability to be linked through a series of computer program modules for calculating and reporting all elements of a complete management resource information system (Figure 3). PMCS has been used for a number of years for entering and reporting project-specific inventories of the entire transportation system in California, for calculating and reporting project priorities, for multiyear programming and annual budgeting of these same projects, and monthly project status reporting from inception through contract completion.
3. Retain the same basic project identification system. California uses a specific hierarchy of codes and numbering criteria for establishing uniqueness for each project or item in the department. This series is coded on every document and accounting file entry for any purpose in the department. As an example, each capital project is given a two-digit location identifier (specific district or headquarters unit), a six-digit unique project number, and a four-character alpha-numeric program code to identify the purpose of the project. This last code provides for additional file sorting by the various program categories managed by the department and for tabulating and monitoring of the annual purpose-oriented state program budget. This feature provides multisort capability to enable reporting and arraying management information in a variety of responses.
4. Include the design of a new computer module in PMCS that would automatically calculate schedules and manpower required for each project in the state transportation improvement program. The approach would be project-specific and, while complex and comprehensive, should be simple to maintain and update. Research into a number of systems designed by others indicated that the complexity of input and variety of detailed project file maintenance at the project-manager level creates large problems in terms of on-time data credibility. Conceptually, this system would not require very detailed task/activity reporting. The project manager, after initial loading of a minimal amount of basic project data needed to make the calculation, would only need to report actual progress in terms of actual dates of accomplishment or new target dates for designated milestones along the calculated project timeline. The new computer module would contain all of the standard formulas and variable factoring to adjust for any special complexities needed in the calculation on a multitude of project types. The system would then automatically calculate and/or update timeline scheduling and manpower distribution from inception of the project through the writing and submission of the final report after completion of construction. The system would be on-line with direct entry of data, calculation, and updating done through cathode ray tube-type terminals located in the districts and headquarters. Specific terminal identification, except for a few master terminals located in headquarters, limits access to specific files. Computer "locks" also protect file integrity.

It was decided by the task force that the myriad of finite detail was not absolutely essential for effective program monitoring and management, cash flow management, and project management and deliv-

Figure 3. California's computerized project-related data base has been in operation since 1969 with improvements ongoing ever since.



ery. Simple "exception style" management reporting was most effective for timely decisionmaking. Years of experience with our existing detailed manpower management systems verified that too much detail tended to create high "fog indices." It also reduced flexibility in project management and resulted in management focusing on the trees rather than on the forest. While a comprehensive system is needed to answer management inquiry, the amount of actual detail involvement in operating and maintaining any system does reach a cost-effective balance point, and data credibility is not directly proportional to the amount of detail involved. By nature and definition, management systems are a threat to the people being asked to maintain and update the system. Many people agree that data malnutrition will destroy a system faster than any other factor.

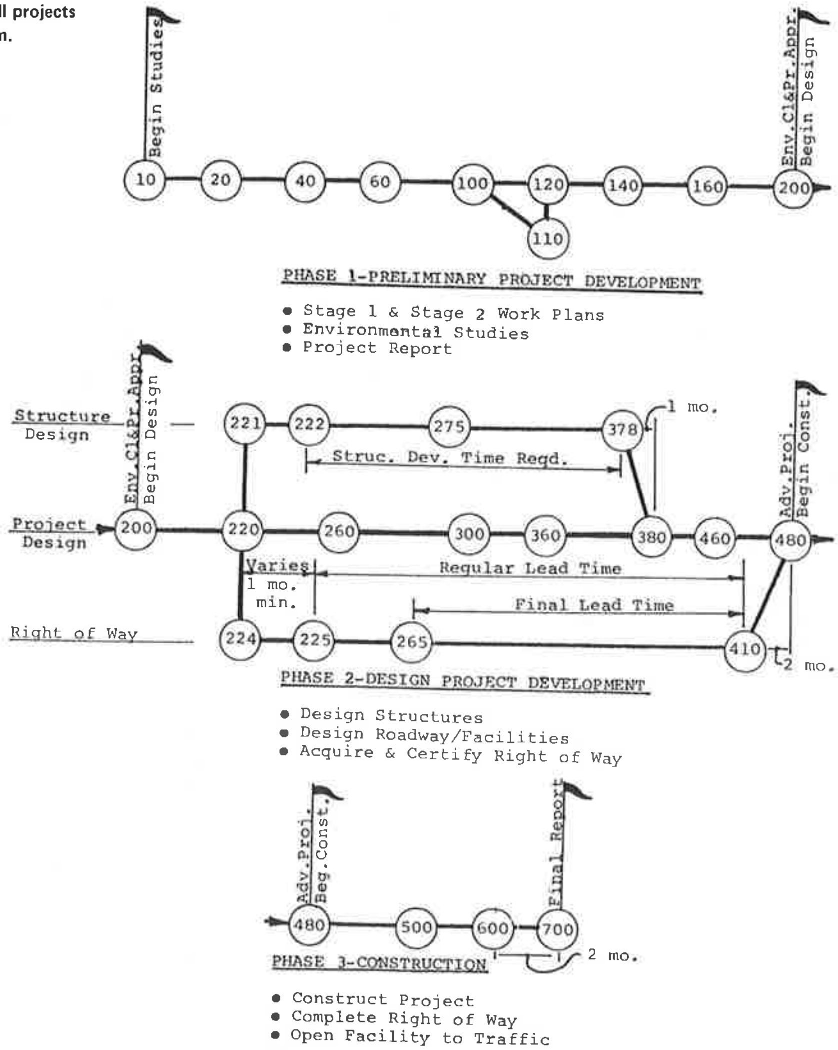
To encourage continuous user participation in the simplified amount of data maintenance required (besides keeping all levels of management interested), the system was to be designed with positive, automated linking between all categories of manpower required and the project schedules. Therefore, if actual project schedules change, and the change is justified and approved, then manpower category levels required for all remaining steps automatically change. Obviously, to maintain optimum manpower levels, it becomes most desirable for the user and project manager to maintain the shortest project timelines--an important factor and ingredient to maintaining optimum productivity.

