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Publication Date

2002-02-01

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The contents of this report reflect the views of the authors who are responsible
for the facts and the accuracy of the data presented herein. The contents do not
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CALIFORNIA PARTNERS FOR ADVANCED TRANSIT AND HIGHWAYS

**SAN GABRIEL VALLEY SMART SHUTTLE TECHNOLOGY (SGVSST)
FIELD OPERATIONAL TEST EVALUATION**

FINAL REPORT

AUGUST 2001

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California PATH Research Report

AUGUST 2001

DISCLAIMER

This work was performed as part of the California PATH Program of the University of California, in cooperation with the University of Southern California; the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the United States Department of Transportation.

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ACKNOWLEDGMENTS

ABSTRACT

This report presents results of the San Gabriel Valley Smart Shuttle (SGVSS) Field Operational Test (FOT). Results are drawn from a comprehensive evaluation of the FOT conducted over a three-year period. The SGVSS attempted to integrate services of three local municipal public transit operators and a regional fixed route operator via networked computer-assisted dispatching, automated vehicle location, and mobile data terminals. The integrated system was never fully deployed. We describe the project, its participants and the history of the project. The portions of the SGVSS that were deployed are evaluated, with special emphasis on one public transit operator. We conduct an institutional analysis of the FOT; institutional issues largely explain project outcomes. The FOT provides many insights on the challenges of service integration. The report concludes with lessons learned.

Key words: Public transit, New technology, Service integration

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CHAPTER ONE

INTRODUCTION

1.1   INTRODUCTION

With the passage of ISTEA in 1991, an extensive effort was launched to develop and utilize advanced technologies to increase the efficiency and productivity of the transportation system. Improving productivity in public transit has been a major policy objective for several decades. Despite massive capital investments and service expansions, public transit continues to lose market share, and productivity continues to decline (Lave, 1991; Pucher, Evans, and Wenger, 1998). Advanced technologies have been promoted as a way to both increase service efficiency and attract new riders. The USDOT has encouraged innovation and experimentation through its support of Field Operational Tests (FOT) and the Transit IDEA program. The State of California has also promoted and supported the application of advanced technologies through its 1995 Advanced Transportation Systems Program Plan (California Department of Transportation,1995) and the 1996 update (California Department of Transportation, 1996), which includes a vision for the deployment of such technologies within the Framework of the National Systems Architecture.

The transit industry has shown significant interest in new technology; vehicle location systems, automated fares, and other applications are being used or considered by many agencies. However, these applications are typically agency specific. Advanced technology applications across two or more agencies are far less common.

This report presents results of an evaluation of a new technology Field Operational Test (FOT), the San Gabriel Valley Smart Shuttle (SGVSS), which attempted to integrate services of three local municipal operators and a regional fixed route transit operator. The purpose of the evaluation was to examine technical performance, user response, and institutional issues associated with development and deployment of the integrated system. The complete system was never fully deployed. While technical problems were serious and extensive, the outcomes of this FOT were primarily a function of institutional and organizational constraints. Institutional issues have been underscored by recent evaluations of transit technology deployments; however, we believe that multi-agency technology deployments raise a host of new concerns.

Our assessment is based on comprehensive and detailed monitoring of the FOT

from its inception to its conclusion, a period of over three years. The research team
conducted repeated in-depth interviews with all project participants. Each stage of the
FOT was documented, and representatives of the research team attended all project
meetings. Field visits were conducted at critical points of planning and deployment, and
extensive observations were conducted during system installation and other critical
periods of the FOT. The research team observed training sessions, monitored operation
of the parts of the system that were deployed, and collected operating data for each
transit operation. Because the total system was never deployed, and because there was
no period of "steady state" operation, a comprehensive performance evaluation was not
possible. Rather, the evaluation was restructured to focus on understanding project
outcomes.

1.2   INTEGRATED PUBLIC TRANSIT

Public transit services are organized as spatial monopolies. Each operator has
exclusive rights to operate a given type of service within a specified service area, and
protection from competing services is vigorously pursued. Fares and service parameters
are set by management and governing boards.   The structure of transit subsidies also
promotes spatial and functional segmentation. Transit subsidies are typically allocated
by political jurisdiction. Growing use of local funds both reinforces these boundaries
between services and increases sensitivity to local community needs and issues.

In urban areas, it is often the case that operating areas overlap, but in these
cases service is typically differentiated (e.g. suburban commuter service and local bus,
local bus and paratransit).   Transit operators have little incentive to coordinate between
services. Such coordination may increase operating costs (reduce schedule efficiency)
while generating negligible additional fare revenue. In addition, the complex
organizational structure of public transit makes interagency coordination difficult to
accomplish.

Geographically or functionally segmented services are often not consistent with
patterns of travel demand. Hence the traveler must negotiate movements between
systems that do not accept one another's transfers and do not coordinate operating
schedules. The lack of integration discourages transit use, and consequently has been
identified as an important area for advanced technology applications (California
Department of Transportation,1995). Advanced technology in principle makes
integration of services easier to accomplish. Advanced communications allows the
sharing of schedule and passenger information so that transfers between services can

be coordinated. If combined with a common fare medium, this would allow "seamless" transfers between systems, whether across modes or geographic boundaries. Reducing barriers to transfers across systems should make transit more attractive and increase its use.

Advanced technology makes many things possible, but transit operators and their decision-makers determine what is implemented.   Cooperation among operators is still required, and information sharing and service coordination across agencies imposes costs on participants. The question is therefore whether advanced technology provides sufficient incentive to accomplish true service integration. In the San Gabriel Valley FOT, there was no commitment to integration by the operators. While some degree of technology integration was achieved, there was no functional integration of services.

1.3   PRIOR RESEARCH

There have been few FOTs of integrated transit services. Most similar to SGVSS is the Santa Clara County FOT, which utilized computer-assisted dispatching, a digital geographic database and automatic vehicle location (AVL) equipment to provide Americans with Disabilities Act (ADA) mandated service throughout the County (Chira-Chavala and Venter, 1997). The service is operated under a master contract and utilizes several different transportation providers. Hence the FOT integrates several different service providers, but all are acting under the direction and control of the master contractor. Evaluation of the Santa Clara County FOT showed that the automated system allowed the county to accommodate rapid increases in demand, and it is unlikely that these increases could have been accommodated with the previous semi-manual dispatching system.

An example of the complexity of multi-agency integration of smart card technologies is reported in Giuliano, Moore and Golob (2000). This FOT included seven small transit operators, and its goal was to implement an integrated Fare Transaction and Vehicle Management/Monitoring System for fixed route operations – essentially a common fare medium and an associated passenger and vehicle monitoring system. Many technical problems were encountered, and they were often the outcome of institutional issues. Lessons learned include

1) approach complex technology testing incrementally;
2) plan for delays;
3) apply strong and consistent management;
4) work with clear formal contractual arrangements between parties;

5) assume little basic knowledge and computing skills among participating staff; and,

6) recognize that ownership and involvement in project outcomes requires having some financial commitment.

There are many FOTs that have attempted various types of integration for the highway system, including "smart corridor" projects which aim to coordinate freeway and arterial traffic management, and traveler information projects which aim to collect traffic data from various sources and provide it to the public via automated telephone or internet. Traffic management coordination efforts have had limited success, often due to the difficulties achieving consensus on operating policies and allocation of responsibility. Contracting arrangements, project management, and lack of clear objectives have been identified as major issues in such FOTs (Hall, 1999; MacCarley et al, 2000).

1.4 THE SAN GABRIEL VALLEY SMART SHUTTLE FOT

The San Gabriel Valley Smart Shuttle (SGVSS) FOT had its origins in a previous FOT named ATHENA. ATHENA was intended to be a demonstration of real-time ride matching and personalized public transit. For a variety of reasons the ATHENA project was suspended, and the SGVSS emerged as the restructured FOT. The Southern California Association of Governments (SCAG) took the lead in restructuring and relocating the project and became the project administrator on behalf of Caltrans.

The intent of SGVSS was to demonstrate the feasibility of integrated public transit. This would be accomplished by using advanced technology to share data across different operations and to achieve some form of service integration. Four transit operators were recruited to participate:

1) the City of Monrovia, which provides local general public demand-responsive service within the city and the adjacent unincorporated area;

2) the City of Arcadia, which provides local general public demand-responsive service within the city;

3) the City of Duarte, which provides local fixed-route service within the city; and

4) Foothill Transit, the regional fixed route transit operator for the San Gabriel Valley area.

Basic information on the services provided by the four transit operators is summarized in Table 1.1 Descriptions of the operators and their motivations for joining the project are discussed in a later chapter. The relevant governing bodies approved participation in the FOT. However, there were no formal contractual arrangements, and no formal scope

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Table 1.1   Field Operational Test Transit Operators

Name	Type of Service	Service Provided By	Average No. of Vehicles in Service	Annual Rider-ship (Fiscal Year 1997-98)
City of Monrovia	Demand-responsive	Contract Operator	6	98,600
City of Arcadia	Demand-responsive	Contract Operator (Change in contractor in 6/99)	14	140,000
City of Duarte	Fixed route (local)	City	2	258,000[a]
Foothill Transit	Fixed route (regional)	Contract Operator	9[b]	1,512,000

Notes: a. A free fare system
                b. Route 187 only; ridership for calendar year 1996

of work was defined for participation.

The FOT included many players in addition to the cities and their contract operators. A system integrator acted as the master contractor, and several subcontractors provided various system elements. There was also a project manager carried over from the ATHENA project, as well as the oversight provided by SCAG and Caltrans.

1.4.1   Proposed SGVSS

The feasibility of integrating public transit systems was to be demonstrated by deploying an advanced technology system capable of compiling, storing and sharing real-time data across different transit operations. In addition, some form of demonstration of service integration using the technology system was to be demonstrated. At the initiation of the FOT, there were several alternative services being considered, including route deviation, inter-agency transfers, and computer-based passenger trip requests.

The SGVSS system network as envisioned by the system integrator included a variety of software, hardware and communications components. The four participating operators and their contractors would share communications via a Wide Area Network (WAN). Dispatch centers would be located at the Monrovia contractor and at one of

Foothill Transit's contractor locations. Dispatch centers would include: GIS map display, a route planner/scheduler, public access interface, a database, vehicle communications capability, and vehicle tracking capability. Monrovia, Foothill Transit, and Arcadia would have vehicle monitoring stations, as would SCAG for the duration of the FOT. The system would be operated via a server located at one of the participant's sites. A wireless data network would send and receive data from vehicles, and the data network would be connected to the server via leased telephone lines. Vehicles would have Mobile Data Terminals (MDTs), wireless communications equipment, vehicle location equipment, and an on-board microcomputer.

The technology concept was to have interchange of information across the four transit operations in real time. In practical terms, this meant the ability to view the location of vehicles on dispatch and monitor station computer screens across operations. It also meant the ability to communicate with both vehicles and dispatchers across operations. In order to accomplish these functions, as well as perform computer-assisted dispatching, some form of dispatching software had to be combined with some form of communications software.

1.4.2 SGVSS Deployed

Parts of the system were deployed, and only limited integration was accomplished. Dispatch centers and vehicle equipment were installed at Monrovia and Foothill Transit, but monitoring stations were not. Only Monrovia shifted its operation to the new system. No equipment was installed at Arcadia, and the Duarte equipment was never actually used. A sufficient amount of hardware and software was deployed to show demonstration of concept: the system allowed for data sharing, automated scheduling and dispatching at Monrovia, and system monitoring. A demonstration test of automated transferring between Monrovia and Foothill Transit was also conducted.

1.4.3 Understanding Project Outcomes

The SGVSS evaluation plan called for a comprehensive evaluation, including technical performance, functional performance, user acceptance, cost-effectiveness and institutional analysis. Since all participants fully expected to deploy and demonstrate the envisioned system, the evaluation team proceeded in the early period of the FOT to develop procedures for conducting the evaluation and collecting the necessary "before project" data. As technical and institutional problems delayed and downsized the demonstration, the evaluation team adjusted accordingly. Ultimately, with no period of

steady state operation even of the limited system deployed, the evaluation was constrained to limited analysis of technical performance, functional performance and user acceptance. Cost-effectiveness could not be addressed, although a cost summary is provided in Appendix 1. The evaluation concentrated on the institutional analysis, as project outcomes turned out to be largely the result of decisions made very early in the FOT.

1.5   ORGANIZATION OF REPORT

The remainder of this report is organized as follows. Chapter Two provides a description of the project and project participants. The participating agencies are described in detail. The SGVSS system is described both as it was designed and as it was deployed. Chapter Two also presents a history of the FOT, from its inception as ATHENA to its final outcomes. Chapter Three presents the evaluation of technical performance and functional performance. Chapter Four presents a case study of Monrovia, the operation that was most affected by the FOT. Chapter Five presents the institutional analysis, and Chapter Six discusses conclusions and lessons learned.

CHAPTER TWO

PROJECT AND TEST DESCRIPTION

This chapter describes the origin of the Field Operational Test, the project participants, the SGVSS system as designed and as installation was attempted, and presents a summary of the FOT outcomes.

2.1   HISTORY OF THE FOT

Understanding the results of this FOT requires an understanding of its origins in the previous ATHENA project and that project's legacy. A detailed history of project events is required to provide context for the overall evaluation.

2.1.1   Origins: ATHENA

The FOT began in 1994 as a project named ATHENA, a demonstration of real-time ride matching and personalized public transit to be conducted in Ontario, a moderate size city located about 50 miles east of Los Angeles. Volunteers were to provide rides in response to real-time requests as a form of quasi-informal carpooling. An advanced technology system was to perform dispatching services and communicate to drivers and passengers via a central computerized dispatching system and Personal Digital Assistants (PDAs). A major defense contractor performed design of the technology system using the standard systems engineering approach of designing to functional specifications.

By the middle of 1996, there was a growing inconsistency between the intent of the project and what was being presented at the preliminary and critical design review stages. The sponsoring agency, the California Department of Transportation (Caltrans), recommended that Ontario review the project. After a temporary suspension of work, the City ceased its sponsorship in July 1996.

Institutional and contractual issues played a central role in the decision to suspend ATHENA (Giuliano, Moore, and Golob,1997). It was unclear whether the informal service would be subject to Public Utilities Commission regulations governing "for hire" transportation, and focus groups of potential drivers and passengers expressed concerns over safety and liability. There were also problems with the design of the system. It was originally conceived as a system with three sub-components: communications, personal transportation operations, and vehicle information and

tracking. The prototype under development when the project was suspended in July 1996 did not yet match the proposed design.

ATHENA had a legacy. By the time the project was cancelled, a highly detailed set of technical specifications and deployment tasks had been developed. Caltrans has a long-term interest in investigating the value of personalized transit service improvements, and sought to relocate the project to another venue so that the FOT could continue. Relocating the project was difficult, as any change that required re-writing the original project specifications or the task schedule could jeopardize funding. Funds for the FOT came from Federal ridesharing funds; therefore the relocated FOT would have to fit within the general description (and technical specifications) of the original project. In addition, project funds were to expire in June 1999, and the FOT included a one-year period of deployment. Thus the new FOT would have to be up and running by June 1998.

2.1.2   Relocating the FOT to the San Gabriel Valley

The Southern California Association of Governments (SCAG), the local Metropolitan Planning Organization (MPO) worked intensively to retain the project for the SCAG region. Caltrans considered shifting funds to a project in Northern California, but was willing to defer to SCAG if a reasonable project could be identified. Negotiations were held first with the City of Los Angeles, which was beginning its own Smart Shuttle project. However, a viable project did not come together.

SCAG then worked to develop a project elsewhere in the region. Ties between SCAG upper management and political leaders in the San Gabriel Valley ultimately made it possible to recruit the City of Monrovia, the City of Arcadia, the City of Duarte, and Foothill Transit to the project. In February, 1997 the project was relocated, and it became the San Gabriel Valley Smart Shuttle Technology (SGVSST) FOT.

To minimize delay, Caltrans and SCAG had intended to retain the original ATHENA technical contractor. However, the contractor declined to continue, and SCAG issued a request for qualifications for a system integrator. Negotiations with the winning bidder began in September 1997, but an agreement could not be reached. The contract was eventually awarded to the runner-up bidder in January 1998.

