Job Expansion: An Additional Benefit of a

Computer Aided Dispatch/Automatic Vehicle Locator (CAD/AVL) System

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Mary D. Stearns, Ph.D.
Project Manager
Operator Performance and Safety Analysis Division, DTS-79,
Volpe National Transportation Systems Center
Research and Special Programs Administration, U. S. Department of Transportation
55 Broadway
Cambridge, MA 02142
T 617-494-2617, F 617-494-3622
stearnsm@volpe.dot.gov

ABSTRACT

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The Denver Regional Transportation District (RTD) acquired a CAD/AVL system that became fully operational in 1996. The CAD/AVL system added radio channels and covert alarms in buses, located vehicles in real time, and monitored schedule adherence. The Operator Performance and Safety Analysis Division, DTS-79, U. S. Department of Transportation's Volpe National Transportation Systems Center, with the support of the Federal Transit Administration's (FTA) Advanced Public Transportation Systems (APTS) Program, examined the human factors consequences of RTD employees' use of the CAD/AVL system.

Dispatchers spend more time communicating about a greater variety of topics. The RTD dispatchers receive and transmit more calls as well as trace transit operations occurring both in real time and retrospectively. Having information, accurate in place and time, meant that the dispatchers could provide accurate information about on-street operations. RTD initially expected that accurate representation of transit operations would reduce the number of street supervisors. Because the street supervisors access to real-time information from mobile data terminals (MDT) in their vehicles, they have assumed more duties. Because they have more autonomy, they perform their jobs more effectively in the field.

Installing information technology in a transit operation leads to many benefits, not all of which can be anticipated. This paper highlights the additional benefit that was realized as a result of installing information technology in a transit operation. The provision of accurate real time information enhanced the resources that employees had to do their jobs. It made it possible for them to act more effectively to support the delivery of transit service. This outcome corresponds to what has happened when information technology was introduced in other sectors of the economy.

INTRODUCTION

The Denver Regional Transportation District (RTD) installed a Computer Aided Dispatch/Automatic Vehicle Location (CAD/AVL) system to upgrade communication, increase the number of radio channels, improve safety on buses, and provide real time monitoring of buses' schedule adherence. RTD installed CAD/AVL on its entire vehicle fleet. This paper describes how the CAD/AVL's information technology helped the RTD employees using it to work more effectively. Using data collected before and after CAD/AVL installation, this paper documents how its information technology assets increased both the number and variety of the duties performed by the dispatchers and the street supervisors.

RTD anticipated that CAD/AVL use would increase the number of dispatchers and decrease the number of street supervisors. The dispatchers and street supervisors continued to perform the same jobs but they were able to do them differently and more efficiently. There were also unexpected changes; the CAD/AVL system's capabilities changed, as well as expanded certain duties. Dispatchers and street supervisors became more productive both because they expanded the variety of their duties as well as performing them more efficiently.

BACKGROUND

RTD provides public transportation for a metropolitan area that has a population of 2.3 million, encompasses forty-four municipalities, and covers 2,400 square miles. RTD operates the 12th largest transit bus fleet in the United States, as well as a light-rail line.

Between 1992 and 1997, RTD ridership increased while, at the same time, service was both expanded and improved. RTD ridership increased 23% while operating hours increased 17%, exclusive of the introduction of light rail service, and its total hub miles 26%, including contractor service. (1) During the same time period, RTD improved its on-time performance, increased the number of routes, and added service to distant locations, including the Denver International Airport

In the early 1990's, RTD recognized the need to upgrade its radio system due to increasing radio congestion. At times of high demand, calls from bus drivers would drop out of the system due to the limited number of radio channels. In 1992, RTD acquired a satellite-based CAD/AVL system, using Global Positioning Satellite (GPS) technology, with differential error correction, to track vehicle location within 100 feet. RTD completed acceptance testing of the CAD/AVL system in 1996.

Castle Rock Consultants evaluated Denver RTD's CAD/AVL system for the Federal Transit Administration, (1) and Stearns, et al, (2) documented the human factors consequences, i.e., changes in work procedures, usability, workload, and training.

