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Second Year Annual Report

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FINAL REPORT

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16. Abstract

The Center for Transit Research and Management Development conducted seven activities during the second year of its operation that are part of a long-term transit research and training program. The seven activities reported here are:

1. Development of Long-term optimal equipment replacement strategies for buses, (including a computer program),
2. Development of computer programs to assist transit personnel in traffic engineering analyses--Transit Action Performance Model (TAPM),
3. Analysis of Bus Maintenance data of the UMTA Section 15 data, with a geographic emphasis,
4. Short Term Ridership Analysis Program,
5. Bus Fuel Economy Study,
6. Research Seminar in Transportation,
7. A four day Workshop "Issues in Bus Procurement"

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1. INTRODUCTION

The Center for Transit Research and Management Development at the University of Michigan is a unit within the Institute for Science and Technology (IST), and is located physically in the University of Michigan Transportation Research Institute (UMTRI). During the second year, the project director was Dr. Cyrus Ulberg, an Associate Research Scientist at UMTRI. Research investigators resided in the Engineering College, the College of Architecture and Urban Planning, and in UMTRI.

This document is the final report of the program for the second year of operation (1984-1985). The body of the report consists of this introduction, a summary of each of the research projects, a description of a seminar offered to undergraduate and graduate students, and a report on an extension course offered by the Center entitled "Issues in Bus Procurement."

Plans for the Second Year

During the first year, the Michigan program was intentionally oriented toward the engineering and hardware aspects of transit operations. This came about partly because of our proximity to the vehicle manufacturing industry, and partly because Center personnel are strongly associated with a technical institute and with the engineering college. During the second year, the orientation of the Center's activities broadened to include some issues that centered on buses, but were not concerned solely with vehicle technology.

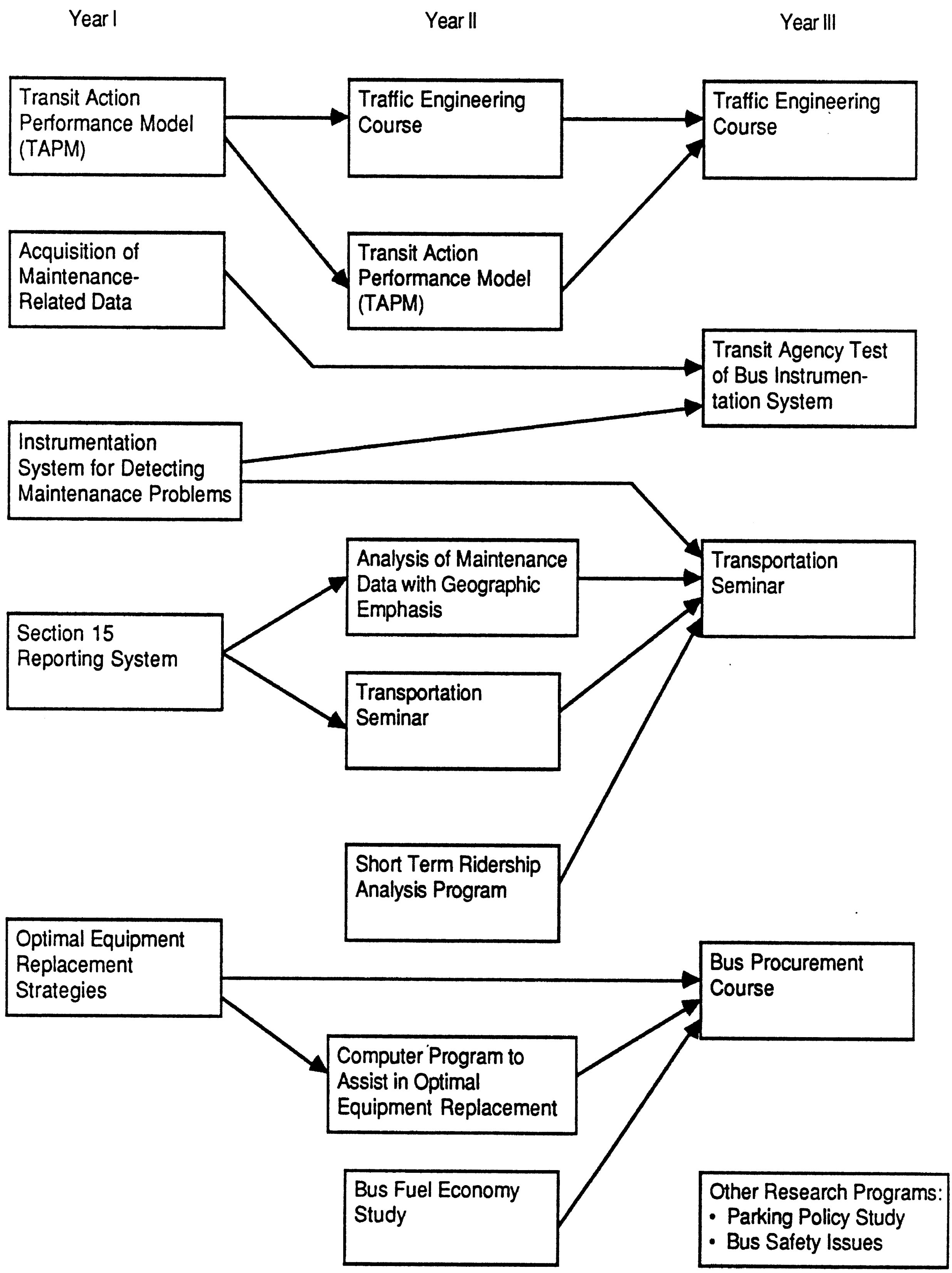
Research activities for the second year included three areas: (1) The further development of purchase decision-making methods (and associated computer programs), (2) the development of traffic engineering computer programs (a continuation of a previous UMTA research program), (3) the analysis of Section 15 data based on peer groups determined by climatic variables. These research projects were continuations of projects begun during the first year of Center operations.

