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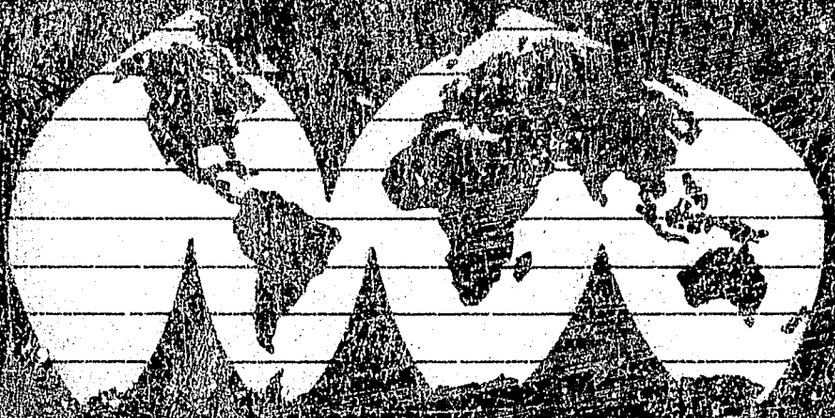
A Report on the

Energy Conservation Services Program



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IMPLEMENTATION OF FUEL COST REDUCTION MEASURES IN COSTA RICAN PRIVATE BUS AND TAXI FLEETS

Final Report

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Prepared for:

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Contents

	PAGE	TITLE
ACKNOWLEDGEMENTS		
LIST OF ACRONYMS		
EXECUTIVE SUMMARY	1	
INTRODUCTION	i	
CHAPTER 1	1.1	PROJECT DESCRIPTION
	1.1	OBJECTIVES
	1.1	SCOPE OF WORK
	1.2	Bus and Taxi Fleet Demonstrations
	1.2	Public Information and Awareness Campaign
	1.3	APPROACH AND METHODOLOGY
	1.4	Project Structure
	1.4	Statistical Design
	1.6	Institutional Arrangements
	1.7	Project Organization and Manpower

	PAGE	TITLE
	1.7	Specialized Consultants
	1.8	Participating Suppliers of Goods and Services
	1.8	Operating Arrangements
	1.9	Diesel Fuel Quality
	1.11	Data Management
	1.13	Time Plan
CHAPTER 2	**2.1**	**BUS DEMONSTRATION PROGRAM**
	2.1	DESCRIPTION OF THE SELECTED ENTERPRISE
	2.2	CORRECT MAINTENANCE
	2.4	RADIAL TIRES
	2.5	INSTRUCTOR TRAINING
	2.6	DRIVER TRAINING
	2.7	DRIVER INCENTIVES
CHAPTER 3	**3.1**	**TAXI DEMONSTRATION PROGRAM**
	3.1	DESCRIPTION OF THE SELECTED ENTERPRISE
	3.2	CORRECT MAINTENANCE
	3.4	RADIAL TIRES
	3.4	INSTRUCTOR TRAINING
	3.5	DRIVER TRAINING

	PAGE	TITLE
CHAPTER 4	**4.1**	**PUBLIC INFORMATION AND AWARENESS CAMPAIGN**
	4.1	MASS MEDIA COVERAGE
	4.2	SEMINAR
	4.3	SPECIAL NEWSPAPER SUPPLEMENT
	4.3	FUTHER ACTIONS
	4.3	Demonstration Reports
	4.3	Brochures
CHAPTER 5	**5.1**	**RESULTS**
	5.1	BUS DEMONSTRATION
	5.2	TAXI DEMONSTRATION
	5.4	PUBLIC INFORMATION AND AWARENESS CAMPAIGN
	5.4	OTHER ACCOMPLISHMENTS
	5.5	COSTS AND BENEFITS
	5.5	Effect of Replication in Host Fleets
	5.6	Effect of Project Repetition
CHAPTER 6	**6.1**	**CONCLUSIONS AND RECOMMENDATIONS**
	6.1	CONCLUSIONS
	6.2	RECOMMENDATIONS
APPENDIX A	**REQUEST FOR SCOPE OF WORK**	

	PAGE	TITLE
APPENDIX B		PROPOSED WORK PLAN
APPENDIX C		DESCRIPTION OF DRIVER ENERGY CONSERVATION AWARENESS TRAINING
APPENDIX D		EXPERIMENTAL DESIGN FOR THE COSTA RICA VEHICLE DEMONSTRATION PROJECT
APPENDIX E		AGREEMENT WITH PARTICIPATING TRANSPORTATION ENTERPRISES
APPENDIX F		FUEL TEST REPORT
APPENDIX G		BUS DATA PROCESSING WORK FLOW
APPENDIX H		TAXI DATA PROCESSING WORK FLOW
APPENDIX I		REPORT ON INSPECTION OF BUS COMPANY MAINTENANCE FACILITIES
APPENDIX J		BUS DRIVER INCENTIVE PLAN
APPENDIX K		BUS INCENTIVE PLAN LETTER

Exhibits

Exhibit 1	Statistical Design - Bus
Exhibit 1.1	Project Structure
Exhibit 1.2	Statistical Design -Bus
Exhibit 1.3	Statistical Design - Taxi
Exhibit 1.4	Project Organization Chart
Exhibit 1.5	Project Participants
Exhibit 1.6	Bus Operations Log
Exhibit 1.7	Taxi Odometer and Fuel Log
Exhibit 1.8	Project Milestones
Exhibit 1.9	Project Activity Schedule
Exhibit 2.1	Composition of Bus Fleet
Exhibit 2.2	View of Bus in Lubrication Shop
Exhibit 2.3	Initial Maintenance Record (Bus and Taxi)
Exhibit 2.4	Continuing Maintenance Record (Bus)
Exhibit 2.5	Driver Training Road Circuit
Exhibit 2.6	Driving Computer
Exhibit 3.1	View of 1985 Model Taxis in Front of COOPETICO Headquarters
Exhibit 3.2	Continuing Maintenance Record (Taxi)
Exhibit 3.3	View of Instruments in the Driver Training Vehicle

Exhibit 3.4	Student Driver Performance Form
Exhibit 3.5	View of Presentation of Certificate -- Taxi Driver Training
Exhibit 4.1	Public Information and Awareness Campaign Plan
Exhibit 4.2	View of Driving Instructor Giving a Radio Interview
Exhibit 4.3	Seminar Program
Exhibit 4.4	View of Seminar in Progress
Exhibit 4.5	Cover Page of Newspaper Supplement
Exhibit 4.6	Testimonial Interviews in Newspaper Supplement
Exhibit 5.1	Cost/Benefit Effect of Replication in Host Fleets
Exhibit 5.2	Costs and Benefits of Repeated Demonstrations

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LIST OF ACRONYMS

BCEOM	A French engineering and consulting firm
CEA	Comision de Energia Atomica (Atomic Energy Commission)
CONICIT	Comision Nacional de Investigacion Cientifica y Tecnica (National Council of Scientific and Technological Research)
COOPETICO	A major taxi cooperative
COTRACOOP	Consorcio de Transportes Cooperativos R.L. (Consortium of Bus Cooperatives)
DECAT	Driver Energy Conservation Awareness Training (DOE)
DOE	U. S. Department of Energy
DSE	Direccion Sectorial de Energia (Energy Sector Directorate)
ICE	Instituto Costarricense de Electricidad (Costa Rican Electric Company)
MIEM	Ministerio de Industria, Energia y Minas (Ministry of Industry, Energy and Mines)
MOPT	Ministerio de Obras Publicas y Transporte (Ministry of Public Works and Transportation)
ORNL	Oak Ridge National Laboratory
RECOPE	Refineria Costarricense de Petroleo S.A. (Costa Rican Petroleum Refinery)
SNE	Servicio Nacional de Electricidad (National Electric Service)

LIST OF ACRONYMS

TRANSMESA	Transportes Metropolitanos S.A. (Metropolitan Transportation S.A.--for San Jose)
UNITRACSA	Union de Transportistas de Carga (Union of Cargo Haulers)
UTC	Union de Taxistas Costarricenses (Union of Costa Rican Taxi Operators)

As Costa Rica's petroleum imports have risen -- equalling 8 percent of its exports in 1965 and over twice that percentage in recent years -- so too has the burden on the nation's economy. The transportation sector accounts for 63 percent of the petroleum products used by Costa Rica -- one of the highest percentages in the world with road vehicles the dominant fuel users in the sector.

Although proper maintenance of vehicles is a key factor in minimizing fuel use, the standard of maintenance for Costa Rican commercial road vehicles is well below the optimum level, owing to low tariffs and a limited understanding of maintenance economics on the part of fleet operators. Moreover, as in most countries, the relationship of specific maintenance actions to vehicle fuel efficiency is not well understood.

Over the past 10 years the major industrialized countries have developed a large body of knowledge on transportation energy conservation, but few developing countries have tapped this important source of foreign exchange savings. Experience in other countries proves that low-cost energy conservation measures can reduce motor vehicle fuel consumption by upwards of 17 percent. For the entire Costa Rican road transportation sub-sector, such measures would translate into annual foreign exchange savings of approximately $17 million (at December 1985 petroleum prices).

PROJECT DESCRIPTION

The project discussed in this report, stemmed from the recommendations in a recent study on energy conservation in the Costa Rican transportation sector.* In response to a request from the AID mission, Hagler, Bailly & Company, prime contractor for the Energy Conservation Services Program (ECSP), with the Transportation Group of Oak Ridge National Laboratory (ORNL), and other special consultants, assisted in implementing two priority recommendations in the study report.

The project focused on demonstrations of fuel conservation measures in private bus and taxi fleets and a public information and awareness campaign. In Costa Rica, buses

*The Transportation Sector in Costa Rica and Opportunities for Energy Conservation, Oak Ridge National Laboratory/Hagler, Bailly & Company, May 1985.

10

and taxis tend to be grouped into cooperatives and umbrella associations that provide convenient host organizations for such a project.

The demonstrations were of a practical nature, and featured proven measures that would produce significant savings under actual operating conditions. Additional criteria were low-cost, short-term impact and high replicability. The measures were (1) driver training, (2) driver incentives, (3) proper maintenance, and (4) radial tires. Energy-efficient driving and maintenance techniques each had the potential to reduce fuel costs by about 10 percent.*

The demonstrations were designed to statistically evaluate the effect of these four controlled measures on operational fuel efficiency, which is also influenced by a number of uncontrolled variables. The project was designed to be capable of detecting differences of 2.5 percent in fuel consumption resulting from the measures applied.

To carry out the demonstration, an adequate number of typical vehicles (24 buses and 16 taxis) was selected and randomly designated for three fuel conservation measures (see Exhibit 1). The measures were applied to the vehicles as follows:

Part 1 (4 weeks)		Part 2 (4 weeks)
Proper Maintenance Radial tires	→ Train all drivers in fuel-efficient driving →	Proper Maintenance Radial tires Driver incentives

The savings attributed to each measure were then determined by linear regression analysis of the specific fuel consumption data that were generated daily by vehicles in the course of the demonstrations.

Because of the pioneering character of the project, a low-cost approach to the demonstrations was chosen that stressed:

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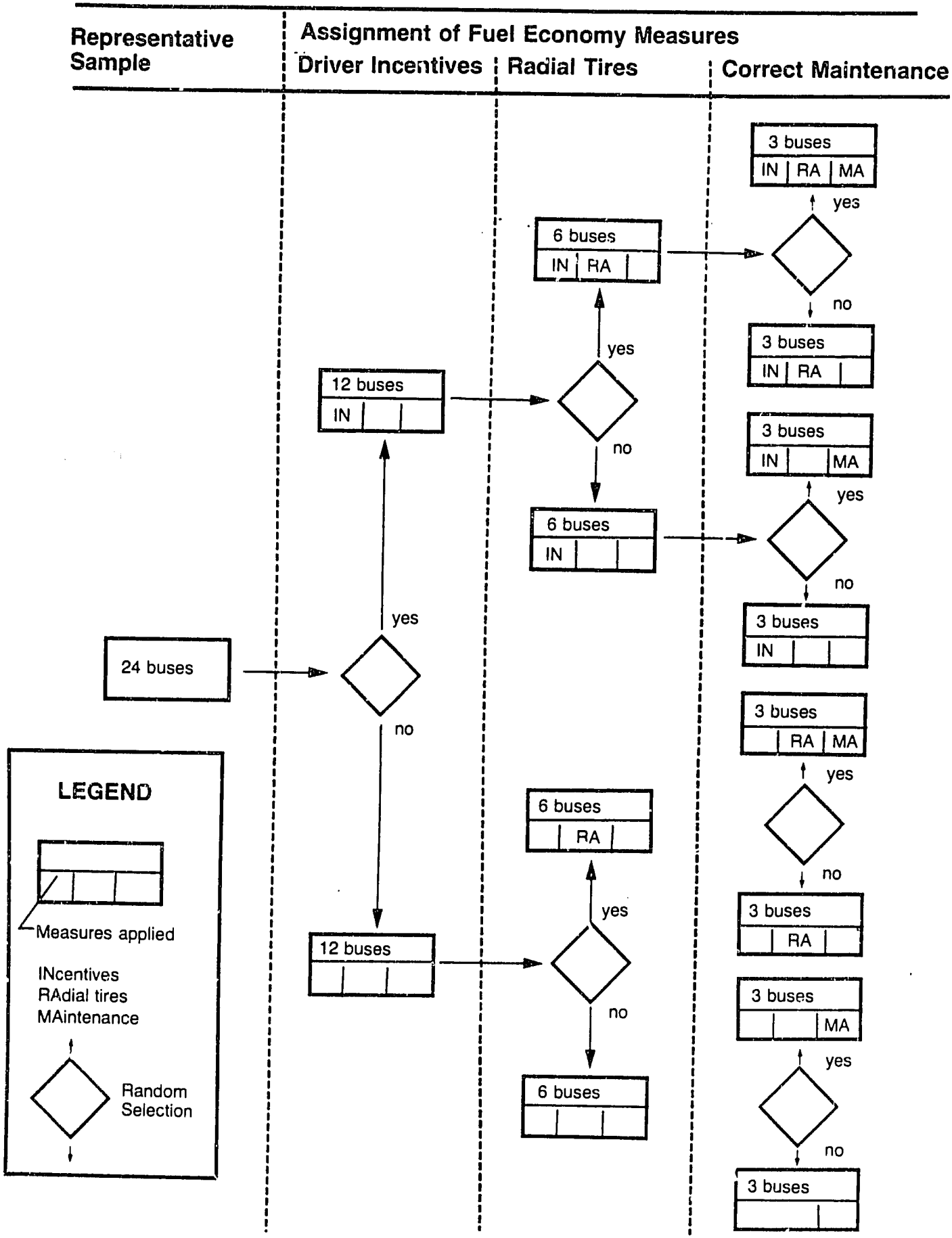
*Driver Energy Conservation Awareness Training (DECAT) -- Review and Recommendation for a National Program, ORNL/TM 9897, Oak Ridge National Laboratory, May 1986.

Exhibit 1
Statistical Design—Bus



12

- Relying heavily on manpower and services provided by participating institutions
- Working through private transportation enterprises and associations
- Using existing facilities, training courses, promotional materials, and existing and borrowed equipment
- Negotiating favorable arrangements with suppliers of goods and services
- Using special consultants in critical areas on short assignments.

The public information and awareness campaign also took advantage of no-cost channels for communication and distribution of information as much as possible. In addition, suppliers of fuel-saving products and services shared costs and furnished seminar speakers.

BUS DEMONSTRATION

The bus demonstration effort took place in Empresa Guadalupe Ltda., one of several companies providing bus service on routes that extend radially from central San Jose to the suburbs. The company is a cooperative of bus operators who retain individual ownership of their vehicles and follow centrally assigned routes and schedules. Twenty-four of the fleet's 41 buses were assigned to the demonstration. Two groups of 12 were randomly selected from the assigned buses, one for improved maintenance, and one for retrofitting of radial tires.

Following completion of the initial 4-week demonstration period (Part 1), all drivers of the 24 buses were trained in energy-efficient driving techniques patterned on the DOE Driver Energy Conservation Awareness Training (DECAT) course, and incentives were given to drivers of 12 buses selected at random. The demonstration was then set in motion again, with improved maintenance, radial tires and driver incentives operative. Following the second 4-week demonstration period (Part 2), data gathering was continued for a further four weeks for use in verifying Part 2 data.

In the course of the demonstration, data were collected through an existing management control system that kept a daily record, by bus, of drivers, hours operated, number of trips, routes, distance travelled, number of passengers, and fuel purchased. After verification, the data were

analyzed at DSE, and were also sent to the Transportation Group, Oak Ridge National Laboratory (ORNL), for analysis.

TAXI DEMONSTRATION

The taxi demonstration effort was hosted by COOPETICO, a cooperative of taxi owners who retain ownership and control of their vehicles. COOPETICO covers about 700 taxis in metropolitan San Jose and 300 in the provinces. Sixteen urban taxis were selected at random to demonstrate fuel conservation measures, and of these, improved maintenance and retrofitting of radial tires were applied to a random group of eight vehicles. Following completion of Part 1 of the demonstration, all drivers were given DECAT training, and the demonstration was resumed. Data gathering was continued for 2 weeks beyond Part 2 as a backup measure.

Fuel purchases and distance travelled were recorded by each driver on special forms, which were collected at the conclusion of each four-week demonstration period. The data were subsequently verified, and were analyzed by DSE. A copy of the data was also sent to the Transportation Group of ORNL for independent analysis.

PUBLIC INFORMATION AND AWARENESS CAMPAIGN

Salient features of the campaign were (1) radio, television and press coverage of key events, (2) a two-day seminar for fleet operators, (3) a special newspaper supplement, (4) reports of demonstrations and results, and (5) brochures for operators of light vehicles, buses, and trucks. A local publicity agency was contracted to assist in the mass media activities and in producing the seminar.

Only the media coverage, the seminar, and the special newspaper supplement were completed by year end -- the planned project completion date. The remaining activities have been rescheduled for 1986.

RESULTS

Demonstrations

The project demonstrated the following savings:

Type Vehicle	Fuel Cost Reduction Measure	Fuel Savings/(Loss)
Bus	Proper maintenance	6.0% to 6.5%
Bus	Driver training	4.1% to 4.2%
Bus	Radial tires	(1.7%) to (1.8%)
Taxi	Driver training	13.4% to 15.1%

The results of all other actions were not significant.

The **bus savings** breakdown was:

Proper maintenance	6.5%	
Driver training	4.2%	
Driver incentives	1.2%	not statistically significant
Radial tires	(1.8%)	negative

Total savings were estimated at up to:

$$100 - (1 - .065)(1 - .042)(1 - .012)(1 + .018)100 = 9.9\%$$

The following **taxi savings** breakdown reflects an unexpectedly high ratio of noise to effect in the data, which made it very difficult to detect treatment effects:

Proper maintenance	1.8%	not statistically significant
Driver training	15.1%	
Radial tires	0.2%	not statistically significant

Total savings were estimated at up to:

$$100 - (1 - .018)(1 - .151)(1 - .002)100 = 16.8\%$$

The effect of upgraded maintenance was found to be significant only in the buses, probably because most taxis were 1985 models with less margin for improvement.

Driver training, on the other hand, yielded a saving of up to 15.1 percent in the taxi fleet, compared with 4.2 percent in the bus fleet. This discrepancy may stem from the fact that the fixed bus routes and patterns of stops limit opportunities for improvement. Also, a non-standard gear box in the driver training bus and low speed limits undermined the effectiveness of the training. The strong showing of the taxi drivers disproved the widespread view that driver training without an incentive would not be effective. In fact, driver incentives, which were given

only to bus drivers, failed to make a significant impact on fuel efficiency. This matter requires further analysis.

The retrofitting of radial tires, which should boost fuel efficiency by some 4 percent, had virtually no effect on either buses or taxis. This result is suspect, and requires further analysis, since in the case of the taxis at least, there is evidence that the radial tires were underinflated.

The less than perfect control of maintenance activities probably restricted fuel efficiency gains significantly -- particularly in the taxi fleet, where control and discipline were seriously loose. For example, if tires had been brought up to maximum recommended pressure and maintained there, fuel efficiency might have been improved by an additional 3 to 5 percent*.

In addition, the reported savings were probably understated owing to the involuntary spread of good maintenance practices to all fleet vehicles indiscriminately in the course of the project. This phenomenon would reduce the registered gains of the vehicles designated for fuel-efficient treatment relative to the baseline group.

Other Results

The project developed an in-country capability for teaching fuel-efficient driving -- the most effective fuel conservation measure. Since the seminar for fleet operators and the special newspaper supplement drew a strong response centering on this measure, DSE will be arranging further training in energy-efficient driving techniques.

The project also proved that demonstration project costs can be reduced substantially by enlisting the participation of related suppliers. All suppliers that were invited to participate responded positively and provided products and services at low cost or no cost.

Costs and Benefits

The cost reduction actions produced savings estimated at $23,100 per year in the 40 vehicles benefitting directly from the program, or almost $600 per vehicle, at a cost of $108,400, including a largely one-time technical

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*DECAT - Review and and Recommendations, ORNL, and Truck Efficiency Measures Matrix, Argonne National Laboratory, 1982.

16

assistance component of some $97,000. (The cost does not include the services of ORNL, nor the goods and services contributed by DSE and local participants, all of which are valued at about $18,100.)

Since most of the project expenditure served to develop a local capability in transportation fuel cost reduction, replications -- with little or no further foreign assistance required -- will pay back costs in a year or less. If extrapolated to the total COOPETICO and Empresa Guadalupe fleets, potential savings are estimated at about $500,000 for a total cost of $366,200, for a payback period of nine months.

RECOMMENDATIONS

1. The experience gained in the project shows that such training and improved maintenance programs are cost effective and should therefore be expanded to all intensively-operated vehicles nationwide (taxis, buses and trucks), with priority given to improved truck maintenance and truck driver training. This large-scale cost reduction program should include:

   - Energy audits of major energy users in the transportation sector, followed by technical and financial assistance in implementation of recommendations

   - Establishment of local fuel-efficient driving training on a permanent basis

   - Upgrading of the country's maintenance infrastructure to provide the high standard of service required by diesel engine fuel systems, at an affordable price

   - A continuing public information and awareness program

   - Regulatory measures to (1) align speed with efficient operating ranges of vehicles, (2) require that vehicle importers furnish fuel efficiency ratings and (3) provide for vehicle emissions inspection to detect inefficient engine operation

   - Structural improvement of the taxi fleet, by requiring smaller more efficient taxis, with fuel consumption curves matched to planned operating speeds and patterns

17

- Further actions by RECOPE to promote installation of filters in all diesel fueling stations nationwide in order to control fuel contamination up to the dispensing pump nozzle.

2. At fleet level, Empresa Guadalupe should take action to improve maintenance and fleet management systems by applying the knowledge gained from the project and by investigating the use of a small computer in management operations and maintenance.

3. Similarly, the National Chamber of Transport should promote fuel cost reduction actions and the adoption of a uniform operations and maintenance data recording and analysis system on the part of its associates.

4. The experience gained in this project should be used for developing similar demonstration and public information projects in other countries.

Introduction

Costa Rica, with a population of 2.5 million, consumes 0.61 tonnes of oil equivalent (toe)* per capita annually, compared with the Central American average of 0.5 toe per capita. Total commercial energy consumption in 1984 was 997 thousand toe, of which 40 percent was used by the transportation sector.

Costa Rica's fleet of 217,324 road vehicles (1984) is the dominant transportation energy consumer, and within the road fleet, the principal fuel consumers are medium and heavy trucks (38.1 percent); automobiles, jeeps and light trucks (33.0 percent); buses (12.9 percent); and taxis (5.5 percent).

In the wake of the petroleum crises of the 1970s industrialized countries have focused massive fuel conservation efforts on these vehicle groups with considerable success; consequently, a sizeable body of specialized knowledge has been created. However, developing countries in general have yet to tap this significant source of petroleum (and foreign exchange) savings. Casual observation of vehicles on Costa Rican roads suggests that their fuel efficiency can be boosted substantially.

This view was borne out by a study conducted in 1984 by Oak Ridge National Laboratory (ORNL) and Hagler, Bailly & Company under the Energy Conservation Services Program (ECSP) of the USAID Office of Energy within the Bureau for Science and Technology**.

In April 1985 the USAID mission in Costa Rica discussed the report with the Energy Sector Directorate (the Costa Rican counterpart organization), and subsequently requested further assistance from ECSP in implementing

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*1 toe = 41.87 GJ = 39.68 x 10^6 Btu

**The Transportation Sector in Costa Rica and Opportunities for Energy Conservation, Oak Ridge National Laboratory/Hagler, Bailly & Company, May 1985

actions that had been identified as priority recommendations.

The energy conservation activities proposed were (1) a demonstration program in bus and taxi cooperatives, and (2) a public information and awareness campaign (see Appendix A).

Subsequently, Hagler, Bailly & Company proposed a work plan (Appendix B) which was discussed with the Office of Energy, the USAID Mission, and DSE, and agreement was reached in July 1985 to undertake the program. Because of the pioneer nature of the effort, specific expertise was also brought to the program from a number of other organizations.