This new computer module system to Automate the Capital Scheduling Plan (ACSP) would be named Person-Year and Project Scheduling and Cost Analysis (PYPSCAN) and that the project to make it happen would be titled the ACSP/PYPSCAN Project.

5. Include a project team to be designated with a project manager and team members selected from within the department to design, computerize, and implement the new system. The multidisciplinary team proposed in this recommendation included engineers and right-of-way agents with expertise in the various technical project functions involved at both headquarters and districts, management and budget experts from headquarters, and the computer systems manager at headquarters that would be involved in the PMCS modifications. Most of these people were to be utilized on a part-time basis. A list of in-house consultants, mainly management, e.g., district directors and division managers in headquarters, were designated as a first-level review team for the ACSP/PYPSCAN Project with emphasis on the concept of the system output reporting. The directorate was designated as the approval authority for all major steps in the process.

6. Be developed as the ACSP/PYPSCAN Project and would be developed in three separate units. The first unit was the basic PYPSCAN development to calculate manpower needs and schedule all projects in the department's capital program. The timeline on the first unit was established at 12 months. The second and third units were for developing a full range of system and management reports and for investigation, design, and implementation of further detailing the basic PYPSCAN concept. The second and third unit schedules would extend the total life of

Figure 4. The milestone control plan for all projects in the new management information system.



the project up to 36 months.

In June 1979, the transportation director approved the task force proposal and recommendations for the ACSP/PYPSCAN Project. The project team was selected, organized, and within a few days of the approval, began conceptual design work on unit 1.

DEVELOPING THE SYSTEM

The project team's approach to handling the very short timeline established to design and implement unit 1 was to divide the work to be done into unit segments, with the first four months assigned to detail design the base system. The entire team worked together on step one, which was to reach a consensus on a standardized activity network and establish a standardized milestone track through the network that would typify most projects. The entire team then worked together to reach a consensus on the variables, modifiers, and complexity factors that would be used in the design of the system. The team was then divided into four separate assignments:

1. Develop policies, procedures, roles and responsibilities and obtain a management agreement and commitment;
2. Develop a design for calculating project schedules;
3. Develop a design for calculating project manpower; and
4. Develop a design for the computerization, including an outline, of input data requirements, on-line features and requirements, basic reports, and user instructions.

The first unit of this system was designed and computerized in about seven months, with data and computer formula calculation testing taking about another four months to complete. During May 1980, 11 months after starting, the project team implemented the basic manpower planning and project scheduling unit of the system statewide.

Policies, Procedures, Roles, and Responsibilities

One of the first and most essential steps in an undertaking such as this is agreement and commitment at the highest level and authority, especially when it is a system to serve expressed management needs. A 35-page booklet of these commitments was developed, presented, and approved by the directorate in September 1979.