Other research activities carried out by center personnel included development of a computer program for analyzing transit ridership and a study of bus fuel economy resulting in recommendations to transit agencies on how to get the best information on fuel economy when purchasing new buses. A transportation seminar led by Center personnel focussed on data and information systems available to assist in research and planning in transportation. The table on the next page illustrates the relationship of second year activities to past and future research programs.

Report Structure

The remaining sections of this report are devoted to individual descriptions of the course and the various projects. Section 2 contains a report on the development of TAPM (Transit Action Performance Model). Section 3 provides a description of the purchase decision-making model. Section 4 contains a report on an analysis of maintenance data with an emphasis on climatic variables. Section 5 describes STRAP, a computer program to assist in the analysis of transit ridership. The bus fuel economy study is summarized in Section 6. Section 7 contains a report on the Transportation Seminar offered at the University this year and Section 8 is a report on "Issues in Bus Procurement" presented jointly with the Ann Arbor Transportation Authority on September 15-18, 1985.

Center Program Development



2. TRANSIT ACTION PERFORMANCE MODEL

The participants in this project were Donald E. Cleveland, Lidia P. Kostyniuk, Gary Waissi, and Wang Wen-Zhi of the Department of Civil Engineering (CE).

The Transit Action Performance Model (TAPM) is a system of user-friendly programs designed to help a transit planner, city traffic engineer, or a consultant evaluate the impacts of actions intended to improve the movement of people on urban streets and highways. The original formulation of TAPM was developed for UMTA under Grant MI-06-0027. The TAPM-software package was originally designed and developed for Apple II microcomputer using APPLE-Pascal. As part of the work carried out under this grant, the TAPM package was extended to include more models and converted to run on the IBM and other microcomputers.

Although considerable progress in the development of the TAPM models occurred during the first year, they were not ready for general distribution. During the second year, the programs were completed and an additional program was added to the package. A complete technical report describing the models and the use of the computer program is published as UMTA-MI-11-0008-02. The existence of the program package was also advertised in UMTA's catalogue of microcomputer software with transit applications. TAPM has been used extensively by students in University of Michigan and Michigan State University CE courses.

TAPM Models

During the first-year research activities, models capable of calculating the effects of the following actions were incorporated in TAPM:

1. Bus signal preemption
2. Isolated intersection signal setting
3. Bus stop spacing

In preparation for the short course in traffic engineering applications for transit managers, which was presented in September, 1984, a number of additions and improvements to the TAPM models were made by Mr. Waissi. These included conversion of the Apple II+ programs for the original three TAPM models so that they would run on the IBM PC family of computers. In addition, numerous small changes in the programs were made which increased the efficiency of operation and the user friendliness of the package.

The package was also structured so that additional programs could be brought into the package with a minimum of effort. Based on the experience during the course, it was determined that additional efforts would be devoted to program preparation for the IBM PC computer. Several changes suggested by the students in the course were incorporated into the program.

The major effort of the year was led by Visiting Scholar Wang Wen-Zhi from Jilin Institute of Technology in the Peoples Republic of China. Guidance was given by Mr. Waissi and Professor Cleveland.

The publication of the new edition of the Transportation Research Board's Highway Capacity Manual (HCM) in the late summer of 1985 provides transit program developers with an opportunity to prepare programs utilizing approaches and parameters which will be used in the U.S.A. for several years. It was decided that there was a need to present to the transit planner an opportunity to analyze high occupancy vehicle (HOV) lane alternatives within the framework of the HCM.

The program is descriptive, in that the analyst can initially evaluate a given freeway main lane configuration with a specified mix of vehicles flowing on it. Initial levels of service and quantitative figures are developed (such as average speed and density, slowness in minutes/mile/person and minutes/mile/vehicle, etc.). The analyst can then introduce several variations in lane usage control to include an additional HOV lane, commitment of an opposing freeway lane to HOV use, introduction of an HOV lane in the direction of interest, limiting the HOV lane to buses, or including carpools and taking into account the possible reduction in passenger vehicle flow as a result of carpooling.

Geometric variables of particular interest because of their effect on capacity and level of service are taken into account as the user is directed to consider in turn the average grade on the freeway and the clearances to roadside obstacles. Commuter vs. weekend user, vehicle mix, and other elements specified in the HCM procedure for obtaining these measures of performance can be specified if default values are not satisfactory. The program has been extensively tested and results are accurate.

The Program in General

The program has been integrated with the three existing TAPM programs and "cleaned up" so that the system and the four programs are now located on one diskette. Because of the structure of the program, additional traffic engineering models may easily be added to the TAPM package. Complete descriptions of the models and this structure are available in the above-referenced technical report.

3. LONG-TERM OPTIMAL EQUIPMENT REPLACEMENT STRATEGIES

The participants in this project are James C. Bean, Jack R. Lohmann, and Robert L. Smith of the Department of Industrial and Operations Engineering. Graduate student Koth Ganesh developed the computer program described below.

Introduction

The problem of replacing capital equipment is one of the most important fiscal decisions facing public transit properties. Such decisions are qualitatively changing due to reduced federal involvement in funding and regulation of capital procurement projects. The problems facing properties now are much closer to equipment replacement problems found in the private sector.

The use of the "low bid" method in the transit industry has been replaced with methods employing life cycle costing and negotiated procurement. UMTA has supported these developments in recognition that operating costs have an important impact in the provision of transit service. Even without UMTA's discontinuance of the requirement to use the "low bid" method, it is to the transit agencies' advantage to take operating costs into account in some way.

One of the difficulties in using life cycle costing or related methods in capital purchase decision-making is that it is difficult to get accurate information on operating costs. Another difficulty is that technology changes over time and the decision process should take that into account.

Research carried out during the second year of Center operation continued a project begun during the first year. Before this research, there was no technique available to handle both changing technologies (improved fuel efficiency, increased maintenance on more sophisticated systems, etc.) and consider a time frame sufficient to accurately balance effects such as high purchase cost versus reduced fuel cost. Both of these abilities are necessary to make economic decisions in the problems faced by transit properties.