2.1.3   Goals of the Restructured FOT

The core of the former ATHENA project was retained in the SGVSST FOT. It remained "a computer system to match ride requests and vehicles" (Southern California Associations of Governments, 1997). Instead of matching private individuals and private vehicles, the system would match private individuals with public transit vehicles. The more ambitious goal of personalized public transit was replaced with route deviation; timed transfers to and from fixed-route services; and real-time, automated dispatching. However, a straightforward application of computer-assisted dispatching, even with state of the art communications technology, did not meet the full criteria for a Field Operational Test. FOTs require some form of innovation and the Santa Clara FOT was already investigating various aspects of computer-aided dispatching (Chira-Chavala and Venter, 1997). In the case of SGVSST, integration became the innovation. This also reflected a consistent Caltrans interest in "coordinated regional integration" as part of the concept for ITS deployments. (California Department of Transportation, 1996).

2.1.4   Challenges

The origin and structuring of the SGVSS FOT influenced the project's progress and outcomes. The new project was more complex, but had a smaller budget and less time to complete. This combination of technical and organizational complexity, limited budget, and tight time schedule explains much of what happened in this FOT, as will be discussed in Chapter Five. Key factors include:

- Decision to rely on "off the shelf" hardware and software
- Limited budget for consulting services
- Pressure to relocate and get the project started
- Decision to participate in the FOT made by board members and city councils, rather than service providers
- No clear service integration objective
- Regional planning agency administering a service operations contract.

All of these factors contributed to the ultimate outcome of the SGVSST project.

2.2   PROJECT PARTICIPANTS

This section presents a demographic overview of the cities involved and outlines the type of transit services provided by the cities, their contract operators and regional transit agencies. This section also describes the roles played by the project sponsor,

project manager, and the consultants responsible for technology integration and the provision of hardware and software.

When the project was relocated to the San Gabriel Valley, what was once a single agency project became a coordinated effort involving a regional transit agency and its service contractor, three cities, and two municipal service contract operators and the local MPO. SCAG was the primary implementing agency and administered the contract on behalf of Caltrans. It was the principle go-between for city representatives and contractors. SCAG contracted with an independent project manager who had performed the same coordinating duties when the FOT was based in Ontario. When the project manager's contract ended in June 1999, SCAG took on this role as well. SCAG was also responsible for hiring a technology system integrator. The integrator acted as lead consultant to the project and hired two subcontractors: an independent consultant who had authored the original system technical specifications and a transit software concept design specialist. This lead consultant also contracted with the vendors of the project software and the Mobile Data Terminals (MDTs) and established service agreements with a wireless communications service provider and a communications equipment installer.

The participating cities of Arcadia, Monrovia and Duarte form a string of three communities along the foothills of the San Gabriel Mountains, just to the east of the larger and more well-known City of Pasadena. See Figure 2.1. Arcadia is the largest of the three cities, and has experienced the most rapid growth. See Table 2.1. Both Arcadia and Monrovia use contract operators to offer general-purpose Dial-A-Ride (DAR) services to residents. The City of Duarte operates its own free, fixed-route shuttle within the city boundaries.

Foothill Transit, a regional transit agency, is a Joint Powers Authority comprised of 21 member cities in the San Gabriel Valley. Arcadia, Duarte and Monrovia are part of the JPA. Foothill Transit is also a contract operation. Two of the agency's routes were included in the FOT: a long haul route running the length of the San Gabriel Valley from Pasadena on the west to the Riverside County border on the east, and a shorter line covering a major commercial corridor in the three participating cities.

2.2.1   City of Arcadia

Arcadia is a city of 11 square miles located in the western half of the San Gabriel Valley, adjacent to the City of Pasadena and 18 miles northeast of downtown Los Angeles. It had a population of just over 53,000 people as of January, 2000. The City is

FIGURE 1   SGVSS Area Map
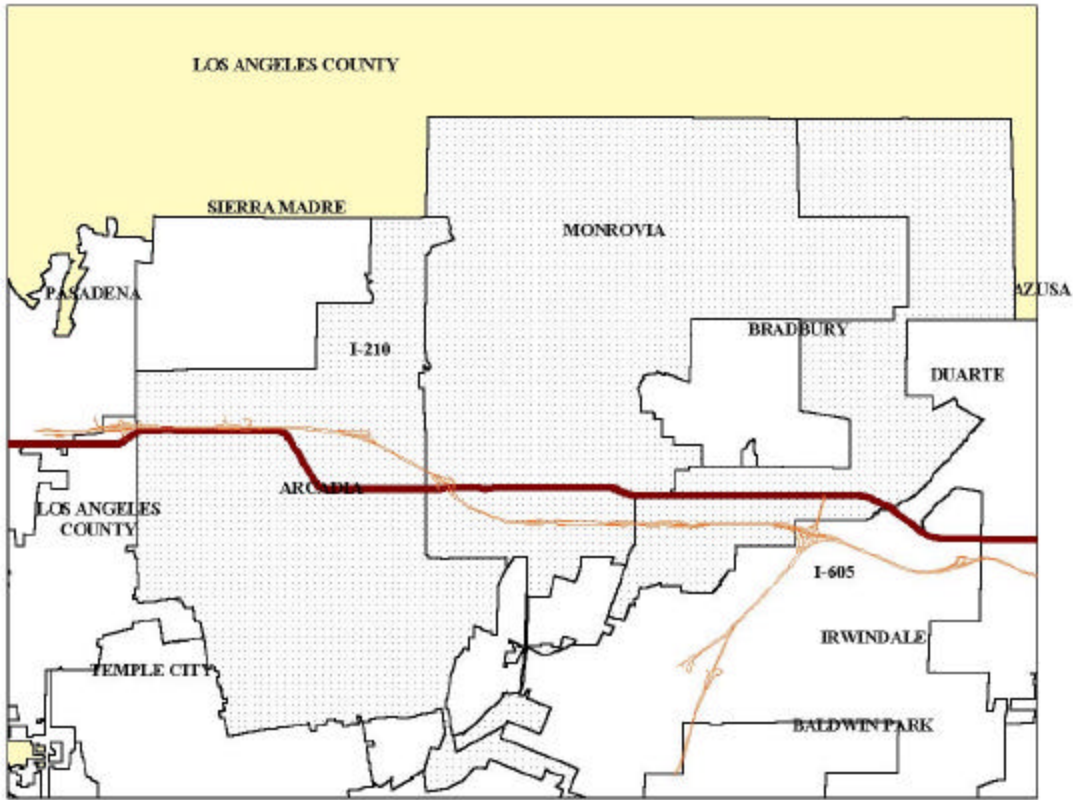
Figure 2.1   The San Gabriel Valley and Participating Cities in the SGVSS FOT

Table 2.1   Characteristics of Participating Cities

	City of Monrovia	City of Arcadia	City of Duarte
Area (sq. miles)	13.4	11.0	7.2
Population (2000 Census)	36,929	53,054	21,486
Population Growth Rate (1990-2000,%)	3.0%	10.0%	4.0%

Race/Ethnicity (2000,%)
  White (incl. Hispanic)
  Hispanic
  Asian
  Black
	63.0%
	35.0%
	7.0%
	8.6%
		45.6%
		10.6%
		45.4%
		1.1%
			52.0%
			43.4%
			12.6%
			9.0%

Median HH income (1990 Census)	$35,684	$47,347	$37,695

Source: US Census (2000)

experiencing relatively rapid population growth in comparison with the other participants in the FOT. SCAG projects that the overall population growth rate between the 1994-2010 period will be 5%. This compares with a growth rate of 13% for all of the San Gabriel Valley. Arcadia has also seen a dramatic increase in its Asian population since 1990. Asians and Pacific Islanders made up 23.5% of the population at the time of the 1990 census. The comparable figure for 2000 is over 45%.

The City is wealthy by LA County standards. Median household income is over $47,000. Still, Arcadia has a percentage of its population that is transit dependent. While almost 82% of Arcadia's residents drive alone to work, over 11% rely on carpools and almost 2% on public transit. For many, the final destination is outside of the City limits. 79% of Arcadia's residential workforce works outside of the City and the average travel time to work is 24.6 minutes.

Arcadia is home to a mix of residences and businesses with a few major regional draws including the Santa Anita Race Track, the Los Angeles County Arboretum and the Santa Anita Fashion Park. Arcadia is also home to other destinations for transit users including hospitals and medical facilities.

Fixed route transit is provided by Foothill Transit and the Los Angeles County Metropolitan Transportation Authority (LACMTA). For intra-city trips, the City is served by Arcadia Transit.   Arcadia Transit is the oldest and largest municipally operated curb-to-curb public service Dial-A-Ride in Los Angeles County. The City began service in 1975, and administers a transit operation with an annual budget of over $760,000 (FY 96-97), funded primarily through the Federal Transit Administration and local sales tax returns. Arcadia Transit is operated on a contract basis with a fleet of 18 vehicles. The service is operated seven days a week and charges fares under $1.00. Service is provided only within the limits of the City of Arcadia, although there are informal agreements with neighboring cities to transfer passengers at designated points along the border. This is coordinated by telephone on a first-come-first-served basis. There is no priority given to transfers and no special fare agreements in place between Arcadia and neighboring jurisdictions. Based upon observations during the FOT, these transfers between Arcadia and Monrovia occur only a few of times each month.

At the start of the SGVSST FOT in 1997, the original 1975 service provider still held the contract. This was a company located in the San Gabriel Valley that also ran DAR and taxi services for other cities in Los Angeles County. The company's agreement with the City required it to maintain a minimum service rate of 5.2 passengers per hour. At the start of the FOT, the Arcadia Transit service contractor had recently

added computer-aided dispatching, a GIS-based Automatic Vehicle Locator (AVL) system and Mobile Data Terminals in the vehicles.

Arcadia hired a permanent transportation manager in March 1998. He immediately re-evaluated the city's Dial-A-Ride service and the city's role in the FOT. In early 1999, he alerted SCAG and the project team that the City of Arcadia had decided to bid out the service for the first time in 23 years. He was hoping to find a contractor with a compatible, automated dispatch system. The intent was to have a new contractor in place by July 1999. Arcadia chose a new contractor with multiple operations in the region. The contractor ran these operations out of a central dispatch center, newly located in the San Gabriel Valley, and using the same paratransit software vendor and products as those used for the FOT.

Table 2.2 gives basic service operation data for the 1995 thorough 2000 fiscal years. Both passengers and service declined through 1997; ridership has increased under the new contractor. Productivity has also increased from 4.7 passengers per total vehicle hour in 1998 to 5.3 in 2000.

The FOT initially budgeted $25,000 for an interface between the relatively new proprietary system used by the City's service contractor and the proposed system for Monrovia and Duarte. The interface would allow other participants to locate the Arcadia vehicles. Similarly, it would allow the Arcadia dispatchers to see the location of the Monrovia, Duarte and Foothill vehicles. The interface did not allow for e-mail capability; and any coordinated transfers would still require a telephone call from one operator to the other. As a result, Arcadia's involvement in the FOT only offered the possibility of enhanced transfers between Dial-A-Rides, and in some cases, between DAR and regional bus service. There was never any prospect of changing the contractor's operations as part of the FOT to try to increase ridership or provide seamless regional transit.

The change in contractors provided both a challenge and an opportunity to the FOT. The FOT sponsors wanted Arcadia's participation. As the largest of the three cities involved and with the largest general public Dial-A-Ride in Los Angeles County, the Arcadia service was viewed as a critical link to the desired goal of seamless transit throughout the San Gabriel Valley. Furthermore, since the new contractor no longer required the FOT to connect to a different proprietary dispatching system, there was still hope of effectively integrating the transit services. There was even some question as to whether the project should continue if Arcadia could not take part. However in the end, both time and money precluded Arcadia from continuing to take part.

Table 2.2   Arcadia Transit

Fiscal Year	Total Vehicle Miles (000's)	Total Vehicle Hours (000's)	Total Passengers (000's)
1995	429.80	34.50	159.60
1996	419.50	34.00	158.90
1997	380.40	29.30	138.60
1998	373.50	30.00	140.00
1999 (new contractor)	374.0	29.0	144.00
2000	400.38	27.59	146.82

2.2.2   City of Monrovia

Monrovia is located directly to the east of Arcadia, twenty miles northeast of the City of Los Angeles. Its population of approximately 37,000 people is located in an area covering 13.4 square miles. SCAG projects that the City's overall population will increase almost 18% by 2010, a rate greater than that of the San Gabriel Valley as a whole. Monrovia is poorer than Arcadia in terms of median household income.

Foothill Transit and the LACMTA provide fixed route transit service in Monrovia. The City also provides demand responsive Dial-A-Ride service throughout the City, to medical buildings in adjacent Arcadia and Duarte, and to adjoining portions of unincorporated Los Angeles County on a contract basis. The service, funded primarily through Proposition A and C County sales tax returns, is operated as Monrovia Transit. Operating and maintenance costs were just over $418,000 in FY 1998. The journey to work transit mode share for Monrovia residents is 3.3%. As in Arcadia, most of the City's workforce (79%) commute to jobs outside the city.

At the start of the FOT, the city's contractor was a local entrepreneur who operated a trucking school as well as the DAR service.   Service was provided using six in-service vehicles and one spare, and operated seven days a week. An operations manager provided day-to-day oversight. The staff included an average of five dispatchers and ten drivers. Turnover was frequent and jobs were often interchanged.

Monrovia Transit carried more than 107,000 riders (about 94,000 with destination and termination points in the City) over 16,000 hours in fiscal year 1996. In fiscal year 1997, ridership declined to 92,616 total riders over almost 18,000 hours, and then increased in 1998. These changes in ridership are explained in part by expansion of service to unincorporated areas (see Chapter Four).

The service contractor's 1999 contract extension – needed because of the FOT-included an agreement for an 84% increase in county hours from 320 to 589 per month (an additional 3,228 hours annually) and the purchase of five new vehicles. It proposed 1,672 monthly maximum hours (up from 1,403) and 20,064 annual hours (increased from 16,836). It also capped the total maximum annual cost of service at $571,824. This is approximately $100,000 more than in FY 1998.

The budget assigned to Monrovia Transit for the FOT was $30,600. From the start, it was apparent that the City and its service contractor were more likely to be affected by the introduction of technology into its operations than any of the other participants. When the project began, Monrovia Transit employed no technology more advanced than voice radio. It relied upon a traditional board for dispatching, and on drivers and dispatchers who knew key destination points in the city, appropriate routes, and vehicle headings. The contractor's operations manager for Monrovia Transit was computer literate, but other staff was not. He left the company by the end of summer 1999, and his position was filled by one of the dispatchers for the remainder of the FOT.

2.2.3 City of Duarte

Duarte is a city of 21,500 in northeastern Los Angeles County. Like Monrovia, Duarte's growth over the past decade has been more moderate than that of Arcadia; although SCAG's projected population growth for Duarte for the period 1994-2010 is 16%. Measuring 7.2 square miles in area, Duarte shares a border on the north with the cities of Monrovia and Bradbury and the Angeles National Forest; on the east with the City of Azusa; on the south with the Santa Fe Dam Recreational Park in the city of Irwindale; and on the west with Monrovia. The city is traversed by the I-210 Freeway and is the northern terminus of the I-605 Freeway.

Apart from growth rates, Duarte shares other characteristics with its neighboring cities and co-participants in the FOT. Duarte and Monrovia have nearly identical median household income figures. At the time of the last census, Duarte's median household income was $37,695. All of the cities in the FOT also have similar share of the workforce using public transportation. Duarte's transit mode share of 3.1% also reflects the countywide average.

Duarte's Public Works Department operates the Duarte Minitrans, a fixed-route service consisting of two routes and 58 stops that form a loop through the City. The blue route goes clockwise and connects with fifteen (15) Foothill and/or MTA stops. The green route goes counter-clockwise and connects with fourteen (14) Foothill and/or MTA

stops. There are five pairs of stations along Duarte's western border with Monrovia. The annual operating and maintenance cost for the shuttle service has averaged over $273,000 in recent years. The primary source of funding is local sales tax returns.

Service operates 6 days per week on approximate 60 minute headways. Both lines operate from 7 a.m. until 7 p.m. weekdays. Only the green route operates on Saturday, running from 9 a.m. until 6 p.m. There is no service on Sunday or on major holidays.

The shuttle is operated using city employees and two in-service (and two spare) vehicles. All service is fully accessible to the disabled. The service is free of charge. The Duarte vehicles have radios, which share the City-owned channel with other departments. Duarte does not have a full time dispatcher. The transit supervisor checks the drivers in the morning, but does not continuously monitor the service throughout the day.

