Cost Study: Before, During and After AOS Implementation

(October 1996 – May 1999)

Abstract:

This study compared AATA operating costs over two different time period: before and during AOS installation. While neither additional operating costs nor operating costs savings were traceable to AOS at this time, the implications of this report, while not conclusive, are optimistic regarding AOS's cost impacts over the longer run.

Overview of AATA's Advanced Operating System

In 1997, the Ann Arbor (Michigan) Transportation Authority began deploying advanced public transportation systems (APTS) technologies in its fixed route and paratransit operations. The project's concept is the integration of a range of such technologies into a comprehensive system, termed the "Advanced Operating System" (AOS) to "smart buses", "smart travelers," and a "smart operation center" to benefit from timely and coordinated information on critical aspects of transit operation and maintenance. The prime contractor for the project was Rockwell, and providers of other integrated subsystems included: Digital Recorders Research of Triangle Park, North Carolina; Trapeze Software of Mississauga, Ontario; Prima Facie of King of Prussia, Pennsylvania; REI of Omaha, Nebraska; Red Pines Instruments of Denbigh, Ontario; and Multisystems, Inc. Cambridge, Massachusetts. Evaluator for the project was a team from the Urban and Regional Planning Program of the College of Architecture and Urban Planning, University of Michigan.

"The Smart Bus"

Central to the system is the deployment of automatic vehicle location (AVL) technology in order to provide continuous real time data on the location of transit vehicles. Each bus determines its location using global positioning satellite (GPS) technology; differential corrections are broadcast to the vehicles so they can calculate their locations within one or two meters. A Mobile Data Terminal (MDT) in each vehicle stores complete route schedules on an insertable memory card. The GPS system provides accurate time to the vehicles. Buses compare scheduled times and locations with actual locations to determine their schedule adherence. If a bus determines that it is running late, the driver is advised, and if necessary, the onboard computer notifies the Operation Center. The AVL also triggers an outside destination announcement and the internal next-stop signs and announcement. It also integrates location data with fare collection, electronic controlled engine data and ultimately, automated passenger counters,

The AATA network makes use of extensive timed transfers at four major transfer points. When a bus is running behind schedule, AOS enables digital bus-to-bus communications to improve the transfer between buses; the driver of the first bus can send a digital request (that includes the bus' location) to hold the second bus to ensure that a passenger will not miss a desired transfer.

Video surveillance is provided on board vehicles for security, as well as to help resolve any claims that may arise.

On the paratransit side, drivers receive their entire schedules and mark their arrival and departure times with date, time and location information as well as all the features above.

"The Smart Operation Center"

The AATA Operation Center collects and acts upon information provided by the transit vehicle and drivers. Each AATA bus has an 800 MHZ radio and onboard computer. The system minimizes voice transmissions by providing data messages that summarize vehicle status, operating condition, and location. Out-of-tolerance engine conditions such as oil pressure and temperature are reported in real time to the onboard computer, the Operations Center and the Maintenance Department.

Through the use of real time displays of vehicle location and schedule adherence reporting, dispatchers working at the Operation Center can manage the system and assist drivers by inserting overload vehicles in the system or recommending re-routing options. All changes to the route and schedule database are noted and automatically updated.

Onboard the vehicle, the driver has an onboard emergency system. When encountering a life-threatening situation, the driver covertly alerts the dispatcher, who immediately notes the vehicle's location on the system's center map and dials the appropriate agency. The system also allows the dispatcher to open up a central public address system inside the vehicle to monitor the situation. The system also supports responsive reporting of routine, non-life-threatening emergencies, such as passenger inconvenience.

For paratransit vehicles, reservations, scheduling, flexible integration with fixed-route, and after-trip information utilize Trapeze software. All of these elements are based on real-time information generated with the Rockwell TransitMasterTM software.

"The Smart Traveler"

The "smart travler" a person informed about his or her transportation options, as well as about current conditions relative to transit use. Inside the bus, next stop announcements, date, time and route are given to passengers utilizing the onboard public address system and a two line LED display. The driver also has the ability to trigger timed and periodic announcements for special events that can be made to support the system. Outside the bus, the current route information is announced to waiting passengers, and the destination signs are changed based upon the location. Kiosks provide real-time bus location information at selected locations; ultimately this information will be provided to travelers at their home or workplace via telephone, cable television or internet.