Even if all these shortcomings are sufficiently addressed, engineering economics cannot hope to provide a complete solution to the capital replacement problem. These decision are managerial in nature. That is, they are affected by two classes of problem characteristics: qualitative constraints and effects such as political and social considerations, and quantitative effects such as economic impact. For the forseeable future, the qualitative aspects of these decisions are best made by experienced managers and are not addressed directly in this study. However, the algorithm and computer program developed in this study will allow the manager to evaluate the quantitative parts of the problem more quickly and accurately. Thus the manager will be free to devote more time to the qualitative aspects of the problem. The overall effect should be a better, more informed equipment replacement decision.

The objectives of this study were to:

1) Extend the state of the art in engineering economics to the point where problems with the complexity found in the transit industry can be solved quickly and accurately on a micro computer.

2) Describe a method by which this system can be used to deal with uncertain data.

3) Develop a prototype micro computer code implementing this

research to prove that the techniques described in (1) can be implemented to run fast enough to be of use in (2).

The Equipment Replacement Problem

Equipment replacement has been studied in the field of engineering economics since the 1940's. The initial models assumed that technology is stationary (i.e., the equipment available tomorrow is identical to that available today.) The question was simply to determine when maintenance costs were sufficiently high to warrant replacement with an identical copy.

In the transit industry, it is clear that this assumption is inadequate. Improvements are being made in the efficiency of engines and drive trains which could lead to improved fuel economy. On the other hand, design restrictions imposed by the federal government have led to increased weight of buses and increased maintenance costs.

Engineering economics has begun to deal with the effects of changing technology in recent years. However, another problem has only recently been addressed. That is the problem of dealing with an indefinite horizon. Solutions could only deal with finite time periods. In order to make an accurate assessment of the economic impact of alternative replacement scenarios, it is necessary to model both changing technology and an indefinite time horizon. The first model to successfully address these problems simultaneously was supported, in part, by this grant.

The details of the technique developed are contained in the technical report UMTA-MI-11-0008-01 and in a publication by the principals in this study entitled "A Dynamic Infinite Horizon Replacement Economy Decision Model." It may be found in <u>The</u>

Engineering Economist, Vol. 30, pp. 99-120.

BUSREP

BUSREP is a computer program to assist in the bus replacement decision-making process. A complete description and instructions for its use are available in UMTA-MU-11-0008-01. The program allows the user to compare alternatives including making no investment in new buses, rehabilitating existing buses, or buying a fleet of buses from among a set of several alternatives.

The program allows the user to deal with uncertainty in data concerning operating costs by quickly and conveniently trying many alternatives and conducting a sensitivity analysis. The program also allows for a wide variety of scenarios for future technological changes. It is written in BASIC, so that it can be portable to virtually any computer system.

The program was used by all the students in the course entitled "Issues in Bus Procurement" given in September, 1985. With minimal instruction, students were able to use the program quite effectively. They were all interested in obtaining copies of BUSREP. The program will be included in UMTA's catalog of software for transit when it is published again in 1986.

4. ANALYSIS OF BUS MAINTENANCE DATA WITH A GEOGRAPHIC EMPHASIS

This research was conducted by Sandra L. Arlinghaus of the Center for Mathematical Geography and John D. Nystuen of the Urban Planning Program.

During the first year of Center operation, Section 15 data were acquired and clean data sets were installed on MIDAS, the Michigan Interactive Data Analysis System. These data were used in this study to analyze the impact of climate on costs associated with the maintenance of buses. A complete technical report on the research is available as UMTA-MI-11-0008-03.

Introduction

Cars and buses heavily scarred from rusty sores are a familiar sight to residents of the Great Lakes Basin as well as to those in other regions that experience heavy concentrations of snow and road-salt, or heat and air-borne salt, near urban surface routes. Other environmental stresses that contribute to the aging of a bus fleet might involve the steepness of the underlying terrain and the density of traffic congestion: steep grades produce extra strain on the motor and power train, and frequent stopping and starting wears the brakes, the engine, and the drive train. Major overhauls can fix these kinds of problems. However, disintegration of the bus-skin is much more difficult to remedy and often forces vehicle replacement.

Environmental stresses vary considerably in different parts of the country. They can have a big effect on a transit property's operating costs and may affect capital cost by requiring the purchase of certain kinds of buses (e.g., those with stainless steel skins). If comparisons are to be made among transit agencies in their operating and capital costs, these variables should be taken into account.

Research

In this study, a set of climate peer groups for buses is generated from a subset of transit authorities participating in the Section 15 reporting system. This responds to the "Potential Data Applications" suggestion in the Fourth Annual Section 15 Report of National Urban Mass Transportation Statistics that "peer groups could be formed based on mode, fleet size, annual operating expenses, and/or such other factors not contained in this report as climate and collective bargaining agreements. Comparisons can be made to the individual transit systems in the group, or to overall group averages." These climate peer groups were then used to show how transit authorities might employ them to analyze age structure and maintenance indicators from Section 15 data.

The mechanics of constructing climate peer-groups involved incorporating material from climatic atlases into the Section 15 data and using the resulting climatic indicators to sort transit authorities into "harsh," "intermediate," or "benign" climate peer groups. These peer groups were determined first according to a simple numerical procedure based only on climatic indicators above, below, or equal to a mean value, and were checked with an approach using linear algebra to associate climate vector with each transit authority. The latter approach also generated a rank-ordering of transit authorities in each climate peer group. It used the lengths of climate vectors (vector norms) measured in a coordinate system with the national average as the origin.

The age structure of the national bus population was examined within these climate peer-groups using population pyramids: graphic devices composed of layers of fixed width (in analogy with layers of bricks) that taper, as do pyramids, with increased elevation. Population pyramids show only very general population trends and reflect balance in age structure across a period of time. Attempts to disaggregate them into shorter fixed time intervals would be difficult, given the unreliability of disaggregated data in active fleet counts. Thus, the population pyramids appears to be the appropriate mode for comparison.

Finally, maintenance data were grouped by both climate and size peer-groups to analyze the impact of climate on buses. The indicators used in this part of the study were the distance between roadcalls and mileage per dollar expended on maintenance.