CAD/AVL Equipment

As part of the CAD/AVL, the dispatchers acquired new equipment with enhanced capabilities. CAD/AVL added radio channels to alleviate the congested communication, displayed real-time vehicle location and schedule performance, and increased safety through accurate location of emergencies. Dispatchers also gained the capability to communicate directly with buses from other divisions, to receive and respond to covert emergency calls from buses, to "playback" past route performance of a particular bus, and to show the locations of buses out of service, for example, during snowstorms.

RTD's dispatchers use dual computer screens (the CAD and AVL screens) that are located side-by-side. The CAD screen is the control center because it lists the radio calls by priority. The dispatchers see vehicles' location on a scalable map on the AVL screen. Dispatchers access response options using "pull-down" menus and can select the desired level of detail to display on the AVL screen.

The street supervisors use laptop computers, Mobile Display Terminals (MDT), while they patrol their sector in a supervisor vehicle. They check out a MDT at the start of their shift and use it to access real time operating information. The MDTs are multitasking and have a windows operating system. The MDT has function keys for frequently used commands. The MDT design does not require street supervisors to recall data-entry commands because they can scroll through them. Display clutter on the MDT is not a problem and they can adjust the screen's brightness

RTD installed transit control heads (TCH) in every bus, mounted on a stalk to the right of the steering wheel, which can be rotated to improve viewing angle. Bus drivers use the TCH as their primary communication interface with the CAD/AVL system and the dispatchers. The TCH has a keypad with precoded buttons, a Liquid Crystal Display (LCD), an internal speaker, and covert microphone. Bus drivers initiate communication with the Dispatch Center by selecting one of the precoded buttons to push.

EMPLOYEE DUTIES

Dispatchers

The CAD/AVL system made the dispatchers' communications more efficient. The AVL screen shows the real-time location of RTD vehicles and updates the information every two minutes. The dispatchers often need to locate RTD's maintenance trucks to assign them to assist a disabled bus. Dispatchers use the AVL display to identify which maintenance vehicle is closest to the disabled bus. Denver dispatchers can contact Boulder buses and Boulder dispatchers can contact Denver buses. They can hold connections between Boulder and Denver buses. Previously, only Boulder dispatchers could talk to Boulder buses and they had to use intermediaries to contact vehicles outside their metropolitan area.

The CAD screen shows bus numbers, route assignments, and operator information. Previously, the dispatchers had to request this information, by radio, from the bus drivers. Dispatchers do not need paper records of bus numbers because the CAD screen displays this information.

Weather and sporting events boost demand for RTD service. The dispatchers work more efficiently in challenging conditions. When RTD operates "load and go" service from their "Park & Ride" lots to the sport stadiums, the dispatchers advise the supervisors of the actual location of the shuttle service to these lots. There is high demand for dispatch service during snow emergencies and their call volume may double. The CAD/AVL system does not "lose calls" during snow emergencies when there is heavy call volume because bus calls can not drop out of the radio system. The CAD retains all the messages it receives and dispatchers respond to them by priority.

The size of the dispatch staff at RTD's Dispatch Center has increased 22%, to eleven, since the implementation of CAD/AVL. In 1996, five dispatchers were on duty during peak hours compared to three in 1992. The number of dispatch hours per weekday has increased 46%. The increased hours cover peak hour operations. Using CAD/AVL software commands, the lead dispatcher can reassign dispatcher positions quickly, without changing workstations, to respond to variations in the operational demands during the course of a day.

Street Supervisors

The street supervisors have more radio channels and receive more information from both their radio and the MDT. Street supervisors can call buses directly without being patched through by a dispatcher. Supervisors send and receive messages using the MDT. When the MDT receives a text message, it places the message in the Received Messages window and emits an auditory alert, a beep. The MDT beeps at 30-second intervals until the message is viewed or deleted.

Street supervisors use the MDT to perform many of their tasks. . They are able to retrieve information about a bus from the MDT in their vehicle. They can review headway information; request information about a route or vehicle or a voice channel to talk to a particular bus; and select, edit, and fill out forms electronically. A supervisor can locate a bus and determine whether it is ahead, or behind, schedule by entering the bus number or the route and block on the MDT. The MDT reports the bus location using a text message. Street supervisors can retrieve bus drivers' schedules and extra board assignments from the MDT.