The bus and taxi subsectors, which were chosen as the focus of the project, tend to be grouped into private-sector cooperatives that were thought likely to facilitate cost-efficient conduct of the demonstrations and dissemination of their results. Because buses and trucks in Costa Rica are heavy diesel vehicles, the same fuel-saving techniques applied to both.

It is important to note that the demonstration component was set in an operating environment rather than in a laboratory or on a test track. It was, therefore, subject to certain economic, political, and social forces beyond the control of the project management. As a result, the project has many imperfections. Nevertheless, the fuel conservation measures employed were of sufficient strength to overcome the deficiencies and yield credible results.

This report, which covers the nine month period July 1985 to March 1986 consists of six chapters. **Chapter 1** provides background, with descriptions of the objectives, scope of work, approach, methodology and planning details. **Chapter 2 and Chapter 3** recount the implementation of the demonstrations in the bus and taxi enterprises respectively, and **Chapter 4** describes the public information activities conducted and planned. **Chapter 5** reports the results and accomplishments, and examines the relationship of benefits to cost. **Chapter 6** lists the conclusions reached and recommendations for further programs and actions.

Finally, the appendices provide detailed information on several of the subjects treated in the report.

OBJECTIVES

The project sought to set the stage for a 17 percent reduction of Costa Rica's road transportation fuel bill by demonstrating fuel-saving actions and prompting vehicle operators and fleet managers to carry them out. Specifically, the project endeavored to:

- Demonstrate proven, low-cost techniques for increasing fuel efficiency in the bus and taxi subsectors, and show that they are cost-effective
- Disseminate the techniques and results to the entire bus and taxi subsectors, as well as to the driving public
- Raise energy consciousness throughout the transportation sector and on the part of the driving public
- Provide additional practical information on energy conservation techniques to the entire transportation sector and the driving public
- Establish permanent resources in Costa Rica for carrying forward an energy conservation program encompassing the entire road transportation sector
- Achieve the above objectives on a low budget.

Furthermore, as an initial field effort in transportation fuel cost reduction, the project is intended to provide USAID with information that will be useful in energy strategy formulation and in assisting other countries to reduce motor fuel consumption.

SCOPE OF WORK

In accordance with guidelines received from the USAID Mission in Costa Rica (see Appendix A), the consultants assisted DSE in designing, planning, and conducting a project that focused on the application of energy conservation techniques to transportation fleets, the measurement of

their impact, and the dissemination of useful information to fleet operators and the driving public. To establish a practical character and strong credibility, the project was limited to the use of proven techniques under actual operating conditions. Other criteria used in selecting techniques were low-cost, short-term results, quick payback, and high replicability. In addition, the project provided for the development of local technical resources, training materials and information needed to generate and implement an energy conservation program in all road transportation subsectors.

The primary activities of the consultants were planning, coordinating, and technology and knowledge transfer. DSE personnel and the participating fleet operators and suppliers were heavily involved in implementing the project, so that the overall effort was highly cooperative.

Bus and Taxi Fleet Demonstrations

The demonstration activities centered on driver training and vehicle maintenance, which are measures that can be implemented quickly, using local resources to a great extent. A further advantage of these measures is that they provide high savings and replicability. Other demonstrated measures were retrofitting of radial tires and the use of driver fuel efficiency incentives. The demonstration program was carried out in one bus and one taxi cooperative, stressing short-term results and reductions in fuel costs.

In the case of measures requiring equipment, supplies and specialized services, private-sector suppliers were persuaded to participate in the demonstration, providing products and services under advantageous conditions. In addition, the demonstration relied heavily on the use of existing DOE driver efficiency training materials (DECAT light vehicle, school bus and truck) that were adapted and translated.

Public Information and Awareness Campaign

The campaign entailed the design and implementation of a program to stimulate the interest of selected audiences and the driving public in transportation fuel conservation. The demonstration results were a key element of the campaign. Furthermore, the program was designed to convey practical information on energy conservation measures to vehicle operators and fleet managers, and to persuade them to implement the measures.

The campaign made maximum use of local resources within the sponsoring institutions, and, as in the demonstrations, suppliers were invited to participate. Extensive use was made of energy conservation material gathered from DOE and U.S. state energy offices, and from other countries, which reduced the costs of writing, art work, and layout. With respect to dissemination, the National Chamber of Transport, Union of Costa Rican Taxi Operators (UTC) and COTRACOOP are providing cost-effective channels for reaching much of the target audience.

APPROACH AND METHODOLOGY

The project approach was governed, to a great extent, by the need to work with a budget that was low relative to the broad scope of work. Under these circumstances, the project objectives were achieved by:

- Relying heavily on manpower and services provided by DSE, MOPT and RECOPE

- Using existing resources where possible. For example, the DOE DECAT program (See Appendix C) was adopted virtually intact, DOE and U.S. state energy office promotional materials were adapted, driver efficiency training classes were held in MOPT road safety training facilities, and MOPT personnel provided art, audio-visual and photographic support services

- Using special consultants in critical areas such as maintenance, data collection, driver incentives, and -- with respect to demonstrations -- statistical design and computer-assisted processing and analysis of results

- Relying heavily on private-sector suppliers of goods and services to participate in both project components

- Working through private-sector organizations of fleet operators, i.e., the National Chamber of Transport, UTC, a bus cooperative and a taxi cooperative

- Focusing on low-cost, short-term fuel conservation measures with high replicability

- Using no-cost channels for dissemination of information; i.e., the National Chamber of Transport and UTC (fleet operators), the MOPT vehicle tax office (driving public), and the Journal of the Association of

Architects and Engineers (engineers). These channels were supplemented by paid newspaper advertisements and free mass media exposure of various sorts

- Developing transportation energy conservation expertise in DSE, MOPT, RECOPE, the National Chamber of Transport, and UTC, including training DECAT instructors in each organization.

Various aspects of the project approach and methodology are explained in the next sections.

Project Structure

The project was structured as shown in Exhibit 1.1. The demonstrations were designed to alter the prevailing view in the transportation industry of Costa Rica that the inadequate margins provided by the state-controlled tariffs permit only minimal preventive maintenance. The four variables selected for the demonstration -- driving training, driver incentives, correct maintenance and radial tires -- are all feasible given the current financial constraints of the industry because they involve small outlays and have a short payback period.

The public information component was designed to disseminate the demonstration results as well as to provide a broad range of fuel conservation information useful to the entire road transportation industry and the driving public.

Statistical Design

The project sought to evaluate the effect of four variables on operational fuel efficiency, which is itself subject to the effects of a number of other variables such as route, passenger load, traffic conditions, driver, weather, and bus characteristics. The following procedure was used:

1. Determine the size of the demonstration fleet and the duration of the demonstration required to distinguish a fuel efficiency improvement as small as 2.5 percent attributable to any of the four controlled variables. This calculation was based on the standard deviation observed in baseline data (specific fuel consumption) for buses and for taxis.

2. Select a representative sample of the desired number of vehicles, and randomly assign half each vehicles to

Exhibit 1.1
Project Structure

Operational Demonstrations

- Bus Fleet (24 vehicles)
  - Driver training
  - Driver incentives
  - Correct maintenance
  - Radial tires
- Taxi Fleet (16 vehicles)*
  - Driver training
  - Correct maintenance
  - Radial tires

Public Information and Awareness Campaign

- Publicize instructor and driver training
- Four paid press releases
- 2-day fleet operator seminar
- Press, radio, and television interviews
- Special newspaper supplement
- Bus and taxi demonstration reports
- Brochures for operators of light vehicles, buses, and trucks

*Driver incentives could not be implemented because of the reluctance of taxi owners to establish a precedent.

a group that will implement each measure, and half to a group that will not, as shown in Exhibits 1.2 (buses) and 1.3 (taxis). This method resulted in the random application of each measure to 50 percent of the demonstration fleet.

3. Carry out the demonstration in two parts as follows, introducing a further measure -- fuel-efficient driving training -- before proceeding with Part 2:

Part 1 (4 weeks)		Part 2 (4 weeks)
Correct maintenance Radial tires	➡ Train all drivers in fuel-efficient driving ➡	Correct maintenance Radial tires Driver incentives

4. Collect and analyze data. Although two variables -- maintenance and radial tires -- were applied throughout, driver training and driver incentives were operative only during Part 2. Driver incentives were, in fact, used only for the bus fleet because of apprehensiveness on the part of the taxi owners. Further details on the statistical design are provided in Appendix D.

The demonstrations generated the following data on a daily basis:

Buses	Taxis
Bus no.	Taxi no.
Date	Date
Route	
Distance travelled in km - 1st shift - 2nd shift	Distance travelled in km - 1st shift - 2nd shift
Fuel purchased - liters and colones	Fuel purchased - liters and colones by shift

These data were transferred to machine-readable form using microcomputer spreadsheet software. The data were reformatted by a BASIC program which added variables representing treatments. PC-based statistical software was used to screen the data from errors and estimate the treatment effects by means of regression analysis.

Exhibit 1.2
Statistical Design—Bus

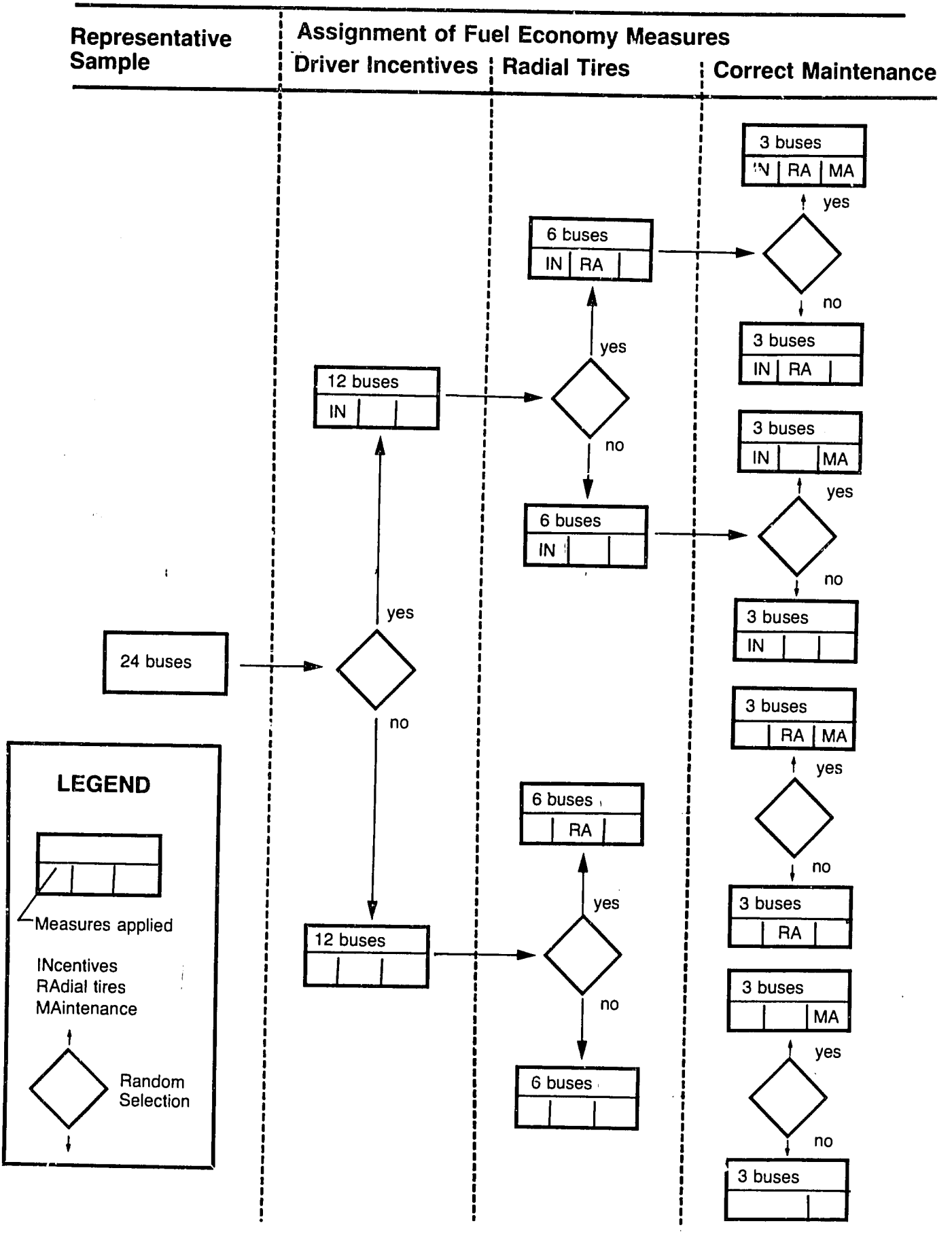
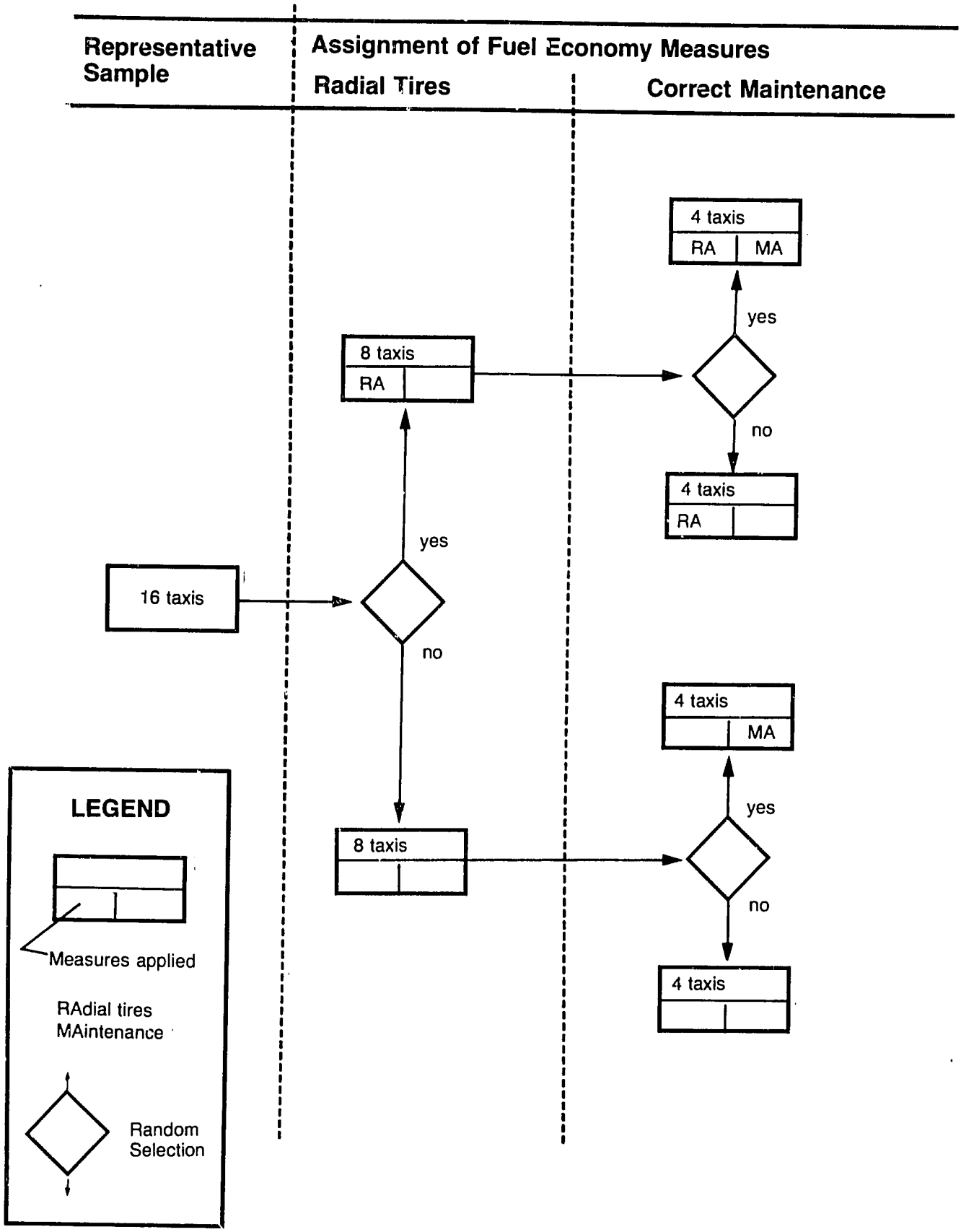
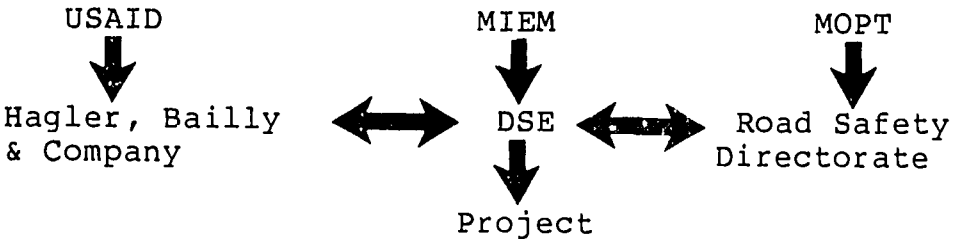


Exhibit 1.3
Statistical Design—Taxi



Institutional Arrangements

The following institutions were involved:



The project was co-sponsored by the Ministry of Industry, Energy and Mines (MIEM) and the Ministry of Public Works and Transportation (MOPT), with implementation responsibility assigned to DSE. Organizationally and physically, DSE is located within MIEM, although it is staffed largely by RECOPE employees and co-sponsored by SNE, CONICIT, ICE and CEA.

In addition, the following groups provided support and essential resources:

- Road Safety Directorate, MOPT - Training facilities and an instructor, graphics, audiovisual material, and photography
- RECOPE - Fuel quality control, public information services, and an engineer
- National Chamber of Transport - Bus fleet, maintenance facilities, fueling station and manpower
- Union of Costa Rican Taxi Operators - Taxi fleet.

RECOPE is the sole petroleum refiner and importer in Costa Rica. This public company is also active in petroleum exploration, renewable energy development, and support of bus transportation.

The National Chamber of Transport is a private-sector organization that encompasses most of the Costa Rican bus industry. In addition, its affiliates include some truckers and the Union of Costa Rican Taxi Operators (UTC). Primarily, it serves as a lobby group for the road transportation industry, dedicated to maintaining the private character of the industry.

UTC is an umbrella organization whose affiliates account for over 1,300 of the 1,800 taxi operators in Costa Rica.

It works jointly with the Chamber of Transport to promote free enterprise in its subsector.

Project Organization and Manpower

The project organization and staffing are shown in Exhibit 1.4, with a comparison of actual and planned manpower. Two full-time engineers were provided by DSE as planned, but only one part-time person was provided -- two fewer than planned. The missing personnel were the internal coordinators in the host fleet organizations, which proved to be a serious setback that was only partly offset by contracting people on an occasional basis.

The manpower shortage was exacerbated by an accelerated project schedule (owing to a late start), constraints on availability of drivers and vehicles, unforeseen staff changes, and data quality problems.

In retrospect, adherence to schedule and the quality of the results would have been greatly improved by selection of host enterprises with centralized authority (vehicles owned in common) and provisions for adequate administrative and logistic support. The need to refer decisions to individual vehicle owners resulted in delays and an unforeseen administrative work load.

Because of the personnel constraints, the project staff had to be supplemented with contract typists, mechanics, translators, and a computer data entry clerk.

Specialized Consultants

Consultants with special qualifications were employed to reinforce critical activities (principally in the demonstration component) as follows:

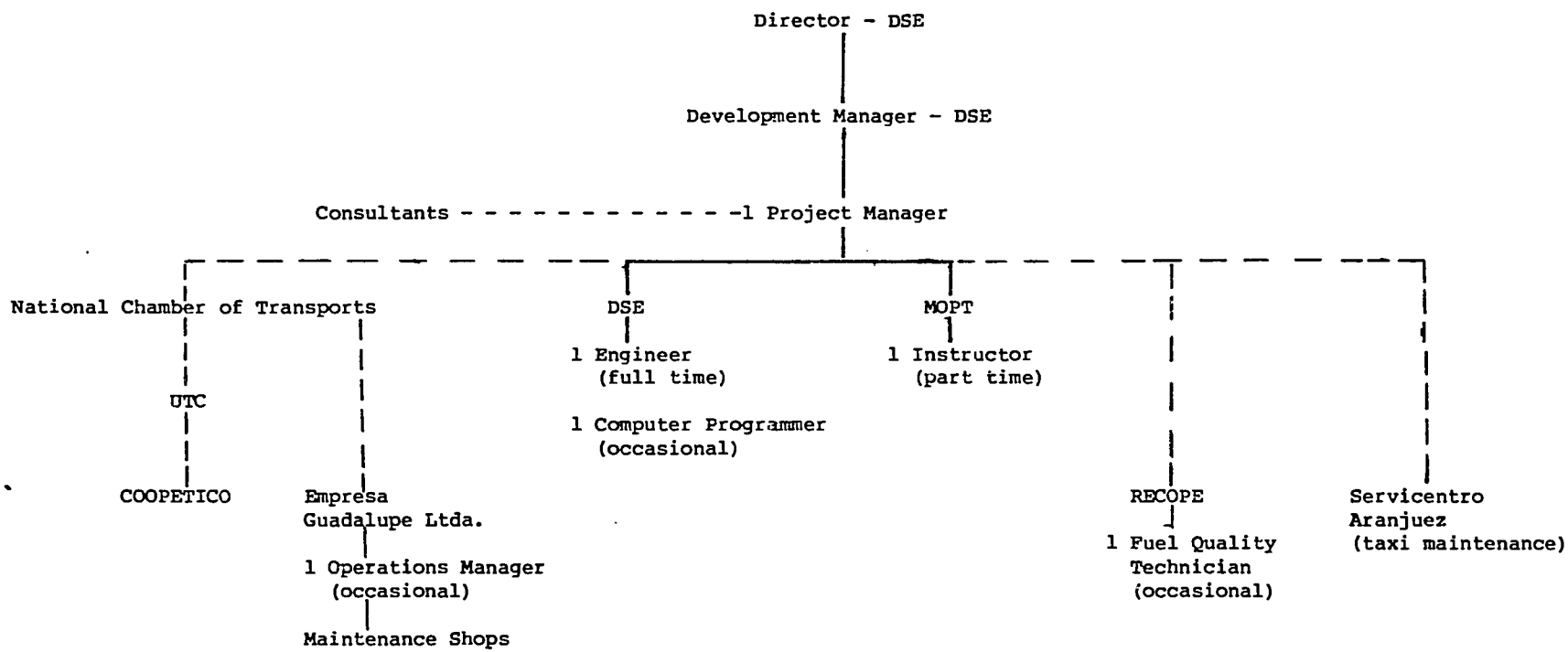
1. **Dr. David L. Greene, Transportation Group, ORNL, Oak Ridge, TN (6 days in-country, 2 visits)**

   - Analysis of baseline vehicle operational data
   - Statistical design of demonstrations
   - Data processing and analysis work flow design and implementation
   - Training of DSE personnel in data processing and analysis

2. **Mr. Boris Hubar, Director, DOE DECAT Training Center, Las Vegas, NV (13 days in-country)**

Exhibit 1.4

Project Organization Chart



Total Manpower
(Planned manpower
in parentheses)

2 Full Time (2)

1 Part Time (3)

3 Occasional (1)

- Installation of training vehicle instrumentation
- Layout of driver fuel efficiency training road circuit
- Design of bus and taxi maintenance programs
- Supervision of initial vehicle maintenance actions

3. **Mr. Claude Peyrebonne, BCEOM, Paris (5 days in-country)**

- Design of demonstration data collection systems
- Design of driver incentive plans
- Design of a fuel efficiency brochure for car buyers
- Overall technical design of the demonstrations

Owing to delays in selection of a taxi cooperative and assignment of demonstration taxis and buses by the cooperatives, the time of Messrs. Greene and Hubar was not used to maximum advantage. (They were unable to postpone their visits owing to other commitments.)

Participating Suppliers of Goods and Services

In all cases where local suppliers were invited to participate in the project their response was enthusiastic. They were told that in exchange for the provision of goods and services at reduced prices (or donated), the project would publicize their participation in the public information campaign.

The participating suppliers, together with the products or services provided to the project, are listed in Exhibit 1.5. In addition, several of the suppliers provided speakers for the two-day Motor Vehicle Fuel Conservation Seminar given under the public information component, and provided financial support to the project's newspaper supplement on transportation fuel conservation.

Operating Arrangements

The project attempted to obtain the use of facilities and equipment at no cost as far as possible and was, on the whole, successful.

Project staff was housed in the DSE offices and documentation center, which are located in MIEM in San Jose. DSE provided logistic support, including a Jeep Wagoneer. This vehicle was equipped with special driver performance measuring instruments, and served as a driver training car as well as for transportation of project staff members.