Calculating Project Schedules and Manpower

The ACSP/PYPSCAN Project team assigned to this task worked closely with the team developing the manpower calculation portion of the system. A historical data base of some 4000 projects was developed, thoroughly reviewed, and adjusted to reflect the latest processes. Schedule information and manpower expenditures were tabulated. Project variables (e.g., size, details of construction work, environmental study type process involved, weather zone, traffic volumes, etc.) were also tabulated. These data were then analyzed statistically in the computer through a whole series of linear regression combinations to find significance and identify any commonality with known variables. Output from these analyses was then reviewed rigorously by the team. This review resulted in adjusting the output of the statistical analysis and introducing the professional judgments of the team to finally arrive at agreed-on formulas for calculating timelines and manpower. This assured credibility with current methods and procedures. In the team's analysis and study of data, they found the key variables affecting project timelines and manpower requirements to be (a) project type, (b) project size, (c) weather terrain zones, (d) location, (e) environmental study, and (f) manpower categories.

The key control mechanism in PYPSCAN is a Milestone Control Plan (see Figures 4 and 5). Every project is developed and completed in three separate phases; preliminary project development, design project development, and construction. Preliminary project development includes developing and obtaining approval of conceptual features for the project and conducting and obtaining approval of the environmental impact study. Design project development includes detailed project design and contract plan development, structures design and contract plan development, and right-of-way engineering, appraisal, and acquisition. Construction encompasses all engineering inspection including structure work and contract administration activities as well as any right-of-way cleanup activities required to complete the project.

Each project phase is further defined in terms of major milestones. As shown in Figures 4 and 5, 28 major milestones have been identified with some of the milestones not calculated on minor projects where they are inappropriate, e.g., where no major environmental study, structures, and/or right-of-way are involved.

Seven basic milestone configurations are needed to distribute time and manpower across the full project timeline. Each milestone configuration has a series of formulas developed because of variations of time and manpower distribution between milestones. These formulas are further modified by factors related to the key variables discussed earlier.

The entire series of formulas for timeline and manpower calculation is loaded into the computer in the form of matrix tables. A master "decision" table matches project variables identified on the specific project and automatically selects the appropriate formulas, factors, and milestone type and performs the calculations. As noted earlier, the decision regarding development of the system was to keep the user involvement simple. To accomplish this and still produce quality information required an intensive project team effort to assure building all of the required complexities into the computer tables and calculations. Standardization has been maintained, while providing for uniqueness in terms of specific project variables. The on-line input is simple, as shown in Figure 6, which depicts the cathode ray tube screen display the user sees while inputting basic project data.

Figure 7 shows the calculation screen. The user performs the calculation by simply placing an "x" at the start date on the milestone portion of the screen and pushes the "execute" button. The computer then calculates the timeline and manpower required and displays them on the screen as dates on the milestone portion and person-years by category, spread by fiscal year.

An override feature is provided to enable the user to adjust his or her schedule if either the uniqueness of the project requires any further adjustments along the timeline, or if actual progress varies from the target timeline calculated. When an override is performed, the manpower is automatically adjusted to match the overridden timeline.

During the design phase of the project (see Figure 4), three separate timelines exist. Structures design, project design, and right-of-way each have separate pathways. These are linked at key milestone points on the project design line. During the calculation process, a simple critical-path analysis is automatically performed. If either or both structures and right-of-way timelines are longer than project design, a message displays on the screen to inform the user that structures and/or right-of-way timelines are controlling and the succeeding milestones have been "adjusted by __ months".

Figure 5. Milestone control plan node identification.

PHASE	NODE #	TITLE
	10	Initiate Studies-Start Phase I
	20	Stage 1 Work Program
	40	Stage 2 Work Program
	60	Circulate Draft Project Report and Draft Envir. Doc.
I		
	100	Submit Project Report
	111	Project Report Approval
	120	Circulate Environmental Doc.
	140	Hearings
	160	Request Project Approval
	200	Project & Envir. Doc. Approval
		End Phase I - Start Phase II
	220	Geometric Base Maps
	221	Bridge Site Submittal
	222	Begin Bridge Design
	224	R/W Map Submittal
	225	Start Regular R/W Work
	260	Skeleton Contract Layouts
	265	Final R/W Maps
II	275	General Plans
	300	District Dummy Plans
	360	Environmental Re-Evaluation
	378	Bridge PS&E
	380	District PS&E
	410	R/W Certification
	460	HQ PS&E Complete
	480	HQ Advertise
	500	Approve Contract
III		End Phase II - Start Phase III
	600	Job Complete
	700	Final Report - End Phase III

OUTPUT REPORTS

The system now produces a whole series of management

Figure 6. PYPSCAN CRT screen: basic on-line project data input screen.