The MDT's do not have an AVL screen. Street supervisors would like to have the same AVL screen that the dispatchers have. Their laptop computer could store a map but sending location information would require the laptop computer to have copious memory and enhanced speed.

Denver RTD employed 25 street supervisors and two supervisors in 1996, an increase of two supervisors since 1992. The two additional supervisors do not represent an increase in the supervisors in the field because they were hired to cover vacations and extra duty shifts to end the use of part-time substitutes. By 1996 and 1999, the number of street supervisors increased to 29, including the two supervisors.

JOB EXPANSION

Dispatchers

Operation of CAD/AVL created a need for an additional dispatch position and as well as new duties for the dispatchers. RTD added a second supervisory lead dispatch position to handle administrative functions, i.e., adjusting the software parameters for the CAD/AVL system and operating the "playback" feature. "Playbacks" show whether a bus actually provided service on a route and how well it adhered to its schedule. RTD departments request use of the "playback" capability to resolve questions.

The second lead dispatcher plays back past operations upon request from other RTD departments and may do several "playbacks" per day. RTD's Schedule Planning and Customer Service staff request CAD/AVL data to evaluate route performance and respond to customer complaints about service. For example, RTD received a complaint from the parents of a high-school student that the student was constantly late for school due to a late bus. The "playback" showed that the bus was on time. There also have been expressions of interest in accessing this database by emergency services and planning agencies in the Denver area. RTD plans to place CAD/AVL consoles in other RTD departments so that departmental personnel can access the system's information.

RTD records the radio calls to the Dispatch Center in an internal daily report called the "Dispatchers' Daily Activity Log." Dispatchers enter and code calls, using RTD's problem codes, into the CAD while the incident is open. The calls recorded in this log are a low estimate of the total number of calls they receive each day. The log records only incidents that have been assigned one of RTD's problem codes by the dispatcher. CAD/AVL transfers information automatically to RTD's main frame when a problem code has been assigned

Figure 1 shows how the volume of calls during a typical day in 1996 has increased as compared to 1992. The temporal distribution of calls is similar between 1992 and 1996. More than one quarter of bus calls to the Dispatch Center occurred during the afternoon peak hours which represents one eighth of the day.