Total ridership for both shuttles during the FOT increased over previous years, reversing a two-year decline that began in 1994 when ridership reached a peak of 298,168. The City attributes this to an increase in the average length of one 58-stop circuit (from 60 to 75 minutes) due to traffic congestion. See Figure 2.2. The FOT's budget for Duarte was $27,000. The FOT outfitted the Duarte buses with Mobile Data Terminals despite the absence of a dispatcher.

2.2.4 Foothill Transit

Foothill Transit was created in 1988 as a public/private partnership model for urban transit systems. It serves 21 member cities, including all three FOT participants, and a portion of the unincorporated area of Los Angeles County in a 327 square-mile area in LA County's San Gabriel and Pomona Valleys. The service area stretches from the LA County line on the east, downtown Los Angeles and Pasadena on the west, the San Gabriel Mountains on the north and the I-60 Corridor and the Orange County line on the south. Foothill Transit is governed by a five-member executive board that includes four city representatives and one appointee from the Los Angeles County Board of Supervisors. At the start of the FOT, the mayor of Monrovia was chair of the Foothill Transit Board.

Foothill began operation with two local bus lines, and currently operates 27 lines (more than 259 buses) over a total of 400,000 hours transporting 12 million annual passengers. The agency also operates special event services. Foothill uses two different contractors to operate the bus services and a third to manage the company.
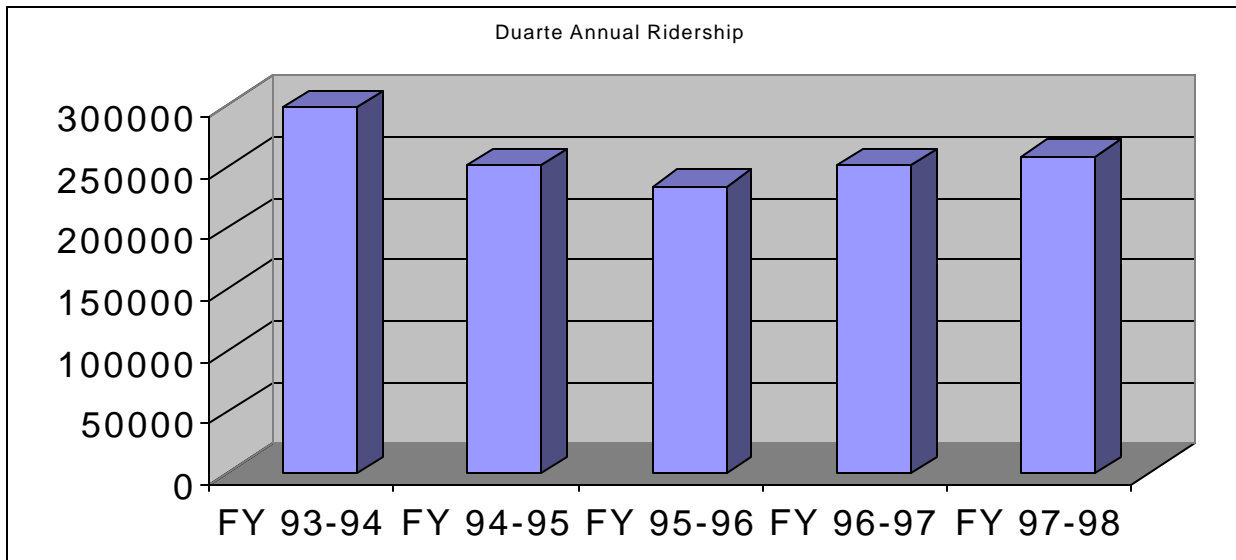
Figure 2.2   Duarte Annual Ridership, Fiscal Year 93/94 - Fiscal Year 97/98.

The standard local bus fare is $0.90. Fares may be paid with cash, a metrocard, a monthly pass or MTA/Foothill joint passes.

Since its inception, Foothill has gained a reputation for reliable and cost-effective transit service. Average operating cost per revenue hour is low ($52), and farebox recovery ratio is high (48%) for a suburban transit service. Foothill surpassed required cost/passenger and subsidy/passenger savings required as part of its 1988 spin-off from the Southern California Rapid Transit District.

Two of the Foothill lines were incorporated into the FOT. Foothill Route 187 is a 25-mile, regional intercity route between the cities of Claremont and Pasadena. It traverses all three participating cities and serves Arcadia City Hall, Duarte City Hall, Arcadia Methodist Hospital, Santa Anita Race Track and Fashion Park, and the Duarte Transcenter. The latter is a timed-transfer point. Because of the length of this route, there are often concerns about on-time performance and schedule adherence. Foothill surveyors reported 100% schedule adherence during certain tests (westbound, Sep. 1998; eastbound, Oct. 1998 and westbound, Oct. 1998), although the route also scored a 69% mark for schedule adherence on the westbound line in a test in December 1998. (Appendix 2) The score represents the average for each month in a given direction. Route 187 has long headways along portions of its route during midday hours, and low utilization in the late evening. It occasionally suffers from slow speeds, overloaded buses, and low utilization in early evening in Arcadia.

The FOT also involved Foothill Route 184, a short 6-mile route running along Huntington Boulevard in Arcadia, Monrovia and Duarte. It also serves principle locations within the three cities, including Arcadia City Hall, Duarte City Hall, Monrovia City Hall, Arcadia Methodist Hospital, City of Hope Hospital in Duarte, and the Santa Anita Race Track and Fashion Park in Arcadia. Route 184 has one of the lowest operating costs/revenue service hour in the Foothill Transit system.

There were initial plans to also include Foothill Route 721 in the FOT. This is a local feeder route to a commuter rail station in the City of El Monte. It is a peak-hour-only service with low ridership. Foothill considered testing out technology-based applications that would permit route deviation, but these plans were abandoned early in the FOT.

2.2.5 Southern California Association of Governments and the Consultant Team

The Southern California Association of Governments has been designated by the US Department of Transportation as the Metropolitan Planning Organization for Ventura, Los Angeles, Orange, Riverside, San Bernardino and Imperial counties and for the 184 cities within those counties. SCAG works through these cities and a host of sub-regional councils, including the San Gabriel Valley Council of Governments. SCAG is the largest Council of Governments in the United States, covering over 17 million people and 38,000 square miles.

SCAG contracted with Caltrans to administer the FOT, with funding coming from the federal government through the California State Department of Transportation's New Technology Program. However, as a planning organization, SCAG has limited experience in implementing technology tests. It has been more successful at deploying advanced traveler information systems, where the concern is the integration of information and not service delivery. As a result, SCAG identified roles for a number of consultants to play in the FOT:

1) Project manager: The project manager was an independent consultant originally hired to oversee the ATHENA project for the City of Ontario. This transportation consultant was identified to perform the same coordinating duties on behalf of SCAG and contracted with the agency through June 1999, the intended end of the FOT. At that point, SCAG's Project Administrator for the FOT took on this role.

2) <u>Lead consultant / technology and system integrator</u>: The lead consultant was a transportation and engineering firm responsible for the design and implementation of the system network. This firm contracted directly with SCAG in January 1998 for a period extending through June 1999. This was subsequently extended through the end of December 1999. The scope of work included system procurement, system testing, installation, field-testing and support during operation. The lead consultant assembled a team of several subcontractors, vendors and service providers. Agreements included:
   a. a subcontract with an independent consultant who had authored the original system technical specifications
   b. a subcontract with a transit software concept design specialist;
   c. a purchase and license agreement with a software developer for dispatching and scheduling software, including training;
   d. a purchase agreement for Mobile Data Terminals meant to send and receive vehicle, trip, and passenger information by wireless data communications, linking fleets and scheduling/dispatch software systems;
   e. a service agreement with a wireless communications service provider; and
   f. a service agreement with a communications equipment installer

2.3   THE SGVSS SYSTEM

Extensive hardware and software resources were deployed to support the FOT. Hardware choices were refined as the FOT progressed, and as the systems integrator and vendors agreed on how to meet the functional specifications defined by the systems integrator (BRW, May 1 as revised July 31, 1998a). All of the hardware decisions made during the course of the FOT were consistent with both these functional specifications and the systems architecture put forward by the systems integrator and the FOT sponsors. There were, however, key functional shortcomings that ultimately drove the participants to decline a final, in-service test of the system's capabilities, and to decline continued use of the SGVSST system after the conclusion of the test.

2.3.1   System Architecture and Functions

A high-level block diagram describing the architecture of the SGVSST system appears in Figure 2.3. The SGVSST system consisted of three subsystems. These are
   1) the In-Vehicle Subsystem (BRW May 1 as revised July 31, 1998b),

2) the Dispatch Center Subsystem (BRW May 1 as revised November 23, 1998c); and

3) the Communications Subsystem (BRW May 1 as Revised July 31, 1998d).

This architecture is designed to enable cooperation transit agencies to

1) monitor their own and each other's vehicles on a computer monitor via Automatic Vehicle Location, including display of real time schedule adherence information;

2) provide real time decision support for Dial-A-Ride vehicle-passenger assignments, up to and including automated scheduling and dispatching;

3) coordinate interagency passenger transfers, both between DAR services and between DAR services and fixed-route services;

4) combine fixed-route service with limited DAR service by defining route deviations for fixed-route vehicles; and

5) improve operations and service via improved management information reports.

As indicated in Figure 2.3, vehicle locations and driver messages transmitted from the vehicles are routed to the Central Message Server, which transmits vehicle messages to the appropriate transit operator and vehicle locations to all transit operators via the Wide Area Network (WAN). Drivers communicate only with dispatchers serving the drivers' respective operator.

Messages, including DAR trip assignments, are dispatched to drivers from the Dispatch stations and received on the Mobile Data Terminals located in the vehicles. Driver responses, including acknowledgements, traveler pick-ups, drop-offs, no shows, and the like are executed via the MDTs.

Coordinated, interagency transfers require interagency communications. These dispatcher-to-dispatcher communications do not occur via the WAN. These occur via an e-mail system routed through Internet Service Providers (ISPs).

2.3.2 The In-Vehicle Subsystem Specification

The In-Vehicle Subsystem consists of (BRW May 1 as revised July 31, 1998b)

1) a Mobile Data Terminal, including a micro-computer;

2) an onboard wireless communication capability controlled by the MDT's micro-computer; and

3) Automatic Vehicle Location equipment consisting of a Geo Positioning System including a micro-computer with odometer, speedometer, and gyroscope inputs to permit dead reckoning navigation.
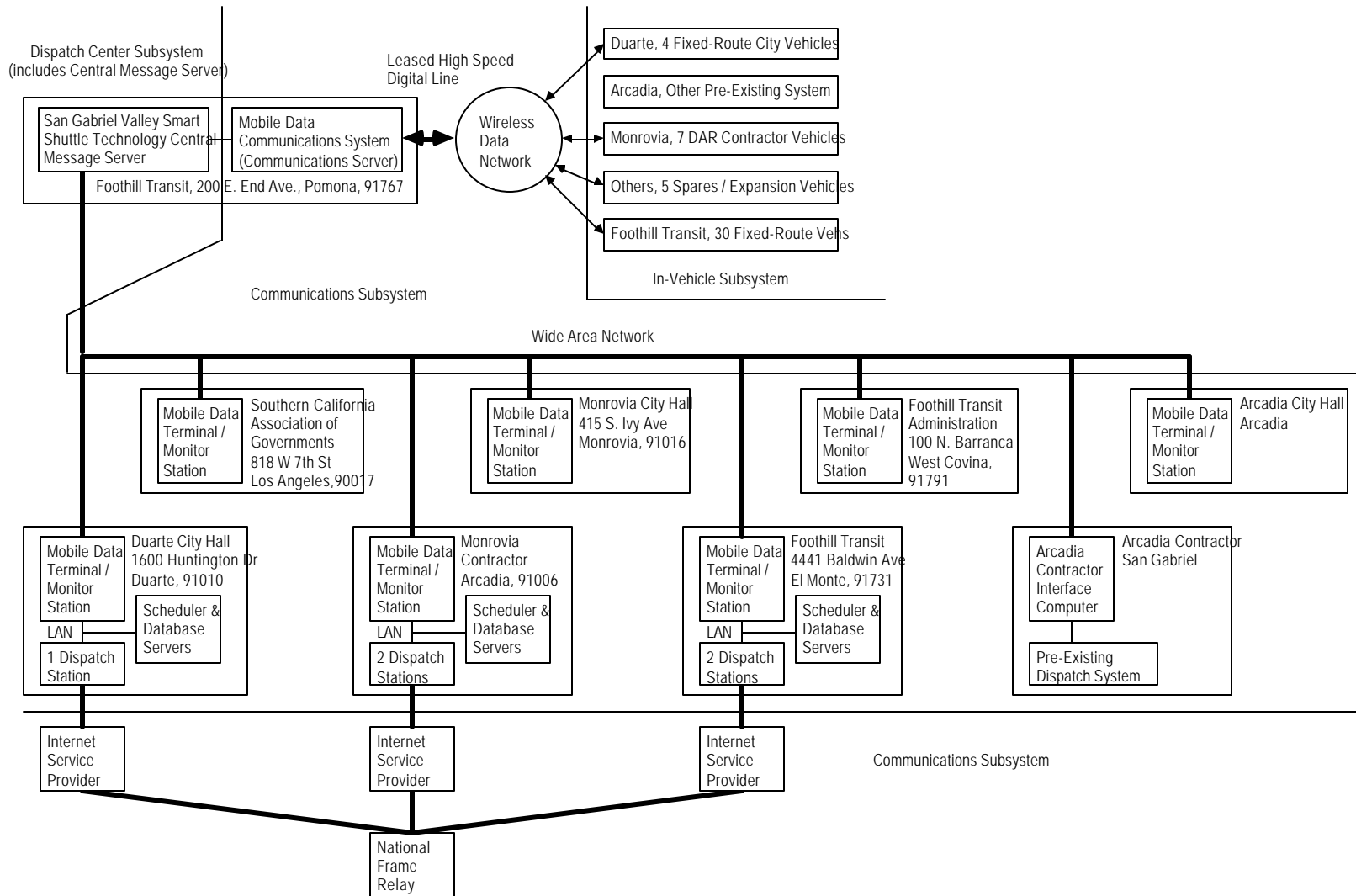
Figure 2.3   SGVSST System Architecture.

See Figure 2.4 for a more detailed block diagram of the In-Vehicle Subsystem and component interfaces as installed during the FOT. A total of 46 vehicles were to be equipped with In-Vehicle subsystems for the FOT, including

1) 4 City of Duarte buses,
2) 7 City of Monrovia service contractor DAR vehicles,
3) 30 Foothill Transit buses, and
4) 5 spare and expansion vehicles, including supervisor vehicles.

In addition, a number of In-Vehicle Subsystems were also installed in City of Arcadia service contractor DAR vehicles, but installation was terminated when the system integrator discovered the communications demands associated with these new systems exceeded the capacity of the Arcadia service contractor's communications system.

The MDTs were used intensively by Monrovia's contract DAR operator, but had no routine role for the fixed-route operators. No coordinated transfers or route deviations were ultimately attempted in revenue service as part of the FOT. Consequently the drivers for the fixed-route operators had no reason to use the MDTs in their vehicles. Further, the MDTs installed on the Foothill Transit buses were placed in a location that made it impossible to use the MDTs on a routine basis.

2.3.3   The Dispatch Center Subsystem Specification

The Dispatch Center Subsystem consists of (BRW May 1 as revised November 23, 1998c)

1) the Central Message Server;
2) Dispatcher Stations;
3) Mobile Data Terminal Servers / Monitor Stations connecting the Dispatcher Stations to the wide area network;
4) connections between Dispatch stations and frame routers permitting e-mail communications between Dispatch stations supporting cooperating transit services.