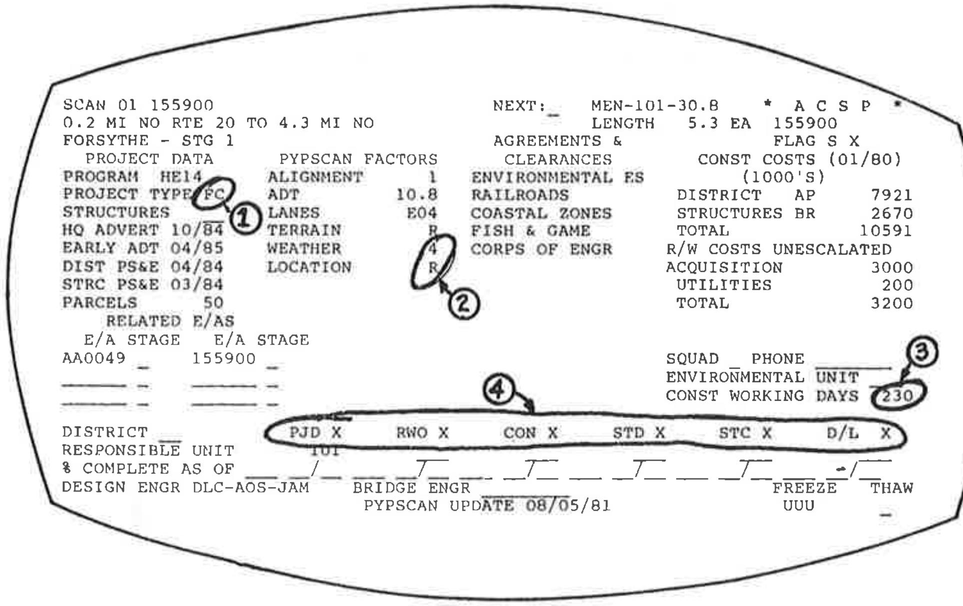
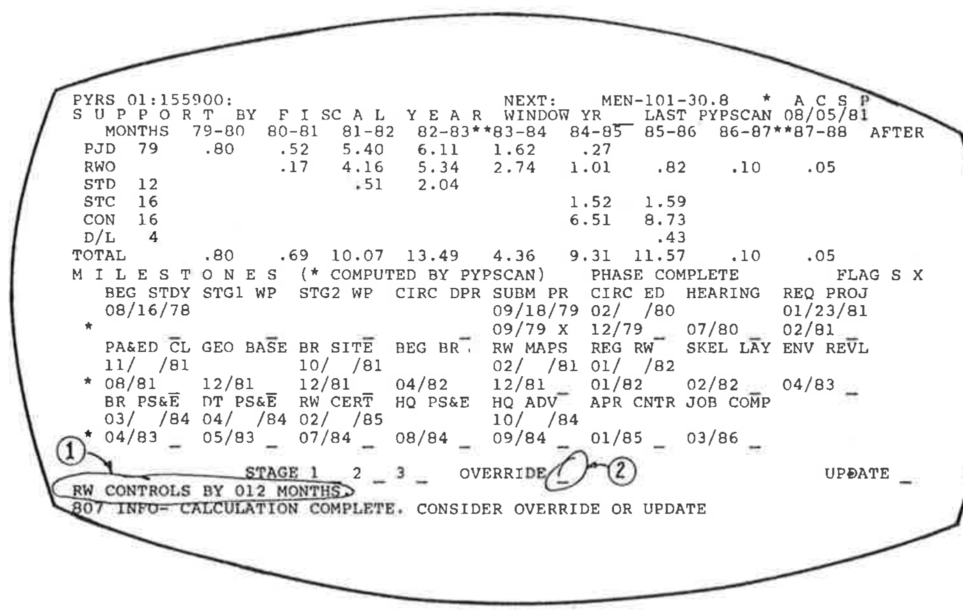


Figure 7. PYPSCAN CRT screen: on-line PYPSCAN calculation for project schedules and manpower.



reports for use in resource planning, resource programming, and tracking planned against accomplished. What will be discussed and shown in the following section is an abbreviated version of system output reports to provide the reader with just a flavor of types of reports available. It should also be understood that the system has been designed to produce reports from the highest to lowest levels of management. Multiple sorts are available on practically any combination of items or features included in the system. A few of the special manpower planning and milestone selection reports have become instant "best sellers."