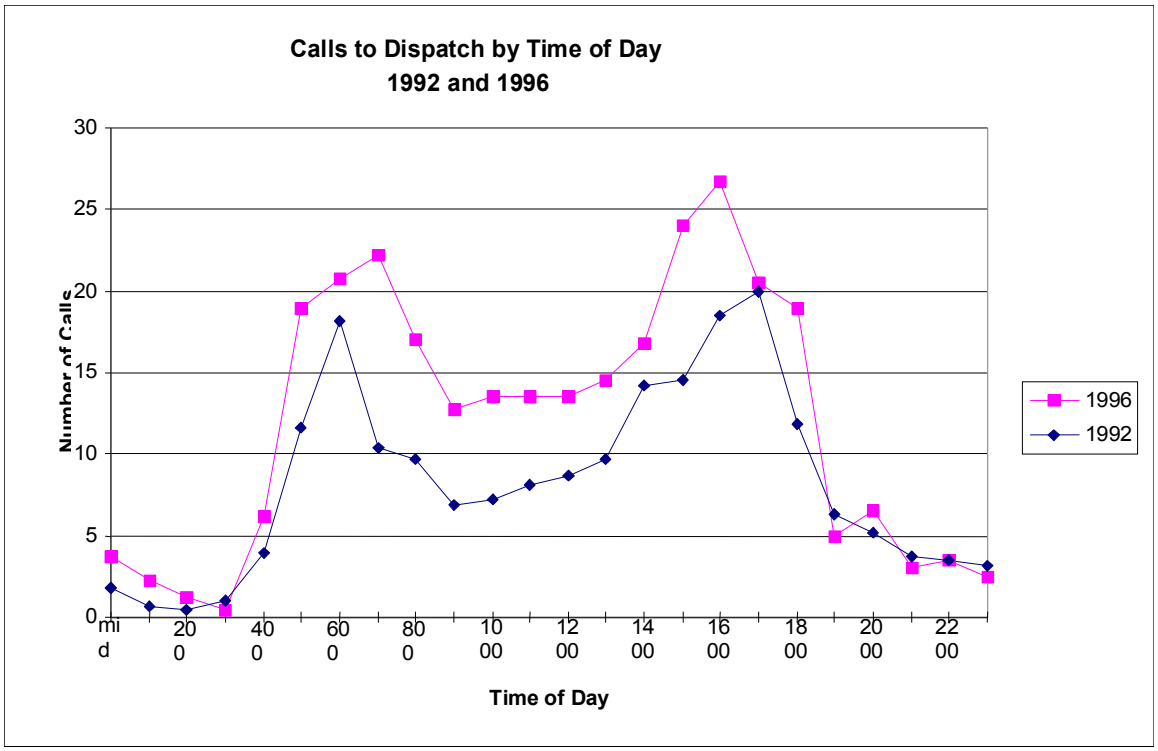

Figure 1. Calls to Dispatch by Time of Time, 1992 and 1996

The use of CAD/AVL has shifted the distribution of the types of radio calls to the Dispatch Center from the bus drivers. Figure 2 shows the twenty most frequent reasons that bus drivers called the Dispatch Center classified using RTD's problem codes. These twenty most frequent reasons for contacting a dispatcher represent more than two-thirds of all the calls received by the dispatchers in 1996.

The number of calls from bus drivers asking for "policy information/direction" has doubled since 1992 and now is more than one-fifth of the calls to the dispatchers. "Policy Information/Direction" calls refer to situations where a bus driver needs to ask about RTD's operating policy, for example, on transfers. The bus drivers also make more calls to ask the dispatchers to hold another bus for connecting passengers. The proportion of these calls increased from 1% in 1992 to 9% in 1996.

Dispatchers' communications with bus drivers has increased because their reasons for making a call have changed. Bus drivers can not transmit a request for information about RTD's policies or request connections using the coded buttons on the TCH. These requests require verbal communication with the dispatchers and may require extended explanations or interpretations. The increased proportion of these calls shows why the dispatchers are doing more communicating with bus drivers.