Figure 2.5 gives a more detailed block diagram of the SGVSST Central Message Server and component interfaces as installed during the FOT. Figure 2.6 gives a more detailed block diagram of the Dispatch Station and interfaces. Each Dispatch Station is connected to the wide area network via a local area network (LAN) connection to an MDT Server / Monitor Station. Communications between these two workstations take place over the LAN connecting them. The LAN also connects these stations to
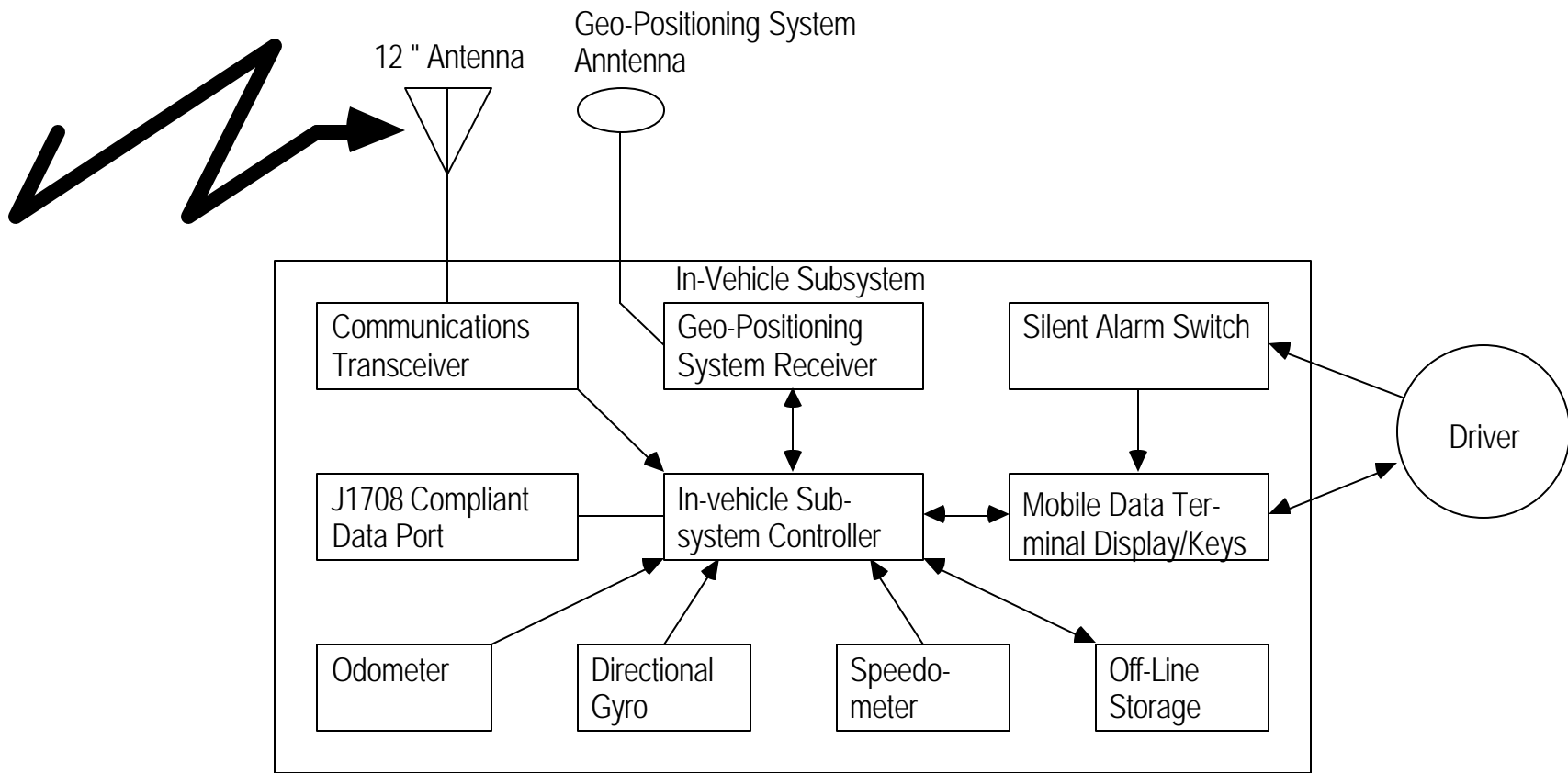
Figure 2.4   The SGVSST In-Vehicle Subsystem with Interfaces.
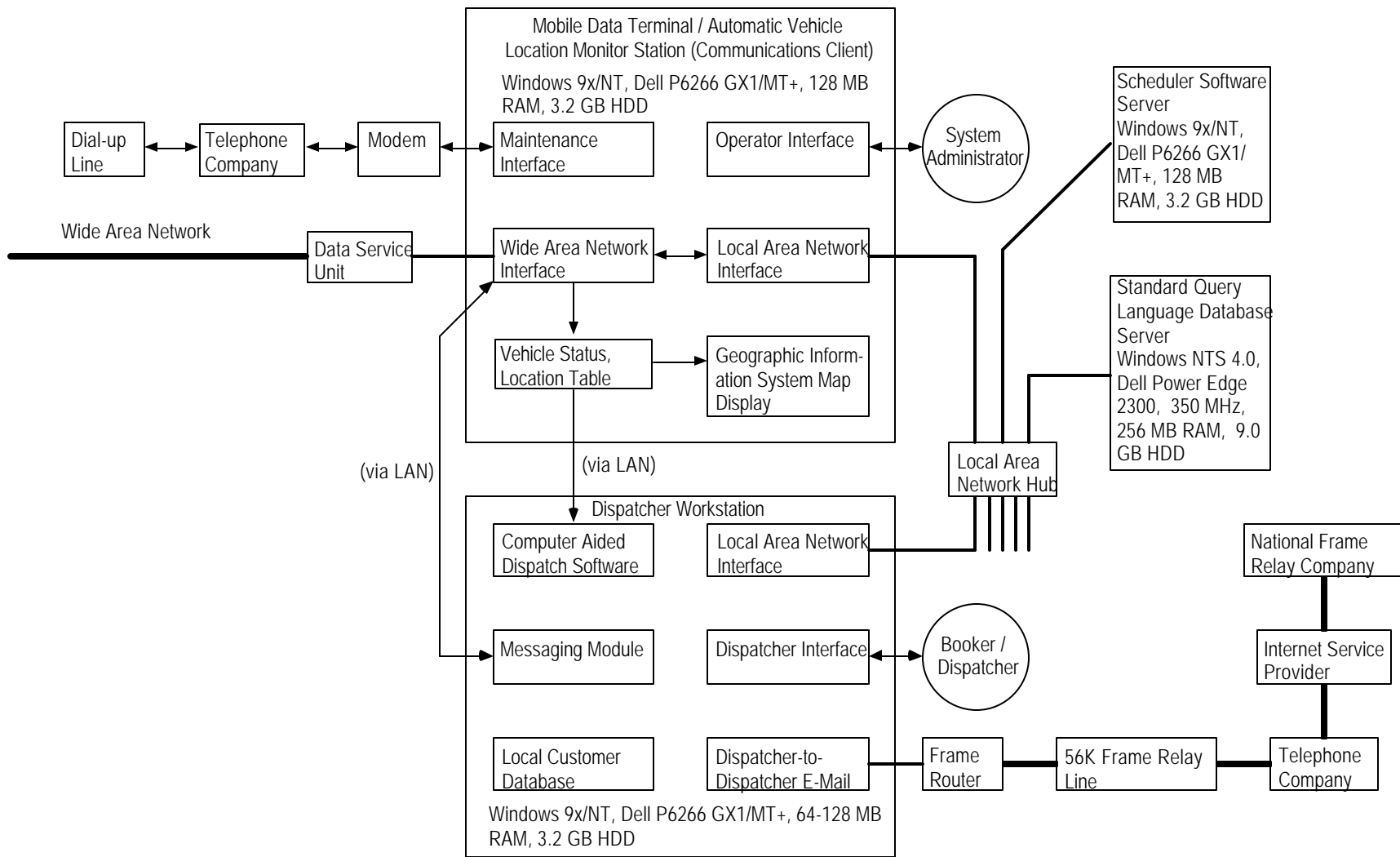
Figure 2.5 SGVSST Mobile Data Terminal Server / Monitor Station and Dispatcher Workstation, with Interfaces.
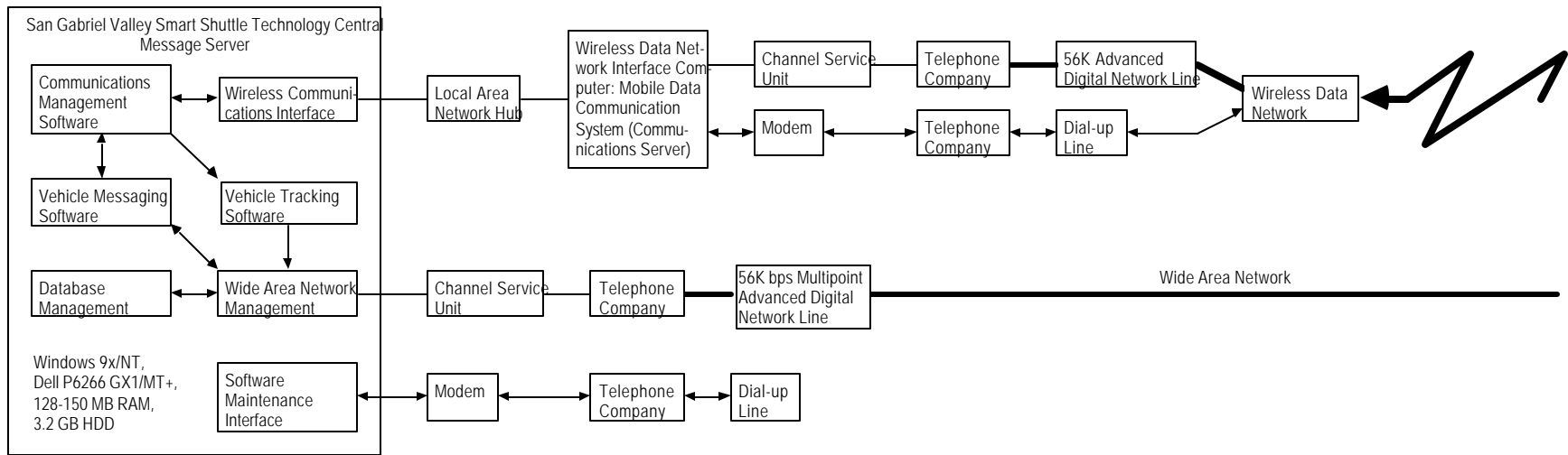
Figure 2.6 The SGVSST Central Message Server and Mobile Data Communication System, with Interfaces.

additional servers executing functions necessary for automated passenger assignment, vehicle dispatching, and scheduling. This configuration is specific to the paratransit software vendor. The Dispatcher Station, the Monitor Station, and the Scheduler interface through the Standard Query Language Database Server.

As a small fixed-route operator, Duarte needed only a Dispatch Station, but even this was probably unnecessary, given that the Duarte Shuttle generally required no dispatcher. A Monitor Station would have sufficed. The installation at the Foothill Transit facility in El Monte included two Dispatch Stations. As a regional carrier, Foothill Transit is considerably larger than the Duarte service. Foothill Transit relies upon centralized dispatching, but neither of the Dispatch Stations was ever used in routine service by Foothill Transit dispatchers.

The City of Monrovia service contractor made the only intensive use of the FOT dispatch equipment. The installation at the service contractor's facility also included two Dispatch Stations. One was used for call taking and trip assignment, and the other was used for trip assignment evaluation and vehicle dispatching. No installations were ever made at the facilities of either of the service contractors used by the City of Arcadia.

2.3.4   The Communications Subsystem

The Communications Subsystem consists primarily of (BRW May 1 as revised July 31, 1998d)

1) a wireless data network with links to and from transit vehicles;
2) a Mobile Data Communications System (MDCS) consisting of a data network interface computer linking signals from the wireless data network to the Central Message Server (CMS);
3) Advanced Digital Network (ADN) leased lines connecting the wireless data network to the MDCS, and serving as Wide Area Network (WAN) connections linking the Central Message Server to the Dispatch and Monitor stations; and
4) frame router connections to a national frame relay service, permitting e-mail communications between Dispatch stations supporting cooperating transit services.

These elements are indicated collectively in Figures 2.3-2.6. The in-vehicle communications equipment is considered part of the In-Vehicle Subsystem. The Central Message Server is considered part of the Dispatch Center Subsystem, but the MDCS is essentially a communications server, and is part of the Communications Subsystem.

The on-site elements of the e-mail system that permits cooperating dispatch centers to communicate are also part of the Dispatch Center Subsystem, but the national frame relay service and the frame routers used to connect the Dispatcher Workstations to this service are part of the Communications Subsystem.

The special role of the Communications Subsystem in this FOT is shown in Figures 2.7 and 2.8. These figures compare the communication element of the SSGVSST deployment to the standard, single agency deployment typical for the vendor who provided the computer-aided dispatching system.

2.4   SUMMARY OF FOT OUTCOMES

This section provides a chronology of the key events of the FOT. The chronology provides a context for the subsequent chapters.

September 1994

Caltrans and the City of Ontario initiate ATHENA FOT.

October 1996

The City of Ontario cancels contract with ATHENA technology provider per Caltrans recommendation.

December 1996

SCAG proposes transfer of ATHENA to City of Los Angeles Smart Shuttle project.

February 1997

Caltrans agrees to designate SCAG as cooperative partner and move FOT to San Gabriel Valley Smart Shuttle Technology project. The project schedule assumes contracting with technology developer by November, development and field testing by spring 1998, full deployment by June 1998, operation through June 1999.

April 1997

SCAG hosts tours of the Arcadia and Monrovia contractor facilities, and the City of Duarte facilities.

San Gabriel Valley Smart Shuttle Technology Central Message Server

- Manages Wide Area Network message traffic
- Connects to MDCS via a shared disk drive
- RX message directory
- TX message directory
- Simple, 250 lines of code
- Reads and writes to interface specifications

Padded RX Messages

Padded TX Messages

Mobile Data Communications System (Communications Server)

- Reads and writes to interface specifications

Leased High Speed Digital Line

Wireless Data Network

Stripped RX Messages

Stripped TX Messages

Multiple Agency In-Vehicle Subsystem

- Mobile Data Terminal
- Contoller (Computer)
- Communications Transceiver

Padded RX Messages

Wide Area Network

Padded TX Messages

Multiple Mobile Data Terminal Servers (Communications Client)

- Communicates with the Communications Server
- RX message directory
- TX message directory
- Reads and writes to interface specifications

Local Area Network

Dispatcher Workstation

Structured Query Language Database Server

Scheduler Software Server

Figure 2.7 SGVSST Multiple Agency Communications Architecture for Scheduler / Dispatcher System Installation.
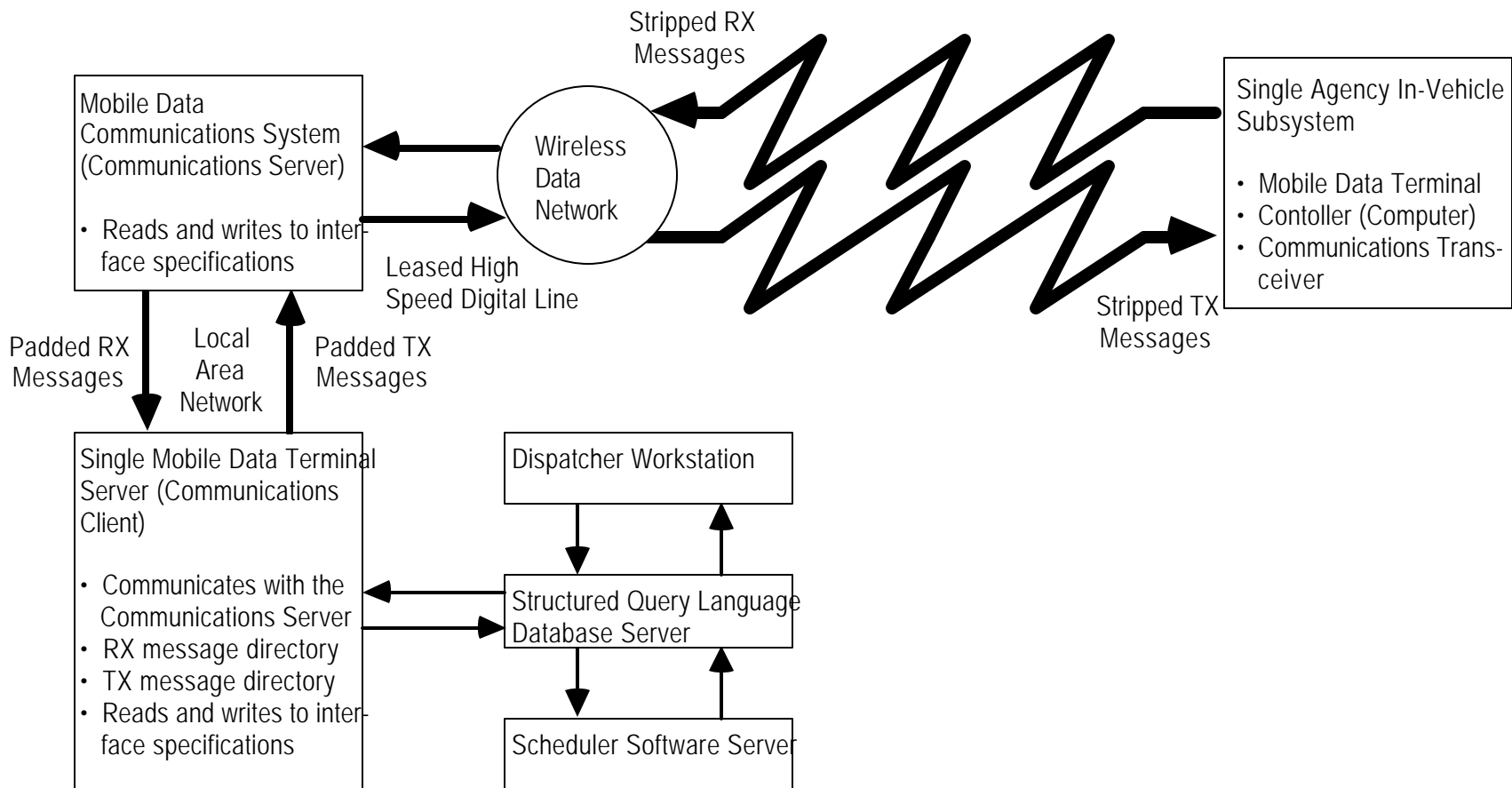
Figure 2.8 Standard Single Agency Communications Architecture for Scheduler / Dispatcher System Installation.

