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Research Problem Statements

Operation, Safety, and Maintenance of Transportation Facilities

TRANSPORTATION RESEARCH BOARD / NATIONAL RESEARCH COUNCIL

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RESEARCH PROBLEM STATEMENTS

OPERATION, SAFETY, AND MAINTENANCE OF TRANSPORTATION FACILITIES

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category

III materials, construction, maintenance

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Preface

An important function of the Transportation Research Board is the stimulation of research toward the solution of problems facing the transportation industry. One of the techniques employed by technical committees in support of this function is the identification of problems and the development and dissemination of research problem statements. The aim of this activity is to provide guidance to financial sponsors such as governmental agencies, research institutions, industry, the academic community and others in allocating scarce funds and manpower to the solution of transportation problems.

The problem statements in this circular represent a composite of efforts by seven of the Group 3, Section C committees. They should not be considered an all inclusive recognition of maintenance research needs but, instead, represent only the problems identified by those committees. Since many of the statements may touch upon the scopes of several other elements of the Board, the circular is being distributed to a wide range of interest areas.

A standard system was not used to establish priority ratings and committee chairmen used different systems. It is likely that some current research in progress and recently completed research was overlooked which may have altered the recommended priorities. It should also be noted that subjective evaluation of research needs probably created a bias in favor of applied research as opposed to theoretical studies.

While the problem statements have been assigned a number and arranged within categories by alphanumeric designation of contributing committees *this arrangement does not establish recommended priorities within categories*. The ordering of statements under individual committee listings *does* reflect that committee's evaluation or priorities.

Contents

Committee A3C01 - Maintenance and Operations Management

PROBLEM NO. A3C01-01

Title: MAINTENANCE QUALITY ASSURANCE

Problem: Transportation agencies expend enormous funds annually in maintaining the roadway infrastructure. The quality of the work performed by contract and force account is difficult to assess because systems are generally not in place to make these assessments. Quality assurance (QA) systems have been in place in the highway construction field for some time now and their success has been documented. Although not all maintenance activities lend themselves to this system, many do and could benefit from its application.

Objectives: Identify current systems for determining maintenance QA; determine those maintenance activities that lend themselves to QA procedures; and develop a manual and training program to facilitate the development of QA in maintenance.

Current Activities: Advancements in this area have been made by the DOTs in Ohio, Florida, California, Iowa, Virginia, and others.

Urgency: There is an urgent need to provide transportation agencies with a means of assessing and improving the quality of maintenance activities.

PROBLEM NO. A3C01-02

Title: MANAGEMENT SYSTEM EFFECTIVENESS

Problem: Centralized efforts to plan and control maintenance in large organizations have not been effective, especially in systems that are not responsive to local interests and needs. Attempts to effectively manage work quality and productivity from "headquarters" have not been successful, except in small organizations where "headquarters" is across the hall. A decentralized approach to managing maintenance may well be far more effective.

Objectives: Identify, test and evaluate alternatives to traditional approaches to management system operation in large organizations. Isolate the characteristics which have promoted system effectiveness in highway maintenance organizations.

Current Activities: Some efforts are being made to increase system effectiveness, but decentralized approaches are not being evaluated.

Urgency: There is an urgent need for practical research on the ways in which maintenance management systems can become more effective. Substantial improvements and cost savings are possible, if decentralized management practices can be successfully implemented.

PROBLEM NO. A3C01-03

Title: QUANTIFY THE CONSEQUENCES OF PAVEMENT CONDITION

Problem: It is important to assess both the costs and benefits of any proposed maintenance activity and objectively evaluate the economic and other consequences of different actions. The influence of pavement roughness on vehicle operating costs is not well established. Not enough is known about the potential for pot holes and shoulder drop offs to cause accidents.

Objectives: Establish quantitative models to evaluating the impact of pavement conditions on vehicle operating costs, lost time, accidents, pollution, and user comfort.

Current Activities: Unknown

Urgency: Information needed to assist in decisions in risk management.

PROBLEM NO. A3C01-04

Title: REDUCE MAINTENANCE MANAGEMENT PAPERWORK

Problem: A number of maintenance management systems seem to be little more than an added burden on maintenance supervisors. The paperwork, in particular, is frequently viewed as the major negative element in a given system. In addition, the integration of maintenance management systems with other systems increases the likelihood that paper will become even more dominant.

Objectives: Identify, test and evaluate options to existing paper processes, especially within lower management

levels. Define cost-effective alternatives to written documentation of maintenance resource use, accomplishment and cost.

Current Activities: Some isolated efforts to consolidate paperwork have been undertaken by most transportation agencies.

Urgency: The potential for cost savings and system effectiveness are significant in relatively large organizations which require complete documentation of maintenance activities.

PROBLEM NO. A3C01-05

Title: EQUIPMENT NEEDED TO EVALUATE CONDITION OF HIGHWAY FACILITIES

Problem: Corrective highway maintenance could be eliminated or minimized if maintenance is conducted in a more timely manner. This means anticipating needs and applying preventive maintenance treatments. Current information on maintainable highway components condition is insufficient.

Objectives: Distress measuring or sensing procedures are needed to detect maintenance element characteristics that indicate the onset of failure or can anticipate failure. Devices or procedures are needed to detect voids under culverts, pipes and conduits; extent of hidden defects in bridge joints; the condition of concrete and steel in culverts or drainage pipes, particularly in unaccessible locations; steel paint adequacy; steel fatigue cracks; sign and marking reflectivity; defects in monolithic decks on box beams bridges; bridge deck distress and delamination; prestressed concrete steel condition; and crack detection in structural concrete and steel.

Current Activities: A survey should be conducted to determine equipment available or under design.

