Data Base Management System for Transportation Improvement Program Development, Monitoring, and Analysis: A Case Study

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ABSTRACT

The Chicago Area Transportation Study, as metropolitan planning organization (MPO), is charged with providing its Work Program Committee and Policy Committee with feedback on the impact of the 5-year transportation improvement program (TIP) and on the region's transportation, social, and economic needs. In fulfilling this requirement it became apparent that MPOs are lacking adequate means for managing TIP data that could be very valuable to TIP development, monitoring, and analysis. Those inadequacies are described and efforts to address them through the development of a structured data base management system (DBMS) are discussed. Problems encountered are noted and the potential for future refinement of DBMSs for TIPs are suggested.

In an effort to fulfill the federal requirement for comprehensive, continuing, and cooperative planning, the Chicago Area Transportation Study (CATS), as metropolitan planning organization (MPO), initiated an impact analysis component in its unified work program (UWP) (1). The purpose of this activity was to provide information to programmers, planners, and implementors about the progress of the transportation improvement program (TIP) in accomplishing the region's transportation goals (2). In fulfilling this requirement it became apparent that MPOs were inexperienced in managing TIP-related data, which could be very valuable to TIP development, monitoring, and analysis. Inadequacies that were realized at CATS through the impact analysis efforts are described. Efforts to address those inadequacies through the development of a structured data base management system are discussed. Problems encountered are noted and the potential for future refinement of the data base management system for TIPs is suggested.

INADEQUACIES OF THE TIP DATA BASE

In a fiscally constrained environment the major function of the transportation improvement program (TIP) should be to select the combination of projects that provides for the most effective achievement of the region's goals and priorities. This function requires that the metropolitan planning organization (MPO) process information about the entire transportation system's needs and rank implementation in an organized and logical manner. The information needed for this function includes operating characteristics of the system, physical deficiencies of the system, estimates of future demands on the system, and relative costs of projects as well as impacts of projects on pertinent transportation and urban planning issues. Unfortunately the information for this process has not been available in a readily usable form for the following four reasons:

First, various components of the system (bus, rail, urban highway, and so forth) are programmed, built, acquired, operated, and maintained by separate, autonomous agencies. Therefore, data on the needs of each system are often incompatible with each other.

Second, funding procedures for federally aided projects require that the TIP be constantly modified. The dynamic nature of the TIP makes monitoring of trends and of accumulated impacts of the TIP on the transportation system difficult.

Third, the need for maintaining detailed, standardized information about the TIP had not been recognized in the past. Therefore, previous TIPs contained little more than descriptive information.

Fourth, data generated for and by other transportation planning functions (i.e., long-range plans, projected travel demand, and the state's roadway condition data) were not compatible with one another or with TIP data.

To provide the best possible information to programmers for use in TIP development, these basic data problems had to be resolved. It soon became clear that both needs and existing files were complex enough to require a full data base management system (DBMS). What has occurred since has been a gradual progression toward developing a model DBMS. The purposes of such a system include

- The ability to assess the relative deficiencies of all components of the system;
- The ability to monitor trends of past and present TIPs;
- The ability to quickly retrieve, amend, manipulate, and summarize available information for analysis purposes; and
- The ability to develop numerous alternative programs, which show the costs and benefits of various trade-offs between goals and priorities, for review by programmers.

To develop a DBMS that would meet these objectives three steps had to be undertaken: (a) the information about the TIP had to be standardized, (b) a software system for routinely updating this information had to be devised, and (c) a method for cross-referencing the standardized TIP and all other available, pertinent files had to be instituted.

When these three tasks had been accomplished, a DBMS for TIP development, monitoring, and analysis was initiated.

CURRENT CATS TIP DBMS

The TIP data base system that currently exists oper-

ates on the state of Illinois IBM 3033 OS/MVS computer. The data sets are both OS and SAS and are related and maintained with both FORTRAN and SAS software. The structure of the DBMS is shown in Figure 1. There are four types of files: TIP files, transaction files, impact files, and link files.

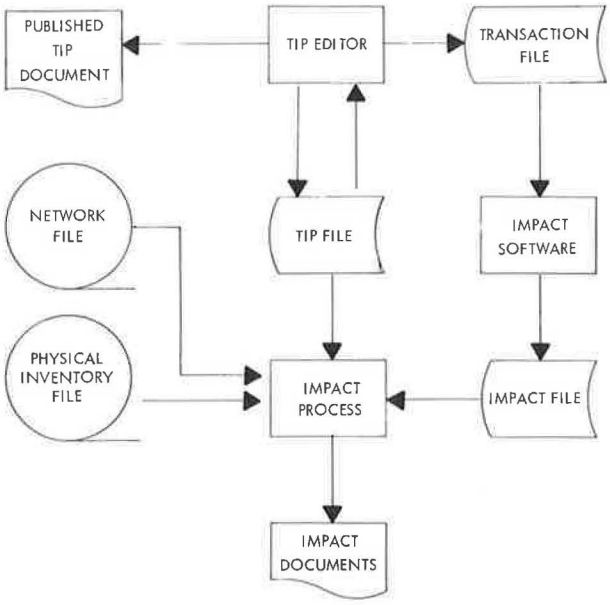

FIGURE 1 Structure of DBMS.

