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Executive Presentation

Recommendations for Better Management of Major Underground Construction Projects

Prepared by the
Subcommittee on Management of
Major Undergound Construction Projects

U.S. National Committee on Tunneling Technology
Assembly of Engineering
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1978

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Cover photograph courtesy of J.F. Shea Company

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Foreword

In recent years expenditures by federal, regional, and local governments on underground construction of public transportation, water supply, and wastewater disposal systems have risen rapidly. At the same time, many of these projects have suffered from delays in completion. One strong bulwark against persistent increases in costs and serious delays in schedules is the application of better management procedures and practices by public bodies responsible for underground projects. Therefore, in 1976, three federal agencies requested the National Research Council to study how the management of such projects can be improved. Their objective was to obtain a set of guidelines that could be used to advance management efficiencies and construction economies. Further, the agencies requested that the National Research Council develop a descriptive model of a hypothetical urban underground transportation project that could be used to examine the ways that current procedures and practices influence the responsiveness, schedules, and costs of underground projects.

Within the National Research Council the study was undertaken by a specially organized Subcommittee on Management of Major Underground Construction Projects of the U.S. National Committee on Tunneling Technology. Early in the study the subcommittee concluded that underground construction costs are rising for the same reasons, in general, that other types of construction cost more from year to year.

Among today's most complicated and costly large projects are those being built underground. This is true because most underground construction takes place in urban environments, because geotechnical considerations assume greater importance than in other types of construction, and because the nature of underground work requires special equipment, techniques, and skills. Accordingly, underground projects are particularly sensitive to management practices.

Whether to write a detailed project management manual or to concentrate on principles that would be broadly applicable was a considerable problem for the subcommittee. It decided to do the latter and to describe the application of the principles to the hypothetical Key City construction project. Because each new underground project is different from those that preceded it, the subcommittee decided that emphasis on principles would be more helpful than a manual, which might have limited applicability and could become quickly outdated.

In December 1978, the subcommittee's report, *Better Management of Major Underground Construction Projects*, was published, after it was reviewed by an independent group, other than the authors, in accordance with the customary procedures approved by a Report Review Committee, consisting of members of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. The report is the basis for this executive presentation, which is intended for use by government organizations at all levels, by professional associations, and by the industry concerned with improving the management and operation of major underground construction projects.

The purpose of this document is to summarize the conclusions and recommendations in the report in order to facilitate their understanding and implementation. The subcommittee hopes its report and this executive presentation will be helpful to their users and meaningful in advancing the cost effectiveness of underground projects.

In the end, better underground projects will result in improved public services and enhanced environmental conditions. Thus, the ultimate beneficiaries of better management practices will be the nation's taxpayers and the local residents.

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Subcommittee on Management of
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Introduction

Some of the work of investigating management problems was done in 1973 and 1974 by the Subcommittee on Contracting Practices of the U.S. National Committee on Tunneling Technology. The results of the study were published in December 1974 in *Better Contracting for Underground Construction*[1], which noted that many of the problems encountered in the contracting and construction phases of underground projects result from actions taken in the development, pre-design, and design phases. The report called for a study to identify the procedures and practices in major projects that contribute to unnecessary increases in costs and to recommend improved procedures that will ensure more efficient and economical execution of major underground construction projects. The study reported here, therefore, is a sequel to the 1973-74 study.

STUDY OBJECTIVE

The objective of the study, as set out in the statement of task established by the sponsoring federal agencies, was to recommend actions that result in public underground projects that are completed on schedule, and at reasonable cost, and operate to design. The study also was to recognize that in completing any project, several goals are important—performing the work safely, minimizing disruption to the community during construction, and minimizing adverse environmental impact. Projects of the scale considered in the study have inherent risks, and all participants need to be prepared to accept their share of those risks.

METHODOLOGY

The subcommittee consisted of owners' representatives, designers, contractors, geotechnical engineers, a management expert, a labor official, an insurance specialist, a lawyer, and a geologist. The members were selected on the basis of their knowledge and experience in planning, designing, contracting, and managing construction of underground facilities. To assure a broad balance of perspective, the members were selected from both the public and private sectors and from universities. As will be described below, other individuals with competence in specific related areas were called on to assist the subcommittee during the study. Thus, the recommendations in this report are based on the judgment and experience not only of the members of the subcommittee but many other experts as well.

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[1]National Research Council (1974), *Better Contracting for Underground Construction.* A report prepared by the Subcommittee on Contracting Practices of the U.S. National Committee on Tunneling Technology. Washington, D.C.: National Academy of Sciences. The report is available from the National Technical Information Service, Springfield, Virginia 22161, under Order No. PB 236 973. The price code is A07 for paper copy and A01 for microfiche. The price schedule may be obtained directly from NTIS.