Urgency: Urgent because of need to make best utilization of available manpower and funds.

PROBLEM NO. A3C01-06

Title: MAINTENANCE MANAGEMENT PERCEPTIONS OF EXPERT SYSTEM

Problem: Artificial intelligence methods are spawning expert systems to facilitate decision-making and analysis of problems in many areas of highway transportation. There appears to be a reluctance to consider the application of such tools in maintenance management. There is a need to estimate the degree to which such tools are or are not applicable to maintenance management and compare that with maintenance engineering managers perceptions of expert systems.

Objectives: Examine state DOTs maintenance management processes for activities, functions and tasks that may be addressed via expert systems. Estimate the possible increase or decrease in efficiency and/or effectiveness of the activity, function or task that might occur by adopting an expert system, if one were available. Estimate the probability of implementation of an expert system in applicable areas.

Current Activities: Carnegie-Mellon and California work.

Urgency: High priority to be able to assess and utilize expert systems technology in maintenance management.

PROBLEM NO. A3C01-07

Title: PROLIFERATION OF UTILITIES ON HIGHWAY RIGHTS-OF-WAY

Problem: As the nation has developed, so has the need for the installation of utility lines within highway right-of-way. In certain highly developed areas, room for additional utilities has become very scarce. The breakup of Bell Telephone Systems and AT&T has further aggravated the situation as additional long distance telephone companies are developing and requesting to locate within the highway right-of-way. There is a concerted effort now underway by the newly developing long distance telephone companies to locate their fiber optic cables within the interstate highway right-of-way.

Objectives: Determine actual effects that the proliferation of utilities within the highway rights-of-way has on maintenance operations and develop methods for improvement.

Current Activities: None

Urgency: Urgency is high. Problems are at hand.

PROBLEM NO. A3C01-08

Title: FEASIBILITY AND EFFECTIVENESS OF INTERACTIVE VIDEO DISPLAY OF COMPUTER LINKED DATA BASE ON ROUTE CONDITIONS AT TOURIST REST STATIONS

Problem: Each state is interested in enhancing tourism opportunities. Tourism events can be publicized in advance. Continued difficulty in adequately and quickly informing the motorists entering a state about highway systems conditions is a criticism of the highway agency. There is a need to examine the potential costs and benefits from the application of advanced video and computer telemetry link to enhance this tourist communication.

Objectives: Determine feasibility and effectiveness of providing tourist information on road closures, bridges out, traffic through construction and maintenance zones, regional weather condition warnings, temporary load embargoed roads/bridges, permanently load embargoed roads/bridges in an interactive video display at tourist/-rest areas. Digitized voice message, color graphics/text displays are all to be a part of any system design. Test in a state with pilot system installations.

Current Activities: Unknown

Urgency: Medium due to implementation lead time.

Committee A3C02 - Transit Bus Maintenance

PROBLEM NO. A3C02-01

Title: INVESTIGATE THE QUANTITATIVE BENEFITS OF, AND THE MOST EFFECTIVE TECHNIQUES FOR, TRANSIT BUS MAINTENANCE TRAINING

Problem: Transit bus maintenance training is considered to be beneficial, but it is not clear if all forms of training are equally useful. Is traditional hiring practice coupled with on-the-job experience sufficient, or do more intensive training programs produce quantitative life cycle cost benefits for an organization?

Objectives: Determine if transit bus training is beneficial, to what extent it is beneficial, and what educational techniques are most effective.

Current Activities: The military has some excellent training programs as does the transit industry.

Urgency: This topic has a high degree of urgency since maintenance training to protect capital investment is becoming a nationwide concern.

PROBLEM NO. A3C02-02

Title: ADVANCE THE STATE-OF-THE-ART IN CREATIVE TRANSIT BUS MAINTENANCE PROBLEM SOLVING

Problem: Considerable work has been done in defining performance measures, collecting raw data and developing information systems to process data on transit bus maintenance. While these techniques are not universally in place, the majority of needed research has been done. What still needs to be done is to develop creative responses to deteriorating maintenance performance. This research effort should be aimed not at identifying problems but at solving them to improve maintenance performance -- building on research already completed on performance measurement.

Objectives: Identify ways to improve transit bus maintenance performance when performance measures indicate a problem. An extension of this work is to provide a guideline for corrective action.

Current Activities: The APTA Bus Maintenance Subcommittee has been making significant strides in the area of performance measurement over the past few years.

Urgency: A study such as this should have high priority because performance measures do not indicate a plan for action.

PROBLEM NO. A3C02-03

Title: DEVELOP A MODEL CONTRACT FOR CONTRACTING BUS MAINTENANCE SERVICES

Problem: Maintenance is essential to providing reliable transit service, and good management is a prerequisite of good maintenance. When maintenance is contracted, the management task becomes one of contract administration and enforcement rather than direct management of personnel. It is important that performance standards,

inspection rights, sanctions for non-performance and incentives be clearly stated in the contract document to assure a satisfactory product. There are also numerous standard clauses that should be included. This effort would provide a synthesis of good contract language for use as a model by transit agencies.

Objectives: Develop a model contract document for maintenance contracting by consolidating the best contracts of those agencies experienced in contracting maintenance. The model would cover the following cases: machine work, unit rebuilds, servicing, running repair, and turnkey maintenance contracting. It would be designed for any transit agency considering contracting major portions of the maintenance operation.

Current Activities: Unknown

Urgency: Since contracting of maintenance is consistent with the current emphasis on private sector participation, this project is very timely.

PROBLEM NO. A3C02-04

Title: DETERMINE THE FEASIBILITY OF ESTABLISHING A TRAINING MATERIAL CLEARINGHOUSE FOR BUS MAINTENANCE

Problem: There presently is no place one can go to find out what bus maintenance training materials are available. Materials provided by manufacturers are not always sufficient and there is evidence that some transit properties are doing very good work in-house.