Results

Although there were clear difference in population pyramids and maintenance costs based on different climatic peer groups, some of the results do not have obvious explanations. The population pyramids clearly showed that buses didn't last as long in harsh climates as in the other categories. However, transit agencies in the intermediate climates tended to have fewer relatively new buses (under 10 years old) than those in the benign climates. Analysis of the maintenance costs showed that transit agencies in the intermediate climate group were higher than costs in both of the other groups. One possible explanation is that transit agencies in the benign climates tend to be in the Sun Belt or in other places where transit agencies are relatively new and cities are relatively affluent. Even though environmental factors indicate that agencies in intermediate climate zones should be replacing buses more frequently, they aren't. The result is inordinately higher operating costs.

5. SHORT-TERM RIDERSHIP ANALYSIS PROGRAM (STRAP)

This research was conducted by Cy Ulberg under contract with the Municipality of Metropolitan Seattle. The work included providing technical assistance to 22 transit agencies on ridership forecasting as well as development of the computer program to assist in the analysis of transit ridership described here. A complete report on the work is available through the Municipality.

Introduction

Transit ridership is dependent on many variables. Some can be affected by transit agency policies and some cannot. In either case, it is important that transit agencies understand how each variable affects ridership. The purpose of STRAP is to provide a means for a transit agency to analyze and understand its ridership.

In the last several decades, transit ridership has varied dramatically. Long-term trends have been influenced by phenomena such as the rising popularity of the automobile, world wars, and population shifts from farms into cities and suburbs. In contrast to these long term trends, short-term ridership gains and losses occur due to more rapidly varying factors, such as seasonal effects, service levels and quality, fares, gasoline prices and supply, parking rates, employment, and population. STRAP deals with the latter type of variables.

Transit agencies have traditionally used a variety of non-statistical and quasi-statistical methods to produce forecasts of ridership. Generally, these methods use interpretations of past trends modified by management objectives for increasing ridership. Most agencies try to project the impact of fare changes and service changes on ridership. The basic problem that agencies deal with is the fact that several influences have an effect at the same time and it is virtually impossible to use non-statistical methods to analyze all of them at once.

There is a need, however, for all agencies, whether large or small, to have a quantitative prediction of ridership for budgeting purposes. Without such a quantitative prediction, it would not be possible to forecast revenues from the farebox. Without some knowledge of those revenues, the agency could not budget for changes in service levels or know what other sources of revenue would be necessary.

Another reason to develop quantitative predictions of ridership is to plan changes in service levels. In order to avoid overloads on buses or operating buses that are not optimally used, the transit agency should have estimates of changes in ridership expected to occur in the near future. One example of this need is to be able to estimate how an energy crisis such as the ones in 1974 and 1979 affect the demand for transit service. This knowledge could affect the number of buses an agency holds in reserve or bus spare levels set by policy.

Besides being able to project ridership in the short run, it is advantageous to a transit agency to be able to understand which variables influence ridership. For instance, suppose an agency invested in a program to improve on-time performance, but experienced no increase in ridership. It may be tempting to interpret the result as a failure of the program. A decision may follow to reduce the investment required to supply on-time performance. However, some other factor, such as lower gasoline price, may have mitigated the positive impact of the new policy. If the new policy had not been put into force, ridership may have actually dropped. Without having some quantitative understanding of how each of the many possible variables affects ridership, it would be very difficult to accurately analyze this situation.

STRAP was written to be flexible in order to deal with a large number and various types of variables and is specifically designed for analyzing transit data. It reduces the time required to manipulate data for the analysis and allows planners and analysts to try many combinations of variables to better understand the transit agency's ridership.

Another important feature of STRAP is that it allows planning for various scenarios. To predict ridership, the analyst needs to predict what will happen to variables that influence ridership. It is never possible to predict those variables perfectly. However, it usually is possible to specify a range within which those variables will remain. Therefore, one can predict a range for future ridership with some certainty.

Theory

STRAP is basically a multiple regression model in which the dependent variable is transit ridership and the independent variables can be any type of data that represent potential influences on ridership. Before discussing the actual regression, it is important to understand definitions of the variables that go into the regression.

The dependent variable (transit ridership). Transit agencies commonly deal with two types of ridership, linked and unlinked. The first counts a trip only once, even if it includes a transfer. The second counts each leg of the trip individually. For the purposes of this model, it makes no difference which one is used as long as usage is consistent.

Ridership is counted in several different ways. Perhaps the most common method is revenue based. Farebox revenue is counted on a regular basis, and estimates of ridership are made from those counts and information from surveys of passengers to determine the frequency with which different types of fares are paid. If the agency has a pass program, the number of riders using passes is estimated from surveys of pass usage.

Revenue counts are often supplemented with other types of passenger counts. One method is the use of automatic passenger counters (APC's). Another more traditional way of checking riders is with standing monitor counts. On-board counts have been employed, but they are much more expensive and are not generally used to check overall ridership. Origin/destination surveys have provided detailed information on passenger behavior as well as ridership counts.

The method used to count passengers has no impact on using the model as long as the method is consistent. However, if the method of counting passengers changes, STRAP could be used to estimate changes due to different passenger counting methods.

Transit ridership tends to vary seasonally. Month to month changes may occur regularly over time. These changes should be dealt with separately from other variables. STRAP automatically computes factors for seasonal changes if that option is requested.

Because of the variations in day to day and month to month ridership, STRAP uses an adjusted ridership figure for the dependent variable. That figure is the seasonally adjusted average weekly ridership for a given month. STRAP uses a twelve-month year (some transit agencies define the year as 13 four-week months) with a specific number of weeks for each month.

STRAP was developed using system-wide aggregate ridership as the dependent variable. There are other possible ways to define the dependent variable. One is to define it as route-by-route ridership. Other possibilities are to disaggregate ridership by type (express vs. local), by time of day (peak vs. off-peak) or by general location (inner city vs. suburbs). There is no theoretical reason that STRAP could not be used to analyze ridership disaggregated by these methods. Another possibility is to use revenue as the dependent variable. Since ridership is generally estimated from revenue data, this may eliminate some of the intervening errors that can occur.