In planning the study, the subcommittee recognized that the major underground construction projects undertaken recently in the United States have been predominantly for urban mass transportation. Other major projects include the Chicago Tunnel and Reservoir Plan (TARP), which is intended to handle large amounts of wastewater. The subcommittee decided that because of the major expenditures for such projects, special attention should be given to them, but not to the exclusion of other projects.

The subcommittee noted that most major underground construction projects are primarily federally funded, either directly, as in the case of construction by a federal agency such as the Bureau of Reclamation, or indirectly, as highway tunnels, urban mass transportation systems, and urban sewerage systems such as TARP, constructed by state, regional, or local entities relying mainly on federal funding. In view of this, the subcommittee considered it important to examine approval and funding practices.

The subcommittee developed a study procedure that it considered useful in examining all aspects of management in underground construction. The procedure involved several steps.

The first step in the study was to develop a hypothetical model of a major urban underground transportation construction project. In this model it was possible to incorporate all actions required for such a large project as well as the critical social, political, physical, and technical considerations that might have a bearing on management. While such a project invariably commands more complex management than commercial or industrial underground construction, the model contains the essential management elements of private undertakings. So, most of the procedures or recommendations for a public project can be used for a commercial or industrial project.

The hypothetical project was named the Key City Model.

From the model the subcommittee developed a list of primary or critical project elements that could conceivably be faced in building an urban rapid transit system. These elements were placed into two categories—those within the transit authority's jurisdiction and those outside its jurisdiction. In all, 26 elements were identified in the first category and 14 in the second. Each of the elements in the initial list was considered to be of importance to management, but the subcommittee did not attempt to rank them in significance at this time. Instead, it attempted to ensure that no important element was omitted.

Then, the subcommittee set about verifying its initial list of the primary elements and ranking the elements in order of criticality. The first step in this process involved a series of interviews of knowledgeable people with managerial expertise in underground construction who represented universities, transit authorities, port authorities, sanitary districts, and engineering firms. The interviews were conducted in July and August 1977 by the subcommittee's consultants and staff officer.

In the second step, a questionnaire listing the subcommittee's elements was sent to 104 persons experienced in underground construction. They rated the importance of each element and added any additional elements they considered necessary. Based on the responses, the list of elements was divided into three categories of importance. The comments, along with the completed questionnaire, revealed a consensus that the elements selected by the subcommittee were the most important.

The third and final step in this process was the consideration of the critical elements by the subcommittee in its third full meeting, when the subcommittee approved the ranking of elements.

The subcommittee also examined whether the elements were generally applicable to major underground construction projects or only to transit projects and found that, with minor exceptions, they were generally applicable to all large underground works. The implications of the elements were considered for the conclusions and recommendations. As a result of the deliberations, the subcommittee decided to send out a second questionnaire that would lead to specific conclusions and recommendations, to develop tentative conclusions and recommendations, and then to subject the tentative findings to searching examination by a group larger than the subcommittee.

The second questionnaire, prepared and distributed in October 1977, was sent to all the respondents to the first questionnaire who had indicated a willingness to complete a second questionnaire, as well as to all members of the U.S. National Committee on Tunneling Technology, to all subcommittee members, and to certain other individuals who had been suggested by subcommittee members—a total of 113 addressees. Longer than the first, and not subject to simple arithmetic analysis as the first had been, the second questionnaire was broad in scope in order to encourage suggestions and ideas. The secondary purpose of the questionnaire was to determine the respondents who agreed to participate in a workshop at which tentative conclusions and recommendations would be subjected to careful examination.

Both during and following the questionnaire procedure, specific tentative conclusions and recommendations were being formulated. While still tentative in nature and subject to revision after further consideration, these statements served as part of the basis of the workshop. These were sent, together with the summary analysis of the questionnaire responses, to the subcommittee members and to those who had volunteered to take part in the workshop.

The workshop conducted in Palo Alto, California, from February 15 to 17, 1978, was attended by 60 people competent in underground construction who represented government, universities, and industry. The participants reviewed the subcommittee's work and the draft recommendations that had been prepared and distributed in advance. They agreed that the subcommittee's procedures and information gathering activities were valid and that the draft recommendations were generally useful and well stated. However, as a result of the workshop there were several changes in and additions to the draft recommendations. The subcommittee chairman invited all participants to write in further comments in the four-week period following the workshop, and several were received. The recommendations were then revised accordingly and reviewed and approved by the subcommittee.