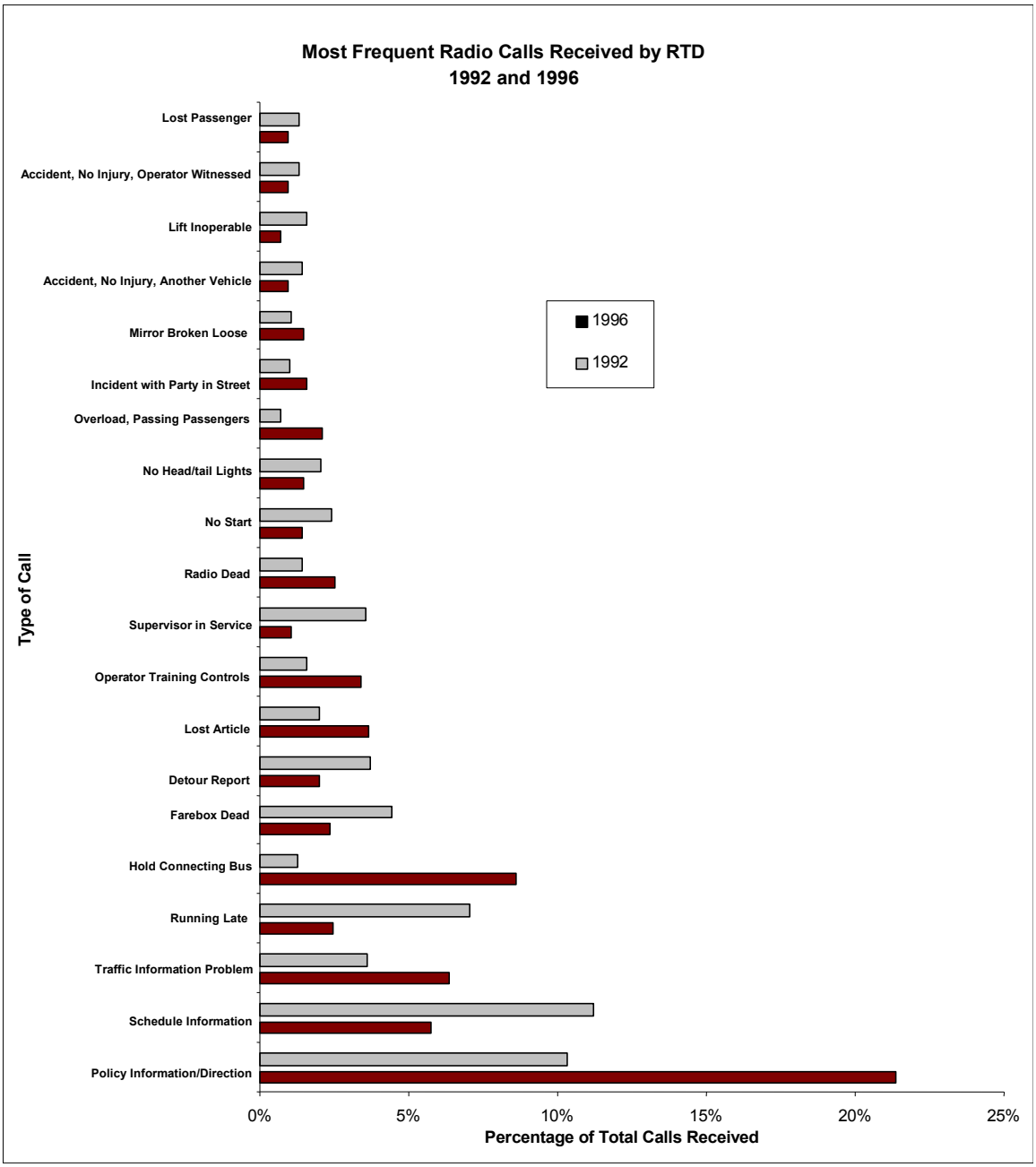

Figure 2. Most Frequent Types of Radio Calls Received at the Dispatch Center, 1992 and 1996

Figure 3 gives additional evidence that CAD/AVL has increased the communication that dispatchers have with bus drivers. By extrapolating from the type of calls bus drivers made to the dispatchers in 1992, it is possible to see if introducing CAD/AVL changed the reasons for calling the dispatchers. By examining the reasons that bus drivers called the Dispatch Center in 1992 and allocating them using the precoded buttons on the TCH, 25% of the calls in 1996 should be “requests to talk. " This extrapolation assumes that the bus driver uses the TCH buttons coded for specific problems such as fare disputes,

bus too full and had to pass up passengers, lift not working, etc., for these problems. The actual use of the TCH buttons did not correspond to the extrapolated. Instead, more than 90% of the calls from the bus drivers in 1996 were "requests to talk." (Figure 3)