Independent variables. Independent variables important to ridership vary greatly from agency to agency and region to region. In a location where there are a large number of choice riders (those with alternate means of transportation available for a trip), economic variables such as gasoline price and transit fare will be more important than in areas where there are few choice riders. Where there are few choice riders, it is likely that service levels, service quality, and employment levels will have relatively greater impact. STRAP can be used conveniently to investigate the relative impact of these different kinds of variables.

No matter which variables are used in ridership analysis, however, there are a few important considerations in interpreting the data. One is the attribution of causation. A regression model can only point out which variables tend to change together. If there is a strong relationship between two variables, that does not specify which one causes which or if, in fact, the two are causally related. There may be a third variable which is causing both to change. For instance, if one finds a positive relationship between employment and ridership, it may actually be change in population that is affecting both. The relationship between employment and ridership may not hold up if population remained constant.

The direction of causation is another important consideration. In most cases, one expects to find a positive relationship between service levels and transit ridership. This may not always be the case, however. If a transit agency experiences greatly increasing demands for service as a result of some other factor such as booming employment, and puts out new service in response to that demand, one may find that ridership is a better predictor of service levels rather than the other way around. STRAP helps to detect directionality in causal relationships by providing for the analysis of lags in effects. The user can either specify a lag in causation that should occur for some theoretical reason or STRAP will compute optimal lags for each variable, if desired.

Multiple regression. Regression is a well-established statistical technique for determining a quantitative relationship between two variables. Multiple regression determines simultaneously the quantitative relationship between each of a number of variables and one variable that is of interest (the independent variables and the dependent variable). In order to use STRAP, it is important that the user understand at least the basic concepts of regression.

STRAP uses changes in variables rather than absolute values of the variables as the elements of the regression equation. This provides more stability to projections than if the variables themselves were used. Since transit ridership tends to change fairly slowly, the method employed by the model reflects the nature of the data. This also means that STRAP is a time series model. An additional advantage of this method is that the coefficients of the regression equation can be interpreted as elasticities.

Analysis of the errors in a regression gives clues to the integrity of the data and the relationships between the variables. STRAP provides information on (1) the average error in the regression, (2) the data points that are in greatest error, and (3) the errors in the most recent data points.

Use of the computer model

STRAP is written in FORTRAN. The documentation for the program can be found in the final report for the project. STRAP will run on an IBM PC or XT with at least 128K of RAM. It will also run on IBM-compatible microcomputers.

The program was advertised in UMTA's catalogue of transit-related software and is currently in use in four different transit agencies.

6. BUS FUEL ECONOMY STUDY

This study was conducted by Cy Ulberg under contract with the Municipality of Metropolitan Seattle. A complete report on the project is available through the Municipality.

Introduction

The primary purpose of this project was to analyze methods available to transit agencies for assessing expected fuel economy data presented by bus manufacturers in response to competitive bid situations. There is probably no single best method to accomplish this assessment, since there are advantages and disadvantages to each approach. Even though transit agencies may be motivated to minimize fuel consumption for energy conservation reasons, perhaps the greatest motivation is economic. One the average, eight percent of the total operating costs of a bus system is in fuel. The money expended for fuel during the life of the bus generally exceeds the initial purchase price. It is the most important consideration in estimating the life cycle cost of a bus.

In recent years, new American bus manufacturers and subsidiaries of foreign bus manufacturers producing buses in the United States have introduced buses to the market which are claimed to have substantially better fuel economy than those of the major suppliers (GMC Truck and Coach and Grumman Flxible). GM and Flxible claim to have improved the fuel economy of their buses substantially. There are currently no unbiased standards available to assess the validity of these claims. Transit agencies evaluating competitive bids must rely on information provided by the manufacturers.

It is important that transit officials understand the sources of information on fuel economy that they receive. This project evaluated various approaches transit agencies can take to obtain accurate information.

Potential approaches

Four approaches were identified for obtaining information on bus fuel economy. The research in this project analyzed each one and explored the possible ways to combine these approaches.

Test track evaluation. Several types of buses have been tested in actual operation on test tracks. Recently (1982), Battelle Memorial Institute tested six buses under the same conditions at the test track of the Ohio Transportation Research Center operated by the Ohio State University. The test methodology was based on standards developed by the Society of Automotive Engineers (SAE 1321). There have been criticisms of the Battelle test and the SAE methodology itself, but this study remains the only recent comparison of a variety of buses. Some bus manufacturers perform their own test track evaluations and base their fuel economy estimates on those tests. Occasionally, transit agencies require third-party test track evaluations of buses being considered for purchase.

Computer simulation. Several computer programs are available that simulate the operation of diesel buses. One, called HEVSIM, was developed by the Transportation Systems Center in Cambridge, Massachusetts. Others were developed by the manufacturers themselves and are considered proprietary. Data on fuel economy presented to transit agencies during the competitive bid process are often based on these simulations.

Dynamometer tests. The Environmental Protection Agency regularly tests automobiles on dynamometers to assess fuel economy. These figures have become the standard for automobile advertising and consumer information. Even though there are some well-known deficiencies in these data, they have provided a commonly used standard. This approach has never been used in a bid situation to compare transit buses.

Fuel economy warranty. This approach has been used very rarely. In it the bus manufacturer is required to guarantee that its buses will achieve a certain level of fuel economy or it will be required to reimburse the transit agency for the cost of the extra fuel consumed.

Research

In order to evaluate these approaches, several types of data were obtained:

Survey of transit agencies. A mail survey of 252 of the largest transit agencies in the United States was conducted to determine (among other things):

- methods for collecting fuel economy information on their current fleets,

- the relationship between fuel economy claimed by the manufacturers and the actual experience with buses in revenue service, and

- the most recent methods used to obtain fuel economy information in bus bids.

These data were used to assess the degree of accuracy with which transit agencies know the fuel economy of their fleets, to asses the usefulness of the approaches currently employed to get information on fuel economy from manufacturers, and to make recommendations for the best approach.