The Key City Model was then completed to illustrate how the recommendations that were advanced in a general manner could be applied to a specific project. The organization adopted for the the Key City Model is only one of several ways in which a project may be organized, and the subcommittee does not recommend it as the best way. However, the selected organization is considered appropriate for the Key City situation and for similar situations. The Key City Model is described in detail in the report.

"The motion to take immediate and decisive action was tabled until next meeting. . . ."

FIGURE 1 Cartoon reproduced from the *Wall Street Journal* with permission of the artist, Joseph Serrano.

Summary

The report and this executive presentation are directed at a broad and disparate audience, primarily officials of federal funding agencies, heads and governing boards of public agencies and corporations, their engineers and managers, and their consultants, as well as executives in large construction companies. All of these people are responsible for carrying out major underground construction projects. Some have great responsibility for decision making, but limited experience in actual construction. Others are expert in one aspect or another—planning, design, construction, or operation.

Major underground projects are those multimillion dollar construction works in which all or a substantial part is built below ground level. They may be public or private in nature—though, for the most part, they are government undertakings such as rapid transit systems, tunnels for water supply and wastewater or flood water disposal, and subways for motor vehicles or trains.

The subcommittee came to the following three conclusions early in the course of its study:

- The management problems in major underground construction projects are similar to those encountered in other projects, but, in addition, have some specific characteristics not generally found in other projects. Thus, the subcommittee's recommendations apply, to a large extent, to the management of major construction projects both privately and publicly financed, above ground or below.

- The characteristics of major underground construction projects vary according to urban, suburban, or rural location and purpose. They also vary according to depth, geology, and size. Because of such variables, the subcommittee decided to frame its recommendations in a general manner rather than attempt to provide a management manual. The hypothetical Key City Model was devised to illustrate how the recommendations can be applied to a specific project.

- The capabilities of the owner, which may be a private enterprise or, most often, a public body, such as a transit authority, sanitary district, or public works department, range widely from a newly organized entity created for a specific project to an established organization with experienced people. Many owners may not be experienced in the construction of large projects, even though they are experienced in the operation and maintenance of completed projects. The range of capabilities also persuaded the subcommittee to frame general recommendations that would be helpful to all owners.

There are many reasons for cost increases, construction delays, and performance defects in underground construction, and all aspects of these problems must be examined to determine what improvements may be required in policies, organization, and procedures. The most important cause of management problems, the subcommittee found, is delayed decisive action, illustrated in Figure 1 on the facing page.

In its study the subcommittee found that management problems arise in each phase of a project, and that some problems persist from the beginning to the end of the project. The project phases, and major management actions required during each phase, are illustrated in Figure 2 (page 9). The 39 most critical elements of a project, as determined during the course of the study, are listed on pages 11 and 12.

The recommended objectives and specific recommendations to support each objective appear starting on page 14.

IMPLEMENTATION OF RECOMMENDATIONS

The federal agencies supporting the study requested a plan of implementation for use by government organizations and by industry and professional organizations concerned with improving the management of major underground construction projects. That plan was submitted separately. The subcommittee believes that the intention of the agencies to make sure that key government officials and underground construction industry leaders are made aware of the recommendations will be helpful in improving management of underground construction projects. Sometime in the future, after these individuals have been informed of the recommendations and have considered them, it would appear appropriate for those agencies to examine the changes made as a result of the recommendations and the effects of those changes.

Project Phasing

Each major project, public or private, starts with the recognition of a need. The process of conceptual planning identifies the facility required to best meet the need. The conceptual plan describes the facility in general terms and, in the light of available information, compares the balance of economic, social, and other benefits against the estimated costs and any perceived adverse impacts. A favorable balance of factors should lead to a recommendation to go ahead and could help establish a mandate for the project. The agency or organization that would be responsible for executing the plan should also be identified or recommended in the conceptual planning phase.

The steps leading to completion and operation of the project are:

- Project Organization

- Project Planning, including review and possible revision of the conceptual plan; preliminary engineering. (The project organization and planning phases can be, and often are, combined.)

- Project Execution — Initial Phase
  — Preliminary Design Phase
  — Final Design Phase
  — Construction Phase
  — Start-up and Operations Phase

The boundaries between the conceptual planning, project planning, preliminary design, and final design phases are not fixed precisely and may not be recognized as separate phases in the execution of all projects. Conceptual planning and project planning phases may be combined, eliminating a "go or no-go" decision between these two functional phases. This is more common in major private projects than in public projects. The project planning phase may include functions frequently carried on in the preliminary design phase or may lose its identity as a phase if combined with the conceptual planning phase. Preliminary design may be combined with final design. This also is more common in major private projects than in public projects. Within most major public projects, sequencing of the work, as it relates to major geographic segments, will result in different segments proceeding through different development phases at any one period. However these phases are divided, the sequence described here is a fundamental requirement to well-ordered project development and execution.