July 1997

SCAG releases a Request for Proposals for Integration Services. Responses are due in September 1997.

September 1997

Four teams submit bids to SCAG. The ATHENA technology integrator declines to bid. Caltrans emphasizes use of off-the-shelf hardware and software in selecting the appropriate team.

Caltrans and SCAG outline the project goals. These are to boost transit operations efficiency (enhanced customer service), ridership and transfers through interjusrisdictional links.

October 1997

The winning bid for technology system integrator selected by SCAG.

November 1997

Tours of the Monrovia contractor and the City of Duarte facilities are conducted on 11/21.

December 1997

A tour of the Arcadia contractor are conducted on 12/3.

January 1998

Contact negotiations with winning the bidder for the integration services contract break down. The project is assigned to the runner-up bidder.

An official kick-off meeting occurs January 29 at Foothill Transit. The technology system integrator introduces the project team, project timeline, and an outline of tasks.

February 1998

Half-day workshops are held for each of the operators.

A SGVSST Advisory Group meeting is held at Foothill Transit.

March 1998

The evaluation team is informed that system integration will involve no actual interface with the Arcadia contractor's system. Only an exchange of electronic information will occur.

A meeting to discuss the Critical Design Review (CDR) is held at Duarte Community Center. The presentation includes subsystem user requirements and an overview of system components. There is also a discussion of communications and dispatch software evaluation, invited firms, requested qualifications, and the evaluation framework. Questions arise over the need for MDTs in Foothill buses given existing keypads in the Foothill vehicles. Also, the Arcadia contractor expresses concern over operating cost of an automated system based on prior experience. There is general agreement that it will be basically impossible to purchase dispatch software off the shelf.

A new transportation manager joins the City of Arcadia and undertakes a review of city's DAR services and role in FOT.

April 1998

The Critical Design Review is held in Arcadia. The CDR clarifies many issues and provides the evaluation team with enough information to complete a draft evaluation plan. The USC team identifies major data problems that impede the process of drafting an evaluation plan. The team wants to test the ability of the Monrovia and Arcadia contractors to integrate with each other and with Foothill Transit.

May 1998

The Final System Specification for SGVSST released.

The system technology integrator meets with SCAG to discuss status and review Caltrans comments related to the communications evaluation. In-vehicle specifications and communications specifications are submitted for review. The Draft System Test Plan is submitted for review.

Software vendor and communications vendors are selected.

June 1998

There is a technical team meeting at the Monrovia contractor site. SCAG places an emphasis on legacy systems, i.e., the Arcadia contractor is constrained by its commitment to its existing system. A training plan is also discussed along with system test plans and the selection of the software vendor.

The system integrator's quarterly report identifies the following project issues: 1) revisions in schedule due to prolonged contract negotiations, 2) decisions related to potential system budget overruns based on existing negotiated bids, 3) ordering and purchasing hardware.

July 1998

The system integrator reports that the expected 1-2 month phased implementation will be backed up by several months. This makes a January 1, 1999 implementation date likely, and a reduced demonstration period a certainty.

August 1998

Caltrans expresses concern about the contracting/licensing issues surrounding the project.

The technical committee discusses contracts, training and software products.

Negotiations continue with software vendor; and the system "Go Live" date is pushed back to November 1998.

September 1998

The software vendor and SCAG sign a software license and maintenance agreement.

A meeting is held to discuss contract issues, particularly licensing, and liability. The most recent project timeline is received at the meeting. It indicates that the technology integrator plans on "going live without AVL" by the end of November, 1998. "Going live with AVL" is planned for early January, 1999.

The software and MDT vendors present their software and discuss training and customization/product deliveries for each agency involved.

SCAG asks Caltrans for a project extension to 12/31/99 due to prolonged negotiations

with software vendors.

October 1998

Technology integrator Quarterly Report (submitted to Caltrans 12/11) includes that "The design was finalized with the input from the vendors/subcontractors. " Also "Attended one day meeting at [Monrovia service contractor] to discuss report formats and messaging with [software vendor] staff..." Complete System Design and System Test Plan listed as being completed with some modifications. Project issues include "Revisions in schedule due to prolonged contract negotiations" and "Decisions related to the potential system budget overruns based on existing negotiated bids." The technology integrator also notes that it will translate GIS data into a usable format using in-house staff, and transmit to the software vendor for review and acceptance of format. The information is to be used to develop AVL mapping for dispatch software.

The technical advisory committee meeting discussion includes confusion between SCAG and software vendor over the base map, and the technology integrator's inability to select its own subcontractors, i.e., SCAG insists on bids.

A new Caltrans New Technology project monitor assigned to the FOT.

November 1998

There is a change in the software vendor staff assigned to the project.

The technology integrator reports that contract discussions with the software vendor on the Phase II contract have been completed. There are more changes in software vendor staffing. The number of MDTs is changed from 53 to 46, saving the project $20,000. The technology integrator reports difficulty in sharing of GIS mapping for multiple applications due to significant data manipulation requirements.

December 1998

Equipment installation is cancelled on 12/14. The operational analysis with the software vendor is postponed. Installation of the Monrovia dispatch software postponed.

The technical advisory team meeting discussion focuses on the need to create client records for Monrovia riders, staff turnover at the software vendor, and training/

installation procedures. The Monrovia service contractor manager raises concerns about data archiving. There is no discussion of interfaces.

January 1999

Duarte implements new route arrangements on 1/1.

The technology integrator quarterly report states that it has completed the procurement process and tested computer hardware for all components of the system and all site locations. A draft Installation Plan was submitted to the software vendor, and the GIS base map was integrated with software. An operational system is planned for March 1999.

Issues include the need to reach agreement with SCAG on procedures to accept the operating system, revisions in the project schedule due to contract negotiations, and potential system budget overruns.

The FOT completion date is extended from 6/99 to 12/99.

Software problems occur, including the need to reconfigure GIS and loss of multiple functionality. The software trainer decides that project needs a different software package.

The technology integrator informs the MDT subcontractor that project has a budget deficit and reduces order for MDTs by 7 units. The final order is 42 units + 4 spares.

The Integration Case 1 (IC1) test fails. This is a test of communication with the MDTs. The dispatch software cannot handle as many vehicles as specified.

February 1999

IC1 is completed

The Monrovia service returns to manual operations on 2/25 for an indefinite period. One problem is driver turnover.

ITS planning projects and the SCAG project administrator are moved from the SCAG planning group to Southern California Economic Partnership (SCEP).

The Foothill Transit Director of Operations leaves. Foothill is represented at technical advisory team meetings by the Manager of Scheduling. The discussion includes problems with software performance, late delivery of MDTs, positive results of training,

and the status of Foothill Transit service bids. The status of the Arcadia system remains unresolved. SCAG is likely to pay third party to write a reporting feature to interface with the software vendor's proprietary reporting software.

March 1999

SCAG requests a project extension, reserving funds for the period from 7/1/99-12/31/99.

SCAG begins planning for promotional possibilities for 29 FT buses, 10 Monrovia vans and 4 Duarte buses. No technology is deployed on Arcadia vehicles.

Software training occurs at Foothill Transit and the City of Duarte. MDT training occurs at the Monrovia contractor site and the City of Duarte.

The Monrovia service is still on manual dispatching.

April 1999

Due to data losses encountered during testing, the technology integrator decides to take Monrovia service off-line until the "Go Live" date.

The report on the Integration Case 2 (IC2) test is released. The system is deemed inadequate to support IC3. Significant problems include dispatch responses to vehicle messages from other fleets, automatic display update, operations and maintenance training and manuals, and optimum dispatch capability.

May 1999

Hardware installation on vehicles is complete. Concerns include the software vendor's provision of reporting capabilities for Monrovia, and SCAG's inability to identify a "drop-dead date" by which the software vendor must provide software fixes. SCAG does not yet have federal approval for a project extension.

"Go Live" is rescheduled for June 1, 1999. Training postponed.

The technology integrator confirms three outstanding problems with regard to the software vendor: free text messaging (requiring new code); fare coding (also requiring a new, but easier, code); and reporting, which is critical to the Monrovia contractor.

The project manager reports that the technology integrator and the software vendor have discovered that the scheduling software is not using real-time AVL data for

schedule adherence. This postpones software training at Foothill.

June 1999

There are continued problems with free-text messaging.

The SCAG project administrator instructs the technology integrator to proceed with engaging a sub-contractor to write report function to interface with the system's proprietary reporting software.

A project team meeting occurs at Foothill Transit. There are continuing problems in messaging between the Monrovia dispatcher and the vehicles. Undocumented software patches appear to be creating new problems. A fare coding glitch with MDTs is still an issue. The decision is made to "Go Live" without real time schedule adherence. "Go Live" is now planned for 6/30/99. The reporting problem is unresolved.

The SCAG project administrator confirms that there will be no real-time schedule adherence by proposed the "Go Live" on 6/30/99. "Go Live" now means bus tracking, automated dispatching, free-text messaging, and fare coding.

The Caltrans project monitor begins process of transferring equipment to participants.

The operations manager of the Monrovia service contractor resigns. He is replaced by one of the dispatchers.

The project manger contract ends. She departs the project.

July 1999

The City of Arcadia acquires a new contractor.

August 1999

Problems with communication between the MDTs and servers continue.

There is a project team meeting. The SCAG project monitor is now designated the project manager. "Go Live" is now scheduled for September. IC3 targeted for 9/13/99. The communications budget is extended for 6 months.

September 1999

The software vendor continues work on software problems.

Go Live" is now scheduled for the first week of October.

The Monrovia service contractor agrees to collect information on transfers to and from Monrovia Transit.

The Monrovia service contractor still overriding the schedule wizard, and the system crashes when more than five MDTs come on line.

October 1999

There is a project meeting at Foothill Transit. Monrovia is running without MDTs. The Monrovia service manager reports that the client database has started dropping people, and that clients are complaining about slower service (as a result of manual reports and MDTs). Monrovia reports productivity is down to 4.5 passengers/hour. An embedded problem associated with the data causes the monitoring stations to crash every 3-4 days on average.

November 1999

Monrovia reports intermittent problems with the MDTs. There is also a problem with estimates of vehicle location at Foothill Transit.

There is a project meeting to review a 7-day test of system availability. The system integrator reports that the software showed overall reliability of 97.7%

Duarte tells technology integrator that City wants to withdraw from the FOT.

SCAG proposes 12/7/99 as the "Go Live" date.

December 1999

The Caltrans project monitor leaves Caltrans New Technology.

Reporting capabilities dominate the monthly meeting at Monrovia. Most issues can be resolved by reformatting existing report information. How to provide a breakdown of County vs. City riders is still unresolved.

SCAG project administrator announces on 12/13/99 that the project is "Live" (i.e. all operations with MDTs and transfers are feasible), and that there will be modifications to reporting procedures to meet Monrovia's and Foothill's needs.

January 2000

The system experiences no Y2K glitches, but Monrovia Transit continues to override the system to improve the speed of operation. Radio are used to overcome occasional MDT difficulties (missing pick-up and drop-off information/assignments). The Monrovia contractor is regularly required to reboot the system when it slows down, and is experiencing MDT "shut off" problems.

SCAG prepares transfer procedures for Foothill Transit and Monrovia Transit, and readies brochures for printer during first week of January. Foothill Transit holds off on press releases due to contractual issues with software vendor.

Foothill Transit alerts SCAG of unresolved problems. These are the scheduling software cannot recognize Foothill run information and update schedules, the MDT/GPS units remain on when buses are idle in the yard, post-FOT airtime and phone charges remain undetermined.

The monthly meeting at Monrovia focuses on transfer procedures and reporting. The Monrovia service contractor reports that he needs on-time performance data right away. Not all MDTs are repaired yet. The cache of incoming AVL data crashes the Foothill system. SCAG reports that Arcadia's choice of communication system is makes integration with the FOT infeasible.

February 2000

The project team conducts transfer test between Foothill Transit and Monrovia Transit using USC graduate students (pre-test on 2/24/2K, and test on 2/28/2K). Foothill conducts limited training for drivers and dispatchers in preparation for the transfer test. This includes e-mail messaging between Foothill and Monrovia dispatchers. No other transfer tests are conducted by the project participants.

March 2000

Schedule adherence displays, signage questions at bus stops, and AVL equipment problems are still pending as of 3/2/2K. Foothill Transit expresses doubt over the number of potential riders taking advantage of transfer service.

SCAG and Caltrans pursue procedures for donating equipment from the FOT to the participating Cities, Foothill Transit and SCAG. This requires the recipients to continue

using the equipment it after the demonstration.

No equipment agreements are in place and no brochures are on buses as of 3/102K, although they are delivered. Caltrans and SCAG express the desire for an official "Go Live" test from 3/6/2K to 3/30/2K, and want brochures on buses to generate customer responses for test run evaluation.

SCAG announces that Duarte is not continuing with the project due to cost considerations, that monitoring stations are awaiting a final software patch, and that buses are live with brochures onboard.

The evaluation team has remained poised to collect as much data as possible from an operational system. The entire post installation test period is now a two-week window in March.

Foothill Transit informs SCAG that it cannot continue to fund the $3K-$4K in airtime and network charges beyond March 2000. Foothill also recommends to its administration that it not keep equipment since it is over a year old, and potential vendors would most likely replace all equipment. This effectively terminates Foothill's participation, foreclosing any opportunity for empirical evaluation of the SGVSST system.

The FOT officially ends 3/30/2K.

April 2000

SCAG turns project equipment over to stakeholders on 4/1/2K, i.e. to the City of Monrovia and the Monrovia Contractor. Foothill Transit agrees to house the communications server.

Sep 2000

Disposition of the SGVSST equipment remains still unresolved per an e-mail exchange between the Caltrans project monitor and SCAG.

CHAPTER THREE

EVALUATION OF TECHNICAL PERFORMANCE

3.1   System Deployment

Most of the installations identified in Figure 2.2 were completed (BRW, November 18, 1998), and most of the functions this hardware was intended to support were successfully enabled. There are important exceptions. Installation of the Monitor Stations was problematic for a combination of reasons, some of which were specific to the sites where the monitors were to be installed, and some of which were related to the programming practices and performance of the vendor providing the dispatching and scheduling system. Integrating the Arcadia contractor's existing automated dispatch and vehicle telemetry systems proved to be a substantial technical challenge. The remainder of the FOT system was effectively being created from scratch, and the additional constraints associated with integrating Arcadia's existing system while at the same time

1) deploying a new system consistent with the functional requirements defined for each FOT participant,
2) remaining on schedule, and
3) remaining within budget

were clearly burdensome for the system integrator. Despite Caltrans' and SCAG's best efforts to ensure the continued participation of Arcadia, this challenge was rendered moot when the City of Arcadia management elected to change transit service contractors during the course of the FOT. The remaining hardware installations were completed in a fashion consistent with Figure 2.2. However, the total number of vehicles equipped for the FOT was 41 rather than 46 (BRW, October 1, 1999), including

1) 9 Monrovia contractor vehicles,
2) 4 Duarte city buses, and
3) 28 Foothill Transit buses.