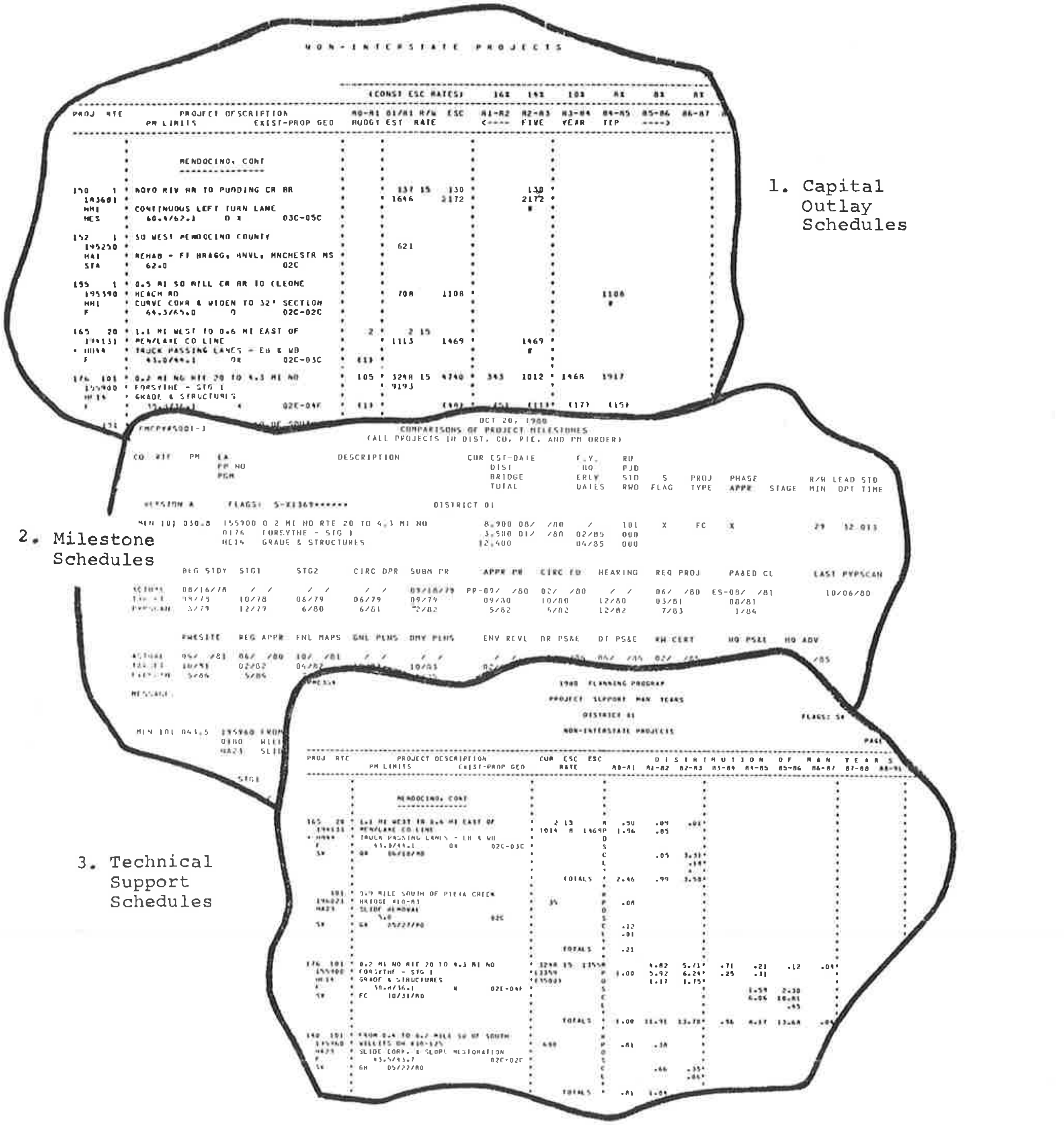
Capital Scheduling Plan

The stated objective of the task force in 1979 was to automate the capital scheduling plan. In May 1980, when the first unit of the new system was implemented and approximately 3000 projects had been calculated and loaded into the system, the capital scheduling plan was automated. A whole series of management reports became available at that time. An example of basic reports that were available are shown in Figure 8 and noted briefly below:

1. Support--Any combination of work functions may be selected for the support series of reports (see Figure 8). The format, a listing by project, is the same as that used for the capital outlay schedule except that the values shown are person-years rather than dollars. The person-year matrix is broken down by work function and by fiscal year as shown on the PYRS screen (Figure 8).