It is highly unlikely that any two major projects have followed the same course or sequence of phases with the same functions assigned to each. During each discrete phase the actions by financing agencies, political entities, other involved agencies, the public, owners, designers, and contractors, influence and possibly affect the progress of the project.

Because each large project is different from those that preceded it and those that will follow, it is impractical to select a particular historical example to illustrate the phasing of a major underground construction project. Figure 2 shows the general sequence of project phases, from conceptual planning to start-up and operations, the major activities that take place in each phase, and the characteristic flow from one phase to the next. The bottom lines of Figure 2 display those activities that continue throughout the project, from the inception of conceptual planning through the start-up of operations.

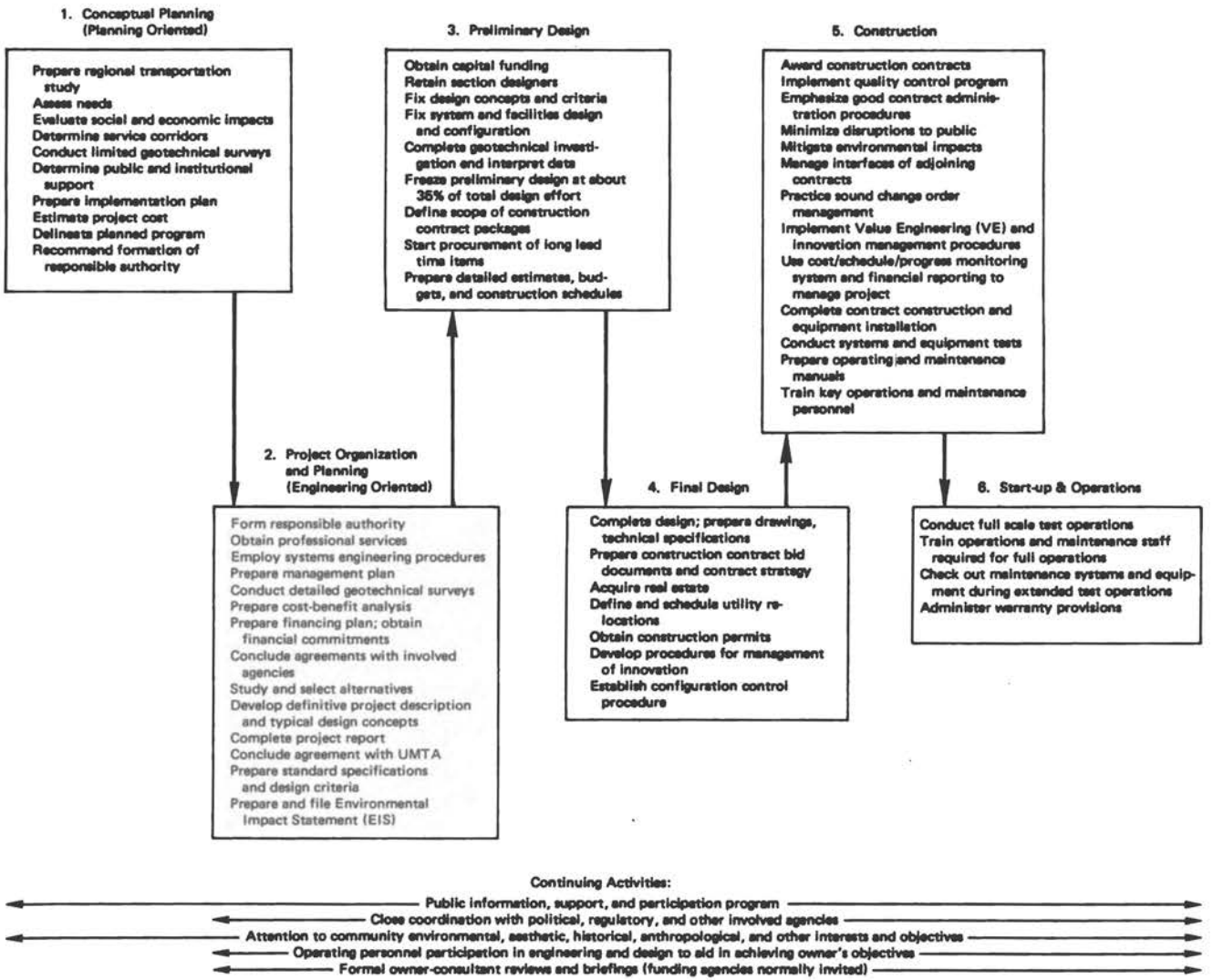


FIGURE 2 Typical project phases (major functions).