3.2   System Integration

The SGVSST system was integrated in four steps, or Integration Cases. These integration cases involved sub-steps, and served as the foundation for subsequent acceptance tests conducted by the system integrator on behalf of SCAG. The technology integrator's system test philosophy focused on validating the SGVSST

system's ability to meet the most specific requirements available. This focus on system level performance de-emphasizes performance specifications for parts, emphasizing instead the performance of incrementally more complex system installations, and permitting subcontractors the opportunity to deviate from specific procedures or to waive specific requirements if the overall functionality of the system could be demonstrated to meet an acceptable standard.

The four Integration Cases became incrementally more complex. Important functionality requirements that the system failed to meet during any test were carried forward into subsequent tests until these requirements were either met, or the FOT terminated.

3.2.1. Integration Case 1: Server and Software Functionality

Integration Case 1 (IC1) verified the functionality of software for the Central Message Server, Automatic Vehicle Location messaging, and wide area network control (BRW December 27, 1998 as revised February 3, 1999). Figure 3.1 shows the hardware configuration for IC1. IC1 was completed on February 23, 1999 (BRW February 25, 1999) at facilities maintained by the vendor providing the scheduling and dispatching system. The test included hard wire communication between the scheduling and dispatching system and the Mobile Data Terminals, resulting in early identification of a mismatch between the communications specifications being used by the MDT subcontractor and the software vendor.

3.2.2 Integration Case 2: Multiple Point Communication Over the Wide Area Network

Integration Case 2 (IC2) replicated IC1 using the wide area network to connect the Central Message Server to multiple dispatch sites (BRW March 1 as revised March 27, 1999). Figure 3.2 shows the hardware configuration for IC2. IC2 was conducted March 3 – March 31, 1999 (BRW April 6, 1999) in the field, connecting equipment at ongoing site installations with additional equipment located at the offices of the system integrator.
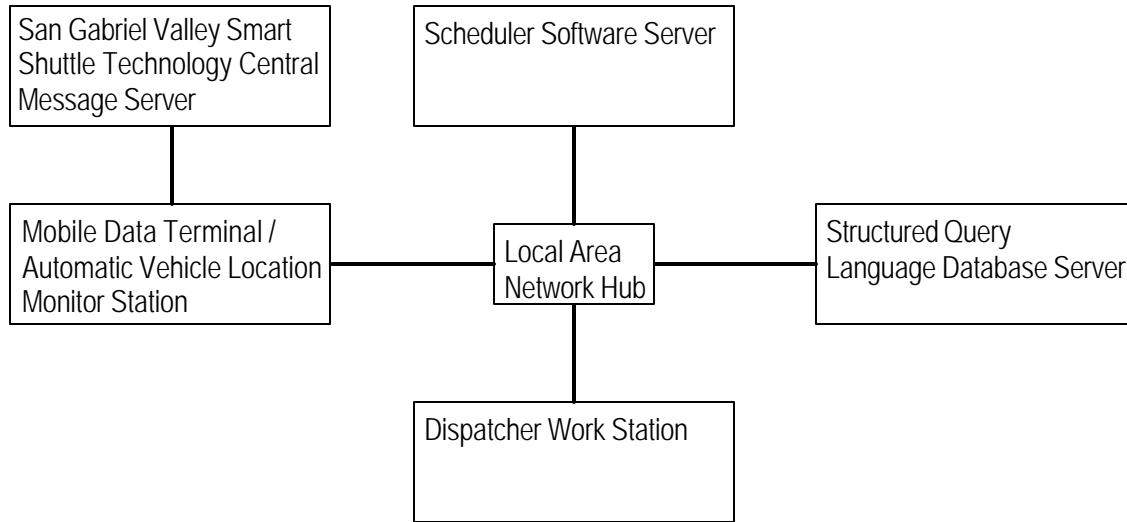
Figure 3.1   Integration Case 1 Equipment Configuration, February 23, 1999.
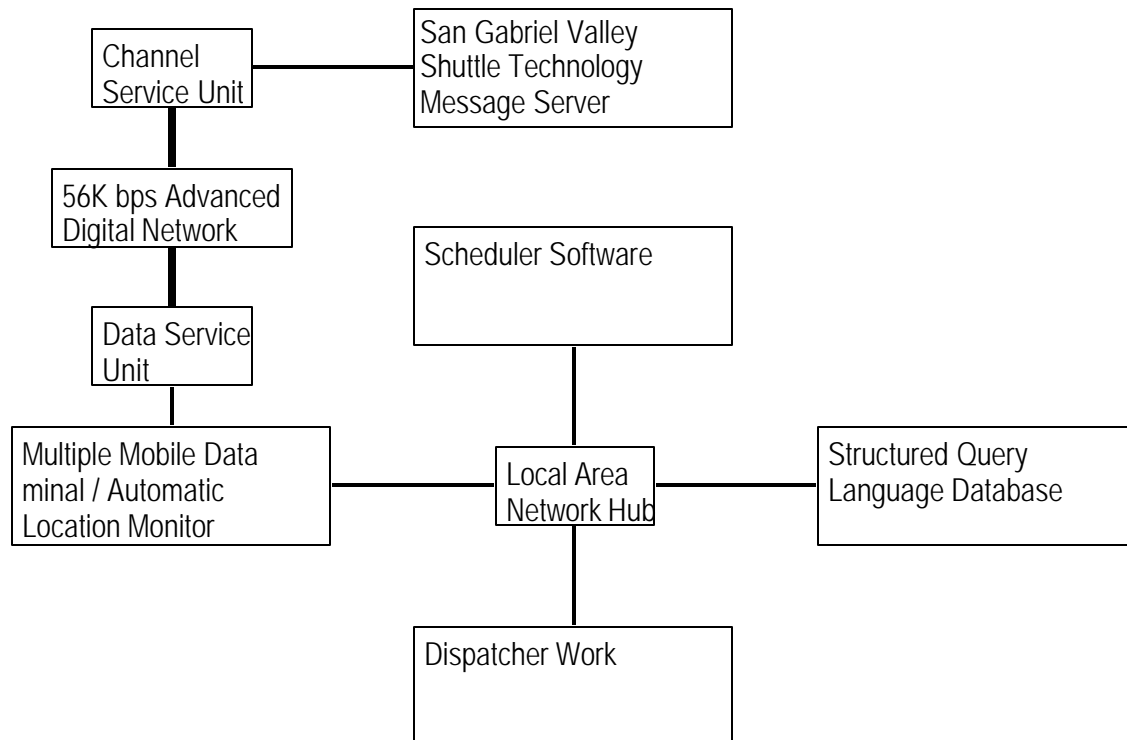
Figure 3.2   Integration Case 2 Equipment Configuration, March 3 – March 31, 1999.
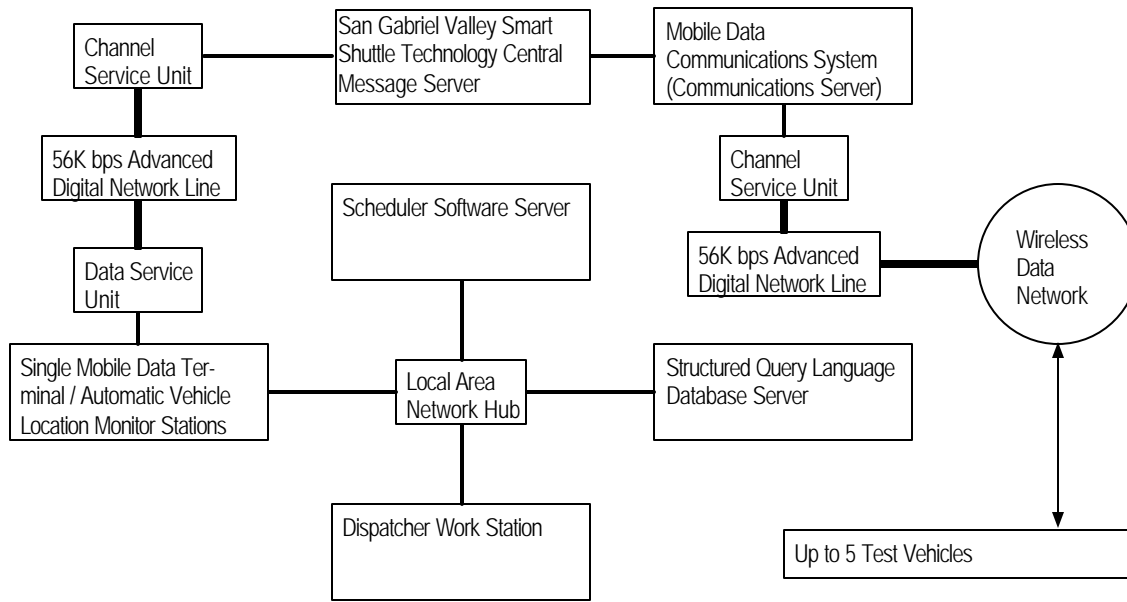
Figure 3.3   Integration Case 3 Equipment Configuration, July 25, 1999.

3.2.3   Integration Case 3: Single Point Communication with Test Vehicles Over the Wide Area Network

Integration Case 3 (IC3) replicated IC2, but added communications with a limited number of test vehicles, and involved a single dispatch site. Communications included radio frequency messaging for both the Mobile Data Terminal and Automatic Vehicle Location functions. Figure 3.3 shows the hardware configuration for IC3. IC3 was completed July 25, 1999 (BRW, April 29 as revised September 27, 1999) in the field, connecting the test vehicles to equipment located at the offices of the technology integrator.

3.2.4   Integration Case 4: Full Scale Test

Integration Case 4 (IC4) was an end-to-end system test that linked all dispatch centers and monitor centers with the entire vehicle fleet. This is effectively the system described in Figure 2.1. IC4 constituted the technology integrators' System Acceptance Test Procedures for SCAG, and was conducted September 30 – October 1, 1999 (BRW, October 1, 1999).

3.2.5   Summary of Integration Case Test Results

The test outcomes are defined in terms of the functions the system is able to execute. Integration Case test results fall into one of five categories. These are

1) Pass (P);
2) Pass (P-D), deviation to be requested;
3) Pass (P-W), waiver to be requested;
4) Fails (F-D), deviation to be requested;
5) Fails (F-W), waiver to be requested;
6) Fails (F-ICx), retest required in a subsequent IC test;
7) Pending; and
8) Not Tested.

"P-D" means that the system meets functional requirements, but not in the way prescribed by the system integrator. The relevant vendor should request a deviation to the requirement, stating that the requirement is met by means other than those prescribed. "F-D" means that the system does not meet functional requirements, but could with additional changes. However, the benefits provided by these changes do not justify the work and delay necessary to execute them. The relevant subcontractor should request a deviation in the requirement, requesting that this function be accepted as is. "F-W" means that the system cannot meet functional specifications, and that it is impractical to meet these specifications. However, the overall functionality of the system is not impacted by the failure. The relevant subcontractor should request a waiver from the requirement. "F-ICx" means that the system fails to meet functional requirements, and this function must be improved and retested in a subsequent IC test. "Pending" means that the data needed to determine whether this functional requirement has been met is still being collected. The meaning of grade "P-W" is undocumented, and there is insufficient information available to permit a meaning to be imputed. Since waivers require a more extreme modification of requirements standards than deviations, a grade of "P-W" is presumed lower than a grade of "P-D."

The number of requirements tested in IC1, IC2, and IC4; and the share of outcomes falling into each category are summarized in Table 3.1. Overall, this approach to system integration was successful. This approach tended to identify problems early, which was important given the short schedule for the FOT; and provided the system integrator with a rationale for eliciting focused responses from the subcontractors and vendors.

Table 3.1   Test Results for Integration Cases 1, 2 and 4

	IC1 Requirements		IC2 Requirements		IC4 Requirements	
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Passed	8	33	41	53	38	73
Passed with Deviation	6	25	1	1	3	6
Passed with Waiver	0	0	3	4	1	2
Failed, Deviation Needed	2	8	0	0	1	2
Failed Waiver Needed	5	21	3	4	3	5
Failed, Retest Needed	2	8	16	21	3	5
Pending	0	0	0	0	3	5
Not Tested	1	4	13	17	1	2
Total	24	100	77	100	53	100

Source: Bonds, John (October 1, 1999) SGVSST System Integration Case 4 Test Report.
Bonds, John (April 6, 1999) SGVSST System Integration Case 2 Test Report.
Bonds, John (February 25, 1999) SGVSST System Integration Case 1 Test
Report.

Table 3.2   Observed System Availability, November 10 – 17, 1999

Site	Total Operating Time (Minutes)	Total Down Time (Minutes)	Percent Availability
Central Message Server (Pomona)	10,080	136	98.7 %
Monrovia Contractor (Arcadia)	5,667	45	99.2 %
Foothill Transit (El Monte)	8,653	141	97.4%
Duarte City Hall	5,400[a]	0	100.0 %
Dispatch Total / Component Average[b]	14,320	186	98.7 %[b]
Total / Component Average Including the Central Message Server, and Excluding Duarte	24,400	322	98.6 %

Source: Bonds, John (November 18, 1999) SGVSST Memorandum to Douglas Smith RE:
Results of IC4 Testing IC4-4.1 & IC4-4.2.
Notes: a. The Duarte site was reported as not operational because an open LAN
connection. The Duarte equipment was on, but not communicating with the rest
of the system.
b. This value corrects an error in the system integrator's calculation. Note that
the Central Message Server is excluded from the calculation.

3.2.6 System Availability

System availability is a measure of how the system was able to support transit operations throughout the normal workday at each site. This is a weaker measure than mean time between failures (MTBF), but the FOT did not last long enough to permit robust measures of system reliability. The system level performance specification for availability is 98 percent. The system integrator tested system availability during the period November 10 –17, 1999 (Bonds, November 18, 1999). The test measure is

Percent Availability = 1 (total down time / total operating time) x 100% **(1.)**

Down time estimates exclude the time required for test supervisors to travel to correct problems, on the assumption that transit operators would eventually be trained to identify and correct recurrent system problems on their own. Results appear in Table 3.2. These calculations are reasonable, but optimistic in that they do not account for the impact a loss of Central Message Server availability has on the Dispatch Stations. If the Central Message Server is unavailable, then the Dispatch Workstations are unavailable. A lower bound on average system availability can be computed by adding the 136 minutes of Central Message Server down time to the down time observed for each Dispatch Workstation. This gives a lower bound on average system availability as 97.0 percent.

It is clear system reliability improved during the course of the test, but early estimates of system reliability would have been pointless. This is largely due to the software vendor's programming practices. The software installed at the Monrovia contractor's facility was not tested and debugged prior to installation. The testing and debugging that necessarily occurred on site was disruptive to the contractor's operations, and disruptive to training efforts. These circumstances sometimes became extreme, and it was obvious that the software vendor's personnel were rewriting code on site. The system integrator reported one case in which an old version of a software module was included in a new software patch. This reintroduced a bug that had been resolved previously (BRW, October 1, 1999).

3.3 Integration Test Case Failure Analysis

The initial failures reflected a mismatch between the programming assumptions of the vendor providing the automated dispatch and scheduling system and the context of the FOT. The FOT focused on the use of technology to coordinate the operations of multiple fleets and dispatchers. The vendor's basic product was not customized for this purpose. The product was organized to support the operations of a single agency providing fixed route service, DAR service, or both. As a result, early requirement failures were associated with the differences between single fleet applications and the FOT. Vehicles from different operators had to be represented in graphical terms by icons with different colors, and were not. Once communication between the dispatchers and the vehicles was established, drivers received messages over their MDTs from multiple dispatchers, and should not. Dispatchers sometimes received MDT messages from all drivers in the system, rather than just their own personnel. And finally the maximum number of vehicles the FOT system was to be able to handle exceeded the maximum fleet size normally managed by the automatic dispatch system.

