INTRODUCTORY REMARKS—EXTERNAL INFLUENCES ON MANAGEMENT

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•EFFECTIVE management of change—coming to terms with change and using it to advantage—is a challenge facing highway maintenance managers today. Before we can cope with changes effectively, we need to recognize and understand them. We need to know their origin, impetus, and direction.

Many of the changes being experienced today are internally generated in responding to recognized needs and problems within maintenance organizations and operations. But many are externally developed, reflecting economic, sociological, technical, or political trends and phenomena completely apart from highway maintenance. It is about these latter changes that this discussion centers. It is intended to set the stage for this management workshop and make clear the context in which maintenance problems must be faced today.

A number of external influences are exerting significant pressures on maintenance programs today. Some of them are major and obvious, like inflation; some are subtle but showing signs of strength, like pollution. But in all cases they represent constraints and conditions externally imposed (for better or worse) on maintenance programs. Let's take a closer look at some of them; first at the economic factors.

Inflation is having a significant influence on maintenance programs. As labor, equipment, and material costs increase, budgets also must increase or programs must be reduced. With the pressures currently felt by legislative committees responsible for budgeting, the latter alternative is often selected.

Figure 1 shows the rise in total highway maintenance expenditures (1). As further shown, current year expenditures are expected to exceed $4 billion and to increase by another $1 billion in the next five years. Some of this increase can be accounted for by the physical growth in our street and highway system. While the total number of new centerline miles on the system is increasing at a very modest rate of less than 2 percent per year, the real magnitude of the system growth in terms of new lane-miles, structures, complex appurtenances, rights-of-way, and special service facilities, such as scenic overlooks and rest areas, is growing at a more significant rate which is more difficult to measure.

Figure 2, the Unit Maintenance Expenditure Index, shows that the expenditures for maintaining a unit highway have increased by over 60 percent since the base-year period of 1957-59 (2). These expenditures are responding to many influences other than inflation. But the greatest single factor in the expenditure increase is the rise in unit costs of labor, equipment, and materials.

A number of types of growth are being experienced in our country today that influence highway maintenance. We have talked about growth of the highway system. Another is population growth, particularly in our urban areas. This increasing magnitude and concentration of our population in urban centers is readily translated into even greater increases in vehicle population and travel on our highways. Figure 3 clearly shows these trends. Vehicle registrations and fuel consumption have been increasing at about two times the population rate (3). While the gallons-per-vehicle ratio (indicative of the miles driven per vehicle) has also shown an increase, a major impact on maintenance expenditures obviously is being made by the increasing total number of vehicles on our highways.

This increase in traffic is complicated further by higher vehicle speeds. Figure 4 shows the increase in average passenger car speeds on rural highways that has been experienced over the last ten years (3). This is typical also for buses and trucks.

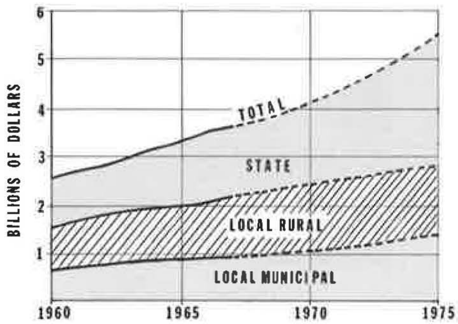

Figure 1. Highway maintenance expenditures.

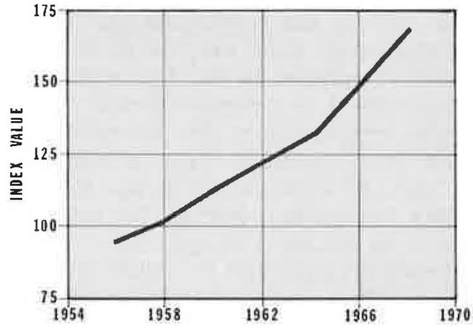

Figure 2. Unit maintenance expenditure index.

Thus, today's highways serve more vehicles and, in turn, generate a greater workload for maintenance agencies. Heavier loads and greater traffic volumes shorten the service life of pavements and structures, generate more litter, and cause increasing deterioration of guardrails, signs, delineators, pavement markings, and other appurtenances.