Critical Elements

The problems likely to be encountered in the management of the construction of a major underground project were identified during the study. The list of 39 critical elements is broken into three groups in order of criticality:

I

Delayed decisive action
Project funding and cash flow
Imposed controls—funding and fund management
Dedication to timely project completion (authority)
Dedication of government and involved agencies to timely project completion
Transit authority organization
Transit authority legal authority
Public acceptance
Selection of consultants
Imposed controls, contracts, procedures
Acquisition of right-of-way and work areas
Schedule and cost management
Administration of and coordination with consultants

II

Environmental impact statements—approval
Construction contract strategy
Risks and liabilities (outside authority jurisdiction)
Risks and liabilities (under authority jurisdiction)
Claims and disputes—construction contracts
Government regulations
Testing, start-up, and run-in
Labor productivity
Contract agreements with utilities and involved agencies (outside authority jurisdiction)
Public and community relations and participation in system planning
Contract agreements with utilities and involved agencies (under authority jurisdiction)
Environmental hearings, analyses, and impact statement
Freezing project features and design prior to start of final design

Existing structures——protection
Operational organization and training
Political action and objectives
Citizen and class action lawsuits
Project labor agreements
Social impacts
Public hearings
System cost-effectiveness analysis
Cost-benefit analysis
Special interest groups pressures
Wrap-up insurance
Equal employment opportunity program
Central procurement

Recommendations

The chief purpose of this executive presentation and the report on which it is based is to diffuse the experience gained from the sometimes costly lessons of completed major underground construction projects so that new owners and management teams can benefit from the experience and learn the best procedures and practices. Underground construction is not a pure or exact science. A critical factor in its success involves a great deal of art—the art of good management. In formulating its recommendations to improve on the management of major underground construction projects, the subcommittee concluded that six major objectives need to be established. Along with each objective, the subcommittee agreed on a group of recommendations that it considered central to attaining the stated objective. Adoption of all the objectives is considered to be both feasible and necessary to make the maximum possible improvement in the management of a major underground construction project, public or private in nature. While recognizing that each project is unique, the subcommittee has stated the objectives and recommendations so that they may be applied to any large underground construction work, most particularly public projects that generally involve a larger number of participants and more complicated funding and approval processes than major private projects. The recommendations suggest ways in which major or significant problems can be avoided, solved, or—when a full solution is beyond the means of the manager—managed in such a way that the project can proceed.

While effective management of major private company projects requires the application of most of the same management practices as for public projects, there are significant differences. Private projects are generally privately funded and escape the controls imposed by funding agencies at federal, state and local levels. Private projects can select professional consultants and utilize construction contracting practices without the restrictions usually encountered by public projects. Political and public requirements are less rigorous for private projects than for public projects. Even so, increasing political and public concern about potential societal and environmental impacts is narrowing the difference between public and private construction projects, and, in the future, private projects probably will need to be as responsive to such considerations as public projects are today.

The six objectives identified by the subcommittee are stated below. Accompanying each objective are the recommendations considered central to attaining it.

TO ESTABLISH THE PROJECT'S GOALS AND OBJECTIVES AND TO ORGANIZE THE PROJECT TO FACILITATE THEIR ACCOMPLISHMENT:

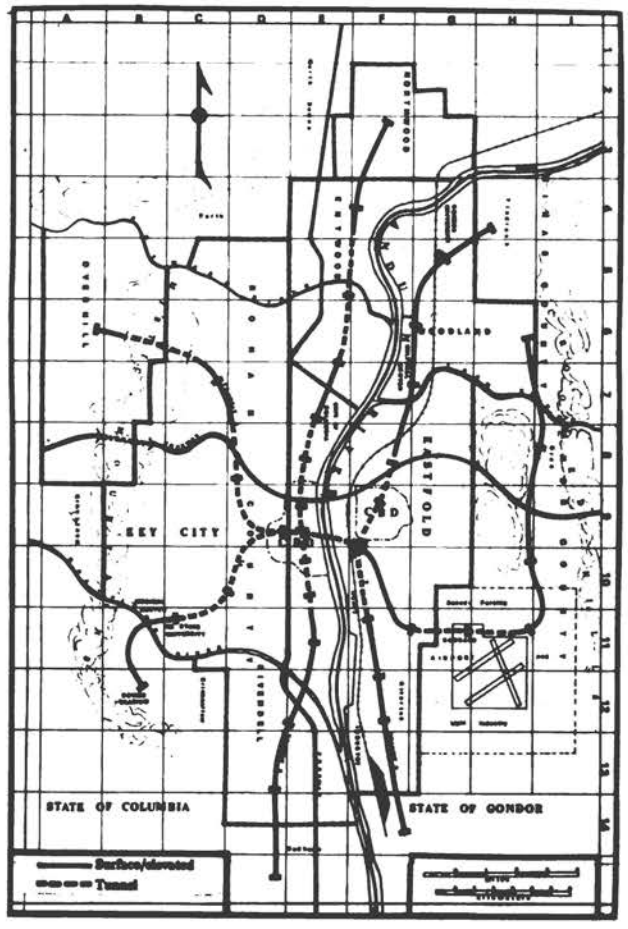
Maximum efficiency can be achieved only if the objectives are firmly established and the project is organized effectively. Therefore, the organization needs to be evaluated and, if found necessary, modified appropriately throughout the life of the project.

1. The owner, the only active member of the future project organization at the time of project inception, should define realistic and attainable goals and guiding policies which will lead to successful completion of the project.

2. The owner's organization should be a staff of highly competent managers and other professionals whose functions are to direct the project, to take the lead in gaining public and political acceptance of the project, to maintain close coordination with and obtain timely action from agencies participating in funding or responsible for regulatory functions, to assist and coordinate the planners, consultants, designers, and contractors in resolving local problems, and to identify and clear potential roadblocks.

3. The owner's organization must determine the management structure for the project which should meet the following criteria:

- Clear lines of responsibility must be established.
- Responsibility should be delegated to the lowest possible implementing level.
- Authority commensurate with responsibility must be granted.
- Reviews should be made of how authority is exercised to ensure that timely action has been taken in reasonable and proper ways to meet project objectives.
- Duplication of functions must be avoided.
- Communications, both vertical and lateral, need to be employed.



Conceptual transit plan, Key City Model.

- Mechanisms for expeditious problem solving must be provided and known.

4. The owner should select well qualified consultants to supplement his staff in the management and execution of planning, design, construction, and coordination. These may include, depending on his staff's capability, one or more of the following: a general consultant, design specialty consultant(s), and a construction management consultant. Consultants should be selected for both competence and successful record of performance in the type of project to be constructed. The work of each consultant should be reviewed periodically and, if found to be of superior quality, the firm should be retained. Consultants engaged in activities involving several aspects should be retained from the start of project planning through project completion and start-up of operations to ensure continuity.

5. The owner should consider retaining an independent group of senior consultants to provide advisory services that do not supersede the responsibilities of the project team but serve the important purpose of assisting the owner or governing board in making the go or no-go decision, in selecting consultants, and in reviewing major decisions throughout the life of the project. These consultants may function as a board or as a panel of individual experts, depending on the desires of the owner. Although the services will be required from the inception to completion of the project, the composition of the group may vary as the project progresses through various stages, provided that key members are retained to ensure continuity. The owner may request these experts to review major planning and engineering decisions, thus aiding in the development of a high degree of project credibility and support. In a project where a general consultant is retained, the general consultant should also have the authority to retain senior consultants as required.

6. The owner's organization must encourage and support and, when necessary, demand prompt identification of problems, problem solving, and

...the die is largely cast by the time construction begins, and some of the major problems impacting construction costs and schedules have their roots in the overall organizational framework.

—*Development of Research in the Construction of Transportation Facilities: A Study of Needs, Objectives, Resources and Mechanisms for Implementation*, a report by the Department of Civil Engineering, Stanford University.

- Set the example for decisiveness and urgency.
- Establish well defined goals.
- Encourage and support other team elements.

decisions by each responsible member within the range of his responsibility and authority. All participants must be stimulated to have a "must-do, can-do" attitude!

- Assign specific responsibilities and accompanying authority.
- Demand prompt and decisive action.
- Eliminate red tape.

TO PLAN THE PROJECT TO ACHIEVE THE OWNER'S OBJECTIVES:

Great opportunity for saving costs exists early in the planning phase when basic decisions determine the scope and extent of the project. Great latitude for changes also exists at this time. Therefore, the decisions taken during the planning phase have long-range importance in furthering the chances for success and controlling the costs of the project.

7. The owner's objectives must be clearly set forth and these should become the criteria for project design. The project must be planned with an eye on the successful completion of the project purpose at the lowest cost for both investment and operation as well as for maintenance over the expected life of the project.