Technology and Costs of Transit Provision

Deployment of technology in public transportation can affect transit costs in four potential ways:

A. The capital costs of the technology itself;
B. Any capital costs foregone because of the investment in advanced public transportation system technologies;
C. Any operating costs associated with the technology;

D. Any operating costs savings throughout the organization associated with automation in the functions that the technology provides.

This section is an exploration into these costs, with the understanding that full effects of AOS were not observable during the time period of this study. Furthermore, since items "B" through "D" above are not line items in the budget of AATA, they will largely be explored qualitatively and anecdotally in this study.

Thus this AOS cost study is focused on two different aspect of costs. The first one is a quantitative analysis of AATA’s operating costs incurred before and during AOS. The second one is a qualitative analysis about potential costs or cost savings associated with AOS.

Capital Costs

The following is a summary of AOS related capital costs incurred to 1999, prepared by Phil Webb, AATA controller.

COMPONENT	VENDOR	Cost per Vehicle*	TOTAL	% of Total
Mobile Data Terminals & related equip – ELFs	Rockwell	$9,106	$682,958	25.90%
Digital Recorder DR500C w/2 line display	Digital Recorder	$8,338	$625,360	23.70%
System Engineering & Project Management	Rockwell	$5,694	$427,055	16.20%
Trapeze Software	Trapeze	$3,481	$261,099	9.90%
Video Surveillance System	REI	$1,650	$123,774	4.70%
Digital Surveillance System w/ 2 cameras	Prima Facie	$1,058	$79,338	3.00%
External sign interface		$864	$64,834	2.50%
Acceptance Testing	Rockwell	$772	$57,930	2.20%
Training	Rockwell	$619	$46,421	1.80%
Work station licenses	Rockwell	$487	$36,500	1.40%
GFI Farebox Interfaces	Rockwell	$399	$29,920	1.10%
Arrival Departure Terminal	Rockwell	$346	$25,940	1.00%
Smart Card interfaces	Rockwell	$296	$22,173	0.80%
Passenger Counting System	Red Pine	$287	$21,510	0.80%
Radio/AVL in supervisory vehicles	Rockwell	$248	$18,594	0.70%
Custom Terminal Engineering charge	Schlumberger	$215	$16,146	0.60%
Radio System Hardware Components	Rockwell	$200	$15,000	0.60%
ELF installation	Rockwell	$192	$14,382	0.50%
Data Logger	Rockwell	$168	$12,565	0.50%
OCIS Work Station	Rockwell	$136	$10,211	0.40%
Central Recording Station	Digital Recorder	$133	$10,000	0.40%
Digital Stop request interface	Digital Recorder	$128	$9,600	0.40%
Zetron controls	Rockwell	$82	$6,140	0.20%
PrimaView Digital Video Viewer System	Rockwell	$74	$5,556	0.20%
MDT – Bus in a box	Rockwell	$72	$5,398	0.20%
POSCATS	Schlumberger	$62	$4,655	0.20%
Spare hard drives	Rockwell	$47	$3,556	0.10%
PrimaView handheld Diagnostic tool	Rockwell	$27	$2,025	0.10%
BTC Radio Equipment	Rockwell	$18	$1,360	0.10%
Total		$35,200	$2,640,000	

* Divided by the fleet number (75 buses)

Operating Costs

The before and during AOS time period is divided mainly based on the time point when AATA started the installation of AOS, also with a consideration of the fiscal year time period. In this study, the operating expenditures incurred in following time period are disaggregated and compared on a monthly basis:

- Before AOS: October 1995 - September 1996
- During AOS: October 1996 – September 1998
- After AOS: October 1998 – May 1999

All expenditures incurred after October 1995 are converted into constant dollar of October 1995 and classified by category and department.