Greater traffic volumes affect maintenance costs in another significant area—traffic control during maintenance operations. As volumes and speeds increase, the cost for maintenance forces to gain occupancy of the roadway—to set up signs, cones, barricades, lights, signals, shields, and to remove them at the end of the job—may more than equal the cost of accomplishing the repair job on the site. Where traffic interruption is of major consequence, expensive methods and materials may be selected to reduce roadway occupancy time, or nighttime or weekend work may be scheduled at premium pay scales.

Figure 5 shows the relationship of maintenance expenditures to traffic volumes on various classes of Ohio's highways as indicated by a 1968 study (4). It is interesting to note that the lowest class on the chart, undivided highway, has the lowest fixed cost as shown by the zero average daily traffic intercept, but the steepest rate of increase as traffic volumes increase. Beyond 9,000 vehicles per day, the undivided highway exceeds the major divided expenditure per centerline mile—probably due in part to the difficulty of performing maintenance on these crowded facilities.

Aging of highway systems is a difficult-to-measure factor that influences increases in maintenance expenditures. Studies in a number of states have shown that pavement service life is affected by age as well as by axle loads. Where large systems are completed and have been in service for many years, the pavement aging factor tends to be

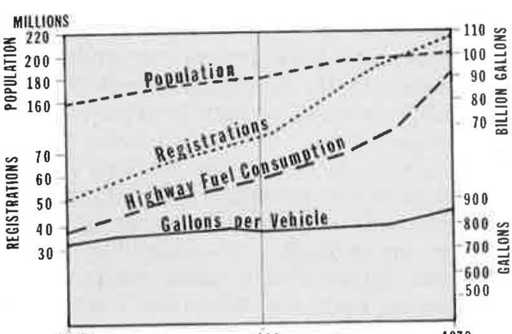

Figure 3. Growth curves.

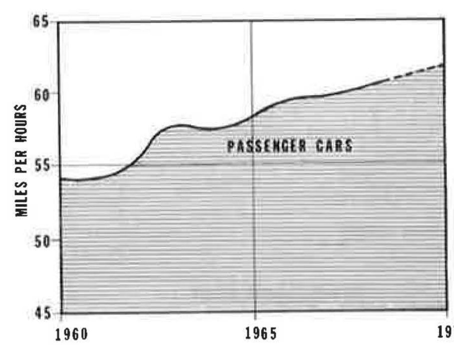

Figure 4. Average speed on rural highways.

"leveled-out" by the continuous resurfacing and renewal that goes on. An exception to this static condition is the Interstate system. Because it is a relatively new system, still under construction, the pavement surfaces on most sections have not begun to "cycle" and the average age is still increasing. This increasing age of the interstate pavements is having a measurable effect on maintenance programs in a number of states. That this factor is a significant external influence was dramatized recently by the controversial GAO report on deteriorating pavements issued in June 1970 (5).

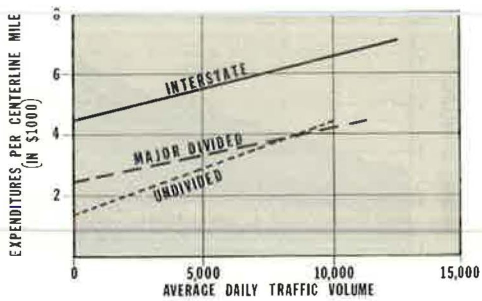

Figure 5. Maintenance expenditure versus traffic, Ohio, 1967.

Structures on the other hand, are not rebuilt on a predictable cycle. Most structures are designed for longer service life than pavements, and in our relatively young highway system, many structures are still in their original service period (6). In fact, as shown in Figure 6, approximately 403,000 of our 563,000 bridges were built prior to 1935. The influence of structure age on maintenance costs has not been separately identified and measured.

The growing use of studded tires on passenger cars also is acting to decrease service life of pavements in the northern states. The magnitude of this wear on pavement surfaces and the ways in which to meet this change are the subject of much current study and research.

Thus far we have been talking about external influences being felt and evidenced in maintenance expenditures. An inspection of Figure 7 helps to show these economic influences. The chart is taken from the 1968 study of maintenance expenditures in Ohio (4). The projection lines for future costs show the indiviual effects of pavement age (due to the interstate influence), increasing traffic, and rising costs of labor in the three wedges. The resulting total expenditure for maintenance, shown by the top line, is expected to exceed $87 million in 1980. On the other hand, if the influence of the rising costs of labor, equipment, and materials were eliminated, Ohio's 1980 maintenance expenditures would be about $54 million.