Objectives: Determine the extent of the problem and the nature of training materials that would be available, assess the quality of available materials, and estimate the annual cost of establishing a transit maintenance materials clearinghouse. If the concept is deemed feasible, the second step would be to fund and implement the clearinghouse.

Current Activities: UMTA currently operates a similar clearinghouse for transit micro-computer users.

Urgency: The bus maintenance community views this need as being critical because too many systems are either reinventing material that already exists or limping along because they cannot find (or cannot afford to develop) the training materials they need.

PROBLEM NO. A3C02-05

Title: MANPOWER ALLOCATION METHODS FOR MULTI-DIVISIONAL TRANSIT PROPERTIES

Problem: With labor being a critical component in the maintenance cost equation, there is a need to ensure that maintenance department employees are used as effectively as possible. This is important not only for the people assigned to a given facility (minimizing lost time) but, for large properties, the distribution of skilled workers among several facilities. The problem is to develop a method for allocating maintenance manpower that is sensitive to maintenance variables -- fleet age, average miles per coach, average speed, roadway condition, etc. The method should be sensitive to maintenance variables without being so complex that management information systems may be assumed as a source of data.

Objectives: Develop a transit manpower allocation model that can be used to distribute maintenance talent among the garages of a multi-division system.

Current Activities: There are a number of systems (e.g. SCRTD) which already do this on an ad hoc basis. Relevant research has been done by Mandle, Carter and Silverman, and by MacDorman and MacDorman.

Urgency: Labor productivity is crucial for minimizing transit maintenance costs.

PROBLEM NO. A3C02-06

Title: ALTERNATIVE DESIGNS FOR TRANSIT BUS ELECTRICAL SYSTEMS

Problem: Bus electrical systems are complex and difficult to maintain. Current technology provides opportunities to redesign the bus electrical system in order to simplify the system operation, improve reliability, and automate bus servicing.

Objectives: Document technology available to simplify transit bus electrical power and control systems. Suggest designs for prototype development. Designs should center on use of multiplexing or related technology, diagnostics and simplification of manufacturing. Designs of this type are currently in use on some automobiles. Such alternatives need to be looked at now for future manufacturing.

Current Activities: None

Urgency: In the interest of remaining current, the application of new electronic control technology to buses should be investigated. This is an opportunity for technology transfer.

PROBLEM NO. A3C02-07

Title: DEVELOP A MODEL PRACTICE FOR THE USE OF ENGINE OIL ANALYSIS

Problem: Engine oil analysis is an established maintenance tool. There are, however, different degrees of analysis and the results of such analysis can be used in different ways. This research should be directed at identifying the most cost-effective practice for fleets of varying size and age.

Objectives: Develop an oil analysis model(s).

Current Activities: Several transit properties now use oil analysis as an input to their work scheduling.

Urgency: The urgency of this project stems from the downstream cost reductions that can be achieved through on condition maintenance. Even though the benefits can be demonstrated conclusively in a theoretical sense (fewer in-service breakdowns and less unnecessary maintenance work), the industry needs to have reliable indicators (and reliable ways to interpret those indicators) before benefits can be achieved.

PROBLEM NO. A3C02-08

Title: EVALUATE THE EFFECTIVENESS OF REFURBISHING ELECTRONIC FAREBOXES

Problem: Transit property farebox reliability decreases as electronic fareboxes age. The capital for replacement of fareboxes is needed in other areas.

Objectives: Evaluate the effectiveness of refurbishing electronic fareboxes to extend their life and capabilities.

Current Activities: The Phoenix Transit has worked over the last three (3) years to develop a farebox refurbishing program.

Urgency: If transit properties begin to replace fareboxes bought in the late 70's and early 80's, an alternative to new purchases needs to be presented to the agencies.

Committee A3C04 - Traffic Safety in Maintenance and Construction Operations

PROBLEM NO. A3C04-01

Title: DEVELOP A SYNTHESIS OF HIGHWAY PRACTICE: HIGHWAY WORK ZONES PRINCIPLES AND TERMINOLOGY

Problem: Improvements in the quality of theory and practice in work zone traffic engineering is being retarded because of a lack of precise and universally employed terminology. Similarly, an organized set of commonly held principles for the design and operation of work zones has not been established due to ambiguous and undefined concepts. The continuing use of imprecise and colloquial nomenclature inhibits the development of improved work zones that will reduce highway losses and expedite traffic movement.

Objectives: Document and refine the terms presently used in designing, implementing and describing the performance of work zone traffic control. This effort should result in a vocabulary of basic concepts and a set of principles that can be shared by both researchers and practitioners.

Task 1. Construct an annotated glossary which standardizes the preferred terms of art that are used for the concepts and principles of design and operation of work zones. Definitions of terms should be sought that avoid the use of slang and the use of concepts that have only regional applicability. Annotation should be appended for each major term and its definition that appropriately explains the traffic control principle and application, including key bibliographical references in the literature and what are preferred techniques or methods. Human factors considerations should be included in this research effort. An alphabetical index of the terms should be provided.

Task 2. The synthesis should proceed to a consideration of motorist, worker and pedestrian characteristics, and needs which must be met in the design and operation of work zones. This should include an evaluation of the contribution of human factors theory and practice to quality of safe and efficient traffic movement in work zones.