Exhibit 1.5
Project Participants

	Product or Service
Private Sector	
Agencia Datsun S.A.	Tires
COOPETICO	Demonstration fleet
Empresa Guadalupe Ltda.	Demonstration fleet, maintenance shops
Filbronzi do Brasil	Fueling station filters
Industria Firestone de Costa Rica	Tires
MADISA	Diesel fuel system service
Multifiltros S.A.	Air filter monitors
Publicidad Contemporanea	Public information service
Quiros y Cia.	Tires, wheel alignment
RECOPE - Press & Communications Directorate	Public information service
RECOPE - Quality Control Department	Fuel quality maintenance
Servicentro Aranjuez S.A.	Taxi maintenance
Public Sector	
MOPT - Course Planning and Production Section	Art, graphics, audio-visual materials, photography
MOPT - Road Safety Directorate	Training facilities, instructor

Driver and instructor training was conducted in classrooms of the Road Safety Directorate, MOPT, and on public roads.

Maintenance work and fitting of driver training instruments were carried out in the maintenance shops of Empresa Guadalupe Ltda., the participating bus cooperative. Since COOPETICO, the participating taxi cooperative, had no maintenance facilities, a nearby automotive service station was used for preventive maintenance and fueling. The service station, Servicentro Aranjuez, was selected largely because most of the COOPETICO taxis customarily use it. These facilities and services were supplemented (for both buses and taxis) by a wheel alignment shop and a diesel fuel system service shop.

Demonstration vehicles and maintenance supplies were provided by the participating fleet operators, and products and services were furnished at reduced prices (or at no cost) by the participating suppliers listed in the previous section.

The terms of participation of the cooperatives were set forth in an agreement signed by both parties (See Appendix E). Potential liability claims arising from work done on vehicles in the course of the demonstrations were covered by liability release provisions in the agreement.

Diesel Fuel Quality

Throughout the demonstrations, an effort was made to provide fuel of consistent quality (free of water and sediment) by the following measures:

1. Single fuel source.

   All fuel used in demonstration buses was furnished by Empresa Guadalupe Ltda. Taxis were requested to refuel at Servicentro Aranjuez, but not all of them complied.

2. Provision of filters for fueling station pumps.

   RECOPE fitted sintered bronze filters in all 15 service stations that it owns, with a view toward persuading independent diesel fuel retailers to do the same. The filters are designed to remove virtually all water and sediment from diesel fuel. The manufacturer of the filters, Filbronzi do Brasil, lent two filters to the project with the

understanding that the service be acknowledged during the public information campaign.

The filters were shipped from Brazil via RECOPE at no cost to the project. The Purchasing Directorate of RECOPE expedited their release from customs, and they were registered as RECOPE property. The Distribution Department of RECOPE then installed a filter on each of the two pumps that were assigned to fuel the demonstration buses and taxis. Ideally, the filters should be located between the fuel storage tank and the dispensing pump, but unfortunately it was necessary to install them at the pump outlets owing to plumbing space limitations on the fuel islands. The filters were subsequently cleaned by RECOPE personnel on request.

3. Inspection of fueling station tanks.

Many service station storage tanks are in poor condition, which gives rise to fuel quality problems. RECOPE thus considered it necessary to determine the condition of the tanks associated with the demonstrations. This task was undertaken by RECOPE's Distribution Department, which inspected them for water and sedimentation, formation of micro-organisms, and seepage. Both tanks involved were found to be in satisfactory condition.

4. Inspection of fuel meters.

To ensure accurate measurement of fuel used in the demonstration vehicles, it was necessary to calibrate the fuel meters in the two fuel pumps. This work was also carried out by RECOPE's Distribution Department.

5. Monitoring of fuel quality.

To ensure consistent and uniform fuel quality during the demonstrations RECOPE periodically drew fuel samples and analyzed them. The following characteristics were determined:

- Water and sediment
- Cetane index
- Distillation curve
- Viscosity

Samples were taken each time the fueling stations received deliveries from RECOPE -- twice weekly at Empresa Guadalupe Ltda. (buses) and on alternate days at Servicentro Aranjuez (taxis). The samples were analyzed in the laboratories of RECOPE's Directorate of Quality Control, and results of the analyses were reported in the format shown in Appendix F.

All fuel tested met or exceeded the official Government standards published in February 1985. Water and sediment were consistently far below the prescribed maximum of 0.1 percent by volume.

Data Management

Analyzing the demonstration results as well as the efficiency of normal vehicle operations depends on an adequate data collection system that takes account of vehicle characteristics, type of service, and operational patterns. For the purpose of the project, it was convenient to use the existing bus data collection system, which is an integral part of the bus company's management control system. In the case of the taxi cooperative, which is more decentralized, it was necessary to create a data collection system.

Management of the demonstration data required:

- Accurate measurement of fuel delivery and a means of monitoring fuel quality
- Collection of information on type of service, volume of fuel delivered, distance traveled, and other variables
- Data processing and interpretation.

Fuel Distribution System. As described in the previous section, measures were taken to ensure that the fuel delivered to the demonstration vehicles was of acceptable quality, and that the volume delivered was measured with adequate accuracy.

Although the demonstrations were primarily concerned with determining relative values of specific fuel consumption, it was deemed desirable to obtain absolute values as well. Absolute data would enhance the value of future performance comparisons other with Costa Rican bus fleets. With this

in mind, the dispensing pumps were calibrated by RECOPE personnel.

Data Collection. The principal differences in the data gathered for the bus fleet and taxi fleet lay in the segregation of routes and drivers: While the buses were routinely rotated over five routes on a biweekly basis, taxis do not follow fixed routes. Therefore, bus data were segregated by route, while taxi data were not. Also, while buses were fueled once per day (following completion of the day's operations), taxis were fueled by each driver at the conclusion of his shift; consequently, it was possible to segregate data by driver only in the case of the taxis. A further difference existed in the responsibility for recording data: In the case of buses, data were recorded by the bus company's operations staff, while taxi data were recorded by the drivers themselves.

Bus data were based on an existing report, which is shown in Exhibit 1.6. A separate report was produced for each vehicle over each of the four-week demonstration periods. Since most bus odometers were inoperative, mileage was calculated by multiplying the number of trips based on drivers' reports, by the known distance of the route. Fuel data were gathered from fuel invoices originating at the bus company's fuel pump.

Drivers were requested to fill their tanks completely at every fueling. (The only exception was bus number 11, which had a damaged fuel tank.) It was not possible to determine the amount of fuel consumed by each driver, since it was not feasible for the buses to return to their base for fueling with each change of driver. Only daily fuel consumption by bus was obtainable.

Since the raw data illustrated in Exhibit 1.6 was found to contain extraneous data and omissions, it was necessary to contract a person to verify and adjust it prior to data entry.

Taxi data were recorded by each driver on the form shown in Exhibit 1.7. Kilometer readings were taken from the odometer, and the drivers were instructed to fill their tanks completely at each fueling.

Data Processing and Interpretation. Data entry and processing were performed in parallel by DSE staff on in-house IBM-XT personal computers and by the Transportation Group,

Exhibit 1.6

Bus Operations Log

EMPRESA GUADALUPE LTDA.

Autobús No. _____ Placa SJB

Fecha	Nombre Conductor	Horario	No. Carrera	Lugar Recorrido	No. Kms. Recorrido	Horas Operadas	Horas Taller	Horas Doc.	No. Tiempo Final	No. Tiempo Inicial	Total Marcas	Monto ¢ colones	No. de Galones	Diesel	Sobrio Chofer	INS Pyndo Cal.	Rasgos Prof.
[illegible]	[illegible]	5 a 12½	6	auto	66	7½		—	6469	5656	813	[illegible]			1½		
"	"	[illegible]	4	Puntal	16	10½		—	6567	6469	98	[illegible]	36⅓	1485=	[illegible]		
[illegible]	[illegible]	5 a 12	5	[illegible]	96	7		—	7125	6567	558	2511=			10½		
[illegible]	[illegible]	12 a 4	7	"	132	11		—	7713	7125	588	2646=			[illegible]		
"	"	5½ a 1	6	Paraxo	72	7½		—	8420	7713	707	3181.50	87½	1699=	[illegible]		
[illegible]	[illegible]	1 a 10	7	"	84	9		1½	9655	8941	714	1953.75			[illegible]		
				Paro			5	12				2677.50	60½	1176=			
[illegible]	Fuerte	5½ a 1	6	auto	66	7½		—	0545	9656	889	3333.75			—		
[illegible]	Vargas	1 a 12	8	"	88	11		—	1240	0545	995	3731.25	71½	[illegible]	1½		
"	"	4 a 12	5	[illegible]	[illegible]	[illegible]		—	2082	1540	542	2439=			[illegible]		
[illegible]	[illegible]	12 a 9	2	"	114	9		1	2676	2089	587	2641.50	75½	[illegible]	[illegible]		
"	"	5 a 2	[illegible]	Paraxo	16	1		—	2684	2676	[illegible]	[illegible]			[illegible]		
[illegible]	[illegible]	2 a 11½	8	"	96	9½		—	[illegible]	3406	769	[illegible]	15½	[illegible]	[illegible]		
												34110.25		2537=	41.62.75		
[illegible]	[illegible]	10 a [illegible]	16	[illegible]													
[illegible]	[illegible]	5 a 12	7½	Puntal	56	7		—	[illegible]	[illegible]	477	[illegible]			[illegible]		
[illegible]	[illegible]	1 a 12	7	"	132	12		—	[illegible]	4612	750	[illegible]	24½	1651=	1½		
[illegible]	[illegible]	5½ a 12	2	Paraxo	[illegible]	[illegible]	3	—	[illegible]	[illegible]	201	904.50			[illegible]		
[illegible]	[illegible]	12 a 7	5	auto	55	7		[illegible]	[illegible]	5656	725	[illegible]	43½	847=	7		
[illegible]	[illegible]	5½ a 12	3	"	33	7½		—	6610	6289	321	1166=			6½		
[illegible]	[illegible]	12 a 2	2	auto	55	8		[illegible]	[illegible]	[illegible]	651	[illegible]	42½	[illegible]	[illegible]		
"	"	2 a 11½	10	Paraxo	170	17½		[illegible]	[illegible]	7243	1316	[illegible]			—		
[illegible]	[illegible]	[illegible]	6	auto	66	8		—	9463	[illegible]	742	[illegible]	13½	1435=	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	66	[illegible]		1½	[illegible]	[illegible]	130	[illegible]	[illegible]	[illegible]	8		
"	"	5½ a 12	7	[illegible]	[illegible]	[illegible]		—	[illegible]	[illegible]	669	[illegible]			[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]		—	[illegible]	[illegible]	1051	[illegible]	66½	1265=	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		—	[illegible]	1914	509	[illegible]			[illegible]		
[illegible]	[illegible]	[illegible]	10	[illegible]	90	[illegible]		—	[illegible]	[illegible]	[illegible]	[illegible]	59½	[illegible]	[illegible]		
												37[illegible]		8410=	3210=		

Exhibit 1.7

Taxi Odometer and Fuel Log

No. 29

Nombre: Guillermo Granados Hidalgo

Dueño

Placa: SJP 365

ESTIMADO SEÑOR: POR FAVOR ANOTE CADA VEZ QUE CARGA COMBUSTIBLE, DURANTE EL PERIODO DE 16 DIC 85 AL 31 DIC 85.

INDICAR CANTIDAD DE COMBUSTIBLE EN EL TANQUE AL INICIAR EL REGISTRO

Reserva /_/ ; 1/4 /_/ ; 1/2 /_/ ; 3/4 /_/

Fecha de compra de combustible	Lectura del odómetro		Gasto de combustible	
	inicio	final	ℓ	litros
16/12				
17/12				
18/12				
19/12				
20/12				
21/12				
22/12				
23/12				
24/12				
25/12				
26/12				
27/12				
28/12				
29/12				
30/12				
31/12				
Ejemplo → 16/12	30312	30581	468	6.5

INDICAR CANTIDAD DE COMBUSTIBLE EN EL TANQUE AL FINALIZAR EL REGISTRO

Reserva /_/ ; 1/4 /_/ ; 1/2 /_/ ; 3/4 /_/

CUALQUIER DUDA QUE USTED TENGA, LLAMAR AL:

TELEFONO: 33-19-55 Dirección Sectorial de Energía

CON : Ing. Antony Araya ó Ing. Alexandra Hernández

ORNL. The software configuration was NWA STATPAK, using SELECT for data definition file creation and MLINREG (interactive) for linear regression analysis. The data were processed at the end of the four-week period composing Part 1 of the demonstration (without driver training and incentive), and following the completion of Part 2 (with driver training and incentive).

The detailed work flow for data processing and analysis is set forth in Appendix G (bus) and Appendix H (taxi).

Time Plan

The original project plan called for four groups of activities to be performed in sequence: (1) preparation for the demonstrations; (2) bus and taxi demonstrations in parallel; (3) data analysis; and (4) public information campaign. When the project start was delayed from July 22 to August 19, all activities had to be telescoped into a shorter time period, since the project still had to be completed by year end.

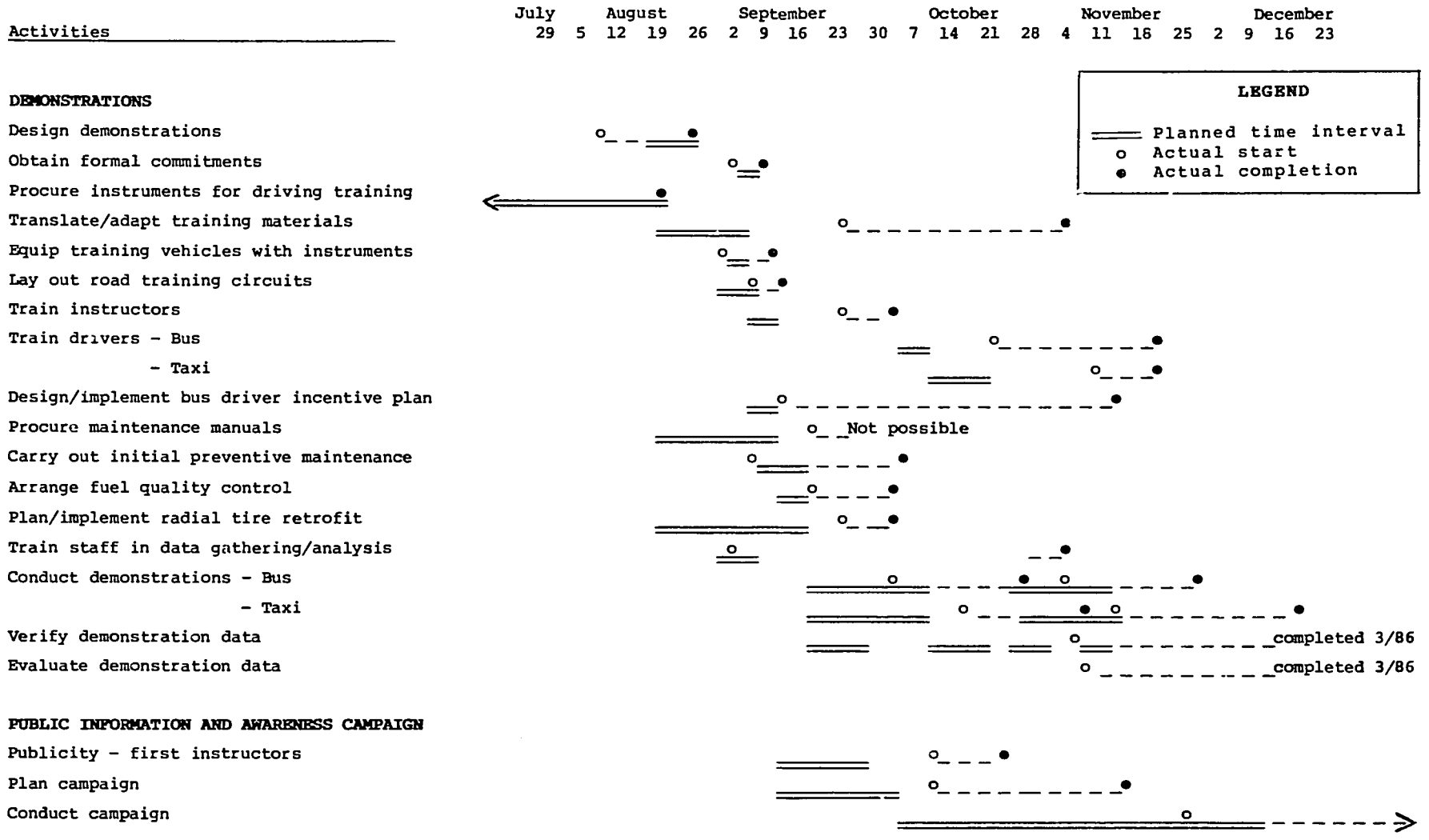
The project milestones are listed in Exhibit 1.8, with their original and revised target dates, together with the actual completion dates.

The three major departures from the original plan were that (1) bus and taxi demonstrations were staggered, 2) the demonstrations overlapped the public information campaign, and (3) data evaluation and public information activities continued into 1986. The slippage and the rearrangement of activities can be seen clearly in the project activity schedule, Exhibit 1.9, which indicates the actual course of events compared with the revised plan.

Exhibit 1.8
Project Milestones

Activity	Plan	Revised Plan	Actual
Train Costa Rican instructor in U.S.	Aug 9	Aug 9	Aug 9
Design demonstrations	Aug 16	Aug 26	Aug 20
Start in-country work	Jul 22	Aug 19	Aug 19
Obtain commitments from bus and taxi fleets		Aug 30	Sep 9
Complete initial maintenance	Sep 6	Sep 6	Oct 5
Install filters on fuel islands	Aug 23	Sep 6	Sep 11
Fit radial tires	Aug 23	Sep 6	Oct 3
Start demonstration - bus	Aug 19	Sep 9	Sep 30
- taxi	Aug 19	Sep 9	Oct 14
Train instructors	Aug 5	Sep 20	Oct 2
Train drivers - bus	Aug 16	Oct 18	Oct 22
- taxi	Aug 16	Oct 18	Nov 21
Apply incentives - bus	Aug 19	Sep 9	Nov 18
- taxi	Aug 19	Sep 9	cancelled
Complete demonstration - bus	Oct 13	Nov 15	Dec 1
- taxi	Oct 13	Nov 15	Dec 15
Calculate demonstration results		Nov 22	Mar 13
Plan public information campaign		Sep 13	Nov 15
Hold seminar for fleet operators	Dec 2		Dec 4
Disseminate demonstration results	Nov 22	Nov 29	
Disseminate brochures		Oct 4	

Exhibit 1.9
Project Activity Schedule - Revised Plan and Actual



Source: Hagler, Bailly & Company

2 BUS DEMONSTRATION PROGRAM

The bus demonstration program sought to produce credible results that would attract the interest of the entire bus sector and prompt replication of the demonstrated fuel reduction measures. To this end, certain criteria guided the selection of the bus company in which the demonstration would take place. The fleet had to be engaged in urban service, with a mix of vehicles (makes and ages) and routes that were representative of most Costa Rican bus operations. Since 27 percent of the country's buses operate in Metropolitan San Jose, the fleet had to operate in this area.

Beyond this, the fleet had to be large enough to provide a demonstration fleet of 24 vehicles. Finally, to facilitate coordination and control of maintenance and fueling, the company would preferably have maintenance shops and a fueling station on its premises.

The National Chamber of Transport presented three affiliated bus companies as candidates for the energy conservation demonstration, and they were inspected by the project staff. Empresa Guadalupe Ltda. was selected because its fleet of 41 vehicles covered six makes and eight model years. The other fleets, in contrast, were made up of Pegaso (Spain) buses only, which were mainly 1981 models.

DESCRIPTION OF THE SELECTED ENTERPRISE

Empresa Guadalupe Ltda. is located in the suburb Guadalupe, on the outskirts of San Jose, and operates five radial routes connecting Guadalupe and contiguous areas with downtown San Jose. Its facilities comprise administrative offices, a conference room, a cashier's office, a tire service shop, a lubrication garage, several maintenance sheds, parts and supply stores, and a large open parking area.

The company is an association of 21 bus operators who own, operate and maintain their vehicles individually. (The typical operator owns one bus.) The fleet composition is shown in Exhibit 2.1. Since the company qualifies as a cooperative enterprise, it is eligible for certain tax waivers and subsidies. For example, TRANSMESA, a

Exhibit 2.1

Composition of Bus Fleet

No. of Units	Make	Year Acquired
9	Mercedes-Benz	1981
2	Mercedes-Benz	1978
9	Leyland	1981
7	Pegaso	1981
4	Pegaso	1978
1	Pegaso	1975
1	Pegaso	1974
1	Isuzu	1981
1	GMC	1978
1	IHC	1977
2	IHC	1974
1	IHC	1970
2	IHC	1969
41	Total	

Source: Empresa Guadalupe Ltda.

government agency, purchases buses and resells them to cooperatives at a third of their import cost to subsidize bus service.

Routes, service levels, and fares are regulated by MOPT. (A representative fare is 3.75 colones, equivalent to seven U.S. cents.) The company assigns routes and schedules to its members on a rotating basis on a bi-weekly cycle. The buses operate on two shifts, commonly from 5:00 a.m. to noon, and from noon to 11:00 p.m., with half of the buses idle, in turn, on Saturday and Sunday. The route most frequently travelled, El Alto, is 11 kilometers long (round trip).

Apart from overseeing operations, including dispatching, Empresa Guadalupe furnishes its members with accounting, financial, insurance, and legal services, grouped purchases and an interface with regulating authorities on such matters as route concessions, fares, and bus procurement. Maintenance and fueling services are also provided, and are invoiced to users.

CORRECT MAINTENANCE

The level of preventive maintenance practiced by Empresa Guadalupe was minimal, consisting mainly of lubricant and filter changes (see Exhibit 2.2). The potential for improving fuel efficiency by upgrading maintenance thus appeared to be good. To realize this potential, project management decided to specify those aspects of bus maintenance that influence fuel efficiency directly, and apply them to half of the demonstration fleet.

The maintenance points closely linked to fuel consumption are:

- Alignment of front wheels
- Lubrication of wheel bearings
- Adjustment of diesel fuel pump and injectors
- Timely replacement of air, oil, and fuel filters
- Draining of fuel tank
- Changing of engine oil
- Lubrication of chassis
- Maintenance of correct tire pressure.

The next task was to assemble the resources needed to carry out an adequate maintenance program for the purpose of the demonstration. Empresa Guadalupe furnished facilities

Exhibit 2.2

View of Bus Lubrication Shop

that could provide all the services but wheel alignment and fuel injection system work. The company's facilities are described in Appendix I. A major shortcoming was the absence of maintenance manuals for each type of bus. Extensive efforts over several months to obtain them were unsuccessful.

The company's maintenance staff consisted mainly of a full-time lubrication specialist who changed engine oil and all types of filters, performed chassis lubrication, reported fairly obvious mechanical deficiencies, and maintained records of work performed on each bus. A full-time tire mechanic changed and repaired tires, and maintained tire pressure upon request from drivers. In addition, there were four general mechanics who worked on their own accounts, selling their services directly to the individual bus owners and maintaining no records by bus. The initial maintenance upgrading activities for the project were carried out by the two full-time employees, as well as by up to three mechanics hired by the project on an occasional basis.

Since the maintenance shops of Empresa Guadalupe were not equipped to perform all the tasks required for the project, they were supplemented by outside private sector shops that brought suitable equipment and skills to the project. For example, front end checks and wheel alignment were carried out by Quiros y Cia., a leading tire dealer and retreading shop, that granted a 25 percent discount on its alignment services. Servicing of fuel systems was provided by Madisa, the Bosch agency. Madisa performed a free diagnosis on every vehicle and granted a special tariff on all subsequent diesel fuel pump and injector repair work.

All maintenance actions relating to the demonstration were controlled by means of specially designed forms. The form used to record initial maintenance actions taken to bring the vehicles up to the desired standard is shown in Exhibit 2.3. Several of the measures listed were already being performed on a routine basis (change of oil and filters, and lubrication), while others were completely neglected (fuel tank drainage and coolant temperature check). The form used to plan and control continuing maintenance actions required to keep the vehicle in its desired condition throughout the course of the demonstration is shown in Exhibit 2.4.