DETERMINING NEEDS: A PUBLIC HEARING
—photograph courtesy of Washington Metropolitan Area Transit Authority

8. Realistic cost estimates, based on the best available information, must be used from project inception. Recongizing that early estimates are based on many uncertainties and variables, and therefore that costs may be overlooked or underestimated, realistic factors for uncertainties and contingencies should be taken into account during early phases. Particular attention must be given to realistic estimating during the preliminary engineering phase because such estimates are usually the basis for project financing. Estimates need to be revised periodically to accommodate changing circumstances.

9. The project management team must plan and execute a program to achieve and maintain the participation and support of citizens' groups and political entities in the planning, design, construction, and early operational phases of the project.

- Keep the public informed.
- Solicit and make use of citizen concerns.
- Maintain liaison with public bodies and interest groups.
- Minimize inconvenience to public.

10. The owner should identify those agencies and organizations that have the potential for either helping or hindering the project in order to establish an understanding with the leaders of these entities that will advance the project.

11. Continued effort must be exerted and close contacts with appropriate agencies maintained to facilitate early approval of the project's Environmental Impact Statement (EIS).

12. Early in the project planning phase, the owner, assisted by his consultants, should develop and vigorously execute a comprehensive plan for financing the project.

13. The project management team must make every effort to obtain early and firm commitments for complete funding by all participating agencies through constant attention to close working relationships, constant flow of information to key funding agency people, and issuance of frequent reminders of dates when necessary funds will be needed.

TO ACHIEVE EFFECTIVE DESIGN ORGANIZATION, SUPERVISION, AND ACCOUNTABILITY:

The success of the project purposes is to a large extent determined by decisions made during the design phase of the project.

14. The owner's staff, or general consultant in instances when one is retained, must provide the design firms with clear-cut design criteria that set forth standards of system quality and continuity that are to be met within prescribed schedules and budgets. Detailed coordination of section design and system wide design is essential. Economy of design, system continuity and safety, realiability, maintainability, and constructibility must be tested against budgeted construction costs and forecast operating costs.

PROJECT DESIGN OFFICE
—photograph courtesy of Parsons, Brinckerhoff, Quade & Douglas, Inc.

15. A continuous review of all phases of design should be carried out jointly by the owner, consultants, and operational personnel to assure that the project goals and objectives are met in a cost effective way.

16. During the preliminary design phase of the project, design criteria should be developed to a stage that the design of basic elements of the system can be firmly established for the final design. Deviations from the design criteria should be made for compelling reasons only, not whims or expediencies.

TO ACHIEVE EFFECTIVE CONSTRUCTION METHODS, PROCEDURES, AND SUPERVISION:

Controlling cost increases, settling controversies and claims, and minimizing delays can be facilitated by sound construction management practices, procedures, and supervision.

17. Contract package size and scope should be selected with proper regard for the resources available and greatest efficiency and economy in using the resources.

18. The owner must closely cooperate and jointly plan with local political entities to minimize disruptions during construction and to gain public understanding and acceptance of those disruptions that must occur.

19. A procedure should be developed for solving design or field problems as they occur during construction. The procedures must be clear and capable of achieving results rapidly.

20. The owner, working with his consultants, contractors, and local agencies, should develop sound labor relations including giving consideration to agreements with labor to ensure continuity of work and to avoid labor disputes.

CONCRETE FORM JUMBO
AND REINFORCING BAR
—photograph courtesy of J.F. Shea Co.

21. The contracting practices recommended in the 1974 report *Better Contracting for Underground Construction* should be adopted.

22. The owner should adopt the recommendations and use the procedures for the settlement of disputes found in the 1977 report *Recommended Procedures for Settlement of Underground Construction Disputes*.

23. The owner should establish and utilize a professional review board to assist in the settlement of construction claims and disputes that cannot be settled promptly by normal contract administration procedures.

TO ACHIEVE SOUND MANAGEMENT OF THE PROJECT:

Construction of a major underground project is big business, and proven management methods need to be employed to complete the project successfully at the planned cost and in the scheduled period. Leadership must be strongly asserted by those with direct responsibility—e.g., owner, project manager, consultants, and chiefs of supporting bodies—for achieving the project objectives—quality, scheduling, and budgets. A complete management plan should be established and then kept up-to-date as changes are required. The management plan and methods adopted should take advantage of experience proven in similar large projects, but they need to be structured to fit the specific project objectives, local situations, and resources available or to be reasonably expected.