2. Milestones--A sample of a project milestone report appears in Figure 9. Any combination of projects and/or sorts is available on this report. This is a basic project delivery report. Periodic statewide monitoring is conducted by using this report and other "exception" reports. In addition

Figure 8. Capital scheduling plan reports: dollars, time, and people.



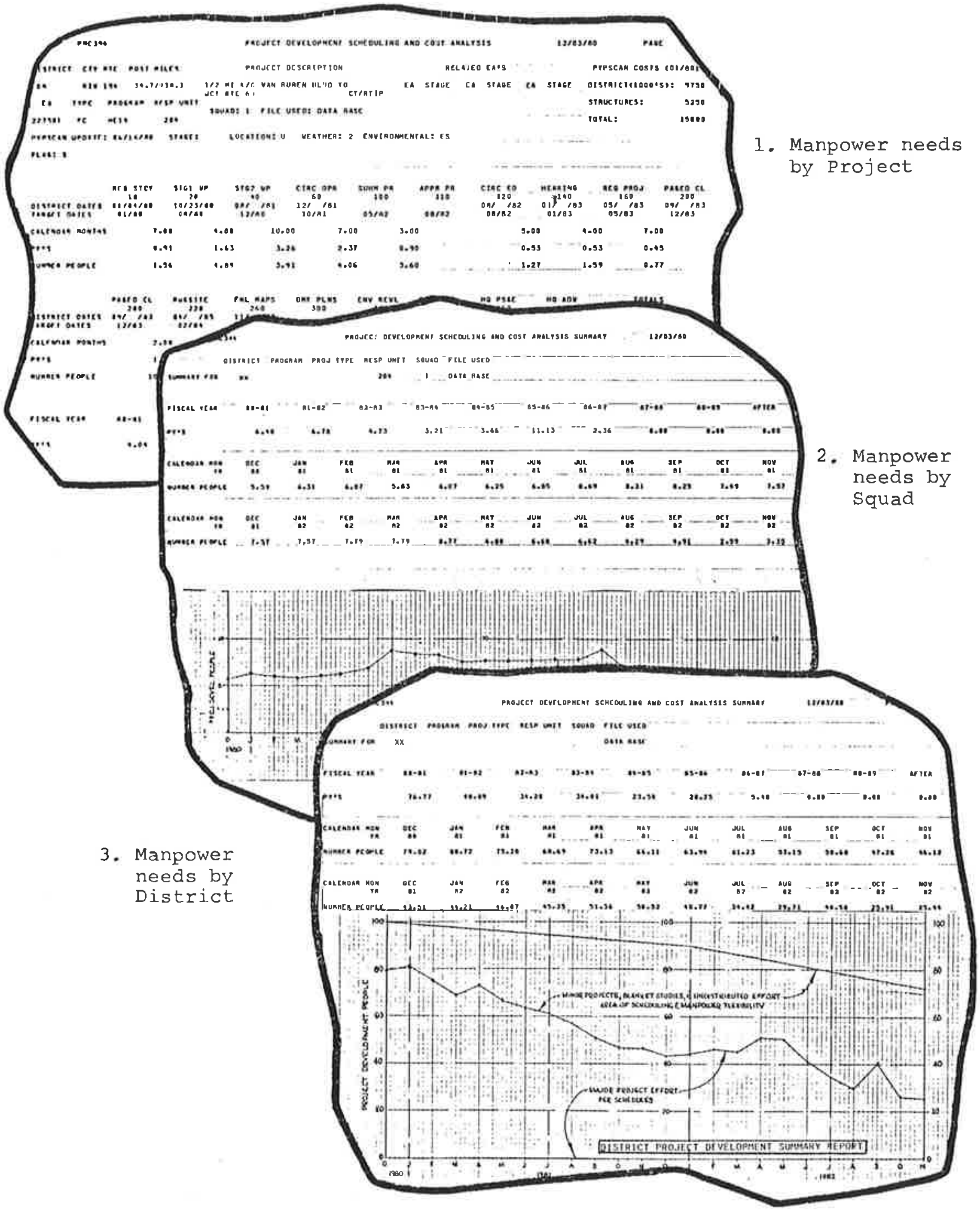
to basic information, there are three rows of dates shown and up to 28 milestones reported on each report. The first row represents the accomplished status dates or project manager's expectations. The second row is the modified PYPSCAN timeline on which the manpower is distributed. These are also the dates that the project manager is held accountable for meeting. The third row of dates shown is the unmodified pure PYPSCAN calculated dates that are used to compare dates for consistency and checking formula credibility.