Test track observation. Dr. Ulberg obtained permission from Flxible to visit to the Ohio Transportation Research Center during an actual test of a bus. The observations were useful for providing an evaluation of that method for obtaining fuel economy information.

Computer simulation assessment. Documentation for HEVSIM was obtained and reviewed. Personal interviews with manufacturers and transit agency personnel supplemented this review.

Dynamometer assessment. Dr. Ulberg interviewed people at EPA responsible for conducting dynamometer tests on automobiles. Discussions were also held with faculty in the University of Michigan's Automotive Engineering Department. From these discussions, the advantages, disadvantages, and costs of this approach for measuring fuel economy of buses were assessed.

Manufacturer interviews. Interviews were conducted with six bus manufacturers to determine the current methods used to develop fuel economy information and the probable success of each of the approaches from the manufacturers' point of view.

Results

Details of the evaluation are available in the final report and in a handbook prepared for transit agency personnel. The basic recommendations were:

1) Only 30% of the transit agencies surveyed are able to determine the fuel economy of different fleets of buses with any accuracy. Improved fuel economy information is necessary before

agencies can know if they are buying buses with reduced fuel consumption.

2) Using test track data is the best way to get information on fuel economy. It can be supplemented with computer simulation data to assess various vehicle configurations.

3) Peer transit agency evaluation of fuel economy will be useful as data collection methods improve.

7. RESEARCH SEMINAR IN TRANSPORTATION

An important activity of the Center during the second year was the offering of a course entitled "Research Seminar in Transportation." It was listed in the University catalog as Urban Planning 671 and was jointly taught by Aaron Adiv and Cy Ulberg. The subtitle of the course was "Information and Data Base Management in Transportation."

The primary objective of the seminar was to explore the state of the art in data bases and analytical methods used in transportation planning in the United States. It was designed to cover topics in all levels of the transportation system, from local public transportation agencies through state and regional systems to coastal and national systems. It was designed to inform as well as provide hands-on experience with utilization of data bases.

Students were required to write a research paper on some original analysis of a data base they came into contact with during the course. They attended two sessions each week, one to hear a guest speaker and one to discuss their paper and general topics on information and data base management.

Guest speakers and their topics were:

Ms. Ann Grimm, Head Librarian, UMTRI
"Bibliographic Resources at UMTRI"

Dr. Cy Ulberg, Director, Center for Transit Research and Management Development, UMTRI
"Transit Rider Analysis - A Case Study in Seattle, Washington"

Dr. Oliver Carsten, Senior Research Associate, UMTRI

"Data Bases in Use at UMTRI: Truck Inventory & Use Survey, Nationwide Personal Travel Survey and National Truck Trip Information Survey"

Dr. Alastair Fischer, Professor of Economics, University of Adelaide, Australia and Visiting Researcher, The World Bank, Washington, D. C.

"Attitude Toward Breath Testing for Alcohol Abuse in Australia"

Ms. Sharon Balius, Assistant Head, Engineering Libraries, University of Michigan

"Data Bases at the Transportation Engineering Library: TRIS - Transportation Research Information Service, NTIS - National Technical Information Service and COMPENDEX - Engineering Index"

Mr. Richard Esch, Manager, Transportation Procedure Section, State of Michigan Department of Transportation

"Data Bases for Transportation Planning in the State of Michigan"

Mr. Adiele Nwankow, Coordinator for Short-Range Transportation Planning, Southeastern Michigan Council of Governments

"Data Bases for Transportation System Monitoring at the Southeastern Michigan Council of Governments"

Mr. Michael Clark, COMSIS Corporation

"Micro Computers in Transportation Planning"

Dr. Richard Curtin, Associate Research Scientist, Survey Research Institute, Institute for Social Research

"Survey of Consumer Attitudes"

Mr. Ronald Fisher, Director, Office of Technical Assistance, Urban Mass Transportation Administration

"Uniform Transit Reporting Information Data BAse, UMTA Act, Section 15"

Mr. Thomas Darlington, Environmental Scientist, Environmental Protection Agency

"In-Use Vehicle Emission and Fuel Economy Data Base"

Mr. James O'Day, Acting Director, UMTRI

"National Highway Safety Data Bases"

Lt. Mark J. Burrows, Senior Investigating Officer, U. S. Coast Guard

"Coast Guard Marine Safety Information Systems (MSIS)"

Dr. Lawrence D. Burns, Program Manager, Manufacturing Sciences, General Motors Research Laboratories

"Automobile Tours: How Do We Use Our Cars?"

These guest speaker sessions were advertised around the campus and generally attracted several attendees other than the participants in the classes.

Students produced four research projects (they were allowed to work in teams) covering the following topics:

- analysis of the demographics of availability of free parking for the work trip

- a study of the impact of safety regulations for bus construction on passenger safety and operating costs

- analysis of Section 15 maintenance data based on transit agency size

- preliminary development of a method for optimal land use planning based on minimization of transportation costs

Organizing the course around transportation data bases has two advantages: (1) allows covering a broad spectrum of transportation issues and (2) stimulates and provides an opportunity for students to do original research. One difficulty with the format is that it requires self-motivation and maturity on the part of the students to get the most out of it. It may not be appropriate for entry-level Master's degree students without work experience. The instructors recommend the format for doctoral students and mature master's-level students.

8. ISSUES IN BUS PROCUREMENT

"Issues in Bus Procurement" was a course given from September 15-18, 1985. It was jointly sponsored by the Center and the Ann Arbor Transportation Authority. The main objective of the course was to provide information to transit management personnel on current important issues in buying buses. It was thought that this course would be of particular interest because of the current availability of new types of equipment, UMTA's allowance of the negotiated procurement process, and the shortage of federal funding for new buses.

One major objective of the course was to draw people together from diverse backgrounds, including transit managers, bus manufacturers and rehabilitators, government representatives, and academics.

