(LRSV). The LRSV was intended to achieve reductions of car weight and damageability, and increased occupant safety and fuel economy. It has proved to be highly successful in all categories.

Car weight was reduced by approximately 900 lb primarily by introduction of rigid foam-filled structure and changing to a front-wheel drive configuration that uses an improved spark-ignition engine. The engine employs an oxygen sensor and a closed loop fuel-air mixture control. Flexible polyurethane covers over resilient bumpers and the use of polyurethane fenders increase resistance to damage and are designed to prevent any front damage in collisions up to 8 mph.

Air bags provide automatic frontal protection to the driver and two front-seat passengers; side-crash protection is enhanced by the lightweight but rigid foam-filled structures and the addition of occupant crash padding to the doors. Frontal barrier tests (40 mph) have demonstrated automatic protection for front-seat occupants at crash energy levels 78 percent higher than required for production cars by current federal motor vehicle safety standard No. 208. Similarly, in a side crash at 25.6 mph, 64 percent greater crash energy-level occupant protection was provided than is required by the safety standard.

This modified full-sized, six-passenger sedan was subject to fuel economy and emission tests that demonstrated that the LRSV goals were well met (22.9 miles/gal city, 36.2 miles/gal highway, and 27.5 miles/gal combined). Therefore, all of the significant goals of the LRSV were shown to be met. The modified car was lighter, safer, and more fuel efficient with lower emissions and incorporated more damage resistance than the production car from which it was derived.

The applicability of RSV technology has been well demonstrated. Some of the advances will soon be or already have been further developed and used by the automobile industry. Included in this category are soft resilient foam bumpers, flexible light plastic fenders, alpha/numeric driver information displays, closed loop fuel-air mixture controls, and judicious use of high-strength low-alloy steel. The advances in the understanding of the interrelations of crush structure, occupant restraints, and vehicle aggressiveness against other vehicles and pedestrians should result in future car improvements. Although some experimental work with foam-filled structures is known to have been instituted by the largest manufacturers, their prior public statements indicated the approach to be impractical for mass production. On the other hand, the good adaptability and economy for mass production is well documented by the RSV producibility study performed by the Budd Company as a subcontractor to Minicars. Considering the new mixes of car weights developing on U.S. highways and the resulting increase in frequency of big versus little car crashes, it is urgent that all practical improvements in small-car crashworthiness be implemented as soon as possible if the otherwise certain increases in crash deaths and serious injuries are to be reduced.

MICROCOMPUTER APPLICATIONS IN TRAFFIC OPERATIONS

Philip J. Tarnoff

The decreasing budgets and increased workloads being experienced by the traffic engineering community demand that available staff and facilities be used with the greatest possible efficiency. The microcomputer equipment currently being applied to a variety of management and technical functions at all levels of industry and government has the potential of serving as a tool to provide these desired increases in efficiency.

Even in the nation's smaller communities, the traffic engineer is reponsible for extensive street facilities. These facilities include signal equipment, signs, and markings that must be effectively operated and maintained. To do so requires the development of detailed record systems organized in a manner that permits the scheduling of facilities maintenance and modernization activities.

In addition to data files, the traffic engineer frequently performs routine engineering calculations for activities related to roadway operations, signal system design, and timing. Many of these calculations are well defined and could be efficiently performed by using a microcomputer.

As consultants to the traffic engineering community, we must frequently review data contained in municipal traffic engineering files. Rarely in any of these communities is any use made of the digital computer. Information is frequently stored in handwritten form by using inconsistent formats. Calculations are performed manually. Where digital computers are used, they are applied on a fragmented basis using a few, poorly documented programs.

The advent of the low-cost microcomputer offers an opportunity to improve this situation. The microcomputer provides the instant availability and quick response that are characteristic of a dedicated computer. It also provides adequate peripheral storage for most traffic engineering applications.

The following discussion of the processing functions that are applied to microcomputer implementation is divided into three categories:

- Data Management—storage, access, and sorting of large quantities of data required for traffic engineering analysis
- Management Information—storage, access, and sorting of data files required for facilities and personnel management
- Computation—engineering calculations to supplement design, operation, and maintenance activities

Although there is obviously some overlap among these categories, the program functions that are of use to a traffic engineering organization will generally fall into one of them.

Data Management

One of the characteristics of a well-managed transportation system is the presence of a regular data collection program that monitors the effectiveness of the system's operation and identifies areas in which modifications may be required. In most cases, data collection will be in the form of machine traffic counts and manually collected, turning-movement counts. Floating car runs are sometimes made to evaluate the quality of the transportation system operation. Accident summaries are also used to identify locations where operational modifications may be required.