There are sociological influences bearing steadily on the maintenance manager that are not so readily translated into costs. One of the most significant of these is the growing awareness on the part of governmental agencies and private citizens of the need to protect our environment. Pollution is a new sin in the eyes of the public and maintenance forces cannot afford to be labeled as sinners. The obvious potential for pollution of soils and water supplies by the use of snow and ice control chemicals has been discussed over a period of years by maintenance engineers (7). This problem or potential problem will come under even greater scrutiny in the future, and maintenance programs must be designed to stand up under such scrutiny.

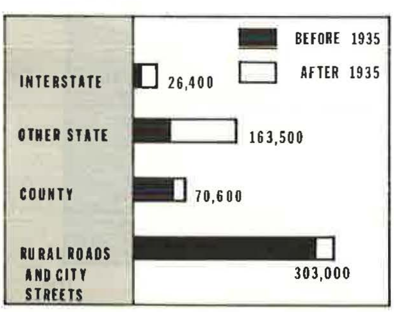

Figure 6. Bridges built in USA.

Environmental concerns will influence turf and vegetation maintenance programs in the future also. The use of soil sterilants, herbicides, insecticides, and growth inhibitors will be restrained or even eliminated in some cases. Ecological concerns may, on the other hand, suggest less frequent mowing and encourage public acceptance of natural cover rather than "golf course fairways" for many roadsides (8). Here the ecologist concerned with wildlife preservation and the maintenance engineer concerned with mowing program reductions may find a common path to their goals.

On the other hand, concerns about excessive noise levels adjacent to urban highways can result in extensive use of tree or shrubbery noise barriers in the right-of-way. And current public awareness of aesthetic as well as functional features of highway systems, places greater emphasis on installation and maintenance of landscape plantings within the right-of-way.

Pollution controls may have another influence on maintenance. Concern about air pollution has led a number of agencies to replace gasoline-fueled, internal-combustion engines with units burning LP gas. The future use of lead-free gasoline, LP gas, electricity, and other forms of power that reduce air pollution can be anticipated, and maintenance equipment fleets may be—and probably should be—in the forefront as this change takes place.

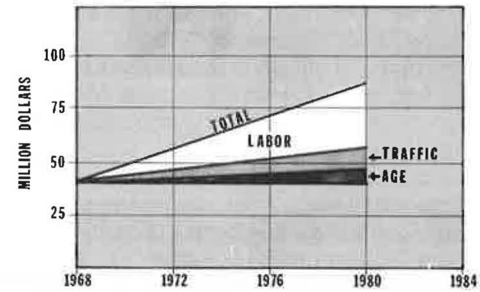

Figure 7. Forecast of annual maintenance expenditures in Ohio.

A pollution problem with which highway departments have been struggling for many years—litter removal—may very well benefit from the renewed public concern over our environment. Regardless of whether or not public concern is translated into greater restraint in littering the highways, we can be confident that it will be reflected in continuing public demands for litter removal by maintenance forces.

In the area of technological factors influencing highway maintenance, the impact of new design and construction concepts must be considered. The use of low-maintenance components such as galvanized guardrail, unpainted steel, aluminum and prestressed concrete structural members, or epoxy coatings and other durable finishes, have greatly reduced the painting work load of maintenance forces.

The continuing improvement of the design of protective membranes and wearing courses on bridge decks and the incorporation of such protective systems in original construction contracts hold promise of reducing the major burden of concrete bridge deck repairs faced by maintenance forces in most states.

The safety standards incorporated in the Federal Highway Administration's "Yellow Book" offer a secondary but significant benefit to maintenance programs. Figure 8 shows results of studies by the State of California to determine the cause of freeway fatal accidents (9). Data from the same study on accidents involving fixed objects, as shown in Figure 9, may serve to indicate where future design changes will be made in the attempt to provide safer highways. The elimination of hazardous headwalls, signs and lighting standards, and other obstructive appurtenances also will reduce potential damage to mowers and snowplows and free areas for better mowing and plowing production. Flatter slopes, as shown in Fig-

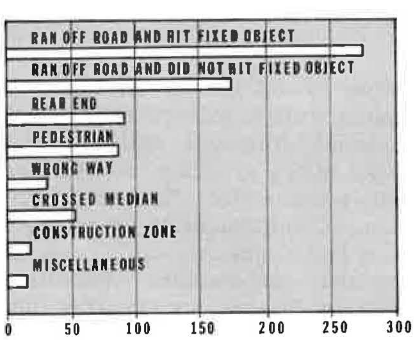

Figure 8. Freeway fatal accidents, California, 1966.