Special Reports: Manpower

Special reports can be generated by selecting special computer sorts of data. Possibilities are numerous. One of the most popular reports, especially to district management, is our version of production planning summary reports. These reports are provided in series for the various levels of management. These reports can be provided for each of the manpower categories, e.g., structures design, construction engineering, and right-of-way. The series for project development and design engineering is shown in Figure 9. All of these reports are "on demand," usually deliverable in from one to two hours following a request.

1. Project-level production reports--This report

Figure 9. Special reports on manpower production: hierarchy of reports at project, squad, and district levels for project development engineering.



is the basic detail "planning" report provided to the project development project manager. As shown, data are detailed for people and time across the full span of project development activities. Note that on the "number people" line, a calculation is shown to indicate the average number of project development people needed across the timeline to keep the project on schedule.

2. Design squad or unit summary report--Shown in the center portion of Figure 9 is a basic squad-level summary report. Normally, a project manager in project development will have a number of projects in various stages of development at any one time. The data calculated on this report are a month-by-month, two-year projection, beginning in the month of the request. It summarizes people needs on all projects assigned to the squad. The graphic display shown at the bottom of the report (now being machine plotted) shows the two-year workload requirements to keep all of the projects assigned to the squad on schedule. This information is used for workload leveling and for project scheduling adjustments.

3. Design section summary report--Shown at the bottom of Figure 9 is a district-level workload summary report. Such reports summarize projections

Figure 10. Special reports for timelines: milestone selection and accompanying bar chart display.

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                                                  AUG 12, 1981                                                      PAGE 1
PMCPYRS002-3
                                              MILESTONE SELECTION REPORT

                                        (ALL PROJECTS IN DIST,CO,RTE AND PM ORDER)

CO   RTE   PM   EA                   DESCRIPTION             CUR EST-DATE     F.Y.
                PP NO                                           DIST           HQ
                PGM                                            BRIDGE         ERLY        DATE 1   DATE 2   DATE 3   DATE 4   DATE 5
FLG   ENV CLR   RU-SQD  PYP DATE          LEAD TIMES            TOTAL         DATES

VER: A     FLAGS:  T-9**********                              DISTRICT 01                 BEG STDY SUBM PR  PA&ED CL DT PS&E  HQ ADV

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              .  0176   FORSYTHE - STG 1                       3,000 01/  /81 10/84 TAR:     /       09/79    01/82    04/84    03/85
              .  HE14   GRADE & STRUCTURES                    11,900           04/85 PYP:     /       09/79     8/81     5/03     9/84
S-X     ES      101-    08/05/81   STD 012  RWO:FNL 18 REG 30

MEN 101 043.5T 195940 0.2 MILE SO OF SOUTH WILLITS OH           725 04/  /81   /    STA: 07/  /80 05/06/81   /  /   11/  /81 07/  /82
              .  0182   BRIDGE #10-125                             0   /  /   07/82 TAR:    07/80    05/81    07/81    03/82    02/83
              .  HA23   SLIDE CORR. & SLOPE RESTORATION          725           07/82 PYP:    07/80    11/80     1/81    11/81     9/82
S-X             101-    07/28/81   STD 000  RWO:FNL 12 REG 15

MEN 128 000.0   19536G RTE 1 TO 0.1 MI WEST FLYNN CR          1,800 01/  /81 84/85 STA: 07/  /81 01/  /82   /  /   05/  /83 09/  /83
              .  0198                                             0   /  /   09/83 TAR:    07/81    01/82    03/82    05/83    09/83
              .  HA22   RESURFACING, LATL SUPP, SUPER CORR     1,800           09/83 PYP:    07/81    01/82    03/82    05/83    09/83
S-X             101-    07/28/81   STD 000  RWO:FNL 00 REG 00
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                                        ALL PROJECTS IN DIST,CO,RTE AND PM ORDER

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CO   RTE PM
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 11,900   S-X   PYP:  | * * * * * * E * * * * | * * * * * * * * * * * | * * * D * * * * * * * | * * * * * * * A         |

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195940  HA23    TAR:  | * * * U * E * * * * * | * D * * * * * * * * * | A                     |                         |
    725   S-X   PYP:  E * * * * * * * * * D * | * * * * * * * A       |                       |                         |

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19536G  HA22    TAR:  |           X * * * * * U * E * * * * * * * * * | * * * D * * * A       |                         |
  1,800   S-X   PYP:  |           X * * * * * U * E * * * * * * * * * | * * * D * * * A       |                         |
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for multiple squads at the district level. They also provide two-year snapshots for top-level district managers to "look out front" for significant problems that they can address early and to identify opportunities for leveling their entire district design engineering workload.