The usefulness of these data would be significantly enhanced if they were collected in a form that would permit automatic entry into a microcomputer. Equipment is currently available that records machine counts and floating car data on cassette tape or in a computer-type memory. This tape can be automatically read onto a floppy disk for permanent magnetic storage in a machine-readable form. Computer programs can then be developed to automatically identify areas of the city that are experiencing changes in traffic demand, or to reformat turning-movement counts for automatic input to signal timing programs. Accident data can be used for automatically identifying high-hazard locations or to evaluate the effect of operational changes.

The advantages of using a microcomputer to perform data storage and retrieval are obvious. A modest investment in computational equipment can reduce personnel time for data, summary, and analysis and can significantly increase the accuracy and use of the collected data.

Management Information

The management information function, like the data management function, is used for storage and processing of data files. The principal difference between these

Tarnoff is a Principal in the Traffic System Division of Alan M. Voorhees and Associates, Inc., McLean, Virginia, and a member of the NCHRP Panel on Methodology for Performance Evaluation of Signalized Network Control Strategies.

functions is the source and use of the data. The data management function is used for engineering purposes, and the management information function is used for improving the engineer's ability to manage the personnel and facilities for which the engineer is responsible.

Perhaps the best examples of management information applications are inventory files and monitoring of personnel activities. As the manager of a large-scale facility, the engineer may be responsible for operating, maintaining, and upgrading signal control equipment, signal displays, signs, painting, street lights, and so forth. An effective inventory system would keep track of the location, age, manufacturer, and maintenance history of all devices. A system of this type would permit the development of a justifiable equipment replacement program. It would be possible to identify the age of equipment at which the maintenance costs exceed the replacement costs. It would also be possible to quantify the benefits of a preventive maintenance program to determine whether the end benefits exceed the programs' costs. The costs, benefits, and scheduling of relamping programs (also a form of preventive maintenance) can be determined. Another benefit of the inventory files is that they would enable the traffic engineer to rapidly identify failing equipment for replacement and to avoid the continuing acquisition of unreliable designs.

Monitoring of personnel activities is an aspect of traffic engineering that is frequently overlooked. This activity is not necessarily performed to keep track of individual performance, but rather to monitor the manpower (and manpower costs) expended on each activity so that a financial assessment can be made of the costs of preventive and emergency maintenance. These data are necessary in order to perform the trade-offs between preventive maintenance and emergency maintenance that were previously mentioned. These data can also be used to identify training requirements if, for example, one individual's productivity appears to lag behind that of other staff members. Finally, these data can be used to plan for and justify the need for additional staff.

The preceding discussion is an example of the types of data that could be incorporated into the management information function of a microcomputer system. The need for additional functions would depend on the responsibilities and size of the traffic engineering organization. Examples of additional features would include budget data, construction costs and bid prices, spares inventories, and the status of on-going projects.

Computation

The traffic engineering profession uses numerous formulas and computational processes. The past decade has seen the development of computer programs to assist in the use of the more complex calculations. Computer programs are currently available for signal timing calculations including plotting of time, space diagrams, and capacity calculations. Simulation programs have also been developed that permit the reliable evaluation of the impacts of alternative changes in traffic operations. Many of these programs have already been modified for microcomputer implementation.

Additional programs that could be usefully implemented on a microcomputer include

- Calculations for signal pole and foundation design
- Cable file programs that calculate conduit size requirements as a function of the cable diameters being installed in the conduit
- Optimized signal-phase sequences for combinations of turning movements
- Statistical analysis for calculations of mean, standard deviations, regression equations, and so forth

Many additional programs have been developed for traffic control applications in communities throughout the country.

Future Developments

Based on the preceding discussion, it is obvious that the microcomputer is a tool that can be used to improve the productivity of a traffic engineering department. However, while microcomputer hardware is inexpensive, software development and documentation can be costly. It is likely that most traffic engineering organizations would be reluctant to invest in a development of this nature. Where software development occurs at the local level, it will probably be a result of the interest and initiative of individual staff members rather than any major investment by the community.

It is more likely that microcomputer software for the traffic engineering community will be the result of the efforts of private industry. Several organizations already offer specialized computational packages for sale. Most of these organizations will offer the microcomputer along with the software. In almost all cases, the cost of the software exceeds the cost of the computer. Most of the software packages contain only the functions identified in the computational category previously described.

It is also possible that federal and state governments may sponsor the development of this software. This approach might lead to more widespread use of the software since it could be offered to municipalities at no cost to the acquiring organization. However, the lead time and ongoing support required for this software could discourage government support of these developments. In addition, consideration should be given to the formation of user groups at either the state or federal levels that would permit sharing of software developed by various agencies.

Therefore, on the basis of the current direction of microcomputer software developments, it appears that these tools will undergo an evolutionary development. However, all traffic engineering organizations should be aware of their potential and should be giving serious consideration to their acquisition or development.