To ensure correct maintenance of air filters, monitors (downstream vacuum sensors) were installed in all 12 buses

Exhibit 2.3

Initial Maintenance Record (Bus and Taxi)

DIRECCION SECTORIAL DE ENERGIA

REVISION DE MANTENIMIENTO

☐ BUS ☐ TAXI

NO. VEHICULO	PLACA	MARCA	AÑO

TRABAJOS A REALIZAR	FRECUENCIA*	FECHA	FIRMA	RESULTADOS Y OBSERVACIONES
1) CONTROL VISUAL DEL VEHICULO				
2) OBSERVACIONES CONDUCTOR				
3) CONTROL ROLES Y DIRECCION				
4) ALINEAMIENTO				
5) REVISION SISTEMA INYECCION				
6) ARREGLO SISTEMA INYECCION				
7) CAMBIO FILTRO AIRE				
8) MEDIDOR PRESION-FILTRO AIRE				
9) CAMBIO FILTRO COMBUSTIBLE				
10) CAMBIO PREFILTRO COMBUSTIBLE				
11) DRENAJE TANQUE COMBUSTIBLE				
12) CAMBIO ACEITE				
13) CAMBIO FILTRO ACEITE				
14) ENGRASE				
15) REVISION SISTEMA ENFRIAMIENTO				
16) AJUSTE FRENOS				
17) PRESION LLANTAS				

* A= Anual M= Mensual T= Trimestral D= Diario

Exhibit 2.4

Continuing Maintenance Record (Bus)

[X] BUS [ ] TAXI

VEHICULO No.:

VEHICULO PLACA:

DIRECCION SECTORIAL DE ENERGIA

REVISION DE MANTENIMIENTO

	OCTUBRE				NOVIEMBRE				DICIEMBRE			
	6	13	20	27	3	10	17	24	1	8	15	22
CONTROL ROLES Y DIRECCION	●	●	●	●	●	●	●	●	●	●	●	
ALINEAMIENTO	●						●					
REVISION SISTEMA INYECCION	●						●					
CAMBIO FILTRO AIRE	●											
SOPLAR FILTRO AIRE	●						●					
CAMBIO FILTRO DIESEL	●											
CAMBIO ACEITE Y FILTRO	●				●				●			
ENGRASE	●				●		●		●			
REVISION TEMP. ENFRIAMIENTO	●						●					
AJUSTE FRENOS	●						●					
PRESION LLANTAS	●	●	●	●	●	●	●	●	●	●	●	

designated for upgraded maintenance. The devices, which were fitted on the instrument panel, provided the driver with a clear indication of filter condition and signalled the need for a filter change.

The scheduling of buses through the outside shops and follow-up of compliance on the part of the buses proved to be one of the most time-consuming and onerous tasks in the maintenance activities. The reasons were the limited availability of buses as a result of operating demands, and the lack of adequate in-house coordination.

Maintenance costs were borne largely by the bus owners. At the outset, a cost-sharing principle was established: The cost of all preventive maintenance work beyond that customarily undertaken by the bus owners would be borne by the project. Similarly, the cost of corrective work arising from diagnoses would be borne by the bus owners, except for work that they normally would have deferred. In the latter case, the sharing of costs was negotiated on a case-by-case basis.

RADIAL TIRES

The substitution of radial tires for bias ply tires is an established technique for increasing fuel efficiency, although the suitability of radials for the under-maintained Costa Rican road network is a subject of some controversy. In any event, the extra cost of radial tires is generally difficult to justify on the basis of fuel savings alone. In practice, their use is justified on the grounds of a longer useful life, including retreading.

Nevertheless, the fuel savings aspect was of great interest to the project, and was demonstrated by operating 12 buses of the demonstration fleet with radial tires, and 12 with bias ply tires. Following random selection of the two groups and examination of their tire makeup, it emerged that nearly all buses had a surprising mix of tires. Typically, the buses were fitted with two radial tires on the front axle and four conventional tires on the rear axle. Most buses used 9.00" x 20" tires, while some had 10.00" x 20" tires on the front axle only. This situation resulted in a complex tire-switching exercise, but the need to procure additional tires was reduced substantially because many bus owners had a reserve stock of various types. In the end 21 new radial tires were purchased, and it was agreed that the cost difference between the radial tires

and equivalent bias ply tires would be borne by the project. This cost was negotiated at a uniform 1,500 colones ($29) per tire.

Since the sole domestic tire maker, Industria Firestone, does not manufacture radial tires in heavy duty sizes, it was necessary to buy imported tires. The bus company elected to divide purchases equally between two suppliers, both of which provided tires of Japanese origin at favorable prices and with special import tax exemptions.

INSTRUCTOR TRAINING

Because improved driving practices can reduce fuel use by up to 12 percent,* project management thought it desirable to establish an in-country capability for teaching energy-efficient driving techniques. To this end, four Costa Ricans were given DECAT bus instructor training. A key feature of DECAT training is in-vehicle practice, with a feedback device to inform the driver promptly of the effect of his driving on fuel efficiency. The techniques taught include good acceleration habits, conservation of momentum, limiting speed, avoidance of high engine speeds, minimizing idling, and correct cornering, cruising and hill climbing.

One Costa Rican instructor, who is currently a road safety instructor with MOPT, received training at the DOE-DECAT Training Center in Las Vegas, Nevada (see Appendix C), and upon returning to Costa Rica joined the project staff on a part-time basis. He first adapted the DECAT course narrative and audio-visual materials to the local context, and then trained four instructors in fuel-efficient bus driving techniques. The instructor trainees came from MOPT, TRANSMESA, Empresa Guadalupe Ltda., and the National Chamber of Transport.

The 2-1/2 day course was given in a classroom of the Road Safety Directorate, MOPT and on a specially-designed 6.75 kilometer road training loop that was laid out on a section of the San Jose belt road. A diagram of the road circuit is shown in Exhibit 2.5. The training vehicle was a 1977 model IHC bus from the Empresa Guadalupe fleet, fitted with the driver feedback instrument shown in Exhibit 2.6. The bus instructor training was carried out September 24-

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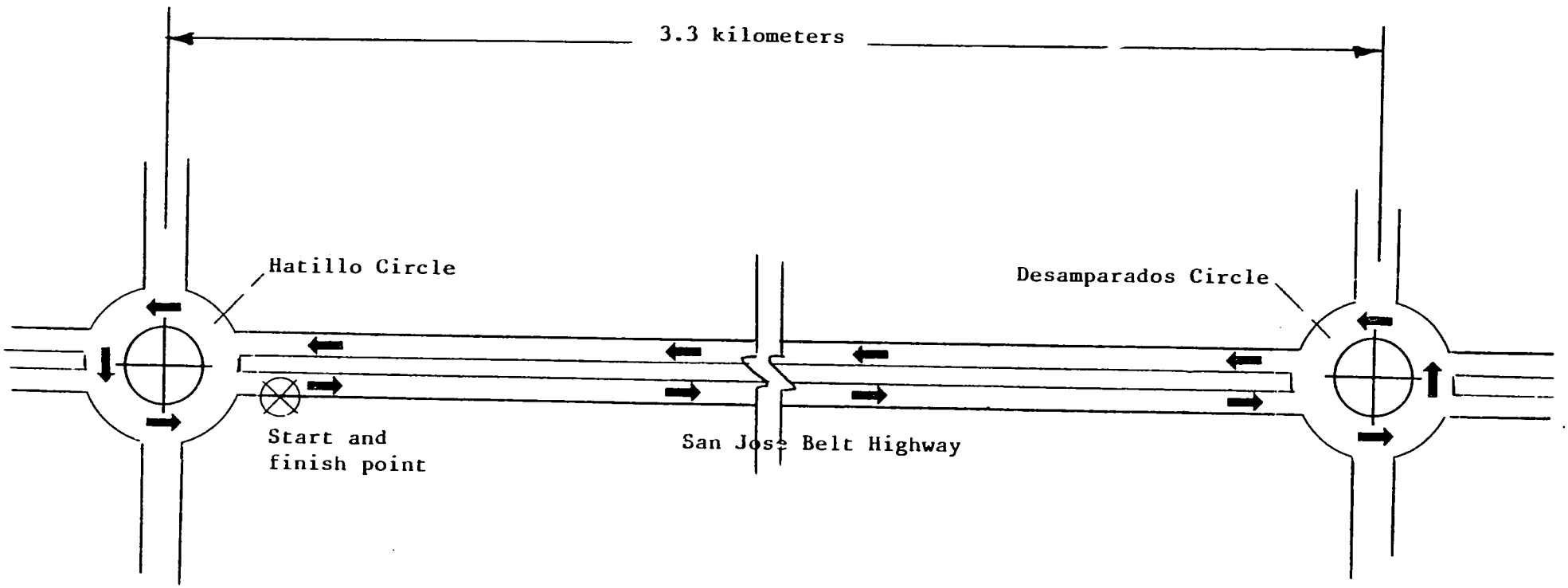
* DECAT - Review and Recommendations.

Exhibit 2.5

Driver Training Road Circuit



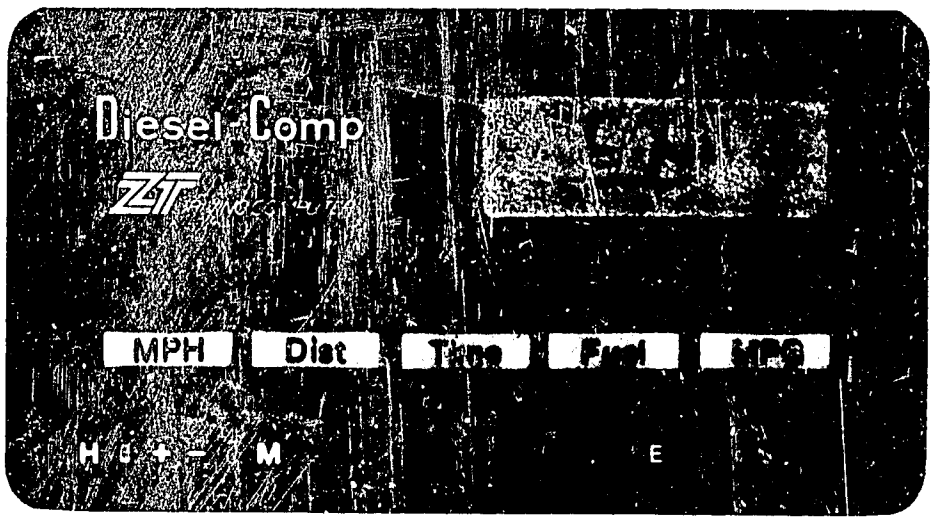
Length of training loop: 6.75 kilometers

Driving time: 7.8 minutes (approximate)

Driving Computer

Diesel-Comp™ ZT4-A

DRIVING COMPUTER



Display showing average MPG to nearest tenth gallon
ACTUAL SIZE

ZT4-A
DISPLAY FEATURES

- **INSTANT MPG** — saves fuel by showing the driver when vehicle is achieving the maximum MPG.
- **AVERAGE MPG** — averages MPG for the entire trip. Also shows instant average MPG.
- **FUEL USED** — shows fuel used - just push button.
- **INSTANT MPH** — an easy-to-read digital display; also reads in Metric.
- **ENUNCIATOR LAMPS** — shows function being displayed.
- **COMPATIBLE** — with mechanical and electronic speedometers.
- **CALIBRATION KEYS** — used to fine-tune clock, distance and fuel readings.
- **TIME** — quartz crystal timing.
- **DISTANCE** — shows distance travelled and distance since fillup.
- **AUTOMATIC CONVERSION** — to Metric or Imperial gallons
- **TRIP ODOMETER** — gives accurate distance travelled, useful for state tax and/or revenue mileage and is easy to reset.
- **MEETS** — all diesel engine manufacturers requirements.

26, and certificates were presented to all trainees in a formal ceremony at the end of the course.

DRIVER TRAINING

Using a Costa Rican adaptation of the DECAT course, all 44 drivers of the demonstration bus fleet were trained in fuel-efficient driving techniques. The one-day training cycle provided more classroom training and more practical training than the half day cycle generally used in the United States. The training was programmed as follows:

Morning	1.	Slides accompanied by narrative
Afternoon	2.	Drive training circuit without -- then with -- fuel-efficient driving techniques. (All trainees in turn; two trips each)

The entire class rides along and observes.

The planned throughput was ten trainees per day, but owing to high absenteeism, this rate was not achieved. Consequently, it was necessary to extend the training period beyond the five days planned. Training actually lasted from October 31 to November 22.

As with the instructor training, classroom instruction was given in facilities of the Road Safety Directorate of MOPT, and practical instruction on the 6.75 kilometer public road circuit.

During the training, problems were encountered with the gearbox and the speed limit. A high-ratio gearbox had been retrofitted to the bus, and shifting of gears was very difficult for drivers not familiar with it. Unfortunately, no immediate solution for this problem was found. Also, by observing the speed limit of 40 km/hr (25 mph), which is the prevailing non-highway limit in Costa Rica, the bus had to operate in an inefficient range in terms of fuel consumption. For this reason, the project manager raised the speed limit to 60 km/hr (37.5 mph) for on-the-road training. Moreover, the higher speed is in keeping with actual driving practices in Costa Rica.

As in the case of the instructors, a formal graduation ceremony was held at the conclusion of the training, with the presentation of a certificate to each student driver.

DRIVER INCENTIVES

The bus company had already had some experience with driver incentives. However, none of the incentives was specifically aimed at fuel efficiency, and none had linked reward directly to performance on a continuing basis. Since the incentives had not produced a permanent effect, management was not enthusiastic about the subject. Nevertheless, the project staff felt that incentives were likely to be a necessary catalyst in stimulating drivers to apply DECAT techniques initially and on a continuing basis.

Against this background an incentive plan was designed, as set forth in Appendix J. Essentially, it entailed (1) determining the fuel savings attributable to driver comportment, and (2) sharing the savings with the driver on a progressive scale; i.e., the driver receives 35 percent of savings under 5 percent, 50 percent of savings between 5 and 10 percent, and 65 percent of savings over 10 percent.

A group of 12 buses was selected at random for the incentive treatment, and the agreement of their owners was sought and obtained. Because some of the buses were owner-operated on one of the two shifts, the incentives were applied, in fact, to only 17 hired drivers. The plan was then announced to all concerned parties by means of the letter reproduced in Appendix K.

The bus demonstration began on October 3 and was completed on December 1. Subsequently, another month's data were gathered, for use in verifying the results of the earlier analysis.

The organization of the taxi demonstration was governed by the same criteria that guided the bus demonstration: It was essential to provide credible results that would capture the attention of the entire taxi sector and lead to implementation of the measures demonstrated. Thus, project management sought a taxi enterprise located in San Jose, where some 68 percent of the nation's taxis operate. The fleet had to have a mix of vehicles resembling the national profile. And to facilitate the coordination and control of maintenance and fueling, maintenance and fueling facilities should be available on the company's premises.

UTC arranged introductions to three taxi cooperatives, all of which either had a high proportion of 1985 vehicles, or were in the process of renewing their fleets. A fourth cooperative, COOPETICO, however, still had an appreciable number of old taxis that could be kept in service during the demonstration period. Unfortunately, at the time of the selection, COOPETICO did not have in-house maintenance and fueling facilities, but project management believed this problem could be resolved by engaging the services of a service station located 200 meters from the taxi base. Thus, COOPETICO appeared to satisfy most of the requirements, and was selected for the demonstration.

DESCRIPTION OF THE SELECTED ENTERPRISE

COOPETICO R.L. is an association of 1,800 taxi owners and drivers. It covers some 700 taxis in metropolitan San Jose and 300 in the provinces, accounting for more than half of the 1,786 taxis in Costa Rica.

Most owners have one taxi that operates 24 hours a day on two shifts, one of which is driven by the owner, and the other by a hired driver (often a close relative) who is paid 30 percent of gross receipts. Some taxis operate on only one shift, in which case the owner is generally the sole driver.

COOPETICO's headquarters are located near downtown San Jose, and consist of administrative offices, two radio-dispatching stations, an automotive supply shop, and a

maintenance shop that was installed too late for use in the project. There are also several branch offices in other major cities throughout the country. A total of 40 people are employed in the headquarters and branches.

The company qualifies as a cooperative enterprise under legislation designed to promote such enterprises through tax waivers and subsidies. For example, COOPETICO procures new taxis for its members through TRANSMESA nearly free of duties and taxes, which amount to 400 percent of the cost of the vehicle.

CORRECT MAINTENANCE

The prospects for demonstrating the effect of good maintenance practices on the taxi fleet were influenced by two circumstances: (1) the fact that most of the fleet had recently been replaced with new vehicles (Exhibit 3.1), and (2) the lack of a maintenance organization in the company.

Although vehicles operating 300 to 400 kilometers per day quickly accumulate wear, few of COOPETICO's 1985.taxis had yet required fuel injection system servicing -- a critical area for diesel engines. For example, the five 1985 model taxis in the group selected for maintenance actions had the following odometer readings at the mid-point of the demonstration:

Make/Model	License Plate Number	Odometer Reading (Kilometers)
Toyota Cressida	550	97,024
Datsun Cedric	76	56,207
Toyota Cressida	273	43,802
Toyota Cressida	866	69,987
Toyota Cressida	365	39,615

Nevertheless, the significant fuel savings that can be realized by maintaining tire pressure at the upper limit and by keeping air filters in proper condition are independent of vehicle age and condition.

Because COOPETICO had no maintenance organization, maintenance management was left entirely to the individual owner-operators who make up the membership. In general, they wanted to protect their sizable investments in the

Exhibit 3.1

View of 1985 Model Taxis in Front of COOPETICO Headquarters

vehicles, and were eager to improve their maintenance practices. For the purposes of the demonstration, project management persuaded eight owners to use a single maintenance facility over which it could exercise some degree of control. Since most of the drivers customarily refueled at a service station located 200 meters from the cooperative's headquarters, that facility, Servicentro Aranjuez, was inspected and found to be adequate. Terms were negotiated with the owner, and the taxi owners agreed to use the service station for fueling and maintenance.

The maintenance actions relevant to fuel economy were determined and scheduled, and control forms were designed. The form used to record initial work performed to upgrade maintenance to an optimum level was identical to the form used for buses (Exhibit 2.3). The form used to maintain maintenance at the desired level throughout the demonstration is shown in Exhibit 3.2.

To ensure timely changing of air filters, monitors were installed on all eight taxis in the group selected for optimal maintenance treatment. The filter monitors were identical to those installed in the buses, and the cost of 1,349 colones ($26) per unit was shared equally by the project and the user.

Servicentro Aranjuez was not equipped to perform wheel alignment and fuel injection system servicing, so these services were provided in the same outside shops that were used in the bus demonstrations.

Owing to the lack of a central operations function at COOPETICO, the scheduling, expediting and follow-up of maintenance work was carried out by project staff. With eight taxi owners and three independent service facilities to coordinate, this administrative task was a formidable one. A fully responsible field coordinator would have been far more effective in controlling the timing and quality of maintenance work.

As in the bus demonstration, the cost of all maintenance work beyond that normally undertaken by the taxi owners was borne by the project. The most significant maintenance cost absorbed by the project was the labor cost of a taxi engine overhaul, which was 7,425 colones ($144). The need for this major work was revealed in the fuel system diagnosis, and the subsidy was negotiated to avoid withdrawal of the vehicle, and to keep a balance of old and new taxis in the demonstration fleet.

Exhibit 3.2

Continuing Maintenance Record (Taxi)

☐ BUS ☒ TAXI

VEH. No.

VEHICULO PLACA:

MARCA:

DIRECCION SECTORIAL DE ENERGIA

REVISION DE MANTENIMIENTO

	Noviembre		Diciembre				
	17	24	1	8	15	22	29
CONTROL ROLES Y DIRECCION	●	●	●	●	●	●	
ALINEAMIENTO	●						
REVISION SISTEMA INYECCION	●						
CAMBIO FILTRO AIRE	●						
SOPLAR FILTRO AIRE	●						
CAMBIO FILTRO DIESEL	●						
CAMBIO ACEITE Y FILTRO	●	●	●	●	●	●	
ENGRASE	●		●		●		
REVISION TEMP. ENFRIAMIENTO	●				●		
AJUSTE FRENOS	●				●		
PRESION LLANTAS	●	●	●	●	●	●	

RADIAL TIRES

In preparation for the radial tire demonstration, a survey of tire makeup was carried out. The survey revealed that radial tires had already gained widespread acceptance in the taxi fleet. Most taxis imported in 1985 were fitted with radial tires as original equipment, and when replacing a tire, the COOPETICO taxi owners tended to buy the same type.

Since most taxis in the group selected for the radial tire treatment already had radial tires, it was necessary to replace a number of them with bias ply tires to obtain the desired distribution of tire types. The taxi owners involved in the demonstration would normally not have bought bias ply tires, so 16 bias ply tires were bought with project funds. The tires were furnished by Industria Firestone at a 50 percent discount, which resulted in a net price of 1,347 colones ($26) per tire.

The tires were changed in the service station that had been selected for the maintenance operations.

INSTRUCTOR TRAINING

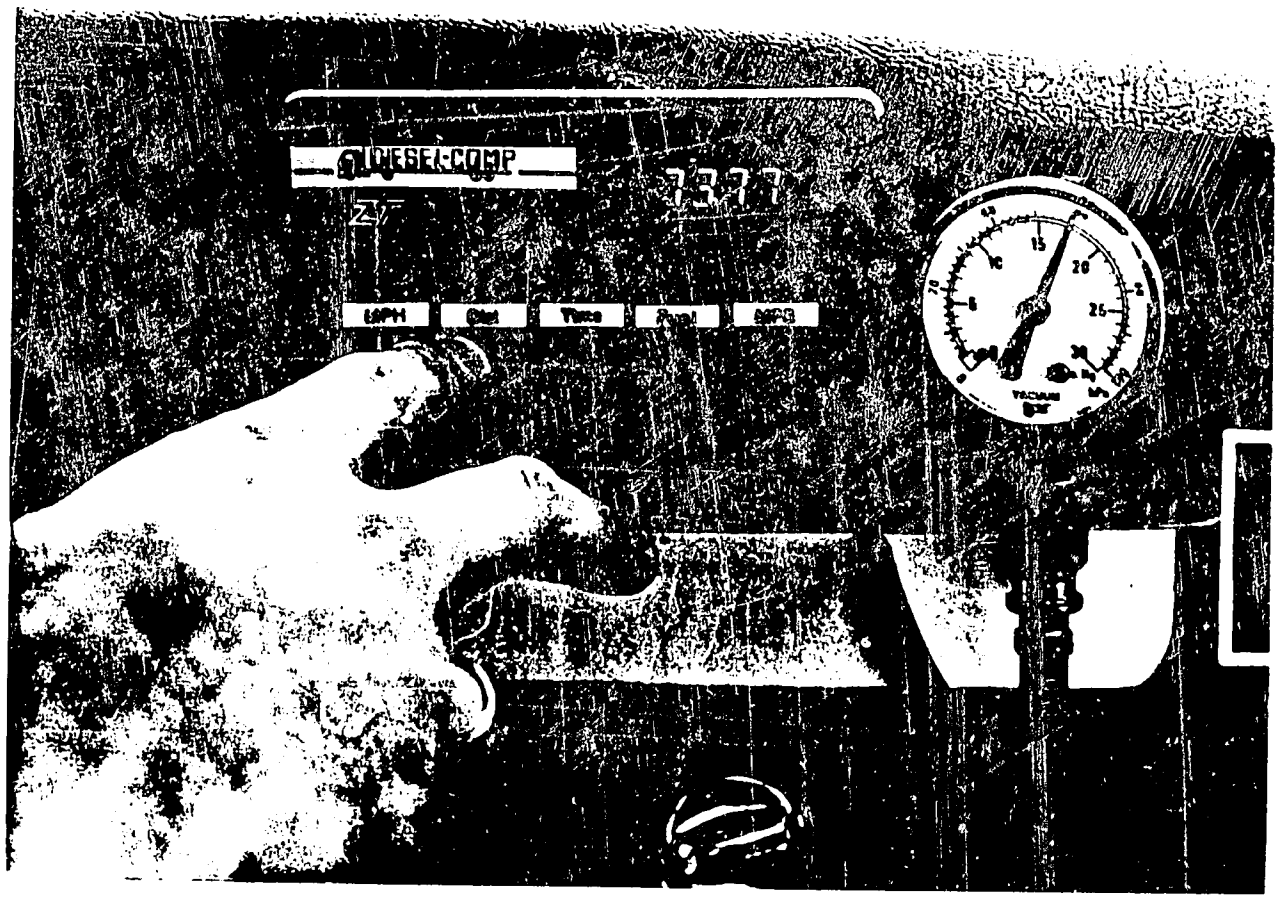
In view of the proven effectiveness of driver training as a fuel reduction measure, the project sought to establish an in-country capability for teaching energy-efficient driving in light vehicles. The approach employed in this endeavor closely paralleled that used in developing bus driving instructors, i.e., the Costa Rican instructor who had received DOE-DECAT training in the U.S. also adapted the curriculum and training materials to the Costa Rican environment and trained four instructors. The trainees were employees of two private taxi fleets (COOPEIRAZU AND COOPETICO), MOPT, and USAID/Costa Rica.

The light vehicle driving course used the same classroom and road training loop as the bus driving course. The training vehicle used was a gasoline-powered Jeep Wagoneer borrowed from the DSE fleet. It was fitted a driving computer and a carburetor vacuum gauge as illustrated in Exhibit 3.3. The light vehicle instructor training took place from September 30 to October 2.

At the conclusion of the training, certificates were presented to the graduating instructors in a formal ceremony.