Task 3. The fundamental principles of design and operation of work zones should be enumerated using the accomplishments of the previous tasks and appropriately described, and pictorially and diagrammatically represented in examples. A starting point for accomplishing this task should be the evaluation of fundamental work zone principals in Section 6A-5 of the *Manual on Uniform Traffic Control Devices*. The goal of this task is to modify and expand the reach of these principles in light of the achievements of the previous tasks, and to articulated specific sub-principles and implementation techniques that will establish a coherent body of professional practices that can enhance traffic movement and safety in work zones.

Current Activities: None

Urgency: The potential to reduce highway losses, and expedite traffic movement by removing inexact and informal language is significant.

PROBLEM NO. A3C04-02

Title: DEVELOP A SYNTHESIS OF HIGHWAY PRACTICE: DESIGN AND IMPLEMENTATION OF TRAFFIC CONTROL PLANS FOR HIGHWAY WORK ZONES

Problem: The evolution of highway and street work zone traffic control practices has accelerated over the past decade. A wide variety of standards, warrants, and guidelines is currently applied throughout the United States for the purpose of expediting traffic through work areas and providing for the protection of motorists, workers, and pedestrians. A major feature of work zone traffic control management is the requirement that Traffic Control Plans (TCPs) be designed for and implemented on all highway projects receiving Federal assistance.

Objectives: Complete a survey of current work zone TCPs that establishes what are the preferred designs for securing efficient, safe traffic movement. This survey should determine what practitioners regard as superior TCP design approaches for different classes of highway and streets in both rural and urban environments, and how TCPs are designed and implemented to accommodate moving and short-term operations, such as maintenance and utility work, as well as longer term operations involving fixed-site construction zones. In surveying the TCPs for different classes of roads and work zone conditions, the authors of the synthesis should identify the systems of data acquisition and use of on-site information for designing, implementing, and altering TCPs (including volume, vehicle mix, pedestrians, accident experience, speed, and congestion/ capacity), as well as the traffic control management techniques employed by jurisdictions to create, apply, and oversee TCPs (e.g., central office design and planning, and coordination with field personnel; field office implementation and oversight; contractor and traffic services subcontractor duties and operations, etc.).

Current Activities: None

Urgency: Urgent because synthesis will help to organize the best designs for safe and efficient traffic movement.

Committee A3C08 - Maintenance Equipment

PROBLEM NO. A3C08-01

Title: IMPROVING MECHANICS SKILLS THROUGH BETTER TRAINING

Problem: The skills of mechanics are constantly being challenged as more and more high technology components and pollution controls are being added to highway department fleet equipment. There is a need to provide appropriate training to keep these mechanics up-to-date on the latest technologies.

Objectives: Develop appropriate training materials to improve mechanics skills.

Current Activities: Unknown

Urgency: These training programs are needed now.

PROBLEM NO. A3C08-02

Title: GUIDE TO STANDARDIZE NON-CRITICAL EQUIPMENT SPECIFICATIONS

Problem: The lack of standardization in preparing specifications for non-critical equipment components may be adversely affecting the cost of equipment purchased by highway departments.

Objectives: Develop a guide for specification writers to follow to offer more standardization in non-critical equipment components.

Current Activities: None

Urgency: This effort has the potential of reducing the cost of equipment purchased by highway departments.

PROBLEM NO. A3C08-03

Title: CONTRACT VS IN-HOUSE EQUIPMENT MAINTENANCE

Problem: The proponents of privatization and contracting for service have fostered the use of outside service providers for equipment maintenance. Few sources of truly unbiased information exist and no comprehensive review of the results exists.

Objectives: Review contracting experiences and report on how to effectively evaluate and use outside service providers for equipment maintenance.

Current Activities: None

Urgency: In order for decisions on privatization to be made, unbiased information is a necessity.

PROBLEM NO. A3C08-04

Title: ECONOMIC REPLACEMENT ANALYSIS FOR MAINTENANCE EQUIPMENT

Problem: Based on analytical procedures, the optimal replacement time for maintenance equipment is when the maintenance and operating costs equal the costs of ownership. From a theoretical standpoint this makes sense, but its application is often impractical.

Objectives: Conduct applied research to identify valid methods for analyzing replacement cycles for maintenance equipment.

Current Activities: None

Urgency: There is an urgent need to ascertain whether current replacement cycles should be adjusted for a more beneficial outcome.

PROBLEM NO. A3C08-05

Title: EVALUATION OF ALTERNATE MANUFACTURES EQUIPMENT

Problem: The matching of the best available equipment to the needs of maintenance operations is a critical decision that will affect maintenance efficiency for many years following the decision.

Objectives: Evaluate and develop a menu-driven computer spread sheet program to evaluate alternate manufactures equipment.

Current Activities: John Deere Company has done some work in this area.

Urgency: This research is critical to the improved selection of the best available equipment to meet the needs of maintenance operations.

PROBLEM NO. A3C08-06

Title: MATCHING EQUIPMENT PERFORMANCE STANDARDS WITH MAINTENANCE TASKS

Problem: The performance standards used in the purchase of new maintenance equipment often do not match the operational demands placed on the equipment in the performance of various maintenance activities. This mismatch of equipment performance standards and operational demands results in sub-optimization of equipment utilization or inefficiencies in the performance of maintenance operations.

Objectives: Develop equipment performance standards corresponding to the operation needs for various maintenance tasks.

Current Activities: None

Urgency: The matching of equipment performance standards with operational demands will have a beneficial effect of the cost of new equipment.

PROBLEM NO. A3C08-07

Title: PREVENTIVE MAINTENANCE PROGRAMS FOR FLEET EQUIPMENT

Problem: The identification and correction of minor equipment problems are considered to be the corner stone of an effective preventive maintenance program. If minor problems are not corrected in a timely manner, serious problems will develop. The costs, in terms of equipment down time and actual repairs, to correct serious equipment problems are often significantly higher than correcting the minor problem.