Marketing

A brochure was prepared and sent out to about 500 transit agencies, manufacturers, and UMTA regional offices in April, 1985. The brochure described the objectives of the course, the general subject matter to be included, and instructions for registration. It was sent to all transit agencies with over 15 buses in the nation and to all transit agencies in Michigan and the neighboring states that could be identified. It was not possible to finalize lecturers and panel participants before the mailing of the brochure, so it didn't contain detailed information about the program.

In July and August, followup phone calls were made to agencies in Michigan and neighboring states. Before the phone calls, ten registrations had been received. It is clear that the phone calls resulted in some additional registrants, but it is unknown how many of the final registrants would have attended without the phone calls. At one point, 42 people said they would attend and pay the fee of $350. This fee covered motel room, some meals, and all course costs.

By the first week in September, several people had canceled their reservations. However, new reservations were being requested until the week before the seminar, especially by manufacturers.

The final total for paying attendees was 27, of which 6 were manufacturer representatives and 21 were transit agency personnel. Some participants on panels and a few visitors were not charged the registration fee. In all, there were 47 participants in the seminar as students, presenters, or a combination of both. A list of the participants is contained in Appendix A. The size of the seminar was close to optimum. Any more would have been too difficult to coordinate with the format used. Fewer participants would have limited the range of discussion.

Program

The program was designed to present a variety of teaching modes, including lectures, panel discussions, small group discussion, and active class participation. A large variety of speakers and panel members was employed. This led to an interesting and varied program, but may have been perceived as disorganized to some extent by the students (see the Evaluation section). The final program is shown in Appendix B.

The program began on Sunday evening with a dinner at the Michigan Union. Ed Stokel, director of public transportation at GMC Truck and Bus, and Mike Bolton, executive director of the Ann

Arbor Transportation Authority, made short presentations on their views of the American bus industry to start the four-day seminar off.

On Monday morning, following a welcome by Howard Bunch, acting director of UMTRI and administrative remarks by Cy Ulberg, the formal sessions began. The first day was devoted to the capital purchase decision-making process. The first speaker was Aaron Adiv, who made a presentation on discounting and net present value calculations. This was followed by a lecture by Michael Burstein of the Industrial Technology Institute on the theory behind the bus replacement computer program that students experimented with in the afternoon.

These lectures were followed by a short break and two lectures on specific aspects of life cycle costing. Cy Ulberg discussed issues involving bus fuel economy and Bill Ribbens of the Engineering School discussed a potential way to reduce maintenance costs for buses.

After a group lunch, the students went to the Undergraduate Library, where a bank of computers was used to give them hands-on experience with BUSREP, the computer program described in Section 3 of this report. Koth Gaṇesh, who wrote the program, instructed in its use. He was assisted by Mike Burstein, Ron Adiv, and Cy Ulberg.

After practicing with the model for a while, the group returned to UMTRI, where a panel was convened to discuss the decision between buying new buses and rehabilitating old ones. Ed Stokel, Gene Hardisty of Flxible, George Pickett of M. A. N., and Dan Morrill of Midwest Bus Rebuilders, as well as the lecturers from the morning session, participated in the panel. The objective of the panel was to give a focus to the relatively theoretical topics that had been covered in the morning and early afternoon.

Tuesday morning was devoted to a discussion of innovative financing methods. The opening panel consisted of Richard White from New Jersey Transit, who discussed three methods employed by his organization to finance buses; David Seltzer, of E. F. Hutton, who discussed various debt financing methods; and Jeff Parker, a private transportation finance consultant, who discussed the use of privatization to take the place of the normal process for buying buses. After the lectures and panel discussion, the panelists went to small rooms where class members could join in small group discussions on the topics that interested them the most.

After lunch a panel was convened to discuss the negotiated procurement process. Arlan Eadie, from Third Party and Contracts Review of UMTA, laid out the process for negotiated procurement from the DOT's point of view. Other panelists included Ed Stokel and Gene Hardisty, who represented GM and Flxible, to discuss the process from the manufacturer's point of view. It was intended that John Fitzgerald of the MBTA be present to discuss his experience during the first major purchase of buses using this procedure. However, since there was an active protest of the process, he was unable to discuss the case publicly.

This session was followed by a presentation on negotiation strategy given by James J. White of the UM Law School. He used a hypothetical negotiation situation to illustrate issues in negotiation strategy. Students formed teams and used the practice problem to actually negotiate a contract. Two teams were videotaped. Because of equipment problems, the tapes could not be shown. However, the students all had enough involvement in the exercise to provoke a lively discussion of the negotiation process.

The Wednesday morning sessions were held at the Ann Arbor Transportation Authority's headquarters. The focus of the sessions was bus specifications. Three small groups were formed to discuss safety, performance, and physical amenities issues. The groups were led by teams composed of AATA staff and UMTRI staff with expertise in each area. The small groups developed issues for consideration in the panel discussion that followed. That panel included the small group discussion leaders and the bus manufacturer representatives.

The morning session was followed by a catered lunch and a tour of the AATA facilities.

Evaluation

An evaluation form was handed out at the last session. It was filled out by 31 of the attendees. They were asked to rate each session and each speaker or panel on two dimensions: usefulness to them and effectiveness of the presentations. They were instructed to answer each dimension independently. In other words, they might have found something to be useful to them but poorly presented, or not useful to them, but presented well. They were also asked if they would recommend this course to others and for suggestions for improving the course and general comments.

Sessions, individuals, and panels were rated on a 1 to 5 scale, with 1 being the most positive end of the scale. In general, the vast majority rated everything at least 3 on both scales. The table on the next page shows the percentages that rated each item as a 1 and as at least a 3.

All but one person said they would recommend the course to others.