Exhibit 3.3

View of Instruments in the
Driver Training Vehicle



DRIVER TRAINING

Most taxis are owner-driven, with a hired driver (often a close relative) on the second shift. Training in energy-efficient driving was given to all the drivers of the demonstration fleet of 16 vehicles -- a group of 27 taxi owners and hired drivers. The Costa Rican version of the DECAT light vehicle driver course was designed to fit a one-day training cycle, compared with the half day cycle used in the United States The training, in groups of five, was structured as follows:

Morning

1. Film: Running on Empty (Spanish sound track)
2. Slides accompanied by narrative

Afternoon

All trainees board training vehicle (Jeep Wagoneer)

3. Drive training loop without fuel efficient techniques. (All trainees in turn; one trip each.)
4. Drive training loop with fuel efficient techniques. (All trainees in turn; one trip each.)

The entire class rides along and observes.

Owing to absenteeism, the planned daily throughput of five trainees was not achieved; consequently, the training period was extended to run from November 11 to November 21. (Five days were originally allocated.) Again, classroom instruction was given in facilities of the Road Safety Directorate, MOPT and practical training was given on the 6.75 kilometer public road circuit used for all bus and taxi training previously described. Trainees were furnished reference data on the form shown in Exhibit 3.4, and their own results were recorded on the same form for comparison.

The principal problem that emerged in the course of the training was the low speed limit. While the fuel-efficient range of the Jeep Wagoneer is 56-72 kph (35-45 mph), the prevailing non-highway speed limit in Costa Rica is only 40 kph (24 mph). The solution adopted was to conduct all on-the-road training at a higher limit of 60 km/hr, which is, in fact, in keeping with actual local driving practice.

Exhibit 3.4

Student Driver Performance Form

TABLA DE DATOS

CURSO MANEJO EFICIENTE

	TIEMPO (min, seg)	CONSUMO (Lts)	KPH	KPL	KPG
1a. VUELTA					
2a. VUELTA					
PEOR VUELTA	7.57	1.16	50.94	5.82	22.02
MEJOR VUELTA	8.0 min.	0.87	50.63	7.76	29.37

DISTANCIA TOTAL: 6.75 Km.

All trainees were given a brochure summarizing the key points of the course, together with a course evaluation form, and the conclusion of the course was marked by a formal graduation ceremony, at which the drivers were given certificates as illustrated in Exhibit 3.5.

The taxi demonstration program started on October 14 and finished on December 15. An additional 16 days' data were gathered immediately afterward to serve as a backup. This proved to be a wise precaution, as much of the Part 2 data were not recorded by the drivers owing to a misunderstanding, and the backup data were used for analysis of results.

Exhibit 3.5

View of Presentation of Certificate
-- Taxi Driver Training

4 PUBLIC INFORMATION AND AWARENESS CAMPAIGN

The public information and awareness campaign, which was designed to disseminate information on the demonstrations and transportation fuel conservation to selected audiences, consisted of five parts:

1. Radio, television, and press coverage
2. Seminar for fleet operators
3. Special newspaper supplement
4. Reports of demonstrations and results
5. Brochures for operators of light vehicles, buses, and trucks.

A plan to produce a fuel efficiency guide for car buyers was abandoned on the advice of the MIEM legal counsel. According to the counsel, such a guide might be construed as recommending certain car models and could be challenged by some car distributors as undue intervention in competition.

The overall plan for the campaign is set forth in Exhibit 4.1. The plan was designed to fit the budget of $4,000 established for this component.

Owing to limited manpower and skills on the part of project staff, the mass media activities and seminar were largely planned and implemented by a publicity agency. The agency, Publicidad Contemporanea, had earlier designed a broader energy conservation campaign for RECOPE.

MASS MEDIA COVERAGE

The mass media campaign was launched on September 26 with the graduation of the driver training instructors, and continued through year-end. Coverage centered on the fuel-efficient driving courses, the seminar, and the demonstrations. The salient features were:

- Paid publication of press releases in four major newspapers. The strategy employed was to establish

Exhibit 4.1

Public Information and Awareness Campaign Plan

Date	Medium	Action or Material	Subject	Purpose	Audience	
					Description	Size
Sep 26/Oct 2	Press Radio	News report	Graduation of Instructors	Raise awareness	Driving public	150,000
Nov 21/Dec 2	Press Radio	News report	Graduation of Drivers	Raise awareness	Driving public	150,000
Dec 6 Dec	Press Press Radio Television	4 releases Interviews	Various Various	Raise awareness Raise awareness	Driving public Driving public	150,000 150,000
Dec 22	Press	Special supplement	Fuel Savings: A Source of Energy for Costa Rica	Raise awareness	Driving public	150,000
1986	Magazine	Article	Transportation Energy	Transfer technology	Engineers	
Dec 3-4	Training	2-Day seminar	Measure for Saving fuel	Transfer technology	Fleet operators	885
1986	Direct mail	Report	Bus Demonstration	Transfer technology Motivate	Bus companies Trucking companies	300 500
1986	Direct mail	Report	Taxi Demonstration	Transfer technology Motivate	Taxi companies Government and industrial fleets	25 60
1986	Direct mail	Brochure	Light Vehicle Fuel Conservation	Raise awareness Educate	Taxi companies Private car owners	25 150,000
1986	Direct mail	Brochure	Bus Fuel Conservation	Transfer technology	Bus companies	300
1986	Direct	Brochure	Truck Fuel Conservation	Transfer technology	Trucking companies	500

Source: Hagler, Bailly & Company

a relationship with the press through paid publication as a means of getting further coverage at no charge.

- Radio, television, and press interviews with project staff members, demonstration participants, and DSE officials.

Exhibit 4.2 shows the driving instructor giving a radio interview.

SEMINAR

A 2-day seminar entitled "Measures for Saving Fuel in Motor Vehicles" was given on December 3-4 at a hotel on the outskirts of San Jose, following the program shown in Exhibit 4.3. Speakers were recruited largely from suppliers who were participating in the project, and admission was free. Exhibit 4.4 shows the seminar in progress.

The target audiences, on a national scale, were:

24	taxi companies
300	bus companies
500	trucking companies
60	large motor vehicle fleet operators (public and private sector)

Owing to a time constraint, all invitations (over 100) were extended by telephone, and 55 people attended:

4	taxi operators
12	bus operators
1	trucker
14	public-sector fleet operators
2	private-sector fleet operators
6	MOPT officials
3	RECOPE officials
2	academic officials
10	suppliers
1	consultant to the National Chamber of Transport

Media coverage consisted of:

4	newspapers
3	radio stations
3	television channels

Exhibit 4.2

View of Driving Instructor Giving a Radio Interview

Exhibit 4.3

Seminar Program

SEMINAR
FUEL CONSERVATION MEASURES IN MOTOR VEHICLES

FIRST DAY

Time	Subject	Speaker
8:00-8:30 am	Opening address	Ing. JORGE MONGE, Vice Minister of Industry, Energy and Mines
8:30-10:00 am	Radial tires for light vehicles (characteristics, advantages); tire pressure Discussion	Mario Crespo (Industria Firestone)
10:00-10:15 am	Coffee	
10:15-12:00 pm	Wheel alignment, radial tires for trucks and buses; engine tune-up Discussion	Guillermo Solano (Quiros y Cia.) Guido Salas Vargas (Colegio Vocacional Monsenor Sanabria)
12:00-1:00 pm	Lunch	
1:00-2:30 pm	Fuel injection systems and their maintenance Discussion	Teodoro Blum (MADISA)
2:30-2:45 pm	Coffee	
2:45-4:15 pm	Air, fuel and oil filters and their maintenance Discussion	Ing. Jose Duque (Fleetguard, Inc.)

SECOND DAY

Time	Subject	Speaker
8:00-9:30 am	Preventive maintenance Discussion	Ing. Victor H. Ramirez (Transmesa)
9:30-10:00 am	Types of oil and how to select them	Ing. Martin Alpizar (Servicios Unidos)
10:00-10:15 am	Coffee	
10:15-11:00 am	Types of oil (continued) Discussion	Eduardo Armijo Caraval (Lubricantes Sinteticos de C.A.S.A.)
11:00-12:00 pm	Diesel fuel quality; effect of poor service stations Discussion	Gonzalo Alpizar (RECOPE)
12:00-1:00 pm	Lunch	
1:00-2:30 pm	Fuel efficient driving Discussion	Rodrigo Munguia (MOPT, Road Safety)
2:30-2:45 pm	Coffee	
2:45-4:15 pm	The demonstration project Discussion	Ing. Antony Araya (DSE)
4:15-4:30 pm	Closing address	Dr. Jorge Blanco (DSE)
4:30-5:00 pm	Awarding of certificates	Lic. Ana Lorena Leon (DSE)

Exhibit 4.4

View of Seminar in Progress

The cost of the seminar was heavily subsidized by a local donor.

SPECIAL NEWSPAPER SUPPLEMENT

An eight-page supplement to the Sunday edition of a leading nationwide newspaper was prepared and published on 22 December (See Exhibit 4.5). It was entitled "Fuel Conservation: A Source of Energy for Costa Rica" and included articles on various aspects of fuel conservation as well as testimonial interviews with two beneficiaries of the demonstrations -- a taxi driver and the manager of the bus company that provided the demonstration fleet (See Exhibit 4.6). The supplement was written and illustrated in a style designed to attract a broad audience, and its cost was largely covered by subscriptions from 17 companies offering fuel economy products and services.

Subsequently, DSE mailed copies of the supplement to all major fleet operations in the country.

FURTHER ACTIONS

Since the campaign was not completed at year-end as planned, DSE is carrying out the remaining activities during this year.

Demonstration Reports

Technical reports on the bus and taxi demonstrations will be prepared and distributed to all bus and taxi fleets through the National Chamber of Transport and COTRACOOP (for buses), UTC (for taxis) and direct mail.

Brochures

Three brochures aimed at light vehicle operators, bus operators, and truckers have been written by the project staff, based on material produced and distributed in the United States. Owing to the small print run, offset and photocopy reproduction will be used.

Exhibit 4.5
Cover Page of Newspaper Supplement

AHORRO DE COMBUSTIBLE : UNA FUENTE DE ENERGIA PARA COSTA RICA

La aplicación de medidas de ahorro en autobuses disminuyó drásticamente su consumo de combustibles.

Pruebas similares en taxis produjeron un ahorro de combustible de más del 20%.

Ministerio de Industria, Energía y Minas

DIRECCION SECTORIAL DE ENERGIA

Exhibit 4.6
Testimonial Interviews in Newspaper Supplement

Roberto Soto:

El buen manejo ahorra dinero

Sr. Roberto Soto: "...todos tenemos mucho que aprender".

Para Roberto Soto, un veterano taxista josefino, fue increíble descubrir tras estar casi tres décadas detrás de un volante, que la mala forma de conducir produce grandes pérdidas de combustible.

Mejor conocido como "Mister Robert", Soto trabaja como taxista desde 1958 y durante su larga carrera ha procurado ser prudente y experto.

Sin embargo, tras asistir al curso sobre técnicas de manejo eficiente, organizado por la Dirección Sectorial de Energía (DSE), afirmó que ahora se considera un chofer más profesional.

"A menudo uno cree que no se equivoca, sobre todo cuando lleva 27 años de conducir vehículos de transporte público. Pero uno sí se equivoca y este curso me lo demostró, pero lo más importante es que aprendí cómo corregir los errores.

De pronto te encuentras en un ejercicio práctico y comparas tus índices de consumo de combustible con el de otros taxistas, y te percatas de que la manera como se conduce un auto determina el mayor o menor consumo de combustible", explica Roberto Soto.

La edad y la experiencia adquirida empíricamente no son obstáculo para aprender, según Soto, quien agrega: "mientras más viejos nos hacemos más difícil nos parece aprender nuevas ideas, pero eso no ocurre en campos como el del ahorro, donde todos tenemos mucho que aprender".

Como otros 24 taxistas de la empresa Coopetico, con quienes comparte su experiencia, además de conducir su propio vehículo, "Mister Robert" ha comprendido que el ahorro y el mantenimiento preventivo son vitales para obtener una alta rentabilidad en su labor diaria.

"Ahora busco el rendimiento en el manejo. Arranco menos el carro y acelero menos, entre otras medidas correctivas. Sé que siguiendo los consejos de los técnicos gano yo, mi cooperativa y el país".

Esta opinión se ha generalizado a los demás taxistas que, como Roberto Soto, participaron en el curso de la DSE y para quienes muchos viejos mitos sobre el ahorro de combustible y el mantenimiento de sus autos han desaparecido.

William Morales:

Ahorrar significa progresar

Sin ahorro de combustibles y mantenimiento preventivo el transporte público no progresará, afirmó el gerente y copropietario de la empresa de buses Guadalupe Ltda., William Morales Chinchilla. 48 de los conductores de sus buses participaron recientemente en el primer curso de manejo eficiente impartido en el país y patrocinado por la Dirección Sectorial de Energía (DSE). Durante varios días recibieron lecciones teóricas y prácticas.

Los resultados de la demostración, comentó Morales, "fueron espectaculares en términos de ahorro de combustibles y funcionamiento de equipo, comparando los dos grupos de buses. Los que siguieron las sugerencias de los técnicos dieron un rendimiento excelente".

Según el empresario de buses, "muchos de los conductores consideraban antes del curso que manejar un vehículo de transporte público consistía en sentarse ante el volante, sin ton ni son".

"Hoy por hoy comprenden que si ahorran y dan un buen mantenimiento a las unidades ganamos todos. De hecho hay, por ejemplo, una mayor preocupación de ellos por evitar los arranques bruscos o de tomar las curvas a alta velocidad", comentó Morales.

La empresa guadalupana inició los trámites para adquirir llantas radiales que, como se demostró economizan muchos colones.

Hay aspectos, dijo Morales, que a pesar de llevar muchos años en la actividad del transporte, "uno sigue ignorando", por lo que esta demostración es considerada trascendente.

Actualmente la firma de transporte, fundada hace 25 años, ha iniciado un proceso de modernización, acentuado en el último bienio, que implica que funcione como un todo, con una sola administración, con sus propios talleres y bombas de servicio de combustibles, y concesiones manejadas por una sola empresa.

Modernización

En opinión de Morales, la empresa de transporte ha hecho un gran esfuerzo para ponerse a la altura de las necesidades del país, a las que el proyecto contribuye, aportando conocimientos, experiencias y un asesoramiento indispensable para ofrecer un mejor servicio al usuario.

Guadalupe Limitada administra cinco líneas, con cuarenta buses, ochenta choferes, diez chequeadores y personal de mantenimiento, que suman 120 trabajadores, interesados en aprender y mejorar en su campo de trabajo, apuntó Morales.

Para él, aplicar algunos consejos muy útiles derivados del proyecto implica una erogación importante, un sacrificio económico, que "no obstante debe hacerse", pero que devuelve con creces lo gastado.

Sr. William Morales: "Los resultados fueron espectaculares en términos de ahorro..."

"Hemos comprendido también que el ahorro en nuestras operaciones debe reflejarse en un estímulo económico para el conductor que es más eficiente con su combustible y su vehículo. Las cosas funcionan bien si estamos juntos y sabemos cómo hacer las cosas bien", concluyó el empresario.

The brochures will be distributed as follows:

Light vehicle brochure	Via UTC, motor vehicle tax/insurance offices, and direct mail.
Bus brochure	Via National Chamber of Transport, COTRACOOP, and direct mail.
Truck brochure	Via UNITRACSA, National Chamber of Transport, and direct mail.

The motor vehicle tax/insurance offices provide a convenient and effective channel for reaching all private vehicle operators, as all car owners must visit these offices annually to pay their fees.

Both the bus and taxi demonstrations registered significant fuel savings, despite the setbacks encountered. The maintenance and driver training activities yielded significant gains in fuel efficiency, which testifies to their value as fuel conservation measures. Driver incentives and radial tires had little apparent impact, largely because of spotty implementation. The use of adequate manpower to ensure tight control of the measures implementated would have increased savings substantially.

BUS DEMONSTRATION

The demonstration data were evaluated by ORNL using two linear regression models that are shown in Appendix G. The first analysis was based on the specific fuel consumption (liters/100 km) parameter, and the second on the logarithm of the parameter. For the two approaches, the fuel savings attributable to each measure were:

Variable	Model No.1	Model No.2	
1. Proper maintenance	6.5%	6.0%	
2. Driver training	4.2%	4.1%	
3. Driver incentives	1.2%	1.0%	not statistically significant
4. Radial tires	(1.8)%	(1.7%)	negative
Combined effect of:			
All variables	9.9%	9.1%	(excludes radial tires)
Statistically significant variables only	8.8%	8.3%	

The combined savings were calculated as in the following example:

$$100 - (1 - .065)(1 - .042)(1 - .012)(1 + .018)100 = 9.9\%$$

Neither analytical approach can be said to be more accurate than the other, so overall savings must be cited as a range -- between 8.3 and 9.9 percent.

The driver training results, which were at the low end of the normal range of savings, were no doubt depressed significantly by the difficulties that trainees encountered with the unfamiliar high-ratio gear box and low speed limit. Also, driver training was completed only 10 days before the end of the demonstration, which reduced the impact of this measure.

The maintenance gain -- also at the low end of the expected savings range -- is probably understated. As the in-house mechanics' awareness and knowledge grew, it is likely that they improved their practices for all buses indiscriminately, inadvertently reducing the fuel efficiency gap between the 12 buses with energy-efficient maintenance treatment and the control (benchmark) group.

In addition, it is possible that the maintenance savings could have been increased substantially by tighter control of tire pressures.

The increased fuel consumption in vehicles with radial tires is surprising since -- all other conditions being equal -- their rolling friction could not exceed that of bias ply tires. While this result is probably valid, it may be attributable to factors other than the radial tires.

TAXI DEMONSTRATION

ORNL also applied two linear regression models to the taxi demonstration data (see Appendix H), and obtained the following savings:

Variable	Model No.1	Model No.2	
1. Proper maintenance	1.8%	1.6%	not statistically significant
2. Driver training	15.1%	13.4%	
3. Radial tires	0.2%	-	not statistically significant
Combined effect of:			
All variables	16.8%	14.8%	
Statistically significant variable only	15.1%	13.4%	

Thus, the overall savings ranged from 13.4 percent to 16.8 percent.

The above results reflect an unexpectedly high ratio of noise to effect in the taxi data which made it very difficult to detect treatment effects. Thus, only improvements of 5 percent or greater had a reasonable chance of being detected in the taxi demonstration.

The strong showing of driver training was surprising, because the consensus was that driver training alone (not coupled with incentives) would not produce a significant impact on fuel efficiency.

The failure of maintenance to emerge as a major factor in fuel efficiency may reflect the fact that much of the demonstration fleet was new. Of the eight taxis that received upgraded maintenance, five were 1985 models. DSE found higher savings linked to improved maintenance, but they were also not statistically significant. Also, serious shortcomings were noted in the adherence to the planned maintenance program. In fact, several taxis failed to use the designated service center.

The retrofitting of radial tires apparently produced a negligible effect on fuel consumption, reinforcing the results reported for the bus demonstration. The reason may have been a failure to inflate the tires to maximum recommended pressure. A review of practices late in the demonstration revealed that both radial and bias ply tires

were being inflated to 32 psi, compared to a maximum 35 psi seen in a random reading of radial tire sidewall data.

Correct management of tire pressure might have increased overall fuel savings to nearly 20 percent, compared with the estimated 17 percent actually achieved.

PUBLIC INFORMATION AND AWARENESS CAMPAIGN

Owing to time pressure, it was necessary to conduct most of the public information campaign without complete results of the demonstrations. This was a serious handicap to the campaign that should certainly be avoided in future projects of this type. Despite this problem the response to the initial activities was encouraging.

The seminar generated requests for driver training from International Transport GASH (a large trucking company), Cotracoop (a large bus fleet), and two government fleets.

The special newspaper supplement generated a large number of inquiries on all aspects of fuel conservation.

As a result of the strong response to the public information campaign, DSE now plans to arrange further training in energy-efficient driving.

OTHER ACCOMPLISHMENTS

Apart from demonstrating significant fuel savings, the project also:

- Developed an in-country capability for teaching fuel-efficient driving -- the most effective fuel conservation measure. The project trained eight instructors in five key transportation organizations plus MOPT and the AID mission, developed all necessary training materials and provided instruments (driving computers) for four training vehicles.

- Proved that demonstration project costs can be reduced substantially by enlisting the participation of related suppliers. All suppliers who were approached for this purpose were receptive and were willing to either donate products and services, or to provide them at low cost.

COST AND BENEFITS

Based on the number of vehicles that benefited directly from the fuel reduction measures, annual savings are estimated at $23,100. The breakdown by measure is:

Proper bus maintenance (12 buses)	$6,300
Bus driver training (24 buses)	8,200
Bus radial tires	(1,800)
Taxi driver training (16 taxis)	10,400
Total savings	$23,100 per year

In addition to fuel savings, the fleets will benefit from additional cost reductions due to increased vehicle life, lower maintenance costs, and fewer accidents. Also, it is likely that further savings were achieved as a result of the fleet operations seminar and other public information actions. These additional benefits have not been quantified; but they are significant, according to DOE's DECAT Training Center.

Effect of Replication in Host Fleets

The project was designed to demonstrate the impact of each conservation measure on fuel consumption, expressed as a percentage reduction. Because of the limited resources available to the project, the number of participating vehicles was held to a minimum, which restricted the project's monetary benefits. Thus, the costs and savings of applying the measures to the host companies' entire fleets were estimated, and are displayed in Exhibit 5.1. The analysis was first carried out only for the measures that had produced statistically significant results; then it was repeated for all the measures demonstrated. Because the incremental cost of extending the fuel reduction measures to the remaining vehicles entails no further foreign technical assistance and relies mainly on a relatively small value of locally purchased products and services, the cost/benefit ratio improves significantly for both the bus and taxi fleets. For both methods, the payback period was about 2 years for the bus fleet and well under a year for the taxi fleet.

Exhibit 5.1
Cost/Benefit Effect of Replication in Host Fleets

	Demonstration Fleet				Total Host Cooperative Fleet		
	Number of Vehicles	Cost $000	Estimated Fuel Savings	Estimated Benefits $000/yr	Number of Vehicles	Cost $000	Estimated Benefits $000/yr
BENEFITS BASED ON STATISTICALLY SIGNIFICANT RESULTS ONLY							
Bus	24	54.6	8.8%	12.7	41	71.2	35.5
Taxi	16	51.4	15.1%	10.4	700	295.0	456.8
Public Information		2.4		Not available			
Total*		108.4		23.1		366.2	492.3
BENEFITS BASED ON ALL RESULTS							
Bus	24	54.6	9.9%	13.9	41	71.2	39.5
Taxi	16	51.4	16.8%	11.1	700	295.0	511.2
Public Information		2.4		Not available			
Total*		108.4		25.0		366.2	550.7

*Does not include cost of goods and services provided by:

	Estimated Cost ($000)
ORNL	9.7
DSE	3.6
COOPETICO	0.2
Empresa Guadalupe	0.6
Suppliers	4.0
Total	18.1

Source: Hagler, Bailly & Company

The host enterprises and their vehicle owners are being surveyed to determine how widely the conservation measures are being used in their fleets, and to obtain their estimates of total savings.

Effect of Project Repetition

A financial analysis of the project indicates a long payback period because of high one-time costs for transfer of technology and knowledge. With local capabilities now in place, however, repetitions of the project would pay back their costs in under a year.