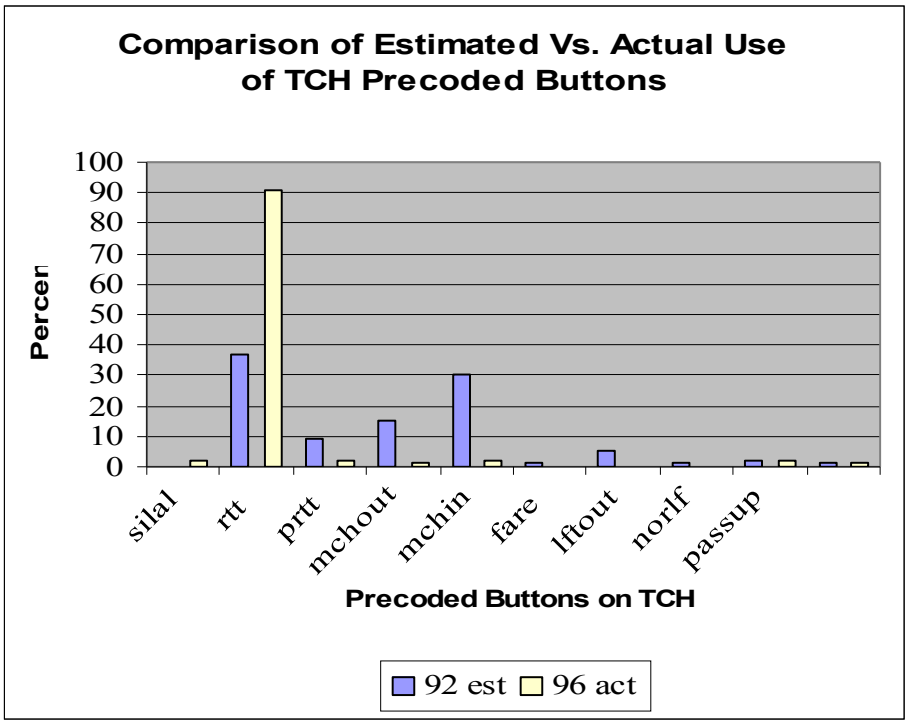

Figure 3. Estimated Vs. Actual Use of TCH Precoded Buttons

Figure 4 quantifies how much time dispatchers spend performing their duties and quantifies the increased length of each dispatcher communication. In 1996, using CAD/AVL, dispatchers spent more time on each communication, i.e., talking on the radio and phone. By contrast, they spent less time handling paper and computer data entry.

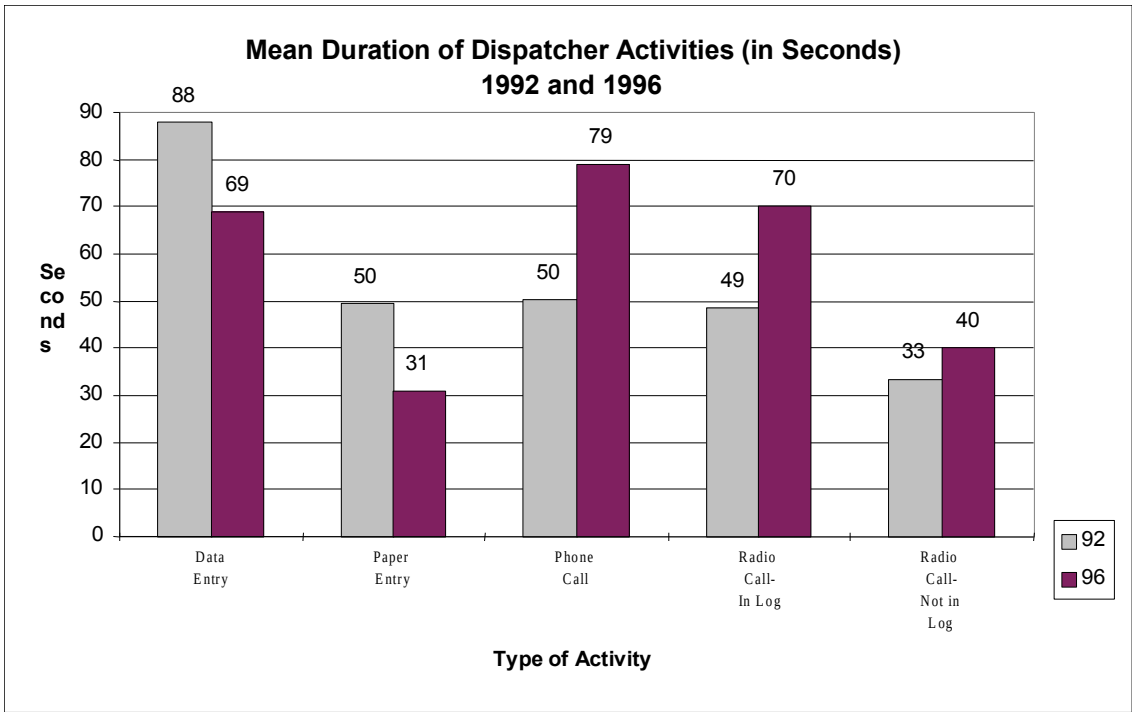

Figure 4. Dispatcher Activities by Time, 1992 and 1996

In summary, use of the CAD/AVL affected the dispatchers' work practices. The dispatchers process an increased volume of communication. They spend more of their time communicating with field personnel. They provide more interpretations of RTD policies and make more arrangements to provide a higher level of service for the transit users. They make the information resident in the CAD/AVL available to other segments of RTD as well as the community. As a result, RTD has increased the number of dispatchers.