The conclusion implicit in figures 1 is that there is no significant operating cost changes between the period before and the period after AOS deployment. The significant increase of expenditures in September 1997 and 1998 are largely due to the facility renovation projects and the increasing amount of depreciation costs classified by the Department of Finance rather than actual purchases that occurred during that month (Figure A2 in Appendix).

By Category

AATA operating costs are classified by ten different categories. Wages are the major expenditures in AATA, accounting for about 45% of its total operating costs. Other large categories of expenses include by expenditures on fringe benefits, purchased transportation and materials and supplies (Figure 2 to Figure 5). Again, in no category was any consistent increase in expenses with the beginning of AOS deployment. It should be understood that for much of this period AOS was under warranty, so no replacement or repair costs would be expected.

By Department

There are 21 different departments within AATA. The amount of expenditures of each department varies. The top 6 departments in terms of the amount of expenditures are: Operations, Vehicle Maintenance, Facility Maintenance, ADA Service, General Administration and Finance. They account for more than 75% of AATA's total operating costs period (Figures A1 to A7 in Appendix).

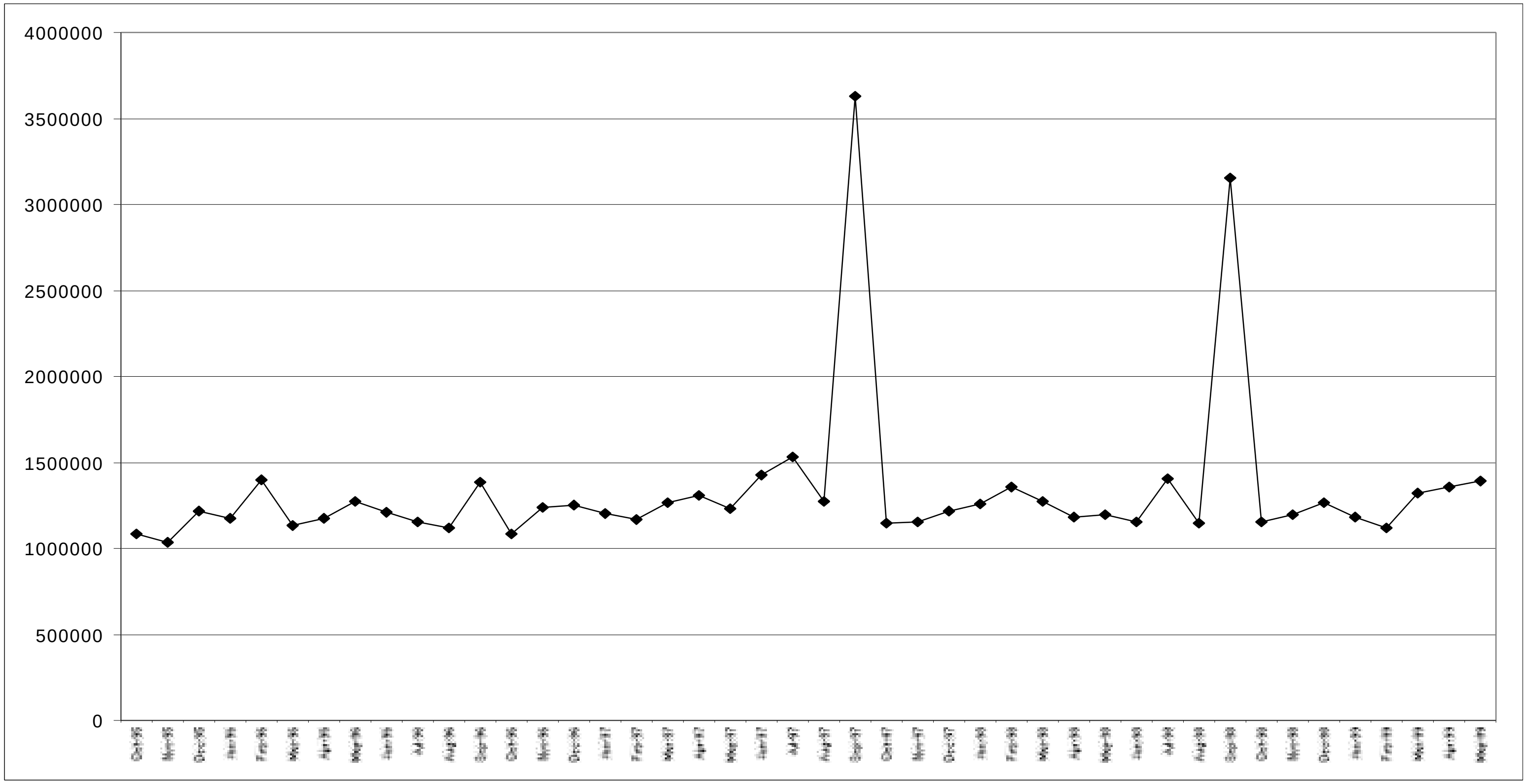


Figure 1 AATA Operating Costs by Category ($ amount are constant $ of Oct. 1995)
Before AOS: Oct. 95 – Sept. 96; During AOS: Oct. 96 – Sept – 98; After AOS: Oct. 98 – May 99.

Figure 2 AATA Operating Costs by Category ($ amount are constant $ of Oct. 1995)

Before AOS: Oct. 95 – Sept. 96; During AOS: Oct. 96 – Sept – 98; After AOS: Oct. 98 – May 99.