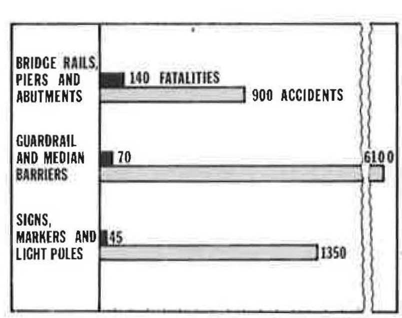

Figure 9. Accidents involving fixed objects, California, 1966.

ure 10, ease mowing operations and reduce erosion and snow drifting problems (10).

The use of high-strength paving on roadway shoulders permits maintenance forces to close a traffic lane and utilize the shoulder without a lane reduction in the traffic flow. Wider bridge decks, as shown in Figure 11, with shoulder sections carried the full length, provide snow storage areas in winter and areas sheltered from traffic for maintenance equipment crossing or working on the structure in the summer (11). On urban expressways, new electronic traffic monitoring and control systems designed to improve speed and capacity are undergoing field testing and refinement. These same systems can serve to control traffic and increase safety when a lane must be occupied by maintenance forces. The list of maintenance benefits from highway design changes could be extensive, but it would consistently indicate that most safety-oriented improvements in highway design also have permitted meaningful improvement in highway maintenance operations.

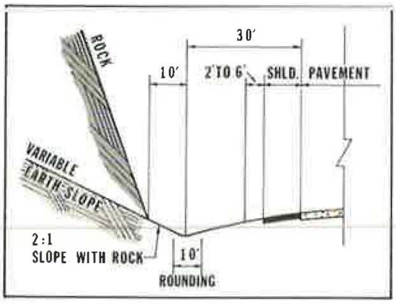

Figure 10. Typical rural safety cut section.

The advances in the communications and information-processing industries have influenced maintenance programs in many ways that need not be enumerated. While our struggles with computer programs and electronic management information systems have generated as much frustration as enthusiasm at times, there is no question about the need for maintenance engineers to know and utilize these vital management tools if they are to control successfully the massive and complex systems for which they are responsible.

External disciplines also are influencing maintenance. The industrial engineer is prominent because of his application of production techniques and analyses to maintenance programs. While the sociologists, economists, and architects, at the moment, concentrate their influence on highway location and design, it is not unrealistic to expect external influences from these or similar sources to join the already-vocal conservationist and ecologist in influencing the maintenance programs of the future.

Traditionally, engineers have been guilty of ignoring or denying the political influences that are a fundamental part of every public works program. Since our system of government is designed to make public officials sensitive to public needs through the political process, engineers have not succeeded, by denial, in making politics go away. And political considerations continue to exert a significant external influence on maintenance. Where this influence is felt in periodic program or personnel changes as administrations change, managers must provide program flexibility and personnel training to meet these changes when they occur. By the same token, maintenance managers must make a realistic assessment of the political sensitivity of their programs, give meaningful attention to public relations and public information efforts, and be quick to respond to valid evidence of public concern.

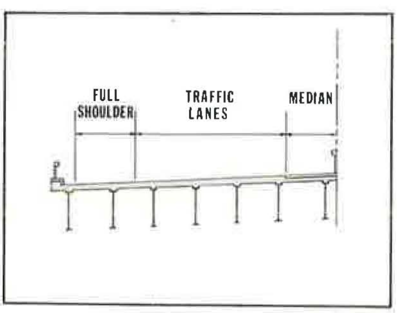

Figure 11. Typical bridge section.

No discussion of influences on maintenance would be complete without a reference to research. In terms of external influences, military research programs and the space program have and will continue to have the most obvious "fall-out" benefits for maintenance. Communication systems, materials, management concepts, equipment, fuels, weather observation, and weather forecasting are undergoing constant change as a result of these programs.

We can readily document the changes and the challenges facing maintenance managers today, particularly external influences in this era of protests, pollution, population increase, inflation, integration, and confrontation. We may not control these external influences but we can control our capability to cope with them and to utilize or modify them, which, after all, is what management is all about—and what we are about as this important conference gets under way.

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