Street Supervisors

Street supervisors locate buses using a MDT. They can speak to the bus driver directly without using a dispatcher as an intermediary. They like the ability of the MDT to give them information without requesting it from others, as well as the information they can access quickly such as bus driver numbers, location, badge number, roster of drivers, route and block for a bus driver. The street supervisors cover more area and have more frequent contact with bus drivers even though the work force was stable in size through 1996 while RTD service expanded.

Because CAD/AVL reduced the street supervisors' duty to perform traffic checks, they have acquired additional, and more varied, duties. Street supervisors report that they

perform their jobs better using CAD/AVL because they can access to more real time information. As a result, they now perform a larger variety of tasks. Because the street supervisors have more information, they are better-informed members of the RTD field management team.

The street supervisors realize that the CAD/AVL performs tasks they used to have to do. The street supervisors said that CAD/AVL has been helpful and that, "it doesn't seem hard." They commented that CAD/AVL is a "“great system, ”“makes the job so much easier." They view it as a way to look at the bus schedule electronically. "With a 'locator system,' (there is)...no need to sit there to tell if a bus will be late."

From 1992 to 1996, the daily mileage covered by all the street supervisor vehicles increased 9%. The increased mileage reflects the expansion of their duties, to monitor the new bus service to the Denver International Airport, as well as the expansion of RTD's service area.

Street supervisors contacted the dispatchers slightly less than forty times per day in 1996 and more than forty times per day in 1992. On average, each street supervisor contacted dispatch an average of 2.5 times per day in 1992 and 2.3 times in 1996. The trend is down because the street supervisors can act more autonomously with more information.

Figure 5 enumerates the street supervisors' daily activities, as extracted from their daily logs. Their activities include contacting bus drivers; meeting and helping with disabled buses; checking the schedule adherence on routes; surveillance checks of RTD's park and ride lots, garages, and downtown stations; checking or creating detours; responding to accident scenes; tracking lost and found incidents; removing sick passengers from buses; giving transfer slips to buses in service; shuttling bus drivers from garage to garage; delivering supplies.

The mean number of route checks per street supervisor decreased from eight in 1992 to slightly more than two in 1996. Time checks dropped from five in 1992 to an average per shift of two in 1996. However, street supervisors have more contact with bus drivers. Personal contact with bus drivers doubled, from slightly more than five in 1992 to almost ten in 1996. There is also an increase in activities classified as "other." This shows that RTD is increasingly using the street supervisors as a resource to support their field operations.