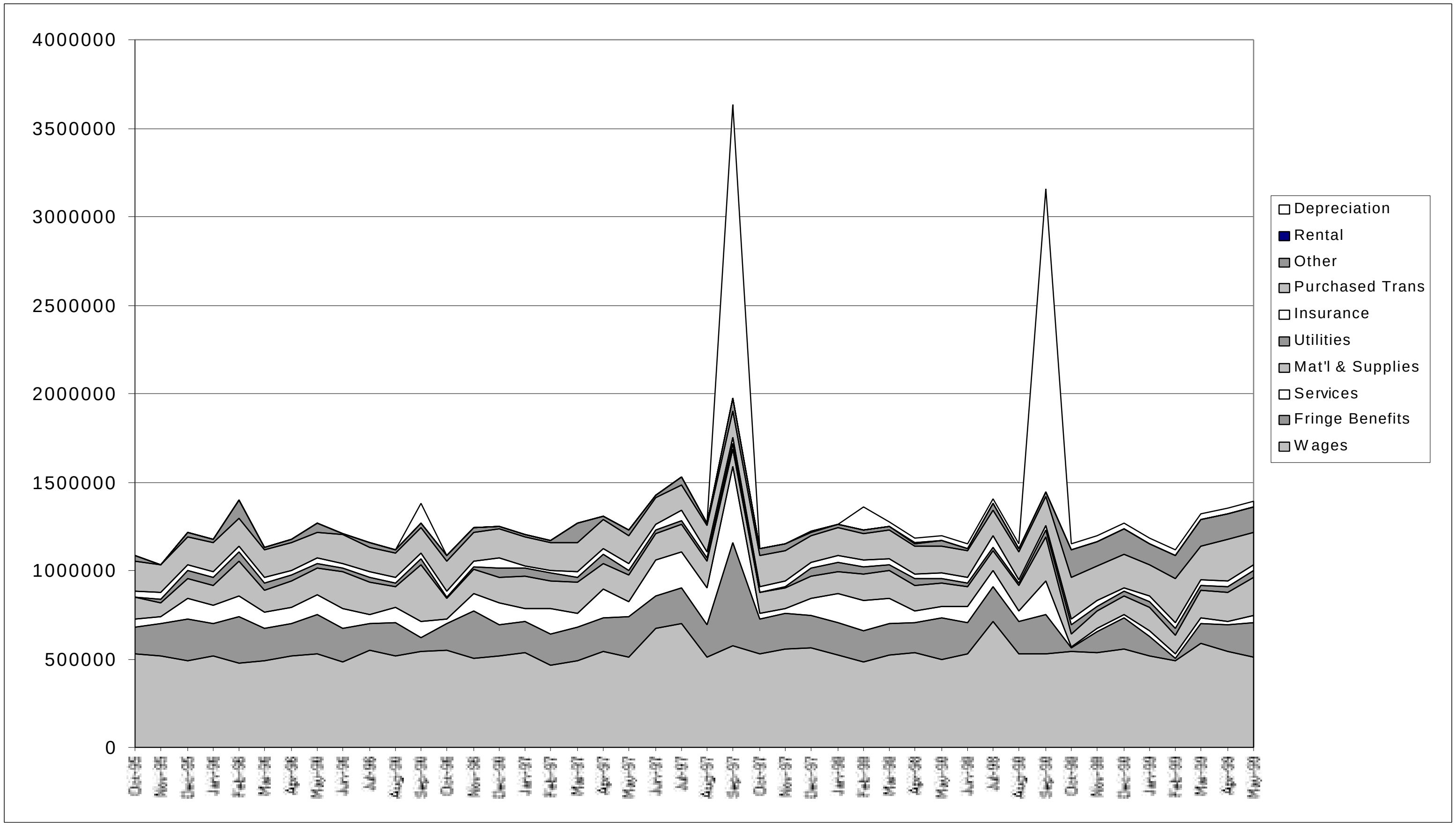


Figure 3 AATA Operating Costs by Category ($ amount are constant $ of Oct. 1995)
Before AOS: Oct. 95 – Sept. 96; During AOS: Oct. 96 – Sept – 98; After AOS: Oct. 98 – May 99.