Objectives: Identify the benefits and costs of using mechanics for a preventive maintenance program. Develop a model preventive maintenance program for highway departments to implement.

Current Activities: None

Urgency: Preventive maintenance programs for highway department fleet equipment could be quite cost effective.

PROBLEM NO. A3C08-08

Title: EQUIPMENT MAINTENANCE PRODUCTIVITY IMPROVEMENT

Problem: Transportation agencies have experimented with several methods to improve equipment maintenance productivity, but more work is needed.

Objectives: Conduct an applied research effort to evaluate and document the effectiveness of promising methods designed to improve shop floor maintenance of highway maintenance equipment. The methods studied should include time measurement, improvement of facility layout, training, etc.

Current Activities: None

Urgency: Effective productivity of equipment maintenance shops is critical to proper maintenance of the highway maintenance equipment fleet.

PROBLEM NO. A3C08-09

Title: REPLACEMENT VS. REHABILITATION OF MAINTENANCE EQUIPMENT

Problem: Rehabilitation of equipment maybe a viable option to buying it new, but it is often difficult for an agency, reviewing rehabilitation options, to determine its associated costs and implications on the level of output.

Objectives: Identify valid methods for analyzing the tradeoffs of replacing equipment versus rehabilitation, and document experience with rehabilitation by public agencies. Attributes that must be taken into consideration include performance, availability, life, maintainability, etc. of rehabilitated versus new equipment.

Current Activities: None

Urgency: It is advantageous for interested agencies to have the information to determine whether it is more viable to buy new equipment or to rehabilitate existing equipment.

PROBLEM NO. A3C08-10

Title: EQUIPMENT OPERATOR TRAINING

Problem: There is a lack of documentation defining the importance of operator training for both equipment operation and maintenance.

Objectives: Determine the influence of operator training, on output, operational reliability, safety, and maintainability of equipment.

Current Activities: None

Urgency: This effort is needed to provide management with information on the effectiveness and usefulness of equipment operator training.

PROBLEM NO. A3C08-11

Title: FUEL CONSUMPTION AND ALTERNATIVE FUELS

Problem: There are several fuel related problems that public agencies will face within the next decade. They include emission constraints in diesel equipment, rising fuel costs, the use of alternative fuels, and fuel shortages. Although fuel is currently in adequate supply, history has taught us that this is not likely to be the case in the future.

Objectives: Conduct a policy level study to determine the

implications on public agencies of fuel shortages, acceptability of alternative fuels, and programs for managing fuel use in the face of changing and diminishing fuel supplies.

Current Activities: None

Urgency: As fuel supplies decrease, it will be necessary to find new and alternative fuels, and to explore ways of managing fuel use.

PROBLEM NO. A3C08-12

Title: EMPLOYEE MOTIVATION

Problem: A number of employee management approaches have been attempted by public agencies to motivate equipment maintenance employees and promote the quality of work conducted.

Objectives: Document and suggest approaches to motivating equipment maintenance employees.

Current Activities: None

Urgency: Employee motivation is of great concern as it influences the quantity and quality of work.

PROBLEM NO. A3C08-13

Title: EQUIPMENT MAINTENANCE MANAGEMENT INFORMATION SYSTEMS

Problem: Currently, commercially available equipment management information systems provide a means to summarize past data so that management can use this information to make future decisions. However, these systems have limited capabilities to conduct forecasts and to facilitate "what if" analyses.

Objectives: Incorporate knowledge based processes into information systems so that systems can aid decision makers in selecting the most desirable options. This will require the development of sophisticated models within information systems.

Current Activities: None

Urgency: There is an urgent need for an equipment maintenance management information system to synthesize data and forecast the consequences of management decisions using "what if" analyses.

PROBLEM NO. A3C08-14

Title: EQUIPMENT MANAGEMENT TRAINING

Problem: There have been national FHWA sponsored courses taught in the past for equipment managers. There are also equipment management courses for small and medium public works agencies. There are, however, no equipment management courses available for professional equipment managers from large counties, cities or state departments of transportation.

Objectives: Create a multi-day, or perhaps multi-week course, for professional equipment managers. It should cover such advanced topics as inventory theory, engineering economic analysis of equipment, the development of equipment management plans, economic analysis of component rebuild intervals, reliability analysis, employee management and motivation, employee training, etc.

Current Activities: None

Urgency: Knowledgeable professionals are required to protect the significant investment by transportation agencies in equipment fleets.

Committee A3C09 - Winter Maintenance

PROBLEM NO. A3C09-01

Title: DEVELOP A SYNTHESIS OF PRACTICE FOR MANAGING SNOW AND ICE CONTROL OPERATIONS

Problem: State management practices vary as they relate to snow and ice control. New information on materials, equipment and management strategies has been developed. The need exists to document and review management practices and to disseminate this information to snow and ice control specialists throughout the country.

Objectives: Develop a synthesis of practice in the area of snow and ice control operations. Different regional expectations and levels of service should be recognized.

Current Activities: Individual states provide coordination on an as-needed basis. Roads Magazine has conducted a two-year survey dealing with some of the management practices. No comprehensive effort is underway.

Urgency: All agencies with snow and ice control efforts (state and local) would significantly benefit. Managers and maintenance personnel will apply results for cost savings, reduced environmental impacts, and improved public safety.

PROBLEM NO. A3C09-02

Title: ABRASIVE EFFECTIVENESS IN WINTER ROAD MAINTENANCE STRATEGIES

Problem: Maintenance agencies use chemical and abrasive mixtures under a wide variety of conditions. The traction capabilities of abrasive and deicing capabilities of chemicals have been evaluated. However, the combined effects have not been evaluated. Abrasives are intended to provide traction and deicing chemicals are intended to melt snow and ice. Combining the materials intended for different purposes produces a wide range of results.