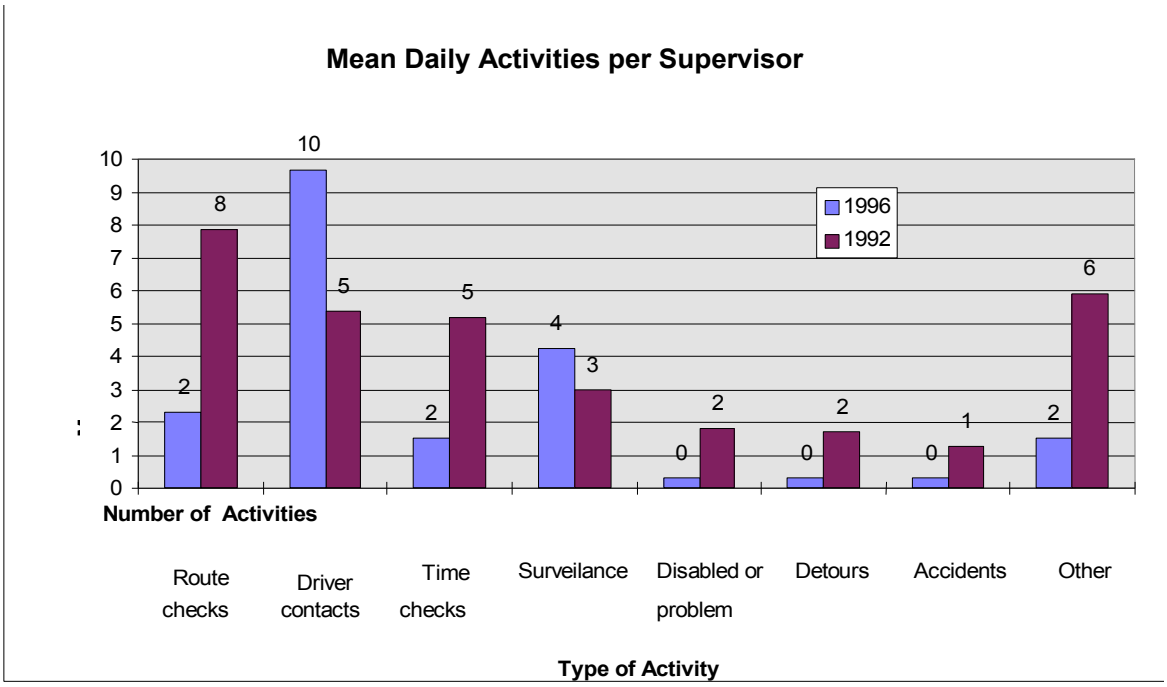

Figure 5. Mean Daily Activities Per Street Supervisor, 1992 and 1996

In summary, the number of street supervisors has remained constant despite an increase in service and ridership. CAD/AVL and the MDT's have transformed the street supervisor into an informed member of the RTD in the field able to handle problems with more independence and more information. They contact bus drivers more and dispatchers less often. They have less need to monitor schedule performance due to CAD/AVL's real time information.

Street supervisor procedures have changed as a result of using CAD/AVL. They now have real-time schedule information from MDT to check schedule /route adherence (replacing loose-leaf binders). They use their MDT to enter reports electronically, i.e., Park and Ride counts, traffic counts, incident reports, and accident reports. They communicate with buses directly (instead of using the dispatcher as a go-between). They send and receive text messages (instead of speaking on the radio) and find this useful for detour information and personnel matters considered sensitive. They no longer need to report their location to the Dispatch Center. The success of providing more information to field personnel is echoed in their enthusiastic adoption of this capability.

CONCLUSION

The implementation of CAD/AVL at the Denver RTD had many benefits. It permits more communication, provides real time location information, and monitors schedule performance in real time. At the same time, the information technology in the CAD/AVL system provided an additional benefit. RTD can provide its riders a better level of service because the dispatchers and street supervisors perform more, as well as more varied, duties.

The dispatchers respond to all the calls from the bus drivers. Calls, which might have been lost by the previous limited number of radio channels, reach the Dispatch Center. The dispatchers now spend proportionally more of their time communicating with bus drivers and other field support personnel. An increased proportion of these calls requires detailed explanations.

People, both inside and outside RTD, have recognized the utility of the information that the Dispatch Center generates for better monitoring the provision of transit service on the street. The dispatchers provide more support to RTD's administrative functions. As a result, RTD has created a second lead dispatch position to process these requests for information.

RTD expected to reduce the number of street supervisors, given that CAD/AVL assumed one of their major tasks, monitoring and recording schedule adherence at the time checkpoints in the field. Instead, they are better able to work effectively and independently in the field. Real time information and direct communication with RTD vehicles has made it possible for street supervisors to talk to bus drivers directly and have personal contact with bus drivers more often. They communicate directly with a particular bus, rather than being patched through via the Dispatch Center, and give immediate feedback to bus drivers about schedule and driving performance. The street supervisors themselves recognize that their role in RTD's operations has become even more critical. They voice the most unequivocal expressions of support for the CAD/AVL system.

These findings parallel what industry has found following the introduction of information technology. "The use of IT can change an individual worker's degree of autonomy in doing his or her job." (3) The street supervisors' ability to act more autonomously exemplifies how the access to the MDT has changed how they do their job. They communicate directly with buses, access schedule and headway information directly, and take more independent actions to support and maintain service in the field.

It also has been noted that, contrary to expectations, " IT, may, in some cases, increase rather than decrease employment. (because)…IT makes coordination more effective and less expensive, the demand for coordination and for …the clerks who provide it may increase.. (3) Bus drivers make more requests for detailed information because they have learned that they are more likely to get through to a dispatcher. It is likely that this type of non-urgent request that can be deferred was set aside prior to CAD/AVL if bus drivers had difficulty reaching a dispatcher. Because dispatchers can respond means that the RTD has improved the level of service it provides.

ACKNOWLEDGEMENTS

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ENDNOTES

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LIST OF FIGURES