24. The project budget must be realistic, it must establish attainable goals; it must be adhered to.

25. Realistic schedules must be established and maintained.

26. Project management needs to adopt cost/schedule/progress monitoring and financial reporting systems with sufficient detail to enable key managers to facilitate decision making. It should

- Define and agree on scope of work.
- Agree early on the engineering budget.

include an exceptions report, listing only current problems or items that appear to be causing problems. It should indicate prospective changes in material costs and labor rates, and actual cash flow compared to the estimated plan. Top managers should take part in the development of the reporting system to ensure that the system meets their needs. The monitoring system should be geared to identify problems or necessary actions before they become critical (or historical) in order that problems may be avoided or actions taken in proper time. In the act of establishing controls, management should structure them toward facilitating forward progress rather than toward preventing relatively minor actions being taken that might have been done differently.

27. Strict control of project expenditures is an inherent obligation of the project management team. The management team must have adequate delegated authority and flexibility in the management of expenditures, and the determination to use and control them.

28. Practices of granting agencies in controlling contract awards, contract forms, and contract changes should be examined in depth by those agencies with the goal of revision to permit the project management team the level of decision authority required to take prompt, responsive action in contract matters. Funding agencies, federal or local, should establish the amount and type of their support—e.g., a fixed dollar limit regardless of end cost or by percentage formula with a ceiling. Thereafter, the implementing agency should have the flexibility to prosecute the project promptly, efficiently, and economically within the established limits, subject only to "audit" reviews for eligible use of funds. These reviews should not be for second guessing but be for the purpose of ensuring that the agency is taking prompt action in prosecuting the project and in identifying and solving problems, and that these actions are in general adherence to project goals and prescribed methods.

- Set construction cost target limitations for designer.
- Forecast and schedule.
- Use reporting system to provide early notice of deviations from scope, budget, schedule.
- Establish responsibility for taking corrective action.

CONFERRING ON THE CONSTRUCTION SCHEDULE —photograph courtesy of Metropolitan Atlanta Rapid Transit Authority

29. The owner should develop a comprehensive risk and liability plan that includes allocation of risks. The owner should also consider the use of wrap-up insurance to protect all parties at a reasonable cost if this is found to be economically advantageous.

30. The owner should determine the scope of real estate acquisition in the early phases of the project and establish an adequate organization to make acquisitions. Early in the project the owner should initiate close coordination with potential public and private developments adjacent to the project that could affect the owner's real estate acquisition program and could possibly lead to joint development. Areas that will be required by construction contractors should be identified by the project management team at the time other real estate requirements are established. The owner should give consideration to implementing a value capture program, which involves acquiring impacted properties in the vicinity of the project and holding them as an investment for future sale.

31. Strong leadership is necessary to foster and maintain morale and productivity. Those who have been appointed to manage a project or major portion of it must exercise their responsibilities and act in a timely manner, taking the positive actions required to get the job done. The productivity of all participants and their role in the project must be emphasized by the leaders of the management team. The project management team must develop a definite program among all the participants to foster and maintain high morale and a sense of commitment to success. The demonstration of progress and achievement is one of the best morale and productivity boosters.

Morale generally starts from action and attitude of the top people of a management team and permeates down through organization levels to successive levels of management when leaders at all levels follow morale building practices and attitudes. The generation and maintenance of morale are leadership obligations. Good leadership is characterized by concern for employee welfare, fairness and impartiality, positive attitudes towards complaints and suggestions, giving credit when credit is due, open communication, respect for employee efforts, and impressing employees with their constructive contribution to the project. Morale makes for teamwork, and teamwork produces far more positive and productive actions than those resulting from individual actions.

TO ACHIEVE SUCCESSFUL START-UP OF THE PROJECT:

Major projects are extremely complex. Accordingly, proper attention must be devoted to preparation for start-up throughout the planning, engineering, and construction phases of the project.

32. Key operations and maintenance positions must be identified during the planning phase, and qualified personnel must be selected for these positions and brought on early to ensure that their expertise is used to plan and design the project.

33. The owner and the other members of the project management team must develop and document operations and maintenance plans and procedures during the early part of the design phase. A complete family of test procedures, operating manuals, as-built drawings, and performance documents should be available prior to the final testing and acceptance.

34. The owner and the other members of the project management team must initiate and schedule adequate time for a thorough program of testing, start-up, and run-in of the system, prior to the scheduled initial operation. Key operations and maintenance personnel should participate fully and responsibly in the testing program to prepare for early and efficient system operation and to train and develop experienced personnel for operation and maintenance.

THE ULTIMATE GOAL:
THE PROJECT IN SERVICE
—photograph courtesy of Washington Metropolitan Area Transit Authority