Objectives: Many agencies combine abrasive and deicing chemicals in a wide range of proportions. The study would look at a range of mixtures commonly used. The abrasive or friction abilities, as well as deicing abilities would be evaluated. The overall intent of this study is to evaluate the effectiveness of different mixtures under common roadway conditions. Results of this study would provide a better method to evaluate the effectiveness of abrasive and deicing chemical mixtures. Savings of chemicals and abrasive would likely result from this research. The benefits of field performance and laboratory testing would be of value to most agencies that have responsibility for snow and ice control.

Current Activities: Many studies evaluate individual deicing chemicals or abrasive. No studies have taken a comprehensive look at abrasives and deicing chemicals together.

Urgency: This research would be of major importance due to the large number of agencies that use both abrasive and deicing chemicals. The negative environmental impact of these materials combined with the vital safety implications of dealing with roadway pavements under winter conditions make the results of this research very important.

PROBLEM NO. A3C09-03

Title: IMPROVING SAFETY OF SNOW REMOVAL EQUIPMENT

Problem: Operating snow removal equipment during winter storms is a hazardous operation. There is a need to improve visibility of the snow removal equipment to the travelling public. In addition, the operator of the snow removal equipment needs improved visibility of other traffic.

Objectives: This research study will bring together past developments that have been made by individual state and local agencies. Many agencies have developed improvements in lighting and other safety features. In addition, this study will develop new methods for improving visibility guidance and safety of winter maintenance equipment. High intensity lighting, automatic warning devices and other new technology will be reviewed and developed.

Current Activities: Individual agencies have made limited progress in this area. No comprehensive study is underway.

Urgency: Safety of equipment operators as well as the traveling public, could be significantly improved with the results of this study. It is of interest to many state and local agencies with snow removal equipment.

PROBLEM NO. A3C09-04

Title: DEVELOPMENT OF AN EXPERT SYSTEM FOR USE IN WINTER MAINTENANCE OPERATIONS

Problem: Previous surveys of winter maintenance practices have been relatively ineffective in developing a scientific body of knowledge which operations personnel use to develop maintenance practices.

Objectives: Select an appropriate personal computer (PC) based expert system shell and conduct interviews with maintenance engineers and operators to develop information which is incorporated into a knowledge base along with any other data available. This system will be verified against operations in several localities during a winter of operations. A PC based expert system beneficial for decision making in winter operations will be developed.

Current Activities: None

Urgency: State and local agencies with significant snow removal efforts would benefit.

PROBLEM NO. A3C09-05

Title: TRANSPORT OF SNOW

Problem: In spite of the number of studies which have been made on snow transport, the theory is still incomplete. The primary emphasis areas include snow plow design and blowing snow control. These impact every aspect of snow removal and control, and demand further investigation.

Objectives: Documented enhanced understanding of snow transport mechanisms.

Current Activities: Unknown

Urgency: State and federal agencies and managers of private facilities in northern climates will benefit.

PROBLEM NO. A3C09-06

Title: DRIVER PERFORMANCE IN ADVERSE WINTER CONDITIONS

Problem: Winter driving presents a variety of hazards including reduced visibility and disorienting physiological phenomena due to the motion of snow. These effects are amplified at night and at high altitudes due to the susceptibility of the eye to oxygen deficiency. There is a need to investigate these phenomena and the relationship to the natural and man-made environment with the goal of ameliorating those aspects which can be controlled.

Objectives: Those factors which are significant in driver performance will be identified. Combined effects will also be documented. Contributing, controllable factors will be identified and suggestions for improving the drivers' environment will be provided in a winter driving guide manual.

Current Activities: None

Urgency: Driver safety programs in northern states will benefit.

PROBLEM NO. A3C09-07

Title: REHABILITATION OF SURFACE AND GROUNDWATER CONTAMINATED BY ROAD SALT

Problem: Improper storage and use of deicing chemicals has resulted in contamination of some soils, surface water and groundwater. Public concern over future contamination is a significant issue in many states and Canadian provinces.

Objectives: Identify and evaluate existing and proposed future methods for restoration of soils, surface water and groundwater contaminated with road salt. Methods will be developed to reduce the salt concentrations for acceptable surface water and for acceptable use as drinking water. Contamination of soil adjacent to roadway and storage sites will be the prime emphasis of this study.

Current Activities: No current activities have been identified.

Urgency: While proper storage and use of deicing chemicals are practiced by most agencies, occasional problems have been identified. Practical methods for cleaning contaminated sites will be valuable to many agencies using deicing chemicals.

PROBLEM NO. A3C09-08

Title: DEVELOPMENT OF AN EXPERT SYSTEM FOR ROAD AND FENCE DESIGN TO ELIMINATE SNOW DRIFT FORMATION

Problem: Appropriate road design as well as snow fence design have been proven effective in reducing snow drifts on highways. The knowledge required is limited to a very small group of engineers and scientists. This project will capture their expertise and incorporate it in a knowledge base which can be expanded as the technology improves.

Objectives: Select an existing rule or frame-based expert system shell, capture the appropriate information in the knowledge base, verify the performance of the system, and disseminate the information to potential users. A personal computer based expert system can be developed for use in snow fence and road design appropriate for use by highway design engineers.

Current Activities: None

Urgency: This research is of importance to all transportation agencies with snow drift problems.

PROBLEM NO. A3C09-09

Title: DEVELOP GUIDELINES FOR THE USE OF SURFACE SENSORING SYSTEMS IN WINTER MAINTENANCE

Problem: Managing snow and ice control operations during the storm requires knowledge of weather conditions and forecast conditions. Actual pavement temperatures are more important than predicted air temperatures. Pavement sensoring equipment now exists that can collect and provide valuable data to managers.