Special Reports: Milestones

We have found that timeline analysis has been highly desired by all levels of management. We developed a five-milestone selection report for this purpose (Figure 10). This allows a manager to select any group of five milestones from the 28 in the system. With the multiple sort capability available in the system, the manager can design a report listing to array any specific section selected along the timeline for an entire group of projects. The produced listings will quickly reveal progress to date, how far ahead or behind the work effort is, and how much is yet to be accomplished. Workload concentrations for any series of activities can also be readily identified. Attendant problems can then be predicted so that early corrective action can be taken. A subroutine that plots a bar timeline across the same selected five milestones is also available (see Figure 10). It is the same type of information as on the data report, but has the advantage of a graphic format.

At present, approximately 25 percent of the major projects in our current five-year plan lack project reports (first major milestone event). We are using this report to analyze this process to see where either processes might be expedited or reassignments made to accelerate delivery.

COSTS

We have recently reviewed our costs to date to develop this system to its current status (slightly more than two years). There has been very little fulltime involvement. Most of the project team's efforts have been parttime with spurts of concerted effort over short time spans. Some members of the project team have other, regular duties directly related to capital scheduling plan type analysis. Their time has been discounted except where identified with specific development activities. The costs are as follows:

Item	Cost
People	$525 000 (equivalent of 15 person-years)
Machinery	$100 000 (computer plus overhead assessment)
Total	$625 000 (for two years with about $250 000 remaining,
Maintenance	$70 000/year (mainly for statistical analysis and system updating)

SAVINGS

The most notable savings are in the budget development area. The new system virtually eliminates most of the old decentralized, manpower-intensive process. We are now in the second budget iteration since implementation of the new system and we estimate an effort savings over the past two years of about $875 000 with a continuing savings of at least $450 000/year into the future. The improvement in the quality of budget information provided is somewhat measured by the plaudits that the department has received from the Legislative Analysts.

BENEFITS

In addition to the quality of management information improvements and services resulting from the system, we conservatively estimate that a 5 percent increase in productivity per year is being realized due to the structured process provided with this new system and should be assumed as a resultant quantifiable benefit. We estimate that this benefit amounts to about a $10 million saving in people costs or an increased capability to an additional $45 million saving in accelerated projects as long as staffing remains constant.

SUMMARY AND CONCLUSION

Managing transportation program resources during this era of limits is a very difficult and complex operation at best. The need for an engineered systems approach, complimented by a comprehensive management information system to provide quality information for decisionmaking purposes, cannot be overstressed.

The new system developed in California has not been offered as a decisionmaking panacea--systems do not make decisions, people make decisions. This system has been designed with a focus directed at the effective management of productivity through informed and timely decisionmaking to make things happen. It has been developed for use in resource management planning and then to measure the effectiveness in carrying out that plan. With implementation of the first unit just one year ago, the system has been used exclusively in a number of resource planning opportunities. The most notable were the following:

1. Used to develop a top-level management evaluation report of the 1980 five-year state transportation improvement program (1980 five-year program was developed prior to system implementation). The report informed the directorate that about one-third ($600 million) of the program was not deliverable as scheduled, and of that total approximately $200 million in projects were not even deliverable within the five years. The evaluation concluded that process times, lagging productivity, and overoptimism in project scheduling were major contributors to the problem along with a staff distribution, not shortage, problem.
2. Used to establish a deliverable 1981 five-year state transportation improvement program.
3. Used to adjust the department's 1980-1981 budget and to develop the 1981-1982 budget.
4. Used to identify opportunities for project reassignment to the centralized design pool to mitigate the staff imbalance problem and to improve program delivery.
5. Used in a number of what-if exercises.

The system is not complete, but we are well on our way to providing a valuable management tool. In conclusion, acknowledgment of the strong support and "push from the top" by the director and top staff, as well as confidence by all organizational levels in the system, has been essential for success. Finally, recognition that the outstanding effort by the project team involved in this development was key to its delivery in the short time allocated.