TIP Files

The TIP file was the first to be developed and is the most important. The TIP file is an OS file of about 1,500 150-byte records. It is stored on a mass storage device. It contains descriptive information about each project. The primary purpose of this file is to maintain information that can be easily amended and summarized for review and publication. It also contains standardized information about fund sources, costs, year (i.e., annual element or multiyear), regional council (a geopolitical programming unit), investment origins (3), award status, and a permanent identification number. Other information such as municipality, type of work, street, and limits of work are free-form character fields. At any time this file can be amended with FORTRAN software created for this purpose. The operation of this software is documented in the "CATS Interactive TIP System User's Manual," available from CATS. Back-up files are automatically created. However, copies of these backup files, as they are approved after any given amendment, are not retained.

Transaction Files

While the TIP file is being amended with the interactive software package designed for that purpose, a transaction file is automatically created to record all changes, additions, and deletions (4). Each record of this OS file contains a field for the date of the transaction, the permanent identification number of the project affected, and the type of action taken (change, addition, deletion). If the action is to add a project, the interactive program automatically assigns a permanent identification number based on the date and time of the transaction. Every transaction is recorded. Therefore, if a project is added, changed several times, and then deleted, each action, including every change, is documented in the transaction file in the order in which it occurred. Consequently this file is continually growing.

Impact Files

To maintain information about trends in TIP programming, impact files, which record the exact status of the TIP each time that an amendment is approved, were created. This entails approximately 10 official amendments each fiscal year. Therefore, there are about 10 versions of the TIP file, in the impact format, for each fiscal year. The impact files are SAS files and contain more detailed, standardized information than do the TIP files. This information includes a three-digit code for the municipality in which the project is located, a code for the description of the work type, and a total cost field. The total cost field contains the sum of the construction and all related preconstruction projects. Preconstruction projects have zeros in the total cost field.

Link Files

Link files are the connection between the project, as a line item in the TIP file, to its location in the physical system. Projects are mapped on highway network maps and coded by node to the current, base network. The permanent identification number ties the link file to the TIP and impact files. This is an SAS data set stored on tape because of its size: approximately 8,000 records.

INTERACTION OF FILES

The TIP, impact, and link files are updated with specially designed software. The TIP update program, mentioned previously, is an interactive program that allows the user to modify, add, and delete projects. It automatically creates the transaction files and assigns permanent identification numbers. The impact files are amended with a batch-entered SAS job, which gleans information from the transaction files and, where necessary and possible, assigns standard codes.

The impact file is then stored as a permanent record of the TIP as it was at the time of the batch update. The TIP file, however, continues to be modified in preparation for the next official amendment. Because of the inconsistencies permitted in the free-form fields of the TIP files, some standard codes must be manually added to the impact files. Currently the link files must be updated manually. When significant changes are made to the TIP the projects that have location and limits changes are selected and recoded. All the files are related by the permanent identification number. The key to other data files in the region's planning functions is the link file.

SYSTEM USES

The system, as it has been developed and refined, has been used for a number of years to continually amend the TIP and summarize various subsets of projects (5). Special listings and summaries are frequently requested by agencies involved in the MPO forum. As the new 5-year program is developed, the constantly changing program needs to be examined by all members of the work program committee (WPC). When approved, the program must be put in final form

almost immediately for policy committee approval before the federal deadline. The ability to rapidly effect changes and produce various versions of project listings has become eminently useful.

The more recent additions to the DBMS (i.e., impact files, transaction files, and link files) have been used to generate several analyses of the TIP on issues pertinent to the regional programming of transportation dollars. The link files allowed the analysis of TIP programming on carbon monoxide hotspots (identified on the network by a travel demand model) and on congestion of the highway at the zonal level. The impact files permitted an analysis of trends in programming by virtue of the permanent identification numbers and the maintenance of each amended version of the TIP. The impact files, as well as the standardized investment origin category codes in the TIP files, made possible the analysis of the consistency of the TIP with the long-range plan (3). Other summaries that are readily available include changes in federal aid-urban programming caused by amendments, identification of projects positively affecting air quality (4), a carry-over analysis for the new 5-year program, and summaries of various subsets of the program by work types (6).

PROBLEMS IN IMPLEMENTATION

Several problems have become apparent as the system has evolved and been used. These problems involved all aspects of a DBMS including data, organization, and user understanding.

Data Problems

Because the previous TIPs had been basically nonstandardized descriptions of the projects, the information about the projects on which the DBMS was initially based was not consistent, complete, or unique. For example, a project described as "structures" may refer to patch work on the deck or major structural repairs. Numerous projects listed as structures or resurfacing actually include intersections, signals, parking lanes, or numerous other jobs within the scope or limits of the project description.

These basic inadequacies in the data can destroy any attempts at standardizing a data base. They occurred for two reasons: First, the incentive to give more complete, consistent, and unique descriptions had never existed before. Second, the information was input from several autonomous sources.