Objectives: Pavement sensors are relatively new to the highway industry. Many agencies have developed management practices that can effectively utilize pavement sensor information. This experience needs to be synthesized and presented in a manner that will be useful to all agencies responsible for winter maintenance. Relating pavement sensor information to the use of deicing chemicals, abrasive and plowing operations is needed. Further, use of information to manage staff and equipment will provide benefits in improved safety and cost savings.

Current Activities: Individual agencies are collecting considerable information relating to the management of winter maintenance operations with pavement sensors.

Urgency: Due to the significant benefits from improved management of winter maintenance operations, this research study is of high importance. The emerging technology will be useful to state and local agencies with winter maintenance responsibilities.

Committee A3C12 - Coatings, Signing and Marking Materials

PROBLEM NO. A3C12-01

Title: FIELD MEASURE OF NO-TRACK TIME FOR PAVEMENT MARKING MATERIALS

Problem: A critical performance measure for pavement marking materials is the time required to dry to a no-track condition, i.e., the point at which the material can no longer be picked up and redeposited by a vehicle tire passing over the line. The effort required to protect a new line during striping has a major effect on its installation cost as well as the safety of the striping crew and the motoring public. A standard laboratory test procedure is defined in ASTM D 711-75 ("No-Pick-Up Time of Traffic Paint"), but there is currently no standard field procedure to measure this characteristic.

Objectives: Develop standardized test procedure to determine no-track time for pavement markings. Such a procedure will make it possible for highway agencies to better evaluate the suitability of a wide range of marking materials for use in their striping operations.

Current Activities: New York State has developed a field procedure patterned after the ASTM laboratory procedure. Pennsylvania has also developed a field procedure that measures whether a material meets a specified no-track time, but it does not determine the actual value.

Urgency: With the increased emphasis on field tests of traffic marking materials, and the move toward regional test centers to accomplish these tests, a standardized test procedure to determine no-track time is urgently needed. Such a procedure will make it possible for highway agencies to better evaluate the suitability of a wide range of marking materials for use in striping operations.

PROBLEM NO. A3C12-02

Title: PAVEMENT MARKINGS FOR COLD-WEATHER APPLICATION

Problem: Asphalt pavement overlays are often completed late in the construction season, making it difficult to schedule and complete the installation of pavement markings on the new overlay. However, adequate pavement markings, meeting the requirements of the *Manual of Uniform Traffic Control Devices* are needed to provide traffic control during the winter months. Durable marking materials are especially difficult to install during late season conditions because many of these materials are especially sensitive to cold temperatures

and moisture. If adverse installation conditions result in premature failure, the higher initial cost of these materials results in a much greater economic loss than for traffic paints. On the other hand, traffic paints are less durable, and their service lives are even shorter on new pavements. It is, therefore, very difficult for new painted markings to survive the winter, especially if traffic volumes are high.

Objectives: Develop and evaluate new pavement markings designed to be installed under low temperature and high moisture conditions. These markings shall also provide durability at a reasonable cost.

Current Activities: None

Urgency: This research has a high priority because it will improve safety and reduce pavement marking costs.

PROBLEM NO. A3C12-03

Title: REMOVAL OF PAVEMENT MARKINGS

Problem: Existing pavement markings must often be removed from pavement surfaces to shift traffic patterns or for other reasons. While considerable research has been completed on this subject, many agencies still have not been able to identify suitable procedures that are capable of removing existing markings to a satisfactory degree and at a reasonable cost.

Objectives: Synthesize the existing information on this subject, and develop an implementation handbook to provide guidance to highway agencies. This handbook would identify all the promising removal procedures and discuss the conditions for which they can achieve suitable results. Information would be provided on required equipment, removal rates, and costs. In addition, guidance would be provided to determine acceptable degrees of removal to ensure that markings left on the pavement and removal scars do not mislead drivers. In addition to synthesizing existing information, any gaps in the technology should be identified and solutions proposed.

Current Activities: None

Urgency: This is a high priority item to improve the safety of motorists where shifting traffic patterns are required.

Committee A3C13 - Sealants and Fillers for Joints and Cracks

PROBLEM NO. A3C13-01

Title: DEVELOPMENT OF A DESIGN PROCEDURE FOR CONTROL JOINT DEPTH AND WIDTH

Problem: Most designers currently do not perform a formal design when sizing the joints for pavement or any flatwork (portland cement concrete) system. The current state of standard practice includes utilization of State DOT standards for all types of slabs, or simply specifying a control joint with no consideration of width or depth. These methods are employed without consideration of slab lengths, widths, or the temperature conditions at the time of placement. Generally, the joint system is not designed, and a joints are installed the width of standard saw blades.

Objectives: Develop a rational design procedure for sizing the control joints in portland cement concrete flatwork. The design procedure should consider both compression and non-compression seals. The method should include a consideration of ambient temperatures at the time of placement, slab thicknesses, temperature gradients, and other environmental factors affecting the movement of the slabs.

Current Activities: No major research activities are presently being performed in this area. The SHRP program is developing cracking sealing equipment and materials. However, this research effort is not considering control joint design in new construction.

Urgency: A practical procedure to design control joint systems is clearly needed. The implementation of such a procedure would reduce the number of premature slab failures caused by poor joint details.

PROBLEM NO. A3C13-02

Title: STANDARDIZED METHODS OF DETERMINING WORKING RANGES FOR DIFFERENT SEALANTS

Problem: One of the major factors in the design of joint width is the working range (compression/tension) of the sealant material. Presently, there are no standard

procedures for determining these ranges for any type of sealant material. The working ranges used are provided by the manufacturer, and are usually based on limited testing and field performance of the material.