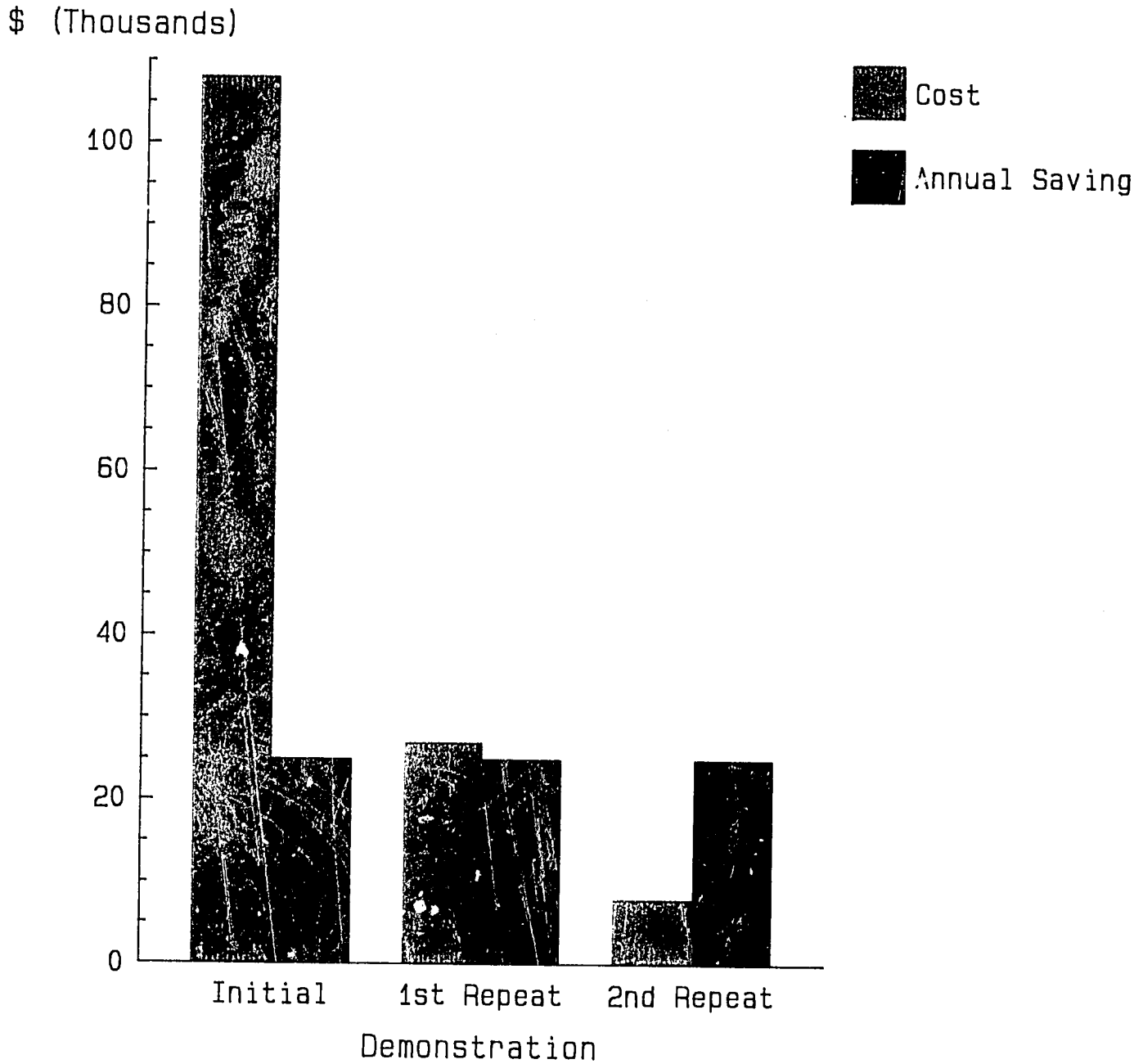
Estimated annual savings of $23,100 were based on a project cost of $108,000 (including a technical assistance component of $97,000) resulting in a simple payback period of 56 months. The project cost included support by foreign consultants (except ORNL), and out-of-pocket costs for instruments, supplies, local services and instructor training abroad; however the cost of personnel and logistic support provided by DSE was not included. The initial project cost and benefits are compared with the costs and benefits of repetitions in Exhibit 5.2.

The first repetition of the project would cost about $27,000, reflecting a greatly reduced need for foreign consultants (20 man-days) and a scaled-down public information component, which would not require the support of a publicity agency.

With no further foreign technical assistance required, the cost of subsequent repetitions would fall to about $8,000. Consequently, the payback period would improve to about 8 months with the first repetition, and about 2 months for all subsequent repetitions.

Exhibit 5.2

Costs and Benefits of Repeated Demonstrations



Source: Hagler, Bailly & Company

CONCLUSIONS

1. The fuel conservation measures demonstrated were effective, and produced significant overall savings in the demonstration fleets; however, their individual impacts varied widely.

2. Driver training was the most effective measure, followed by improved maintenance. The results of driver incentives and radial tire retrofitting were not conclusive, and require verification. Loose control of implementation appears to have blunted some measures and obscured the impact of others; a repetition would probably yield higher savings.

3. A post-demonstration on-site inquiry is needed to fully understand why savings fall short of expected levels. This is particularly true of maintenance measures, where only the initial actions were monitored by project staff, and of driver incentives.

   In respect to buses, driver training savings were depressed by training problems (inappropriate gear box and speed limit) and late completion of driver training. The impact of incentives was diluted by their late introduction, and by the fact that many of the buses designated for this treatment were driven partly by owners' relatives, to whom the incentives were not applied.

   In the case of taxis, maintenance savings were diminished by the pre-existing good condition of many of the vehicles, and by failure of several taxis to use the designated service station in the course of the demonstraton.

4. The project has created a local institutional capability for multiplying the demonstrated benefits on a national scale. This capability resides primarily within DSE, with additional driver training resources in MOPT and in several bus and taxi organizations.

5. Project costs were high relative to estimated savings; however, the costs included a high proportion of one-time technical assistance.

6. The country's vehicle maintenance infrastructure is inadequate to maintain vehicles in optimum fuel-efficient condition, particularly with respect to diesel vehicles. The lack of documentation, equipment and qualified personnel, together with perceived high prices, prevents proper servicing of most of the fleet.

7. The late model taxis that predominate in the San Jose area taxi fleets appear to be operating below their fuel-efficient speed range.

RECOMMENDATIONS

1. The experience gained in the project shows that such training and improved maintenance programs are cost effective and should therefore be expanded to all intensively-operated vehicles nationwide (taxis, buses and trucks), with priority given to improved truck maintenance and truck driver training. This large-scale cost reduction program should include:

   - Energy audits of major energy users in the transportation sector, followed by technical and financial assistance in implementing recommendations

   - Establishment of local fuel-efficient driving training on a permanent basis

   - Upgrading the country's maintenance infrastructure to provide the high standard of service required by diesel engine fuel systems at an affordable price

   - A continuing public information and awareness program

   - Regulatory measures to (1) align speed with efficient operating ranges of vehicles, (2) require that vehicle importers furnish fuel efficiency ratings, and (3) provide for vehicle emissions inspection to detect inefficient engine operation.

2. With respect to the present project, DSE should survey the managers and vehicle owners of Empresa Guadalupe and COOPETICO to determine which measures have been replicated on other fleet vehicles, the results obtained, and the assistance required. The survey should be repeated in early 1987 to assess the long-term effect of the project.

3. TRANSMESA should ensure that the fuel consumption curves of imported taxis are compatible with intended operating speeds and patterns. TRANSMESA should also require bus vendors to provide a suitable number of operation and maintenance shop manuals to buyers of new vehicles, and should procure such documentation for the existing fleet's owners and maintenance shops.

4. Given the many opportunities for contamination in the distribution of fuel to the user, RECOPE should increase its efforts to have filters installed in all diesel fueling stations nationwide.

5. The National Chamber of Transport should promote fuel cost reduction actions and adoption of a uniform operating data recording and analysis system by its associates, and the repair of all odometers to register distance traveled.

6. Empresa Guadalupe should take the following actions to improve maintenance and fleet management systems:

   - Establish an optimal bus maintenance standard and gain agreement of all associates to adopt it. It should also provide adequate in-house facilities, equipment and staff, together with outside contractors, to maintain the standard. In this connection the recommendations of Appendix I should be implemented

   - Negotiate contracts with qualified outside shops for maintenance service beyond the scope of its own shop. Such contracts, by ensuring a strong, stable demand, might prompt the establishment of more high-grade shops

   - Repair all non-functioning bus odometers, and use them as a source of mileage data for operations records and fuel accounting

- Improve operations data collection systems to provide more accurate data

- Investigate use of a personal computer to assist in management of bus operations and maintenance. Applications might include operating data, scheduling of buses and routes, driver incentive systems, maintenance and fuel management.

7. The experience gained in this project should be used for developing similar demonstration and public information projects in other countries.

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AIDAC

FOR STEY PAMELA BALDWIN

E.O. 12356: N/A
SUBJECT: ENERGY TRANSPORTATION SECTOR

REF: TELCON BALDWIN/RODRIGUEZ 4/24/85

1. MISSION AND GOCR WISH TO EXPRESS APPRECIATION FOR TRANSPORTATION ENERGY CONSERVATION STUDY CARRIED OUT BY HAGLER BAILLY & CO. IN JUNE 1984 UNDER CONTRACT STEY. GOCR CONSIDERS REPORT USEFUL IN IDENTIFYING IMPORTANT ENERGY CONSERVATION OPTIONS IN THIS SECTOR.

2. AS A FOLLOW UP OF TRANSPORTATION ENERGY CONSERVATION RECONNAISANCE STUDY GOCR REQUESTED MISSION TO EXPLORE POSSIBILITY OF IMPLEMENTING SOME SPECIFIC RECOMMENDATIONS.

3. PER REF CONVERSATION MISSION REQUESTS THAT HAGLER BAILLY & CO. PREPARE SCOPE OF WORK UNDER CURRENT CONTRACT WITH STEY FOR FOLLOWING ACTIVITIES:

- A) DEMONSTRATION PROGRAM FOR ENERGY CONSERVATION IN ONE TAXI AND ONE BUS COOPERATIVE INCLUDING PROGRAM DESIGN FOR SHORT-TERM (UP TO SIX MONTHS) ACTIVITIES AS WELL LONGER RANGE PLANS TO BE CARRIED OUT BY GOCR. EMPHASIS SHOULD BE ON SHORT-TERM COMPONENT IN ORDER TO GENERATE DATA AND CONCLUSIONS BY DECEMBER 1985.

- B) DESIGN OF A PUBLIC INFORMATION AND AWARENESS CAMPAIGN FOR ENERGY CONSERVATION IN TRANSPORTATION TO BE CARRIED OUT BY GOCR. TASKS INCLUDE CAMPAIGN DESIGN, PROVISION OF RELEVANT DIDACTIC MATERIALS AND SELECTED PUBLICATIONS.

4. MISSION IN CONSULTATION WITH DSE IS WILLING TO PROVIDE UP TO $30,000 FROM GRANT 515-0175 ENERGY POLICY DEVELOPMENT. PROVIDED STEY WILL COVER REMAINING PROJECT COSTS. MISSION IS IN PROCESS OF EXTENDING PACD FOR THIS GRANT UNTIL DEC. 31, 1985.
LINCOLN

Best Available Document

TRANSPORTATION ENERGY CONSERVATION IN COSTA RICA

A Work Plan

Presented by:
Hagler, Bailly & Company
Energy Conservation Services Program Contractor
Washington, DC

Presented to:
USAID/Costa Rica

and

Direccion Sectorial de Energia
San Jose, Costa Rica

June 25, 1985

INTRODUCTION

The Energy Conservation Services Program of USAID ST/EY provides assistance for increasing energy efficiency in the transportation sector. Based on a request from USAID/CR and GOCR and the results of a reconnaissance mission (June 1984) and a preparatory visit (June 1985) to Costa Rica we propose that follow up energy conservation activities be undertaken as set forth below. Prior to initiating in-country work, it is recommended that one of the team's consultants visit the DOE's Driver Energy Conservation Awareness Training (DECAT) facility in Nevada to gather as much information as possible to be used in Costa Rica (see Appendix A).

DESCRIPTION OF ACTIVITIES

Hagler, Bailly & Company proposes to assist GOCR in designing and conducting a two-pronged project consisting of a demonstration program and a public information and awareness campaign. The **demonstration program** will focus on driver training and maintenance, which are actions that can be implemented quickly, using local resources to a great extent. Also their savings impacts and replicability are high. The proposed demonstration program, applying to one taxi and one bus cooperative, emphasizes short-term results.

Instruction in energy-efficient driving techniques would be patterned on the DECAT program. Costa Rican instructors and drivers would be trained using Spanish-language versions of DECAT instructional materials, including visual aids, slides, and training films.

Both the host fleets and two tire suppliers would participate in the demonstrations and would provide necessary products and services free or at reduced prices.

The second component, **a public information and awareness campaign**, would also make maximum use of local resources. It would rely mainly on resources available in the Press and Communications Directorate of RECOPE (Costa Rican petroleum refinery) and the Road Safety Directorate of MOPT (Ministry of Public Works and Transportation). Together with DSE (Energy Sector Directorate), RECOPE and MOPT are capable of designing an effective campaign, producing promotional materials of a good standard and providing efficient channels for reaching the desired audiences. As in the

demonstration program, suppliers would be invited to participate in the campaign, and maximum use would be made of material available in the United States and other countries (brochures, films, etc.).

The principal role of the consultants in the demonstration component will be (1) coordination and (2) technology and knowledge transfer. In the information/awareness component, the consultants will provide advice and samples of promotional materials used in other countries. Much of the implementation work will heavily involve DSE personnel and direct beneficiaries. As such, the overall effort is expected to be highly cooperative.

In addition to Hagler, Bailly staff, three consultant will be brought to assist DSE in (1) methodology (David Greene, ORNL), (2) overall program technical soundness (Claude Peyrebonne, BCEOM*), and (3) vehicle maintenance (U.S. expert).

The activities would follow the schedule shown in Exhibit 1.

A. DEMONSTRATION PROGRAM FOR TAXIS AND BUSES

The proposed program demonstrates the effect of four measures to improve fuel efficiency: driver training, driver incentives, preventive maintenance, and radial tires. These four measures have been selected on the basis of a request from the mission (see Appendix B) and the work performed in-country in 1984 and 1985.

The demonstrations will be structured as shown in Exhibit 2. The effect of each measure will be measured by the change in specific fuel consumption compared to the measure immediately above it.

In the case of taxis, because of the fact that most of the fleets are largely new (and therefore not suitable for a maintenance demonstration), the test fleets are separated into old and new categories.

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*Claude Peyrebonne served for 2 years as technical advisor to the Ministry of Public Works and Transportation (MOPT) in San Jose.

All participating vehicles will be provided with water- and sediment-free fuel.

Driver Training

Description: Train 44 randomly selected drivers in fuel-efficient driving techniques, including good acceleration habits, conservation of momentum, proper tire inflation, limiting speed, avoidance of high engine speeds, idling, cornering, cruising, and hill climbing. Evaluate the change in their fuel efficiency performance against control vehicles.

Level of effort: medium.

Replicability: high.

Time frame: 10 weeks.

Expected energy savings: taxis, 10 percent; buses, 12 percent.

Driver Incentive Plan

Description: Design a financial incentive plan to reward fuel-efficient driving. For a random sample of 18 bus drivers, monitor fuel consumption and provide the driver with prompt and frequent feedback of results. Evaluate the effect on fuel efficiency. Since taxi drivers purchase their own fuel, no further incentive is required for them.

Level of effort: medium.

Replicability: medium.

Time frame: 10 weeks.

Improved Maintenance

Description: Upgrade maintenance in a random sample of 12 buses and 5 taxis, including engine systems, wheel alignment, brake drag elimination, and tire inflation. Evaluate the impact on fuel consumption. It would be helpful to ensure that fuel quality variations be kept to a minimum during program time frame.

Level of effort: high.

Replicability: high.

Time frame: 10 weeks.

Expected energy savings: taxis, 10 percent; buses, 8 percent.

Radial Tires

Description: Equip a random sample of 6 buses and 10 taxis with optimum radial tires and evaluate the effect on fuel efficiency. Tire suppliers will participate in the demonstration.

Level of effort: low.

Replicability: high.

Time frame: 10 weeks.

B. PUBLIC INFORMATION AND AWARENESS CAMPAIGN

This component will consist of assisting DSE in selecting, producing, and distributing promotional literature, publicizing demonstration results, participating in television programs and seminars for fleet operators. The campaign will be carried out using largely resources identified in DSE, MOPT, and RECOPE, together with support from tire suppliers.

Training of First Instructors

Publicize the completion of training of the first group of instructors, using all media that be obtained with the assistance of RECOPE.

Level of effort: medium.

Impact: high.

Time frame: 1 week.

Effect of Replication in Host Fleets

The project was designed to demonstrate the impact of each conservation measure on fuel consumption, expressed as a percentage reduction. Because of the limited resources available to the project, the number of participating vehicles was held to a minimum, which restricted the project's monetary benefits. Thus, the costs and savings of applying the measures to the host companies' entire fleets were estimated, and are displayed in Exhibit 5.1. The analysis was first carried out only for the measures that had produced statistically significant results; then it was repeated for all the measures demonstrated. Because the incremental cost of extending the fuel reduction measures to the remaining vehicles entails no further foreign technical assistance and relies mainly on a relatively small value of locally purchased products and services, the cost/benefit ratio improves significantly for both the bus and taxi fleets. For both methods, the payback period was about 2 years for the bus fleet and well under a year for the taxi fleet.

Promotional Literature

Description: Produce and distribute a brochure dealing with various aspects of transportation energy conservation.

Level of effort: medium.

Impact: medium.

Time frame: 15 weeks.

Fuel Efficiency Information

Description: Publish and distribute a brochure indicating fuel efficiency of all passenger and light commercial vehicles offered in the Costa Rican market using existing information. Publish the same data in newspapers and magazines.

Level of effort: medium.

Impact: medium.

Time frame: 4 weeks.

Demonstration Results

Description: Publicize the results of fuel-efficiency demonstrations through newspaper and magazine articles and through direct mailing of reports.

Level of effort: low.

Impact: medium.

Time frame: 4 weeks.

Television Programs

Description: Participate in a series of panel discussions and interviews.

Level of effort: medium.

Impact: medium.

Time frame: 8 weeks.

Fleet Operator Seminars

Description: Participate in two seminars for public- and private-sector fleet operators on fuel conservation in vehicles.

Level of effort: medium.

Impact: high.

Time frame: 5 weeks.

C. INSTITUTIONAL ARRANGEMENTS

The project will be co-sponsored by MIEM and MOPT, and implemented by DSE. In addition, the following groups will provide support and essential resources:

- Road Safety Directorate, MOPT -- training and graphics
- RECOPE -- fuel quality control and press relations
- National Chamber of Transport -- bus fleet
- Union of Taxi Operators of Costa Rica -- taxi fleet.

All above institutions have committed significant resources to the program (see below for manpower).

D. COUNTERPART MANPOWER

Local manpower will be formed into a task force that will vary in number according to the requirements of the project. The configuration will be:

- DSE: 2 (permanent)
- MOPT: 1 (as required)
- RECOPE: 1 (during demonstrations)
- National Chamber: 1 (during demonstrations)
- Total: 5 persons.

The project will draw heavily from the above manpower resource, and all participating organizations have indicated a willingness to provide all support required.

E. SPECIALIZED CONSULTANTS

Specialized consultants will be used to reinforce critical activities as follows:

- Dr. David Greene, ORNL, Oak Ridge, TN
  - analysis of baseline data
  - detailed design of demonstrations
  - validation of data
  - analysis of results
- Claude Peyrebonne, BCEOM, Paris
  - overall technical assistance
  - fuel quality control
- Maintenance specialist
  - overall implementation of maintenance improvement measures.

F. INSTRUCTOR TRAINING

A total of four Costa Rican instructors will be trained to teach fuel-efficient driving techniques. One of them will be trained at the DECAT Nevada Test Site (Appendix A), and a further three -- one from MOPT and two from the National Chamber of Transport -- will be trained in-country by a Hagler, Bailly & Company consultant (jointly with the DECAT-trained instructor, if possible).

Continuity and dissemination of energy-efficient driver training will be assured by the Road Safety Directorate of MOPT, from which an English-speaking candidate has been selected for DECAT training at the Nevada Test Site.

G. OPERATING ARRANGEMENTS

Driver and instructor training will be conducted in classrooms of the Road Safety Directorate and in public roads.

Maintenance work and fitting of training instruments will be carried out in the shops of Empresa Guadalupe (buses) and Coopeirazu (taxis). These shop facilities will be supplemented by those of Quiros y Cia (alignment and wheel balancing), Madisa (diesel fuel system services), and other outside shops.

Maintenance supplies will be provided by the participating fleet operators, and tires will be furnished at reduced prices by Industria Firestone de Costa Rica and Quiros y Cia.

Throughout the demonstrations, a fuel supply of consistent quality (free of water and sediment) will be assured by the following measures:

1. All fuel will be furnished by filling stations on the premises of Empresa Guadalupe and Coopeirazu.

2. The above filling stations will be filled with sintered bronze filters (10 microns) borrowed from RECOPE. The filters are designed to remove all water and sediment.

3. RECOPE will take samples of all fuel used in the demonstrations and will analyze the samples.

Potential liability claims from work done on vehicles in the course of the demonstrations will be avoided by means of suitable release statements.

APPENDIX A

TRANSPORTATION ENERGY CONSERVATION ACTIONS

Re: Use of DOE Driver Energy Conservation Awareness Training (DESCAT) Facility in Nevada

Following discussions with David Greene (ORNL) and Boris Hubar, DESCAT, Nevada, we conclude that it is advisable for the ECSP consultant to make use of the DESCAT course material in Costa Rica. To do so, it is essential that he take the instructor's course at the facility. The course duration is 5 days (passenger car and buses).

All training materials are provided for later use in training drivers.

It is recommended that the Hagler, Bailly consultant assigned to the Costa Rica activities undergo DESCAT driver training and that he also use the opportunity to gather material and data for use in Costa Rica. Total cost (travel, course, etc.) would be under $2,000.

The consultant would then proceed to Costa Rica and prepare the material and equipment for use there.

Subsequently, a GOCR the Nevada course and begin driver training on his return.

Later, he would train instructors of driving schools, trucking companies, bus cooperatives, private fleets, etc.

PAGE 01 SAN JO 03473 2516502 3286 0/8654 101075
ACTION AID-00

ACTION OFFICE STEY-01
INFO LACE-03 LADP-04 ADDR-03 STDS-01 CMCT-02 CTW-02 SAST-01
STEN-01 RELO-01 MAST-01 020 AI 026

INFO LOG-00 CIAE-00 EB-08 DODS-00 ARA-00 008 W
---012260 2516372 38

APPENDIX B

R 2516462 APR 85
FM AMEMBASSY SAN JOSE
TO SECSTATE WASHDC 1006

UNCLAS SAN JOSE 03473

AIDAC

FOR STEY, PAMELA BALDWIN

E.O. 12356: N/A
SUBJECT: ENERGY TRANSPORTATION SECTOR

REF: TELCON BALDWIN/RODRIGUEZ 4/24/85

1. MISSION AND GOCR WISH TO EXPRESS APPRECIATION FOR TRANSPORTATION ENERGY CONSERVATION STUDY CARRIED OUT BY HAGLER BAILLY & CO. IN JUNE 1984 UNDER CONTRACT STEY. GOCR CONSIDERS REPORT USEFUL IN IDENTIFYING IMPORTANT ENERGY CONSERVATION OPTIONS IN THIS SECTOR.

2. AS A FOLLOW UP OF TRANSPORTATION ENERGY CONSERVATION RECONNAISANCE STUDY, GOCR REQUESTED MISSION TO EXPLORE POSSIBILITY OF IMPLEMENTING SOME SPECIFIC RECOMMENDATIONS.

3. PER REF CONVERSATION MISSION REQUESTS THAT HAGLER BAILLY & CO. PREPARE SCOPE OF WORK UNDER CURRENT CONTRACT WITH STEY FOR FOLLOWING ACTIVITIES:

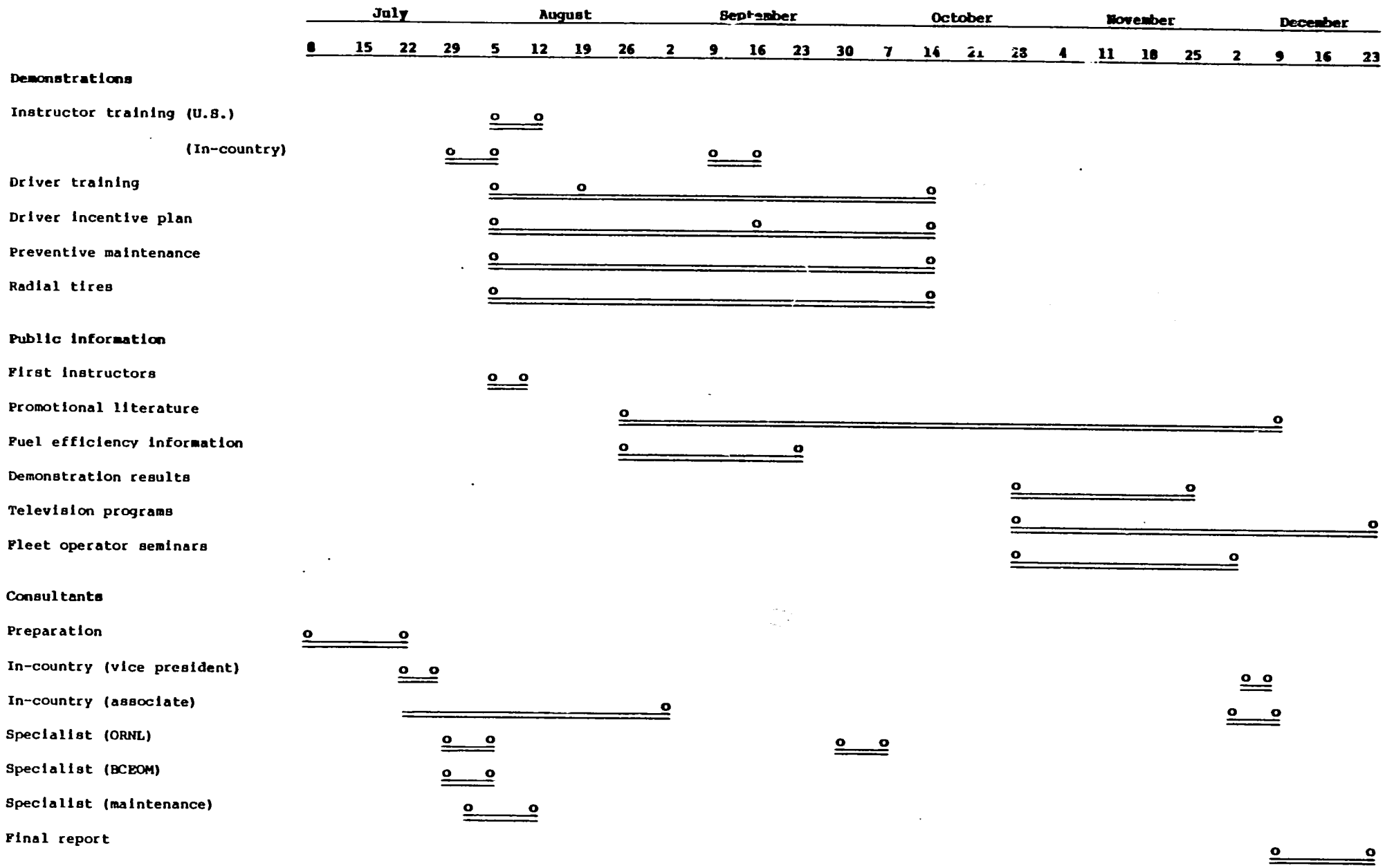
- A) DEMONSTRATION PROGRAM FOR ENERGY CONSERVATION IN ONE TAXI AND ONE BUS COOPERATIVE INCLUDING PROGRAM DESIGN FOR SHORT-TERM (UP TO SIX MONTHS) ACTIVITIES AS WELL LONGER RANGE PLANS TO BE CARRIED OUT BY GOCR. EMPHASIS SHOULD BE ON SHORT-TERM COMPONENT IN ORDER TO GENERATE DATA AND CONCLUSIONS BY DECEMBER 1985.