Communication Problems

Efforts have been made to standardize descriptions among and between sources. However, some problems still exist. Although they know that some general work will be done in a corridor, the engineers themselves do not always have the information necessary to give complete, consistent information on each project at progamming time, especially for a 5-year program. In addition, the providers of the information have yet to see how a well-operating DBMS can be useful and timely; therefore, the incentive does not exist to continue to refine and conform to the standard descriptions. Likewise, potential users of the DBMS (e.g., long-range planners, land use planners, those implementing system management projects) have not been made aware of the many applications and improved information that could be available if the data base were maintained in a consistent, complete manner. These problems would be alleviated to the extent possible with improved communication between the sources of the information, the users, and the systems analysts maintaining the system. A sincere and concerted effort on all parts is essential to eliminate enough of the problems to make the DBMS effort cost-effective.

Level-of-Organization Problems

All DBMSs should be organized to use the lowest common denominator as a means for cross-referencing the numerous files. The current system was developed using project identification numbers as the reference to other files. Then, the demand model's historical record was difficult to access; so a cross-reference was designed to relate the two files. Currently, there are problems in relating the state's roadway inventory to the other files. The TIP information should initially be coded to the state's highway inventory file, which is organized at the finest level of detail of all the files (5). Then aggregations could be made up to links, projects, zones, townships, regional councils, and counties in order to cross-reference other data sources.

Timeliness and Verification Problems

Another problem encountered is in the timeliness and accuracy of updates and summaries after changes are made to the TIP data base. Part of this problem is a lack of person-power. Another part is that the system has not yet been refined to the point of being able to produce standard reports for summary and control checking at key times in the TIP's metamorphosis. A consensus among users must be reached about what those key times are and what information should be reported in order to assure accuracy.

In all of the cases discussed in this section, problems could be minimized by refining software to draw a tighter relationship among data sources, files, and uses. In addition, more communication among users, technicians, and data sources is essential both for defining future directions of the DBMS and for adequate operation of the system currently in use.

FUTURE DIRECTIONS AND APPLICATIONS

Adjustments that should be made to the present DBMS are evident in the previous section. One of the most important changes that is needed is to adapt the system so the file with the most detailed information (in this case the state's highway inventory) is the key file for referencing other data files. Because each of the files involved is structured differently, this change will be a significant one. It will require careful planning and control checks to assure that no information is lost in the process. Another important change is the manner in which new information is input to the system. A systematic process for acquiring information, coding, and inputting must be developed and accepted by all users. The consensus and commitment of all involved parties are essential at this juncture.

A major addition to the current DBMS would be the incorporation of transit data. The system was initially developed for the highway portion of the TIP and relates to existing highway data files. The TIP files and impact files have standardized transit information. But other files (i.e., transit network and rolling stock inventories) are not cross-referenced by the DBMS. When the transit files are

incorporated, a means of relating the highway and transit data files would allow for comprehensive analyses.

In addition, software for more timely entry and editing of the TIP project information in the DBMS should be explored. Currently, an interactive program allows the entry of TIP information into the TIP files (6). A similar program, which would allow entry directly into the state's highway inventory file, would make DBMS maintenance more timely and accurate. For example, when TIP projects are initially entered into the system, automatic checking for reference points along the length of the project could be done and a report produced for user verification. At the same time cross-references to all the files could be automatically summarized to check for missing or inconsistent data. The TIP file used for publication could be produced by machine through the interactive information entry program. Such a software package would essentially eliminate manual coding except in cases where erroneous or incomplete information is found.

Other software that could be built into a DBMS like this one should be applications oriented. Some of these applications would provide more and better feedback for TIP implementors and programmers (the original incentive for the development of the system). Others would enhance additional planning activities initiated by the region's transportation professionals.

To provide feedback, alternative program scenarios might be developed and evaluated in terms of various issues such as life cycle and condition of facilities, relation to other regional plans, and geographic and socioeconomic equity. Fiscal forecasts could be routinely generated based on physical deficiencies, historical costs of projects in previous TIPs, and cost benefits of various investment choices.

Other planning functions could benefit from the use of a DBMS such as this one by obtaining routine reports about awarded projects that effect the highway and transit network. The highway inventory also needs information about the TIP projects that affect the physical system described in the inventory file. Those planners implementing studies that require projections of future conditions would have a standard and accurate source of information about projects programmed for the next 5 years.

Although the benefits of this DBMS appear to be great, developing it to this point has been a tedious process of trial and error. Because there was no prototype from which to begin, the costs have been great. Further developments should prove to have increasing returns because the initial major investment has been made. However, an assessment should be made of the value of further development. In many cases the programming decisions are intentionally made without the aid of technical information. If this is the case more often than not, then developing further software capabilities would be a wasted effort. However, in those cases in which a DBMS for TIP is believed to be beneficial, the effort to set up such a system should be greatly diminished by the experience gained in this effort.

The DBMS for the TIP at CATS has proven to be useful for analyzing aspects of the program and the programming process. It is thought that further development of the system would greatly increase these benefits.

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