	Useful		Effective	
	1	1-3	1	1-3
Capital Decision-Making	25	100	8	88
Adiv - discounting, NPV	8	32	16	68
Burstein - decision-making	12	79	21	79
Ulberg - bus fuel economy	36	92	24	92
Ribbens - bus maintenance	30	91	22	87
Computer Program	28	92	28	76
Panel - Purchase vs. Rehab	17	96	13	83
Innovative Financing	27	86	23	100
R. White - NJ Transit	17	91	26	100
Seltzer - EF Hutton	21	92	25	100
Parker - DC Consultant	33	92	33	100
Small group discussions	9	74	9	74
Negotiated Procurements	78	96	48	91
Eadie - UMTA	76	100	60	96
Panel discussion	46	92	29	79
J. White - negotiation strategy	39	96	48	87
Bus Specifications	36	95	27	95
Small groups	20	88	20	84
Large group	27	88	19	81

Following is a listing of the comments at the end of the questionnaire:

<u>Suggestions for improving the course</u>

More information from UMTA guidelines & rules & laws

More written handouts; specific problems on utilizing NPV; more detail on available financing methods

None at the moment

Need to have better attendance from decision-makers, policy level, etc.

Larger variety of attendees (gen. mgrs., board members, etc.)

Should have more people from the same type jobs

The discounting was too technical; that can be eliminated

More on procurement nego. process

More panel discussion with the coach manufacturers

Keep vendors out

Less academic concerning decision-making. Try to get more representation from transit properties and from the manufacturers

Drop capital decision-making - expand on negotiated procurement and bus specifications

The objectives of discussion on capital decision making were sometimes unclear. Innovative financing, negotiated procurement were best sessions,

Less technical discussion on capital decision-making as most was over the head of the attendees

More and clearer discussion on negotiated procurements; subject should be expanded with examples

More substantive - 1 week or 2 weeks

Less opinion & more hard data regarding procurement methods, fuel economy, etc. Lower profile by equipment manufacturers

More participation by operators (such as NJ Transit) on the panels as presenters. More examples from the operator's experience (here's how SEMTA negotiated an engineering contract - which follows the same procedures (such as zone of consideration, etc.) as a negotiated bus buy)

Get more input from industry as to adjusting content for more practical practices

More comfortable seats. Need to improve your preparation/ organization . . . The video & and computer failures were <u>very</u> disappointing. The snafu involving taping & GM was distracting

Didn't cover all important areas, due of course to time restraints. A second seminar as a supplement would be useful

<u>General Comments</u>

Need more courses of this type. Will improve mass transit for 21st century

One general dinner outing (informal), tour of campus, written materials, more informal atmosphere

Had a very diverse personage

Was only here for Wednesday (9/18) - Concept is great - Need board members, general managers - (maybe APTA is place for management - am not sure) Great start

I believe the session was beneficial to all

Should be more short breaks

Overall the course was very good - I have good things to take back with me

All instructors very good & informative. Course could be improved, but very helpful as is

A very good course for all bus procurement personnel

Decide who you're trying to impact - finance people, maintenance people, procurement, engineering, capital UMTA program, etc.

Very good

Very good. Would like to do it again

Enjoyed the opportunity to meet and converse with manufacturers & users in the industry

The course was somewhat too academically oriented rather than operator experience oriented. Next time, let's stay on the campus

Capital decision-making portion seemed to be better suited to private sector than public

Complete the form after each session. Last day was very good. Not very well organized for the cost

Great!

From the ratings of the sessions and the comments, three general conclusions can be drawn:

1) The course was received favorably in general.

2) The attendees tended to be those directly involved in the procurement process. They had relatively less interest in the decision-making process and financing than might be expected from higher-level managers.

3) The inclusion of manufacturers received mixed reviews.

Appendix A
List of Participants

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Appendix B
Final Program

ISSUES IN BUS PROCUREMENT

Sunday - Sept. 15

7:00-10:00 Michigan Union	Dinner - Speakers on the American Bus Industry Ed Stokel - GM Mike Bolton - Ann Arbor Transportation Authority

Monday - Sept. 16

8:00- 8:30 UMTRI	Welcome/Administrative Cy Ulberg - UMTRI Howard Bunch - UMTRI
8:30-10:30 UMTRI	Lectures - Life Cycle Cost Estimates and Capital Purchase Decision-Making Ron Adiv - UM Urban Planning Michael Burstein - Industrial Technology Institute
11:00-12:00 UMTRI	Lectures and discussion Cy Ulberg - Bus Fuel Economy William Ribbens (UM Engineering) - Bus Maintenance
12:00- 1:30	Lunch - North Campus Commons
1:30- 2:00 Undergrad. library (UGLI)	Introduction to use of computer model to assist in capital purchase decision-making Mike Burstein Ron Adiv
2:00- 3:00 UGLI	Small groups - Hands-on experimenting with the computer model
3:30- 5:00 UMTRI	Panel - Purchase vs. Rehabilitation Mike Burstein Ron Adiv Cy Ulberg Ed Stokel - GMC Ed Kravitz - Flxible George Pickett - M.A.N. Richard Bafarich - Neoplan Dan Morrill - Midwest Bus Rebuilders

Tuesday - Sept. 17

8:30-10:30 UMTRI	Lectures and Panel Discussion on Innovative Financing Methods Richard White - New Jersey Transit David Seltzer - E. F. Hutton Jeff Parker - Transportation finance consultant
11:00-12:00 UMTRI	Small group discussions on financing methods
12:00- 1:00	Lunch - North Campus Commons
1:00- 3:00 UMTRI	Panel discussion on Negotiated Procurement Process Arlan Eadie - UMTA Ed Kravitz - Flxible Ed Stokel - GMC
3:00- 5:00 UMTRI	Presentation on Negotiation Strategy (with video-taped practice sessions) James J. White - UM Law School

Wednesday - Sept. 18

8:30- 9:30 AATA	Small group discussions on special topics in bus specifications Safety - Dolores Jenkins - AATA Oliver Carsten - UMTRI Performance - Mike Preslar - AATA Dave Cole - UMTRI Physical setup - Perry Schechtman - AATA Larry Schneider - UMTRI
10:00-12:00 AATA	Panel Discussion on Specifications Mike Bolton - AATA Small group leaders Ron Manning - GMC Ed Kravitz - Flxible George Pickett - M.A.N. Richard Bafarich - Neoplan
12:00-12:30	Tour of AATA facilities
12:30- 2:00	Lunch - AATA