- B) DESIGN OF A PUBLIC INFORMATION AND AWARENESS CAMPAIGN FOR ENERGY CONSERVATION IN TRANSPORTATION TO BE CARRIED OUT BY GOCR. TASKS INCLUDE CAMPAIGN DESIGN, PROVISION OF RELEVANT DIDACTIC MATERIALS AND SELECTED PUBLICATIONS.

4. MISSION IN CONSULTATION WITH DSE IS WILLING TO PROVIDE UP TO $30 000 FROM GRANT 515-0175 ENERGY POLICY DEVELOPMENT, PROVIDED STEY WILL COVER REMAINING PROJECT COSTS. MISSION IS IN PROCESS OF EXTENDING PACD FOR THIS GRANT UNTIL DEC. 31, 1985
LINCOLN

Exhibit 1

Transportation Energy Conservation Actions Activity Schedule -- Costa Rica



SOURCE: Hagler, Bailly & Company.

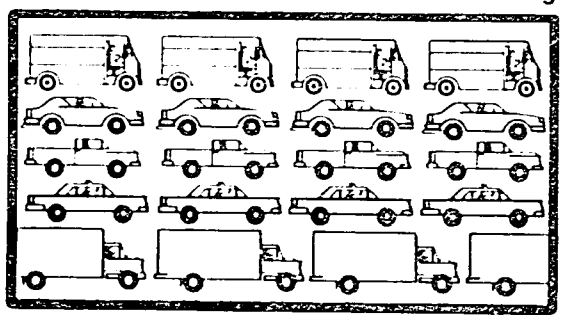
Exhibit 2

Costa Rica Demonstrations

	Bus					Taxi				
	1	2	3	4	5	1	2	3	4	5
No. of vehicles	6	6	6	6	6	10	10	10	5	5
Driver training	X	X	X	X		X	X			
Driver incentive	X	X	X				Not required			
Maintenance	X	X							X	
Radial tires	X					X				

DECAT

Driver Energy Conservation Awareness Training



DECAT for Vehicle Fleets

Every day, you make many decisions that affect your business operations. If your organization includes a vehicle fleet, you are finding that the costs of operating that fleet are rising rapidly because of skyrocketing fuel prices. A decision to utilize the DECAT program described here can reduce your fleet's consumption of expensive fuel and provide other benefits.

DECAT Benefits

Driver Energy Conservation Awareness Training (DECAT), developed by the Department of Energy, is a method by which drivers of fleet vehicles are taught to increase their fuel economy through vehicle care and choice, planning, and driving in an energy-efficient manner. Using slides, films, and in-vehicle training, DECAT effectively demonstrates the need for and methods of energy-efficient:

- driving habits (adherence to speed limits, moderate acceleration, smooth driving maneuvers, and anticipation);
- scheduling and routing (avoidance of traffic congestion, consolidation of short trips);
- maintenance practices (performance of scheduled maintenance, awareness of need for maintenance); and
- equipment usage (use of radial tires, use of downsize vehicles)

These and many other measures, often of small consequence when taken separately, can yield substantial fuel and cost savings when consistently practiced together.

Use of the DECAT program can result in an average fuel savings of 15 percent. Annual cost savings per vehicle are shown in Table 1, which assumes a fuel cost of $1.50 per gallon.

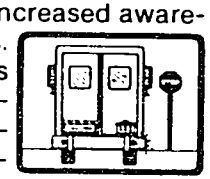
DECAT Fuel Cost Savings Per Year Per Vehicle (in $)

DECAT Fuel Economy Imprvmnt.	Base Fuel Economy at 15 MPG			Base Fuel Economy at 20 MPG		
	5,000 MI/Yr	10,000 MI/Yr	15,000 MI/Yr	5,000 MI/Yr	10,000 MI/Yr	15,000 MI/Yr
5%	25 00	50 00	75 00	18 75	37 50	56 25
10%	50 00	100 00	150 00	37 50	75 00	112 50
15%	75 00	150 00	225 00	56 25	112 50	168 75

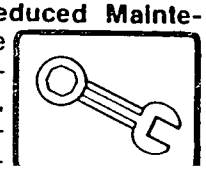
In addition to the obvious fuel and cost savings, there are other important benefits resulting from DECAT training. These include:

- reduced vehicle accident rates;
- increased vehicle life, reduced maintenance needs;
- reduced travel demands;
- reduced traffic congestion; and
- increased public awareness of conservation efforts.

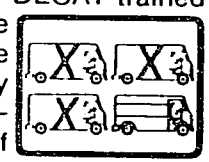
Reduced Vehicle Accident Rates. The emphasis of DECAT is on increased awareness of vehicle operations. DECAT driving procedures share many common features with safe driving practices. Training of 2,000 drivers at the Nevada Test Site has resulted in a 35% accident rate reduction. A DECAT-trained fleet driver will be more aware of surrounding traffic conditions in order to minimize accelerations and unnecessary stops. The driver will also be aware of vehicle conditions, such as engine problems, under-inflated tires, or fuel leakage. This awareness should also increase vehicle safety. In some instances, fewer accidents can mean a reduction in insurance costs.



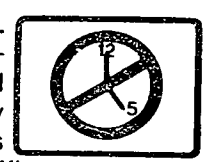
Increased Vehicle Life, Reduced Maintenance Needs. Vehicles are retired for a variety of reasons including accidents, corrosion, wear, and obsolete technology. DECAT-trained fleet drivers would be expected to notice something wrong with the vehicle earlier and be more likely to have repairs made. This earlier repair would reduce the problem of delayed maintenance resulting in major damage and cost. Also, since DECAT drivers put fewer demands on a vehicle (in terms of speed and acceleration), their vehicles should not wear out as quickly. This may increase resale value.



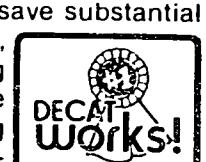
Reduced Travel Demands. DECAT-trained fleet drivers, being more aware of the fuel they are consuming, are more likely to try to reduce fuel consumption. One means of accomplishing this is to choose more fuel-efficient vehicles to accomplish their tasks. Other fuel-efficient DECAT techniques include combining several short trips into one longer trip or sharing a ride. These measures not only save fuel, money, and time, but also reduce travel demand.



Reduced Traffic Congestion. Smoother driving, combining trips, minimizing travel distance, and generally greater driving awareness can assist in reducing traffic congestion. Two other DECAT techniques that will reduce congestion are trip scheduling (rush hour/non-rush hour) and trip routing (main roads or side streets). The effect of these measures would be most apparent where a fairly large percentage of drivers were DECAT-trained.



Increased Public Awareness of Conservation Efforts. Ultimately, to save substantial energy on a national basis, DECAT or a similar training program should be made available to the driving public as well as to fleet drivers. Instituting a DECAT program in your organization and publicizing the results would be an excellent way to prove to the public that energy-efficient driving does work.



Appendix D

EXPERIMENTAL DESIGN FOR THE COSTA RICA VEHICLE DEMONSTRATION PROJECT

D.1

DRAFT

D.2

EXPERIMENTAL DESIGN FOR THE COSTA RICA VEHICLE DEMONSTRATION PROJCET

By

Patricia S. Hu
Transportation Group
Oak Ridge National Laboratory

Introduction

This memo describes the detailed experimental design for the Costa Rica Vehicle Demonstration Project. In this project, four actions are to be implemented to determine their influences on vehicle fuel economy. The four actions are: driver training, driver incentive, installation of radial tires, and regular vehicle maintenance and use of lubricants.

Certain data must be kept for each participating vehicle. For buses, current record keeping is adequate for the experiment. For taxis, a data collection form has been designed and is included as exihibit 1. Each time that fuel is added to the tank, the taxi driver is to enter the appropriate information on the form, which will be kept in the vehicle. In order to assure a satisfactory level of cooperation, the form is designed to collect all of the necessary

information in the simplest manner. At the end of the survey period, the data will be analyzed according to the experimental design described below.

A factorial design is used to detect the major effects of the four different implementations, as well as possible interaction effects among the implementations. Since each implementation or 'factor' has two levels, with or without, the design is a 2x2x2x2 factorial design. With this design, there are 16 possible combinations. Because of the limited number of participating vehicles, the same group of vehicles will be tested under the with- and the without- driver's training condition. In other words, a group of vehicles will be randomly assigned to one of the 8 possible combinations (driver incentive, maintainance and lubricants, and radial tires) for the first period, and vehicle performance will be evaluated at the end of the first period. The same group will then undertake the driver's training course and participate in the same 'experimental' condition for the second period. At the end of the second period, vehicle fuel economy will again be evaluated. By using the same vehicles before and after the drivers' training, the 2^4 factorial design becomes a 2^4 design with repeated measures.

The advantages of the 2x2x2x2 factorial with repeated measures design are that it: (1) is statistically more powerful than the paired Student-t tests, (2) with the repeated

Figure 1.

			Before Driver Training	After Driver Training
WITHOUT INCENTIVE	WITHOUT RADIAL	Without Maintenance + Fuel-Saving Lubricant	G_{111}	G_{111}
		With Maintenance + Fuel-Saving Lubricant	G_{112}	G_{112}
	WITH RADIAL	Without Maintenance + Fuel-Saving Lubricant	G_{121}	G_{121}
		With Maintenance + Fuel-Saving Lubricant	G_{122}	G_{122}
WITH INCENTIVE	WITHOUT RADIAL	Without Maintenance + Fuel-Saving Lubricant	G_{211}	G_{211}
		With Maintenance + Fuel-Saving Lubricant	G_{212}	G_{212}
	WITH RADIAL	Without Maintenance + Fuel-Saving Lubricant	G_{221}	G_{221}
		With Maintenance + Fuel-Saving Lubricant	G_{222}	G_{222}

Let i index the driver's training effect A,

j index the driver incentive effect B,

k index the radial tires effect C,

l index the maintenance and lubricant effect D,

and

n equals to the number of vehicles within A.

The model of this 2^4 factorial design with repeated measures is as follows:

$$
\begin{aligned}
x_{ijkln} = {} & U + B_j + C_k + D_l \\
& + BC_{jk} + BD_{jl} + CD_{kl} \\
& + BCD_{jkl} + S_{n(jkl)} \\
& + A_i + AB_{ij} + AC_{ik} + AD_{il} \\
& + ABC_{ijk} + ABD_{ijl} + ACD_{ikl} \\
& + ABCD_{ijkl} + AS_{in(jkl)} \\
& + e_{ijkln} ,
\end{aligned}
$$

where x_{ijkln} = n<u>th</u> observation at (i,j,k,l) treatment,

$S_{n(jkl)}$ = error term between vehicles, and

e_{ijkln} = error term within vehicles.

The analysis of variance has the following form:

Source	df	MS	F test
Between Vehicles			
B	1	MS_B	$MS_B/MSE_{between}$
C	1	MS_C	$MS_C/MSE_{between}$
D	1	MS_D	$MS_D/MSE_{between}$
BC	1	MS_{BC}	$MS_{BC}/MSE_{between}$
BD	1	MS_{BD}	$MS_{BD}/MSE_{between}$
CD	1	MS_{CD}	$MS_{CD}/MSE_{between}$
BCD	1	MS_{BCD}	$MS_{BCD}/MSE_{between}$
Veh.w.groups	$2^3(n-1)$	$MSE_{between}$	
Within Vehicles			
A	1	MS_A	MS_A/MSE_{within}
AB	1	MS_{AB}	MS_{AB}/MSE_{within}
AC	1	MS_{AC}	MS_{AC}/MSE_{within}
AD	1	MS_{AD}	MS_{AD}/MSE_{within}
ABC	1	MS_{ABC}	MS_{ABC}/MSE_{within}
ABD	1	MS_{ABD}	MS_{ABD}/MSE_{within}
ACD	1	MS_{ACD}	MS_{ACD}/MSE_{within}
ABCD	1	MS_{ABCD}	MS_{ABCD}/MSE_{within}
AxVeh.w.group	$2^3(n-1)$	MSE_{within}	
Total	$2^4n - 1$		

A Special Case

Due to the nature of this experiment, the driver incentive will not be implemented before the drivers take the training course. Figure 2 demonstrates this special case of the experimental plan schematically. In this case, the groups of vehicles which are originally assigned to the treatments with driver incentive prior to the driver training will now be grouped with the ones without driver incentive.

This special case does not alter the mathematical model described earlier. However, the sum of squares for testing the driver incentive effect and the interaction effect between the driver incentive and the driver training are no longer valid. Since three times as much vehicles' information are contributing to these sum of squares, they should be weighted by the harmonic mean of the corresponding cell frequencies, w_h, where

$$w_h = \frac{3}{\frac{1}{G_{111}+G_{211}} + \frac{1}{G_{112}+G_{212}} + \frac{1}{G_{121}+G_{221}} + \frac{1}{G_{122}+G_{222}}}$$

Figure 2.

			Before Driver Training	After Driver Training
WITHOUT INCENTIVE	WITHOUT RADIAL	Without Maintenance + Fuel-Saving Lubricant	$G_{111} + G_{211}$	G_{111}
		With Maintenance + Fuel-Saving Lubricant	$G_{112} + G_{212}$	G_{112}
	WITH RADIAL	Without Maintenance + Fuel-Saving Lubricant	$G_{121} + G_{221}$	G_{121}
		With Maintenance + Fuel-Saving Lubricant	$G_{122} + G_{222}$	G_{122}
WITH INCENTIVE	WITHOUT RADIAL	Without Maintenance + Fuel-Saving Lubricant		G_{211}
		With Maintenance + Fuel-Saving Lubricant		G_{212}
	WITH RADIAL	Without Maintenance + Fuel-Saving Lubricant		G_{221}
		With Maintenance + Fuel-Saving Lubricant		G_{222}

Tel.
Telex
Apartado
San José, Costa Rica

E

ACUERDO DE COOPERACION ENTRE LA DIRECCION SECTORIAL DE ENERGIA, COOPETICO Y EMPRESA DE BUSES DE GUADALUPE.

El Gobierno de Costa Rica en un esfuerzo más por evitar la salida de divisas, pretende demostrar que existen métodos y procedimientos eficaces para incrementar el ahorro del combustible consumido en el sector transporte.

Por esta razón, el Ministerio de Industria, Energía y Minas, a través de la Dirección Sectorial de Energía y con el financiamiento de la Agencia para el Desarrollo Internacional (AID), está trabajando en un proyecto demostrativo, cuyos detalles se describen en el documento adjunto.

Los costos en los que se incurra por concepto de la demostración serán cubiertos, en su mayoría, por los fondos con que el programa cuente para este fin; sin embargo, esperamos que ustedes colaboren con lo que esté a su alcance.

Parte de los gastos por concepto de : compra de llantas, revisión y reparación de los sistemas de inyección, transmisión y rodamiento, costo adicional del aceite empleado en la prueba, instructores encargados de enseñar las técnicas de manejo eficiente y otros correrán por cuenta del proyecto y son beneficios que quedarán en los vehículos y en las personas que participen en la prueba.

Es nuestra responsabilidad que los factores que se van a someter a análisis se apliquen en forma correcta aún sabiendo que son beneficios y que en ninguno de los casos esto significa riesgo alguno para el vehículo o el conductor participante. De ahí que no nos hacemos responsables de ningún daño o accidente que pudiese ocurrir a los vehículos o personas incluidas en la demostración.

La prueba en general es de gran beneficio, no solo para los participantes, sino también para el país, de manera que esperamos su anuencia a cooperar y a hacer, de ser necesario, un pequeño sacrificio para que esta demostración se realice con éxito.

../2..

114

Estando las partes interesadas de acuerdo, firmamos en San José, a las diez horas del día nueve de setiembre de mil novecientos ochenta y cinco.

El Director de la DSE
Jorge Blanco Roldán

El Gerente del COOPETICO
José Rafael Chacón

El Gerente de Empresa de Buses Guadalupe
William Morales

recope REFINADORA COSTARRICENSE DE PETROLEO, S. A.

APARTADO 4351 - SAN JOSE, COSTA RICA — TELEFONO 23-96-11 TELEX 2215 RECOPE

PRUEBAS DE LABORATORIO

Nombre de muestra	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Procedencia	Aranjuez	Aranjuez	Aranjuez	Aranjuez	Aranjuez	Aranju
Fecha de Obtención	25-9-85	27-9-85	30-9-85	2-10-85	5-10-85	11-10-
Fecha entrega plantel	25-9-85	27-9-85	30-9-85	2-9-85	5-9-85	11-10-
N°tanque plantel	101	104	1o4	104	104	110
% Recuperado						
INICIAL	163	162	147	149	143	167
5	194	194	191	183	191	199
10	216	213	211	213	216	222
20	240	238	247	247	249	252
30	257	257	267	270	271	271
40	271	272	283	286	288	286
50	288	287	300	300	299	303
60	303	301	314	313	312	316
70	316	316	328	328	327	331
80	334	332	343	343	343	346
90	356	354	364	367	367	364
95	372	372	380	379	378	381
Final	385	386	392	384	392	393
% Recup.	99	99	98	99	99	99
% Pérdida						
% Residuo	1	1	2	1	1	1
Gravedad API a 15.6°C	33.7	33.7	33.1	33.0	32.8	32.
Indice de octano	53.5	53.5	55.2	55.0	55.0	56
RVP a 37.8°C						
Corrosión (tira de cobre)						
Azufre (%peso)						
Temperatura de inflamación °C						
Indice de octano						
Agua y sedimento(% volumen)	Trazas	Trazas	0.05	0.03	0.01	0.o2
Color	4	4	4	4	4	3
Viscosidad (SSU a 37.8°C)	43.9	41.9	44.5	43.0	45.4	41.
Conradson carbón (%peso)						
OBSERVACIONES:			#	#	#	#

Las muestras marcadas con " # " se encuentran fuera de lo especificado en las Normas Oficiales para el 90% de la destilación.

Analistas: Lic. Juan Bermúdez M. B.Q. Alfonso Vargas M. Lic. Bernardo A.

WORKFLOW FOR BUS DATA PROCESSING AND ANALYSIS

I. DATA ENTRY:

Using any PC editor which produces an ASCII file. Unformatted file, blanks used as delimiters except for character strings (route name) which must be followed by a coma.

Fields

Bus number	Day	Month	Route	Kilometers	Liters	Cost
				Driver 1	Driver 2	

Variable Names

NUM	DIA	RTA	KM1	KM2	LTS	CST

Allowable names for routes are:

alt = Alto

moz = Mozotal

pur = Purral

pil = Pilar

san = San Antonio

The file must be stored on diskette.
A sample of the file format is attached.

II. CREATION OF TREATMENT, ROUTE, AND BUS TYPE VARIABLES:

The file created in step I is read by the BASIC program BUSDAT.BAS which creates a new file (BUS.PRIM.DAT) to be read by the NWA STATPAK "SELECT" program. The output data file should be given an appropriate name, such as BUSSEL.DAT so that its position in the sequence can be easily remembered.

The output file should be checked for obvious errors before submitting to SELECT. This is done by visual inspection of the file output, preferably by printing a hard copy. Obvious errors

should be corrected and BUSDAT.BAS rerun before proceeding to the next step.

A good name for this output file is BUSSEL.DAT.

III. ERROR CHECKING AND FINAL DATA FILE CREATION:

The BUSSEL.DAT file can be processed by the STATPAK program SELECT. The SELECT program can create a data definition file which contains:

1. Description of the input file (BUSSEL.DAT)
2. The error checking tests to be performed
3. Description of the output file to be created (BUSREG.D)

A definition file has been saved under the name BUSCHK.DEF. The error checks in this file include 4 tests:

1. Is the value of liters/100 Km between 15 and 75?
2. Is the value of kilometers traveled between 0.01 and 300?
3. Is the quantity of fuel pruchased >0 and $\leq$ 100?
4. Is the price paid for the fuel betwen 19 and 20.5 colones/liter?

These checks may be changed, as desired, in SELECT and saved again in the BUSCHK.DEF file.

The SELECT program creates a data file for the linear regression procedure. If there are records rejected by this procedure, they will not be included in this final data file (a good name for this file is BUSREG.DAT). These records should be examined to see whether they can be corrected. If so, the best procedure is to correct BUSPRIM.DAT and repeat all steps from there on. If the dat records cannot be correct or if all are acceptable, proceed to the linear regression procedure.

IV. LINEAR REGRESSION PROCEDURE:

The following two regression models should be estimated. Model No. 1 is linear fuel consumption, and Model No. 2 uses logarithm of fuel consumption for dependent variables. Model No. 1 assumes that treatment effects are additive, while Model No. 2 assumes that

they are multiplicative. For small treatm .t effects (10% reductions or less) there is little practical difference between the models, and the choice of which one is better can be determined by which fits the data better.