Objective: Develop testing procedures to measure the working range of sealant materials. In association with the test methods, failure criteria need to be defined for individual sealant materials.

Current Activities: No major research activities are currently being performed in this area.

Urgency: The materials properties affecting the performance of the materials must be determined in order to improve the life and effectiveness of concrete joints.

PROBLEM NO. A3C13-03

Title: FIELD QUALITY CONTROL TESTS OF SEALANT MATERIALS

Problem: Field personnel responsible for observation of sealant installation have no method to verify the material properties of the sealants. They must rely on experience with specific materials.

Objective: Develop relatively simple and rapid field test procedures to verify sealant material properties. The field test methods should correlate with more complex laboratory procedures.

Current Activities: No major research activities are presently being performed in this area. Interfacing this research with the SHRP program investigating maintenance activities should be considered.

Urgency: It has been proven that field quality control procedures provide the owner with a better product, and the means of determining that the material received are the material specified.

PROBLEM NO. A3C13-04

Title: STANDARDIZATION OF CLEAN JOINT FACE CONDITIONS

Problem: One of the most important parameters affecting the performance of the joint sealant system is the condition of the joint face at the time of installation. Presently, there is no standard method of evaluating this condition. Joint face cleanliness affects the adherence of the sealant to the concrete.

Objective: Develop a standard procedure for evaluating the cleanliness of the joint face at the time of installation. The method must be quick, easy and repeatable.

Current Activities: The U.S. Air Force has developed specifications covering the equipment to be used in preparing the joint face. The Utah DOT has investigated using a standard cloth wipe test. The Utah procedures have not been verified for effectiveness or repeatability.

Urgency: Development of such a procedure would reduce the probability of premature joint failures due to adhesion problems. The life of the original sealant system would also be increased if uniform sealant adhesion across the joint faces could be assured.

PROBLEM NO. A3C13-05

Title: BACKER ROD EFFECTS ON PERFORMANCE OF SEALANTS

Problem: Several types of backer rods are presently available for use in pavement joint systems. However, no data are available regarding the effects of the various materials on both the long and short term performance of the joint sealant system.

Objectives: Perform an evaluation of sealant systems employing the different types of backer rod materials. The study should include the following material properties: absorptive and non-absorptive; gassing (open cell) and non-gassing; and resilient and rigid. The studies goal should be to define the best backer rod materials for differing sealant materials.

Current Activities: No major research activities are presently being performed in this area.

Urgency: Any study which defines the parameters which affect the performance of the sealing system is of great benefit. Generally, most early distress and a high percent of later life distress in concrete pavement are problems stemming from joint design and construction.

PROBLEM NO. A3C13-06

Title: LARGE MOVEMENT EXPANSION JOINT SYSTEMS FOR BRIDGES

Problem: In recent years, a move away from the use of finger joint systems for expansion joints in bridges has taken place. The move was toward the use of modular or rubber cushion type systems. In several cases, premature failures of these systems were observed. These failures caused designers to go back toward the finger joint systems. There is a need to investigate the cause of these failures and provide information on the design of these modular systems. This problem may be linked to the working range of sealant materials.

Objective: Evaluate the failures of modular expansion joint systems. The investigation should identify the major causes of failure and outline design strategies to alleviate these problems in the future.

Current Activities: No major research activities are presently being performed in this area.

Urgency: Bridge maintenance is becoming an ever increasing portion of the maintenance budget of state DOTs. Improved expansion joint systems and a better understanding of the performance of these systems is needed to reduce the potential for on-going maintenance.

PROBLEM NO. A3C13-07

Title: INFLUENCE OF TRAPEZOIDAL SHAPE ON SEALANT PERFORMANCE

Problem: The result of most crack sealing or joint routing procedures is a joint reservoir with a trapezoidal shape. Most sealant strain calculations are based on rectangular shape factors. Thus, a clearer understanding of the strain conditions imposed by the trapezoidal strain factor is needed.

Objectives: Develop computer modeling techniques and laboratory procedures to evaluate the strain conditions caused by the trapezoidal shape. The resulting study should also provide a means to determine the proper shape for sealant installation.

Current Activities: Some research has been performed at the University of Michigan in this area. Preliminary finite element analysis has shown that the strain relationships are very complicated for this shape of joint reservoir. A continuation and expansion of this work is needed.

Urgency: Since the trapezoidal shape is a result of most routing operations, knowledge of the strain relationship for the shape would lead to better design of resealing operations and improved performance of maintenance activities.

PROBLEM NO. A3C13-08

Title: ACCELERATED SEALING OF NEW CONCRETE PAVEMENTS

Problem: Current installation guidelines require that new portland cement concrete pavements cure for 7-30 days prior to the installation of field molded sealants. With the emerging accelerated paving technology (fastrack) that allows new concrete pavements to be opened to traffic within 24-48 hours, the current waiting period prior to installation of field molded sealants is not acceptable nor economical. Thus, there is a need for guidelines that will allow for proper joint sealing with minimum disruption to traffic.

Objective: Develop rational guidelines for the installation of field molded sealants in new concrete for both accelerated and normal paving. Since these materials depend upon adhesion for performance, the guidelines should address such issues as moisture content as a function of concrete cure, time of sawing vs. time of sealing, and economical cleaning procedures for variety of mix designs. This would involve both laboratory work and field confirmation work.

Current Activities: No major national research activities are currently underway to identify the proper time to install the various sealants. Some experimental work is being done for silicones and hot-applied materials. Several fastrack projects have been completed in Michigan and Iowa using various materials.

Urgency: There is an immediate need to develop these guidelines to extend the roadway life.