Some of the failures that occurred during the integration tests reflected the logistical difficulty associated with bringing together hardware and software systems from different subcontractors. The system integrator provided extensive system specifications as the basis for inviting bids from subcontractors and defining work plans, but even this could not ensure complete coordination across subcontractors. For example, the vendor supplying the Mobile Data Terminals and the vendor providing the automatic dispatching and scheduling system worked from two slightly different sets of communications specifications. The software vendor originated the SGVSST Message Interface Control Document, yet deviated from this document without notifying the system integrator. This created a variety of problems that were identified in IC2 and IC3, and which had to be resolved before the deployment could proceed.

The system integrator made every effort to avoid these sorts of mismatches in advance, including encouraging subcontractors to write their own acceptance tests, and was usually successful. Further, the system integrator's approach made it possible to quickly identify circumstances in which the activities of different subcontractors required further coordination, and to elicit this coordination.

There were some respects in which the system failed to meet functionality requirements in substantive ways. These failures were substantive enough to have a clear impact on the participants' willingness to retain the FOT system. These failures

ultimately led to the termination of the test, the absence of interoperability tests, and the discontinuation and removal of the system. However, these failures were not surprises. They were identified early, and received continuous attention from the systems integrator and from SCAG. Despite the best efforts of the participants, the systems integrator, and the sponsors, the changes necessary to alleviate these failures were unachievable during the course of the test.

3.3.1   Optimal Automatic Dispatch

The automated dispatch and scheduling system did not use real time AVL data as the basis for optimizing trip assignments to vehicles, nor to calculate estimated times of arrival. Instead, the system imputed DAR vehicle location on scheduled routes and the last traveler pick-up or drop-off recorded via the MDT. This is sufficient to provide a recommended DAR vehicle assignment for a new trip, but is not consistent with the system level performance specifications, and is not sufficient information to permit coordination of interagency transfers.

3.3.2   Schedule Adherence

The exclusion of real time AVL data also makes it impossible to meaningfully evaluate fixed route schedule adherence. This function was a priority for Foothill Transit, which wanted vehicles running behind schedule to show on a computer screen in one color, and vehicles running ahead of schedule to show in another color. Since the system software estimates vehicle locations based on schedule information, it cannot support this function. The system does not compare actual and scheduled locations. This is not consistent with system level performance specifications. Further, the vehicle information that was displayed to Foothill's dispatchers was complex and text was nearly impossible to read.

The means to determine schedule adherence was perhaps the best defined functional requirement of any operator participating in the test. It was one of a very small number of function requirements actually defined by the transit operators participating in the FOT, rather than by the sponsors or the system integrator. The system's failure to deliver this function ultimately had a profound impact on the trajectory of the test. Without locations based on real time AVL data, the system did nothing to simplify interagency transfers. As result, Foothill Transit ultimately declined to advertise this capacity to its riders, and withdrew from the test. This decision marked the effective

end of the program.

3.3.3   Operations and Maintenance Training and Documentation

The vendor providing the dispatch and scheduling software also provided extensive onsite training. However, this training was complicated, delayed, and obstructed by ongoing changes to the system software. These changes were necessary, because the software often did not perform the functions expected by the trainer. Overall, the software was complex, required considerable technical expertise to install and maintain, and was not well documented. The system was likely to require ongoing troubleshooting, but the vendor provided no manuals to support this activity. The systems maintenance requirements were opaque to the operators involved in the test, and it was clear these operators were not in a sufficient state of information to maintain the system.

3.3.4   Operator Reports

From the outset of the test, Monrovia's contract operator stressed the importance of specific reporting capabilities. The prospect of improved reporting was the City of Monrovia's primary motivation for participating in the test. The City wanted to know how many Los Angeles County residents from outside the City of Monrovia were using the City's DAR service, because the City was entitled to reimbursement from the County for this service. There was no way for the contractor's current, manual dispatching system to accurately track this use.

The requisite reporting capabilities existed in the DOS version of the scheduling and dispatching software, and the system integrator received assurances from the software vendor that these reporting capabilities were included in the Windows version of the software to be installed as part of the FOT. The product that was installed did generate a number of different reports, but not the specific reports needed by the City of Monrovia and its contractor. The software offered no flexibility with respect to custom reporting requirements, and virtually no documentation on report functions. As a result, the standard City of Monrovia reporting requirements that the Monrovia contractor had been meeting manually for many years could not be met by the automated system. This was a step backwards for Monrovia, and while not explicitly identified in the system integrator's contract with the software subcontractor, inconsistent with both the system specifications and the assurances offered the systems integrator.

3.4 Additional Field Tests and Results

Most of the field tests planned for the FOT evaluation could not be executed because the FOT concluded at the end of March, 2000, almost immediately after the deployment was complete. However, the evaluation team was able to complete preliminary field tests of some subsystems and capabilities in support and anticipation of an end-to-end, revenue service test of the completed deployment.

3.4.1 Coordinated Interagency Passenger Transfers

The evaluation team conducted a pretest of the SGVSST system's capability to support coordinated interagency transfers on February 24 and February 28, 2000. The purpose of the pretest was to evaluate the feasibility of transferring between Foothill Transit buses in operation on Routes 184 and 187 and Monrovia Transit's DAR service, and to fine tune draft test procedures. The team also wanted to determine the appropriateness of the three designated transfer points. These were Myrtle/Olive (Foothill Route 184), Huntington/Monterey (Foothill Route 187 eastbound) and Huntington / Mountain (Route 187 westbound). Each transfer point is the first bus stop entering the City of Monrovia. Transfers to the Duarte Shuttle were to occur at Huntington and Highland. Further, since the Duarte dispatcher's station was unstaffed, this constrained the way coordinated transfers involving Duarte could be achieved. The Monrovia service contractor could drop off travelers at the designated Duarte transfer point, but there was no Duarte dispatcher to accept or originate dispatcher-to-dispatcher messages. SCAG's project administrator had decided to eliminate other proposed transfer points.

Graduate Research Assistants, clearly identified as Foothill Transit Survey Takers, requested transfers from either of the two Foothill routes to Monrovia Transit, providing a final destination somewhere within the City of Monrovia or within the adjacent County area served by Monrovia Transit. The Research Assistants were aware of the location of the transfer point, but they were told not to inform the driver of this unless asked. MDTs had been installed in Foothill buses, but the Foothill Transit management had decided these would be used only to issue silent alarms. The driver was supposed to radio the transfer request to the Foothill dispatcher, giving bus route, direction and final destination.

Once the Research Assistants were dropped off at the transfer point by Foothill Transit, the Monrovia DAR vans were to pick them up and deliver them to their final destination. The Research Assistants then reversed the process, and made calls to Monrovia Transit from somewhere near the final destination, requesting to be delivered to the established transfer point/bus stop. The Research Assistants attempted to complete four round trips, or about one round trip per hour.

In all but one case, Foothill drivers who weren't aware that coordinated transfers were possible radioed the Foothill dispatcher for instructions. The Foothill drivers made a total of seven requests to their dispatcher, but five did not communicate the final destination. It was left to the Foothill Transit dispatcher to radio back to the driver and confirm the final drop-off point in Monrovia. In most cases, drivers had to be reminded of where the transfer points were located.

Two transfers were aborted on February 24. In the first case, the driver was unaware of the transfer procedures, and the Research Assistant asked to be let out at the transfer point. She then called Monrovia Transit herself. In the second case, the target destination was close enough to the Foothill Transit bus route to make a transfer to the van unrealistic. The Foothill driver recommended an alternative drop-off point instead. Final test destinations within Monrovia were revised for the February 28 pretest and any subsequent tests.

As a result of the pretest, the evaluation team identified problems associated with the level of activity in the Foothill Dispatch office. Successful transfers required clear instructions from Foothill Transit to Monrovia's service contractor, and attention to responses from the service contractor. However, the Foothill dispatcher is responsible for a number of competing tasks. During the course of the pretest on February 28, the Foothill dispatcher

1) assigned buses to drivers (at one point during a shift change, there were 10-12 people standing in front of the dispatcher's window);
2) communicated with drivers by radio (rather than MDT);
3) took in job applications;
4) handed out job applications; and
5) tried to repair the office photo copier.

The computer terminal where dispatcher-to-dispatcher free text messages were sent was located behind the Foothill dispatcher. It was necessary for Foothill management personnel to assist the dispatcher with coordinated transfers during the

pretest. When drivers radioed in transfer requests, the dispatcher was attentive and communicated the information so that the assisting manager could send a free-text message to the Monrovia service contractor. In those (intentional) instances in which the Foothill dispatcher was not given a final destination, it was up to the manager to ask the dispatcher to get the additional information. Once the manager departed and the dispatcher was left alone to communicate with the drivers and communicate with the Monrovia service contractor via free-text messages, some critical information was lost. Confirmation messages from the Monrovia service contractor back to the Foothill dispatcher became problematic. In three cases, the Monrovia dispatcher asked for clarifying information. Given the level of activity and noise in the Foothill dispatcher's location, the Foothill dispatcher was unable to hear the message signal indicating the arrival of e-mail messages from the Monrovia contractor.

The situation was better in the Monrovia dispatcher's location, but this was partially because the Monrovia contractor had found it necessary to separate the functions of call taker / trip booker and dispatcher to make use of the new automated system, doubling the personnel compliment at the Monrovia service contractor site. E-mail messages from the Foothill dispatcher were appearing on the Monrovia dispatcher's screen, rather than the call taker's screen, which required the dispatcher to pass the request to the call taker to be queued and returned to the dispatcher.

3.4.2   Tests Forgone

As noted above, the FOT period during which the system was to be deployed and functioning shrank steadily during the course of the test. The evaluation team planned field tests of the fully deployed system in revenue use as soon as the system was available. Ideally, evaluation of system performance should occur after the system has been in a few months of revenue use, to make sure transit operators, drivers, and patrons are reasonably familiar with the options and requirements the new system presents. In this FOT, the Go-Live date was repeatedly delayed. This sequentially reduced the time available for measurements, and made it necessary for the evaluation team to remain poised to begin post-deployment field work the moment the SGVSST system entered revenue service. Table 3.3 summarizes the milestones in the deployment. Table 3.4 summarizes the various delays in the Go-Live date, and the reasons for these delays. Taken together these milestones and other events reflect an accumulation of delay and a steady compression in the schedule for the test. Progress

Table 3.3   Summary of FOT Hardware and Software Deployment Milestones

Date	Milestone
7/11/97	SCAG releases Request for Qualifications for technology integrator for FOT.
7/30/97	SCAG releases Request for Proposals for integration services.
9/97	Caltrans emphasizes use of off-the-shelf hardware and software in selecting appropriate team.
1/20/98	SCAG enters into agreement with lead consultant for system integration.
2/98	System integrator holds half-day workshops for each participant to discuss user requirements for system.
3/98	System integrator submits concept design. Announcement that there will be no interface with Arcadia contractor's automated dispatching system, only information exchange. Questions arise over need for data terminals in Foothill buses.
4/9/98	Critical Design Review
4/28/98	Dispatch software demonstration
5/1/98	System integrator releases final system specifications.
5/13-14/98	System integrator submits communications specifications for review and conducts site surveys of the proposed locations for computer equipment.
5/98	Draft system test plan is submitted for review by system integrator. Software vendor and communications vendors selected.
6/98	Development of system test plans. SCAG authorizes system integrator to proceed with procurement of software and communications services.
9/1/98	System integrator signs limited authorization to proceed for software design and development. Beginning of operational review of Monrovia contractor.
9/8/98	Software license and maintenance agreement between software vendor and SCAG signed. Meeting held to discuss concerns over licensing and liability issues.
9/17/98	Phase I contract for dispatch and scheduling is signed by system integrator. Software vendor and MDT vendor present software to participants and discuss training and customization/product delivery. SCAG and software vendor report on licensing problems regarding base maps.

Table 3.3   Continued

Date	Deployment Milestone
10/98	Phase I contract between software vendor and system integrator signed. (Phase II to be addendum of original and signed at a future date). MDT vendor signs contract. System integrator orders computer hardware and software; hardware delivered to system integrator and Monrovia contractor. System integrator and software vendor finalize integration of SCAG GIS base map into system.
11/17/98	SCAG accepts System Specifications.
11/98	Contract discussions between system integrator and hardware vendor on Phase II contract are completed. Contract with communications vendor near completion. Number of MDTs assigned to project reduced from 53 to 46. System integrator reports difficulty in sharing GIS mapping for multiple applications due to amount of data manipulation.
12/14-15/98	Equipment installation, dispatch software installation and operational analysis at Monrovia contractor postponed. Discussion with Monrovia contractor on need to create client records and data archiving.
1/99	Software vendor conducts training at Monrovia contractor. Software problems occur including need to reconfigure GIS. MDT vendor installs units in one of each type of vehicle in FOT. FOT completion date extended form 6/99 to 12/99.
1/15/99	Integration test #1, originally scheduled for 12/15, cancelled due to problems with MDT interface format. System integrator also reports concerns over incomplete fare coding methodology and software space requirements.
1/23-24/99	Software vendor conducts system test using both computer and manual systems at Monrovia contractor.
1/30/99	Software fails IC1 test of communication with MDTs. Software cannot handle as many vehicles as specified.
2/23/99	IC #1 completed. Of the 24 requirements, 8 pass, 6 pass with deviation, 2 fail and require retesting, 2 fail and need deviation requests, and 5 fail and need waivers. Significant failures include communication client failure, automatic display update and dispatcher alerts.
2/25/99	Monrovia contractor returns to manual operations due in part to driver turnover.
3/11-15/99	Software training at Foothill Transit and at City of Duarte. Monrovia contractor still on manual operations.
3/22/99	MDT-software interface test (IC # 2) begins. Formatting for communication is reported to be incorrect. System is deemed inadequate to support IC #3. Significant problems include dispatch response to other vehicles and automatic display updates.

Table 3.3   Continued

Date	Deployment Milestone
3/23-25/99	MDT training at Monrovia contractor and Duarte.
4/99	System integrator reports loss of information in system (e.g. pre-booked rides) while testing MDTs. Hardware installation in vehicles completed.
5/13/99	Expiration date for FOT extended to 6/30/00.
6/99	Reported software difficulties: software not using real-time AVL for schedule adherence, free-text messaging not working, scheduling server not passing messages through to MDTs. Software patches appear to create new problems. Reporting issue for Monrovia unresolved. Caltrans begins procedures to transfer equipment to participants.
6/25/99	Project Manager reports that free text messaging is working but that fare-coding issue is still unresolved.
6/29/99	"Introduction to AVL" training at Foothill Transit
6/30/99	System integrator begins "product only" support
7/99	Software fix for "No Shows" needed. Communication problems between MDTs and server. Software vendor continues troubleshooting; system integrator conducts "live MDT" field tests with drivers. (IC # 3)
8/99	Software vendor commits to delivering schedule adherence real-time capabilities by 9/17/99. Communications budget extended for 6-month period.
9-10/99	System crashes when more than 5 MDTs come on-line. Monrovia contractor running without MDTs. Contractor reports that client database is dropping names. Monitoring stations crashing on average of every 3-4 days due to problems associated with data load. Software vendor begins generating reports.
11/99	Software vendor continues on-site work at Monrovia contractor. Monrovia contractor reports only intermittent problems with MDTs. Software vendor uncovers problem with algorithm used to calculate bus' ETA when a vehicle is off-schedule. System scores 97.7% on 7-day operational test; passing is 98%. (IC # 4)
12/6/99	Monrovia contractor's monitor goes down. New monitor delivered. Foothill Transit completes task of inputting route data for schedule adherence; but determines that getting schedule adherence would require polling previous AVL data for each stop and is not feasible.