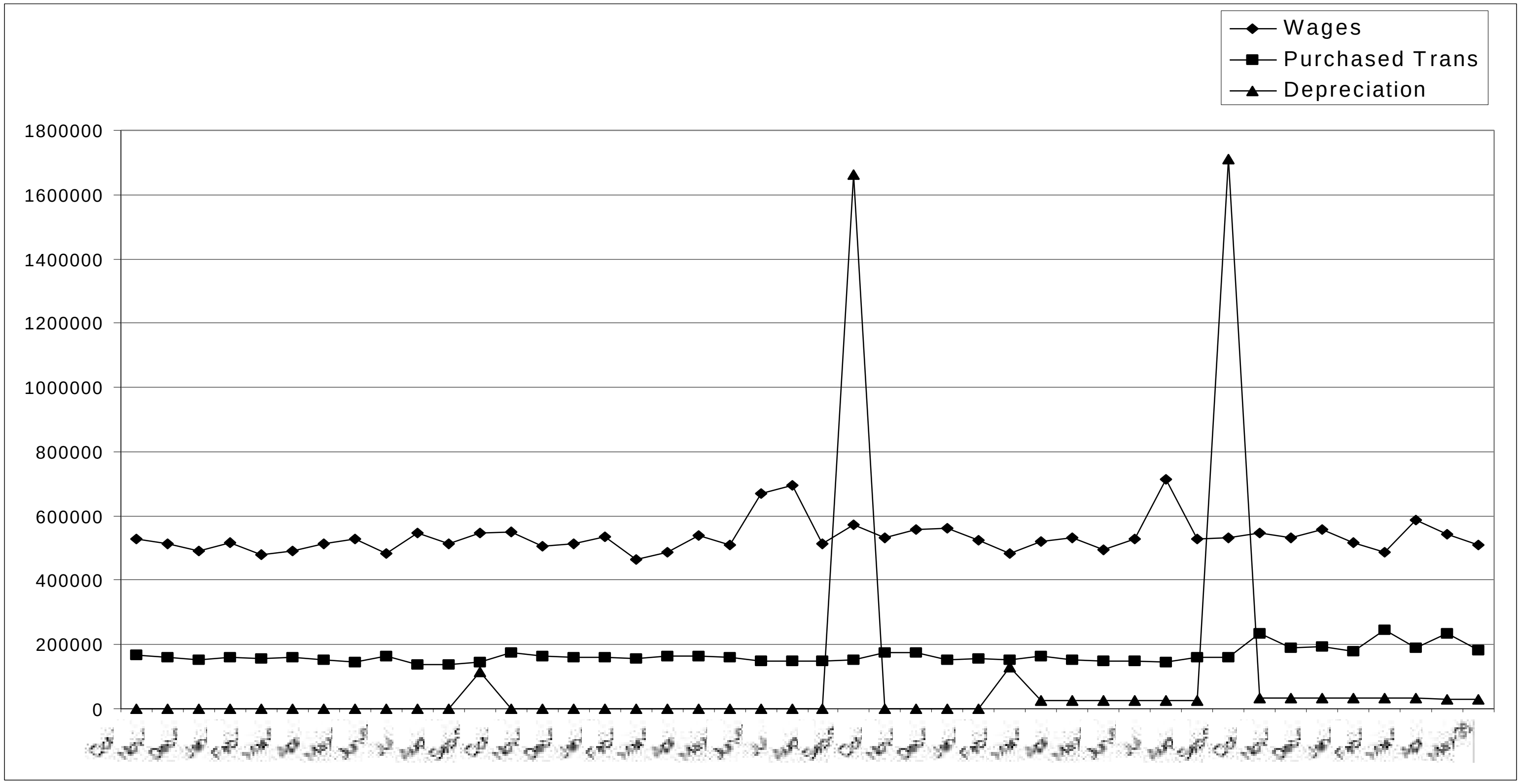


Figure 4 AATA Operating Costs by Category ($ amount are constant $ of Oct. 1995)
Before AOS: Oct. 95 – Sept. 96; During AOS: Oct. 96 – Sept – 98; After AOS: Oct. 98 – May 99.