Linear Regression Model NO.1

$$\text{Specific fuel consumption} = \beta_0 + \beta_1 M_1 + \beta_2 M_2 + \beta_3 M_3 + \beta_4 M_4 + \beta_5 R_1 + \beta_6 R_2 + \beta_7 R_3 + \beta_8 R_4 + \beta_9 R_5 + \beta_{10} T_1 + \beta_{11} T_2 + \beta_{12} T_3 + \beta_{13} T_4 + \epsilon$$

Where $\epsilon \sim N(0, \sigma^2)$

Linear Regression Model No. 2

$$\ln(\text{Specific fuel consumption}) = \beta_0 + \beta_1 M_1 + \beta_2 M_2 + \beta_3 M_3 + \beta_4 M_4 + \beta_5 R_1 + \beta_6 R_2 + \beta_7 R_3 + \beta_8 R_4 + \beta_9 R_5 + \beta_{10} T_1 + \beta_{11} T_2 + \beta_{12} T_3 + \beta_{13} T_4 + \epsilon$$

Where $\epsilon \sim N(0, \sigma^2)$

BUS DATA FILE FORMATS

1. BUSPRIM.DAT

NUM	DIA	MES	RTA	KM1	KM2	LTS	CST
Bus Number	Day of Month	Month	Route Number	KMs by Driver 1	KMs by Driver 2	Liters Purchase	Cost Refund

2. BUSSEL.DAT

LKM	NUM	DIA	MES	KMS	LTS	CST	R1-R5	T1-7
Liter per 100 KM	Bus Number	Day of Month	Month	Kilometers Traveled	Liters Purchased	Cost of Fuel	Route	Treatment

M1 - M4
Mark

M1 = Mercedes
M2 = Leyland
M3 = Pegaso
M4 = International

R1 = Alto
R2 = Purral
R3 = Pilar
R4 = Mozotal
R5 = San Antonio

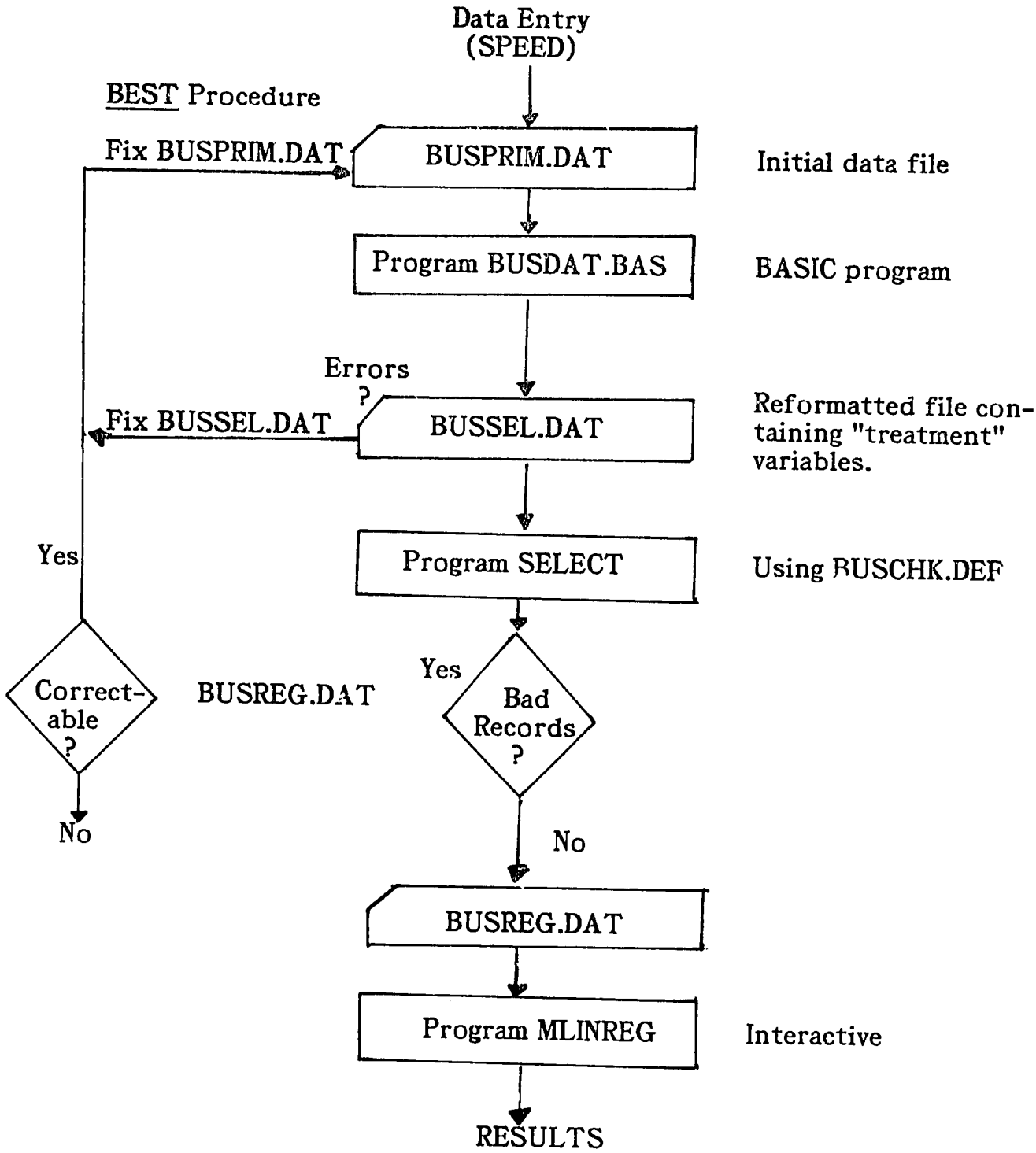
T1 = Maintenance
T2 = Radials
T3 = Training
T4 = Incentive

3. BUSREG.DAT

LKM	R1-R5	T1-T4	M1-M4
Liters per 100 KM	Routes	Treatment	Marks

BUS DATA PROCESSING WORKFLOW

RAW DATA TABLES



I. DATA ENTRY

The original taxi data are entered in a file called "TAXIPRIM.DAT" in the following order using free format with blanks as delimiters.

NUM	DIA	MES	ODOM	CST	LTS
taxi number	day of month	month	odometer reading	cost of purchase	liters purchase

The file must be stored on diskette. A sample of the file format is attached.

Notes:

1) In cases where the taxi driver has entered kilometers traveled in place of the odometer reading, the odometer reading must be computed and entered as usual for the programs to work properly.

2) If the driver skips a record, proceed as usual. This should be detected in step III.

II. CREATION OF TREATMENT AND MAKE VARIABLES & LITERS/100 KM

The file created in step I is processed by a BASIC program called "TAXIDAT.BAS" which creates a new file containing kilometers traveled, liters per hundred kilometers, and the price per liter of fuel, as well as (0,1) treatment and taxi make variables. The program tests for the first occurrence of a taxi's number and then begins calculating kilometers traveled by subtracting last period's odometer reading from this period's. Thus fuel purchased is associated with distance traveled since the last refueling. This is exactly correct if the tank is always completely filled.

When a calculation is completed for one record the taxi number and odometer reading are stored. The next record is then read. If the old and new taxi numbers do not match, calculations are skipped, NUM and ODOM are stored as NUM1 and ODOM1 and another record is read.

The format of the output file, "TAXISEL.DAT" is as follows:

LKM	NUM	DIA	MES	KMS	LTS	PR	T1-T4	M1-M5
Liters per 100 KM	Taxi Number	Day of Month	Month	Kilometers Traveled	Liters Purchased	Price per Liter	Treat-ment	Marks

III. ERROR CHECKING AND FINAL DATA FILE CREATION

The file TAXISEL.DAT is to be read using STATPAK's SELECT program. This program performs a series of data checks (and can perform data transformations) and produces an output data file for analysis by MLINREG.

The SELECT program can create a data definition file which contains:

1. A description of the input file;
2. The error checking tests to be performed; and
3. The description of the output file to be created.

A sample data definition file has been created, named TAXICHK.DEF. This file performs the following tests:

1. Is 1/100 km between 6 and 12?
2. Is the price paid for fuel between 18 and 21?
3. Is the value of kilometers traveled between 0 and 350?

Those records which pass all tests are included in the output file TAXIREG.DAT. Excluded records should be inspected to determine whether or not they can be corrected. If the records are correctable, they should be corrected in TAXIPRIM.DAT and the subsequent data processing steps should be repeated. If no corrections are possible, then TAXIREG.DAT is the final database, and should be either: (i) merged with other data sets in final form or (ii) directly analyzed using MLINREG.

IV. LINEAR REGRESSION PROCEDURE

The following two regression models should be estimated. Model No. 1 is linear fuel consumption, and Model No. 2 uses logarithm of fuel consumption for dependent variables. Model No. 1 assumes that treatment effects are additive, while Model No. 2 assumes that they are multiplicative. For small treatment effects (10% reductions or less) there is little practical difference between the models, and the choice of which one is better can be determined by which fits the data better.

Linear Regression Model No.1

$$\text{Specific fuel consumption} = \beta_0 + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3 + \beta_4 T_4 + \beta_5 M_1 + \beta_6 M_2 + \beta_7 M_3 + \beta_8 M_4 + \beta_9 M_5 + \epsilon$$

Where $\epsilon \sim N(0, \sigma^2)$

Linear Regression Model No. 2

$$\ln(\text{Specific fuel consumption}) = \beta_0 + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3 + \beta_4 T_4 + \beta_5 M_1 + \beta_6 M_2 + \beta_7 M_3 + \beta_8 M_4 + \beta_9 M_5 + \epsilon$$

Where $\epsilon \sim N(0, \sigma^2)$

TAXI DATA FILE FORMATS

1. TAXIPRIM.DAT

Fields

NUM	DIA	MES	ODOM	CST	LTS
Taxi Number	Day of Month	Month	Odometer Reading	Cost of Purchase	Liters Purchased

2. TAXISEL.DAT

1	2	3	4	5	6	7	8-11	12-16
LKM	NUM	DIA	MES	KMS	LTS	PR	T1-T4	M1-M5
Liters per 100 KM	Taxi Number	Day of Month	Month	Kilometers Traveled	Liters Purchased	Price per Liter	Treat-ment	Marks

T1 = Maintenance*
T2 = Radials*
T3 = Training*
T4 = Incentive*

M1 = Cresida
M2 = Datsun 220
M3 = Cedric
M4 = Datsun 120y
M5 = Volvo

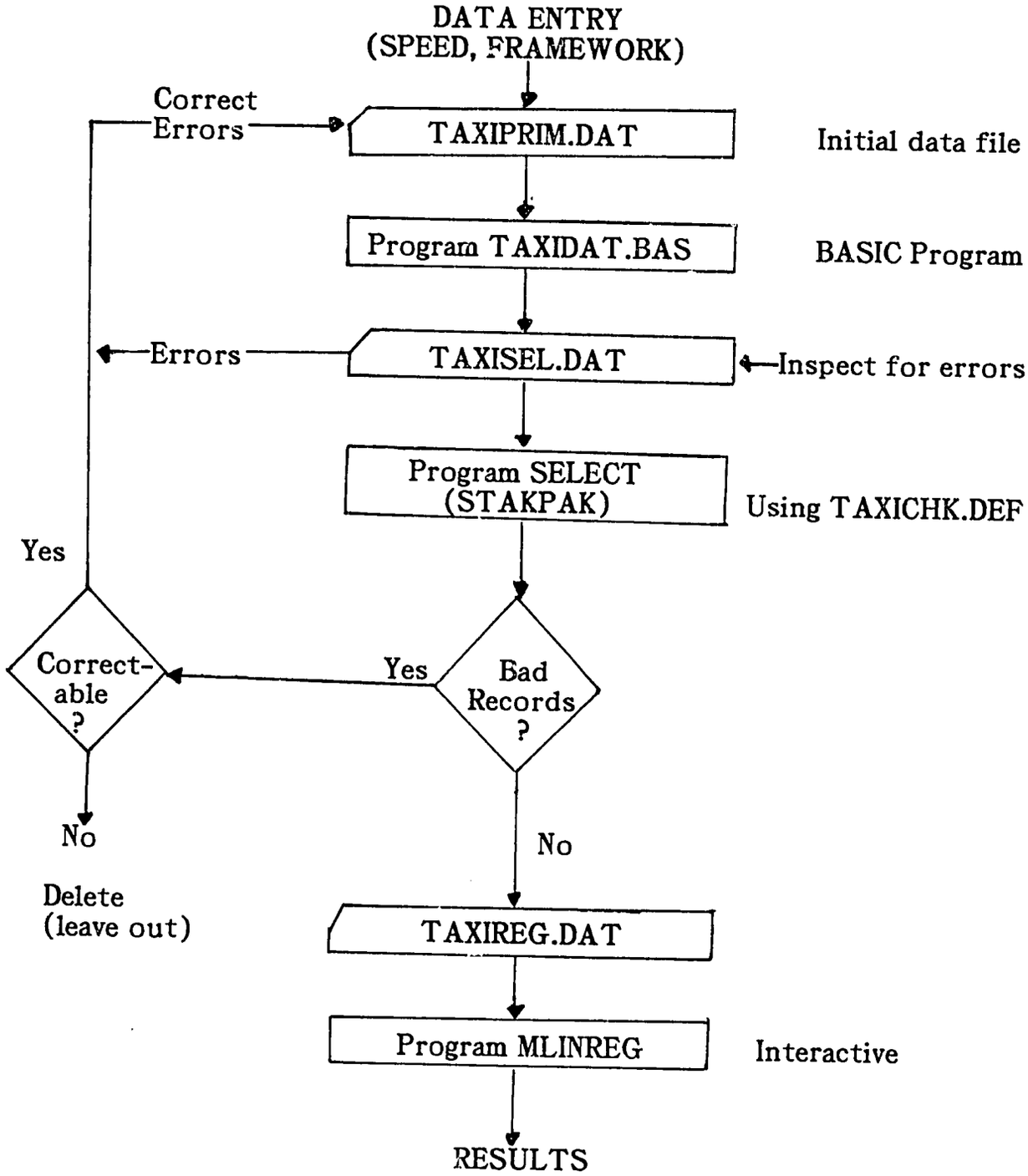
3. TAXIREG.DAT

1	2-5	6-10
LKM	T1-T4	M1-M5
Liters per 100 KM	Treat-ments	Marks

*(1 = yes 2 = No)

TAXI DATA PROCESSING WORKFLOW

DATA TABLES (CARDS)



REPORT ON
MAINTENANCE FACILITIES INSPECTION
GUADALUPE BUS

General condition varied from POOR to ADEQUATE.

1. Fuel Station

   a. This area was rated GOOD. The buses during fueling are covered to prevent rain from entering the diesel system.

   b. There is a slab (concrete and level) which will facilitate accurate fuel recording in that the vehicle tank will be reasonably level, regardless of the direction when fueled.

   Though there is a filter (1 gallon in volume) at the pump to remove contaminants, there is no evidence this filter has been taken apart for service.

   Note: There is a drain cock at the bottom to remove water. There was no evidence to prove this was checked regularly.

2. Tire Repair Shop

   a. This area was rated slightly LESS THAN ADEQUATE.

   b. Tires are repaired by the old hand method using hammer and wedge-type tools.

   c. There is adequate air supplied by a centrally located compressor shared by the lubrication shop.

   d. The inspection turned up only one tire gauge but was of a high

quality in good condition.

e. There was no evidence that any tire rotation and inspection exists.

f. There is no tire balancing equipment at the bus yard.

g. There was no backlog of vehicles awaiting tire repair.

Recommendations

a. There needs to be a general update of the tire equipment (at least a pneumatic impact wrench for tire removal and replacement).

b. Several extra tire gauges of good quality should be purchased and checked regularly for accuracy.

c. If no other method can be afforded, then at least a static balancer should be purchased. (I consider this, however, a very low priority, considering driving conditions, etc.)

3. Lubrication Shop

a. Overall rated GOOD.

b. Most of the tools and supplies are adequate.

c. Oils and lubricants meet all specifications and require no improvement.

d. Work area is covered to prevent rain water from interfering with work. Two walls provide at least partial shelter from wind and dust.

e. Work area has one of the few concrete floors in any of the work areas suitable to roll a floor jack on.

f. One great asset in this area is that there is a hoist capable of lifting an entire bus for maintenance.

g. On the negative side, there was no place in the lubrication area

for "clean work" - cleaning oil and fuel filter components, etc.

h. There was no place set aside for parts washing - container or solvents were not present.

i. The mechanic supervisor is well motivated and appears to apply all he knows to the vehicle. (Because of the language difference, an adequate interview was impossible).

Recommendations

a. Clean up the lubrication area; get rid of the junk, trash, etc.

b. Fabricate from oil drums (or like vessels) a parts-washing container. Fabricate a cover to keep out dirt when not in use. Should be about waist high or 30 inches.

c. Set aside a clean area to do parts washing, probably in supply room.

d. Provide the lubrication person with the lubrication manuals that apply to the particular vehicles.

e. Set up preventive maintenance schedules (oil and lube) based on monthly, quarterly, semi-annual, and annual inspections. What should be done at these intervals is noted elsewhere in the report.

4. Repair Shop Facility (Sheds and outbuildings)

a. Generally this area is rated POOR by American standards. Conditions are such that they resemble temporary field facilities.

b. Specifically

(1) Sheds and other outbuildings provide little more than shelter from the rain.

(2) Trash and residue from past work is allowed to accumulate.

130

(3) Shop floors look as if they were once concrete, but have deteriorated to the point of being not much more than packed dirt. The conditions are such that it would be next to impossible to roll a floor jack over it.

(4) The shop was void of the most simple shop equipment - jacks, stand jacks, work benches, parts cleaning equipment, welding equipment and supplies (gas and electric), shop lighting, air compressor, drill press, press (10 ton), bench grinder, etc.

Recommendations

a. That at least one bay/stall be prepared for clean work (for pump and injector work especially). This should have walls and a smooth level floor. (This area could also be used for wheel alignment.)

b. The following shop equipment either be purchased or fabricated.

(1) One 5-ton floor jack with wheels.

(2) Six to eight trussels or stand jacks (2-1/2 ton).

(3) Two or more work benches (heavy duty), 30" x 6'.

(4) Three mechanic vises, large capacity, 4" to 6" jaws.

(5) Pneumatic wrenches, one 3/4" drive and two 1/2" drive (for the tire shop).

(6) One or two parts washing tanks, 30 gallon capacity.

(7) One voltage tester.

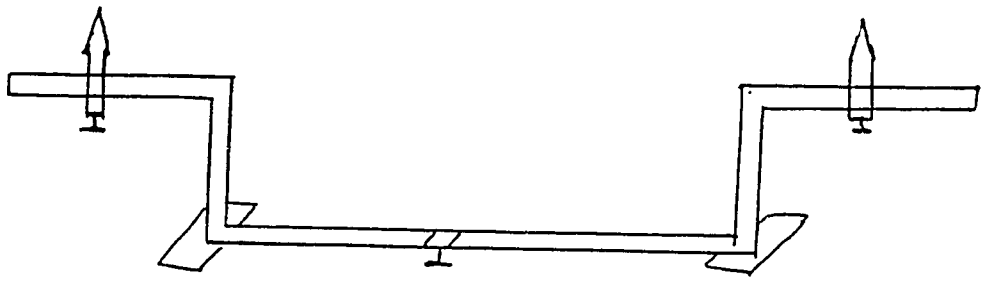
(7) One voltage tester.

(9) One wheel mounted battery charger, 12-24 volt system, heavy duty.

(10) Two bench grinders, heavy duty.

(11) One each electric drill, 1/2" drive and 3/4" drive.

(12) One front axle alignment trammel, truck capacity.



(13) Air and water should be available in the repair shop (each stall).

(14) One wheel dolly to remove dual wheels, as on unit (prevents damage to seals, etc.)

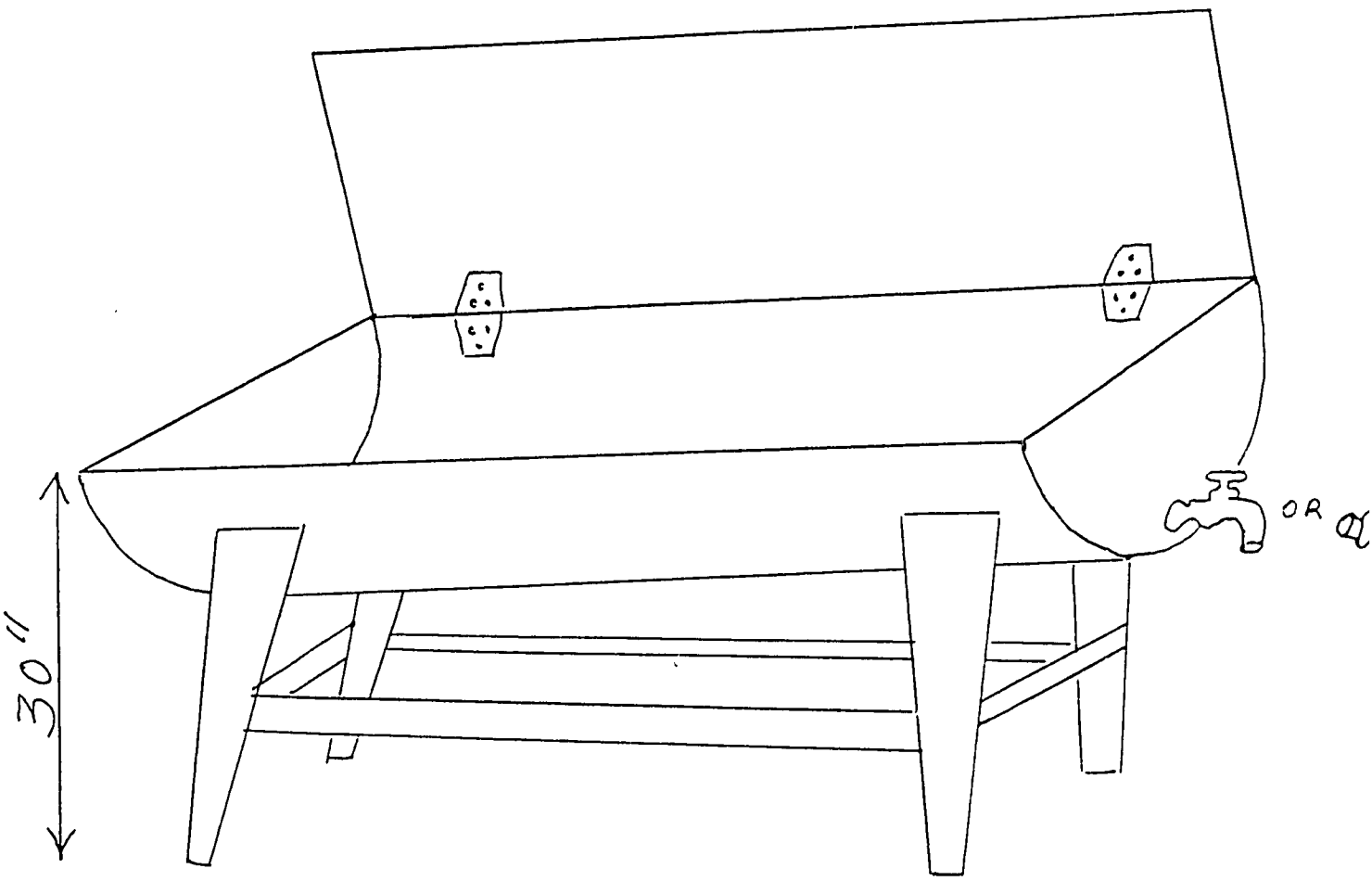
(15) Electrical extension cords, 50' with lights.

(16) Rags or waste material for parts and hand cleaning (continuous supply).

(17) Welding equipment, electric 250 amp capacity, gas with tips and cutting head, wheel mounted.

FABRICATE PARTS CLEANING TANK

Diesel Fuel/Kerosene/Cleaning Solvent



1. Cut 55 gallon barrel in half.
2. Weld on legs and braces.
3. Should have cover to keep out dirt.
4. Should have drain valve or plug to clean/drain.
5. Length of wire mesh/screen along bottom to keep parts out of dirt.

The incentive plan is applied in parallel with driver training. The bonus is related to the fuel savings achieved by a driver in Part 2 of the demonstrations (after driver training) in comparison with Part 1 (before driver training). The plan is structured as follows:

Fuel Saving Part 2 vs. Part 1	Portion Awarded to Drivers	Portion Retained by Owner
10%	65%	35%
5 - 10%	50%	50%
5%	35%	65%

This arrangement allows the driver to benefit most at the highest savings level.

It is desirable to supplement the above award with a non-monetary incentive; for example:

- The percentage awards for every driver are posted on a large table, prominently displayed.

- Certificates of recognition are awarded to the best drivers. The awards are delivered by a prominent person in a ceremony publicized by the communications media.

The incentive plan is announced after Part 1 (the baseline period) to avoid bias of the fuel use during that period. Since the incentive is calculated by the driver, all driver changes must take place at the company's fueling station, and be accompanied by a complete filling of the fuel tank. If the bus is driven partly by the owner, the sharing of savings does not apply while he is driving.

Appendix K

San José, Costa Rica

Telef.: 331055
Telex: 2363, Em
Apartado: 126/212
San José, Costa Ri

K.2

13 de noviembre de 1985

Señor

Conductor de Autobús
Empresa Guadalupe
Presente

Estimado señor:

La Dirección Sectorial de Energía, como es de su conocimiento, está realizando en la empresa para la cual usted labora, un proyecto demostrativo sobre como reducir los consumos de combustibles. Para ello se les impartió un curso de manejo eficiente. El entrenamiento consiste en aprovechar la experiencia suya conduciendo en aras de reducir los costos de transporte, que tanto perjudican a la empresa.

Usted fue seleccionado entre otros compañeros de trabajo suyos como participante activo del proyecto. Es de nuestro conocimiento que una reducción en el gasto de combustible será de gran beneficio para la empresa en que usted labora.

Como se expuso en el curso de entrenamiento que recibiera se pueden lograr reducciones de hasta el 20%. Sin embargo, el costo del combustible en la unidad que usted conduce, virtualmente la determina usted. Es por esta razón que concluimos en que si hay algún ahorro se deberá principalmente a su voluntad y por ello usted deberá ser partícipe en esas ganancias. Como parte del proyecto se pretende distribuir las ganancias de la siguiente forma:

1.- Cuando el ahorro es menor del 5%, las ganancias serán distribuidas así : 35% para el chofer y 65% para la empresa.

2.- Si se reduce entre un 5 y 10%, su beneficio aumentará al 50% y el resto comprenderá a la empresa.

3.- Sin embargo, si usted ahorra más del 10%, la empresa percibirá el 35% de ella y usted el restante 65%.

../2..

Señor

Conductor de Autobús
Empresa Guadalupe
Pág. # 2
13-11-85

... Adjunto a esta nota le adjunto una hoja ejemplo para que aprecie los ingresos extra que usted recibiría en cada caso. Sin nada más en particular y en espera de su aceptación total, se despide,

Atentamente,

Ing. Antony Araya J.
COORDINADOR

Gladys

Anexo

TABLA MUESTRA DE CONSUMO, AHORRO Y GANANCIAS POSIBLES

GASTO ¢ BUS	AHORRO 5%	GANANC. SUYA ¢	AHORRO 7.5%	GANANC. SUYA ¢	AHORRO 10%	GANANC. SUYA ¢	AHORRO 15%	GANANC. SUYA ¢
34200	1710	598.5	2565	1282.5	3420	2223	5130	3334.5
36100	1805	631.8	2707.5	1353.8	3610	2346.5	5415	3519.8
37050	1852.5	648.4	2778.8	1389.4	3705	2408.3	5557	3612.4
38000	1900	665	2850	1425	3800	2470	5700	3705
39900	1995	698.3	2992.5	1496.3	3990	2593.5	5985	3890.3
41800	2090	731.5	3135	1567.5	4180	2717	6270	4075.5