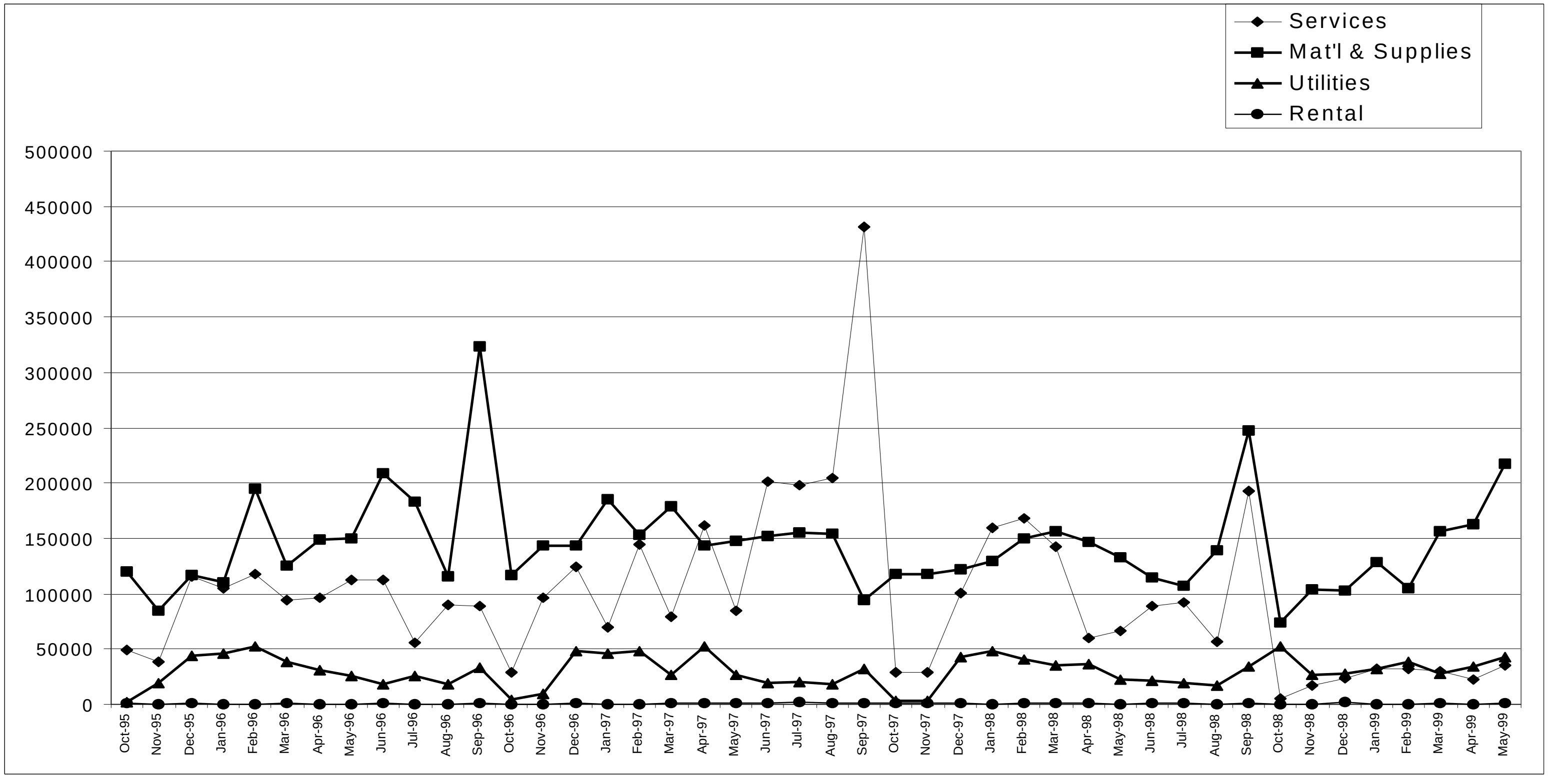
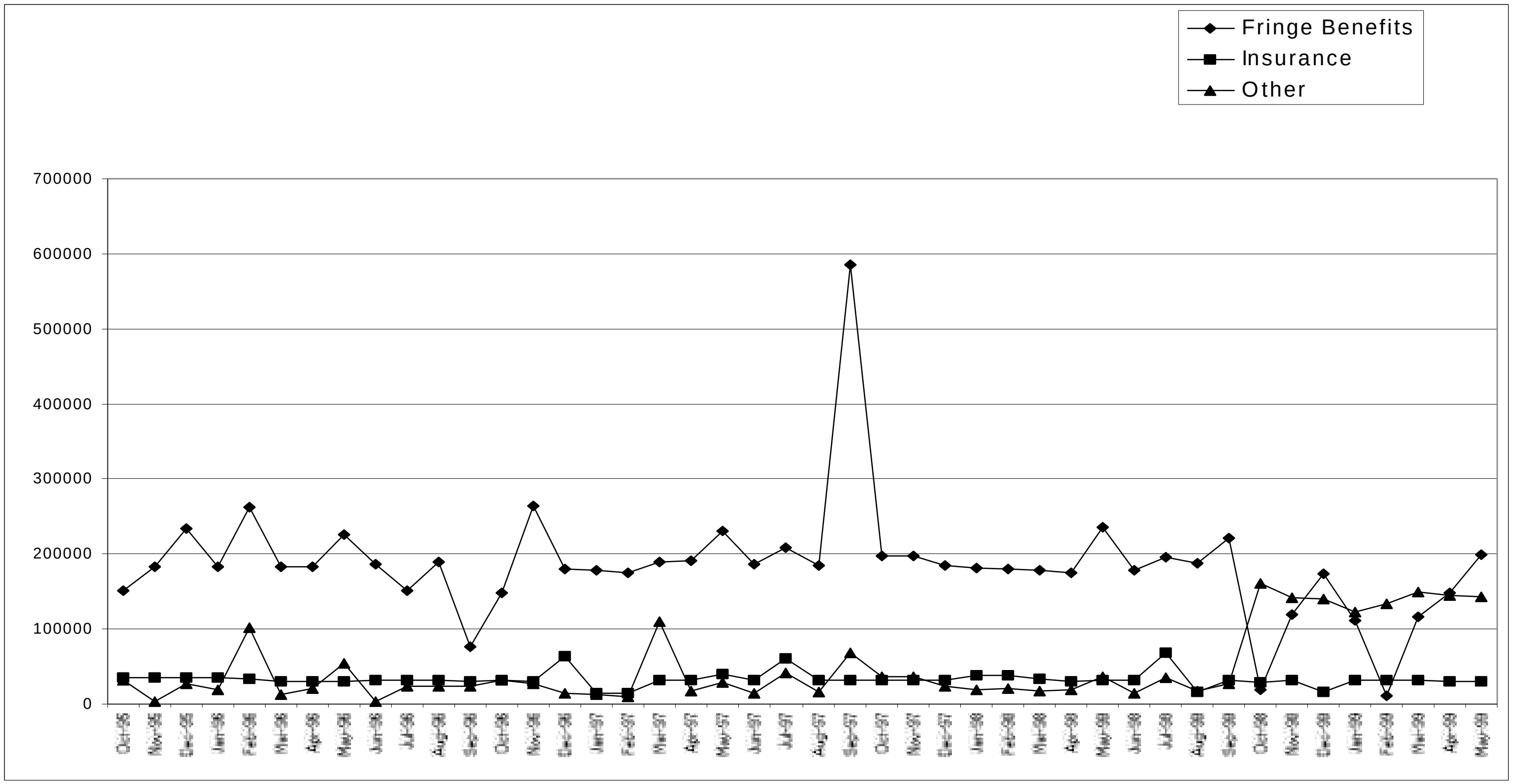


Figure 5 AATA Operating Costs by Category ($ amount are constant $ of Oct. 1995)
Before AOS: Oct. 95 – Sept. 96; During AOS: Oct. 96 – Sept – 98; After AOS: Oct. 98 – May 99.



Potential Costs or Costs Savings Associated with AOS

The Advanced Operation Systems are very important technological improvements to AATA. Its capital costs (2.7 million in total) were incurred very visibly. However, the benefits of these investments in terms of labor or capital savings are less clear, especially in the short run. In order to assess the potential range of effects, interviews were held with AATA's senior staff members. Based on early experience with AOS, it appears that the system will affect a broad range of operation, and management with regard to potential costs or costs savings. The areas of anticipated impact are described below.

Maintenance

DDEC (Detroit Diesel Electronic Controls) is an electronic system and is integrated into the engine, so mechanical problems such as low coolant or oil will be reported immediately. The function should save drivers' labor and time since the computers will provide all mechanical information when bus drivers start the vehicles every morning. Anticipated benefits include the prevention of mechanical problems and interruption of bus service.

There is also potential costs savings by reducing the number of road calls if the buses are more reliable. And more importantly, if the system becomes more reliable, passengers confidence with AATA's transit system will also increase. This kind of change is important but hard to be measured by dollar amount.

As AOS is still in warranty period, AATA does need to maintain an inventory of AOS parts right now. Thus in contrast to the maintenance cost described here, a currently unknown amount will need to be devoted in the future to maintaining an inventory of AOS parts in the future.

Operations

One important feature of AOS is the consistent and accurate time setting throughout the whole transit system. For example, it becomes easier and more efficient for dispatchers to monitor the operating process, and to coordinate transfers and paratransit. The uniform time will also provide better documentation and data quality throughout the system, and will facilitate ready reconstruction of events when any incident occurs.

Costs of Legal Claims

Another important component of AOS is the three inside video cameras on each bus (installed in February 1997, operational in August 1997). These video cameras can not only capture the activities inside the bus, but also some activities outside of the vehicles. Although there is some capital cost and maintenance expenditures on the cameras, they will help to resolve complaints and legal claims, both in terms of time and cash cost. In the long run, the video camera will also reduce the number of legal claims. And if the legal claims decline, AATA's insurance costs will decline too, although the trend is not clear at present, mainly because there is a time lag with the legal claims data.

Human Resources

There is no need for AATA to hire more technicians in order to run AOS at present. However, since AOS produces lots of data, there is a need to better compile and analyze the database. A new programmer might be necessary to perform this task in the future.

AOS totally altered the nature of the drivers' and dispatchers' training. While there were initial costs in retraining existing drivers and dispatchers, it is believed that this training will simply be incorporated into training overall, and need not require significant additional expenses.

Conclusions

The implications of this report, while not conclusive, are optimistic regarding AOS' cost impacts over the longer run. While neither additional operating costs nor operating cost savings were traceable to AOS at this time, prospects are for at most modest increases in operating costs associated with deployment of the technology. At the same time, operating cost savings, while currently unrealized, have the potential to grow to significant levels as benefits described above begin to accumulate.