Table 3.3   Continued

Date	Deployment Milestone
12/99	System experiences only minor monitor problems for 4-week period from mid-November to mid-December. Monrovia contractor continues to reboot system and override it to improve speed of operation. Occasional difficulties with MDTs missing pick-up and drop-off information. Continued use of radios to support MDTs.
1/25-27/00	Unresolved issues include reporting capabilities (reporting without considerable data manipulation), recurring communication cost estimates and software's inability to recognize Foothill Transit's run information. Foothill Transit reports to SCAG that schedule adherence is now a low priority since summary on-time reports cannot be created. Foothill also concerned that MDT/GPS units remain on while buses are idle.
1/00	Cache of in-coming AVL data crashes Foothill system. Some MDTs still in need of repair. SCAG reports that Arcadia's choice of communications system is incompatible with FOT integration.
2/00	Transfer and free-text messaging test scheduled for 2/9 is cancelled.
2/24-28/00	Foothill conducts limited training for drivers and dispatchers in preparation for transfer test (including e-mail messaging) with Monrovia contractor.
3/13/00	SCAG announces Duarte's withdrawal from test due to cost considerations. Monitoring stations awaiting final software patch.
3/22/00	Foothill Transit informs SCAG that it cannot continue to fund network and airtime charges beyond March 31. It also decides not to keep equipment because of its age (except for AVL equipment for possible use in fleet-wide system).
3/30/00	FOT ends. SCAG turns over equipment to stakeholders. Foothill Transit agrees to house the communications server for use by Monrovia contractor.

Table 3.4   Summary of Go-Live Schedule Changes

Old Go-Live Date	New Go-Live Date	Reason for Delay in the Go-Live Date
6/98	11/98	Agreement between Caltrans and SCAG for SGVSS FOT (February 1997) assumes development and field-testing by the spring of 1998 and full deployment by 6/98. In July 1998, system integrator reports delay due to prolonged contract negotiations, decisions related to potential system budgets based on negotiated bids, ordering and purchasing hardware, and status of Arcadia integration.
11/98	1/99	In September 1998, system integrator and SCAG announce plans for "Go-Live without AVL" for November but push back "Go-Live with AVL" to January 1999. System integrator reports that detailed contract negotiations require revising budget and schedule.
1/99	3/99	In January 1999, system integrator reports that operational system now planned for March 1999. Reasons for delay include translating GIS data into usable format and review/acceptance by software vendor.
3/99	Mid May-Jun 1,1999	Unresolved software issues (including free text messaging and fare coding), failure of IC #2 and late delivery of MDTs result in floating "Go-Live" date.
6/1/99	6/30/99	On 6/17, SCAG reports that unresolved MDT/software interface problems will move "Go-Live" without AVL to 6/30. SCAG defines "Go-Live" to mean bus tracking, automated dispatching, free-text messaging and fare coding.
6/30/99	9/99	Delay is due to multiple software-related difficulties, including communication between MDTs and server, and lack of schedule adherence capabilities.
9/99	10/99	System crashes when more than 5 MDTs come on-line. Software vendor still working on system fixes.
10/99	12/7/99	Fixes are required on 15 Foothill Transit MDTs. Recurring system crashes in October due to data load.
12/7/99	12/13/99	Project declared "Live" for MDT operations and transfers

was consistent through the FOT, and even accelerated toward the end. However, no responsible use of available resources could have accelerated progress sufficiently to secure enough time to evaluate the system during the course of the FOT. Since none of the participants retained the system for subsequent use, there was no opportunity to collect additional evaluation data after the FOT concluded.

As a result of these delays, and the abrupt termination of the test, the most complex tests associated with IC4 and FOT evaluation were never completed. There never was an end-to-end test of the SGVSST system's ability to support the interagency coordination functions it was designed to enable. Route deviation exercises were abandoned during the course of the test because, despite the best efforts of Caltrans and SCAG to persuade the project participants of the importance of route deviation, Foothill Transit's policies and bus size would not permit route deviation experiments. Duarte had expressed an early interest in route deviation applications that might reduce run times, but this interest was rendered moot by Duarte's absence from the latter portion of the FOT. As noted above, the evaluation team completed a pretest of transfer capabilities, but transfer opportunities were never advertised to the public, and no other coordinated transfers were ever undertaken in revenue service.

Once it was confirmed that the schedule adherence function would not be provided by the vendor providing the computer dispatching system, Foothill Transit elected to discontinue participation in the FOT. See Appendix 2 for Foothill Transit's 1998-99 Monthly Schedule Adherence summary. Duarte had effectively made an unannounced withdrawal from the program months earlier. These decisions precluded any opportunities to test the system's capability to support coordinated transfers between fixed route and DAR services or timed transfers between fixed route services. This marked the operational conclusion of the FOT. The formal end of the FOT came when the remaining participants concluded that the shared cost of maintaining the Communications Subsystem was prohibitive.

CHAPTER FOUR

MONROVIA CASE STUDY

Monrovia Transit was identified early on as the participant most likely to be significantly affected by the SGVSS FOT. As noted in Chapter Two, the Monrovia Transit contractor used a completely manual booking and dispatching system. It was anticipated that shifting to an automated system would affect all aspects of the operation. The SGVSS evaluation plan called for a detailed analysis of impacts on this system, including user response, productivity and cost-effectiveness as well as technical and functional performance. The lack of any period of steady-state FOT operation precludes many aspects of the evaluation. Nevertheless, impacts at Monrovia were significant in a number of dimensions. This chapter presents results of FOT impacts in Monrovia.

4.1   MONROVIA TRANSIT

As reported in Chapter Two, Monrovia Transit is a general public demand-responsive service funded by the local return portion of the Los Angeles County sales tax earmarked for transportation. Like many such services in the county, Monrovia Transit was created as a result of the availability of local return funds. The City of Monrovia contracted the service to a local provider, a small transportation enterprise that operated municipal demand-responsive services and a truck driver training school. The same contractor operated the service from its inception; its contract was renewed several times without going out to bid. At the start of the FOT, the contractor had been operating the service for 14 years.

As with many such services, Monrovia Transit was not a high visibility activity in the city. It was shuttled from one department to another before finally being assigned to the planning department. The service was certainly low cost: the contractor was paid a flat rate of $28 per vehicle service hour in 1998. Although the service contract included performance and reporting requirements, the service was not closely monitored. It would appear that as long as the contract provisions were met and few complaints arrived at City Hall, the service was judged to be satisfactory by the City.

Why then did Monrovia agree to participate in the FOT? Interviews with City staff and the contractor indicated that the Mayor was a staunch supporter, and once it was known that he wanted this to happen, both the City staff and the contractor complied. At

this time, the mayor was a member of the Foothill Transit Board of Directors. Both City staff and the contractor saw potential benefits from participation. The City staff was most concerned about being compensated for County trips. Monrovia Transit had agreed to serve a small portion of unincorporated area adjacent to the city, but they were not satisfied on the compensation arrangements. They felt that County trips (e.g. trips serving county residents) were on average longer than other trips, and thus were more costly to serve. They thought the automated system would be able to document origins and destinations of county trips and identify County residents taking intracity trips. This would allow Monrovia to receive more adequate compensation from the county. In addition, the ability to monitor the contract operation was deemed potentially attractive.

The Monrovia contractor saw several advantages to participation. First, they saw the automated reporting capability as a way to more efficiently generate the reports required under their contract. These included reports on on-time performance. The contract required reservation rides to have an estimated pick-up time +/- 10 minutes of the request time, and all ride requests to have pick-up times within + 30/-10 minutes. Under the manual system, a one-day random sample of time-punched dispatching tickets was used to calculate on-time performance each month. Automating this process would allow more efficient and comprehensive analysis of on-time performance. Second, they also were interested in documenting in-County trips. The longer trips reduced productivity, cost more to serve, and made it more difficult to maintain targeted productivity of 5 trips/vehicle service hour. Third, the contractor saw the FOT as a way to shift to state-of-the-art dispatching without incurring the substantial start-up costs, and therefore improving future potential business opportunities.

4.1.1 Operating Characteristics

Basic historical operating data were obtained for Monrovia Transit. Figure 4.1 give monthly total passengers for fiscal years 1995-96, 1996-97, and 1997-98. Monthly ridership varied substantially over the three years, from a high of about 9,500 in August of 1995 to a low of 6,600 in January of 1997. This variability was not due to changes in the supply of service, as vehicle service hours remained relatively flat over the same period. However, the reported share of county trips increased in 1996-97, with a high of 21 percent in December 1996 and January 1997. This pattern supports the concerns raised regarding the cost of serving county passengers.
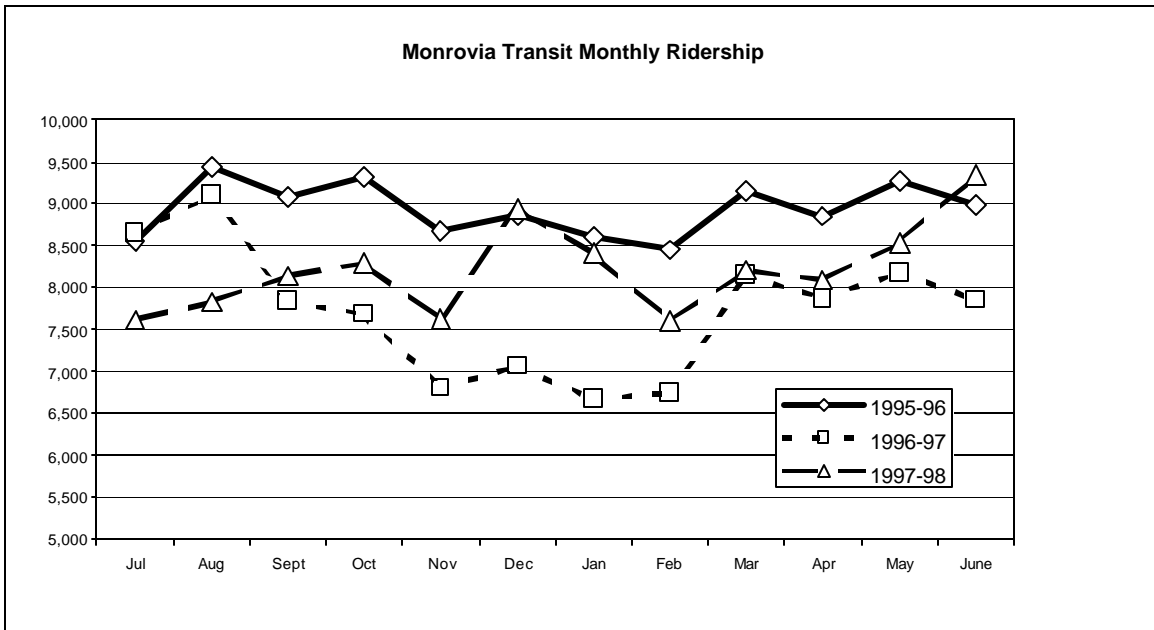
Figure 4.1   Monrovia Transit Monthly Ridership, Fiscal Year 1996 – Fiscal Year 1998.

Table 4.1 gives basic operating data for the same period. However, data for only the first half of FY 1997-98 are available. In 1995-96 Monrovia Transit was a very cost-effective service, with per passenger operating cost of less than $4.00. As noted above, in 1996-97 there was a large increase in county trips (averaging about 1200/month, about double from the year previous). More service hours were provided, operating costs went up, but ridership went down. The following year productivity seemed to be improving, parallel with a slight reduction in the share of county passengers. Note that it is during this period that discussions about participating in the FOT were taking place. The operating data show that Monrovia's concerns about county trips were well-founded.

4.1.2   Monrovia Contractor Service Operations

Prior to the FOT, the Monrovia contractor was operating a rather primitive system. Dispatching was completely manual, and driver and vehicle logs were completed by hand. The operations manager used a simple spreadsheet program to generate the required reports. The dispatching procedure was:

1) Call taker records origin, destination of call request on ticket, provides an estimate of pick-up time, and time stamps ticket.

2) Trip is assigned to a driver, driver copies call via radio, ticket is time stamped a second time.

Table 4.1   Monrovia Transit Operating Data

	Total Passengers	Vehicle Service Hrs.	Total Operating Cost	Cost per Passenger	Passengers per Vehicle Service Hr.
1995-96	107,232	16,280	$418,080	$3.90	6.59
1996-97	92,616	17,896	$452,531	$4.89	5.18
1997-98[a]	47,149	8,174	$223,479	$4.74	5.77

Note: a. First six months only.

3) Driver radios that pick-up has been made, or the passenger was a no show, ticket is stamped a third time.

4) Driver radios that drop-off has been made, ticket stamped fourth time and placed in driver/vehicle file.

Figure 4.2 gives a more detailed flow chart of the manual dispatching process, indicating decision points and paths for each step of the process. All communications between the dispatcher and the drivers consisted of voice communications occurring over a radio. During periods of low demand, the entire dispatching process was handled by one person with sufficient experience.

The operations manager estimated that less than ten percent of all trips are advance reservations. The obvious question is "How could a simple system perform at a relatively high level of productivity, given generally six vehicles in service, and given that most trip requests are on demand rather than by reservation?" Field observation showed that dispatchers were very familiar with the local geography, and that many passengers were repeat customers whose travel patterns were known to the dispatchers. They therefore were able to assign trips quite efficiently.

The time-stamped tickets were the source for the on-time performance reports required by the contract. The operations manager took a randomly selected one day each month, entered the day's ticket data by hand into a spreadsheet, and calculated on-time performance by comparing actual pick-up time with the estimate provided by the call taker / dispatcher. Driver logs were the source of trip, passenger, vehicle service hour, and mileage data. Data from these logs were tallied up each day, the totals were entered into a spreadsheet, and monthly passenger counts, vehicle service hour counts, etc. were generated. Since the contractor was required to report passengers and was paid by the service hour, the driver logs were essential. Thus the operations manager decided that all paper logs would be retained during the FOT until such time that the

Clients   **Call Taker / Trip Booker / Dispatcher**

```
┌─────────┐      ┌────────────────────┐              ┌────────────────────────┐
│  Start. │─────▶│ Provide Name, Address,│─────────────▶│ Write down traveler Name, Address,│
└─────────┘      │ Origin, and Destination.│            │ Origin, and Destination on ticket.│
                 └────────────────────┘              └────────────────────────┘
                        No                                       │
                         ◇                                        ▼
                    ◇ Correct? ◇◀──────────────────────┐ ┌────────────────────────┐
                         ◇                              │ │ Read back traveler Name, Address,│
                        Yes                             │ │ Origin, and Destination.│
                         │                                └────────────────────────┘
                 ┌──────────┐                           ┌────────────────────────┐
                 │ Confirm. │──────────────────────────▶│ Time stamp ticket and post the ticket│
                 └──────────┘                           │ to the dispatcher board.│
                                                        └────────────────────────┘
                        No                                       │
                         ◇                                        ▼
                    ◇ Cancel trip? ◇◀──────┌───────────┐◀──────
                         ◇                  │ Flag call for delay.│
                        Yes                 └───────────┘
                         │
                         └──────────────────▶┌──────────────┐
                                             │ Cancel booking.│
                                             └──────────────┘
```

Vehicles   **Telephone Communication**

                                Radio Communication

```
                    Yes  ┌──────────────┐              ┌────────────────────────┐
               ◇ Break time? ◇────▶│ Request break.│─────────▶│ Coordinate ASAP calls with advance│
                    ◇                └──────────────┘          │ bookings and driver breaks.│
                    No                                         └────────────────────────┘
                    ▼                                                   │
            ┌───────────────┐                                          ▼
            │ Await assignment.│                          ┌────────────────────────┐
            └───────────────┘◀──────────────────────────│ Use the radio to notify the drivers of│
                    │                                     │ their new assignments.│
                    ▼                                     └────────────────────────┘
            ┌───────────────┐                             ┌────────────────────────┐
            │ Acknowledge assignment│───────────────────▶│ Time stamp the ticket a second time.│
            │ and sign off.  │                            └────────────────────────┘
            └───────────────┘
                    │
                    ◇  Yes
               ◇ Trouble? ◇──────────────────────────▶┌────────────────────────┐
                    ◇                                   │ Troubleshoot assignments.│
                    No                                  └────────────────────────┘
                    ▼
            ┌───────────────┐                           ┌────────────────────────┐
            │ Pick-up client, radio con-│──────────────▶│ Time stamp the ticket a third time.│
            │ firmation to the dispatcher.│             └────────────────────────┘
            └───────────────┘
                    │
                    ▼
            ┌───────────────┐                           ┌────────────────────────┐
            │ Drop-off client, radio con-│─────────────▶│ Time stamp the ticket a fourth time.│
            │ firmation to the dispatcher.│             └────────────────────────┘
            └───────────────┘                                       │
                                                                    ▼
                                                        ┌────────────────────────┐
                                                        │ Post the ticket to the vehicle pocket│
                                                        │ on the dispatcher board.│
                                                        └────────────────────────┘
```
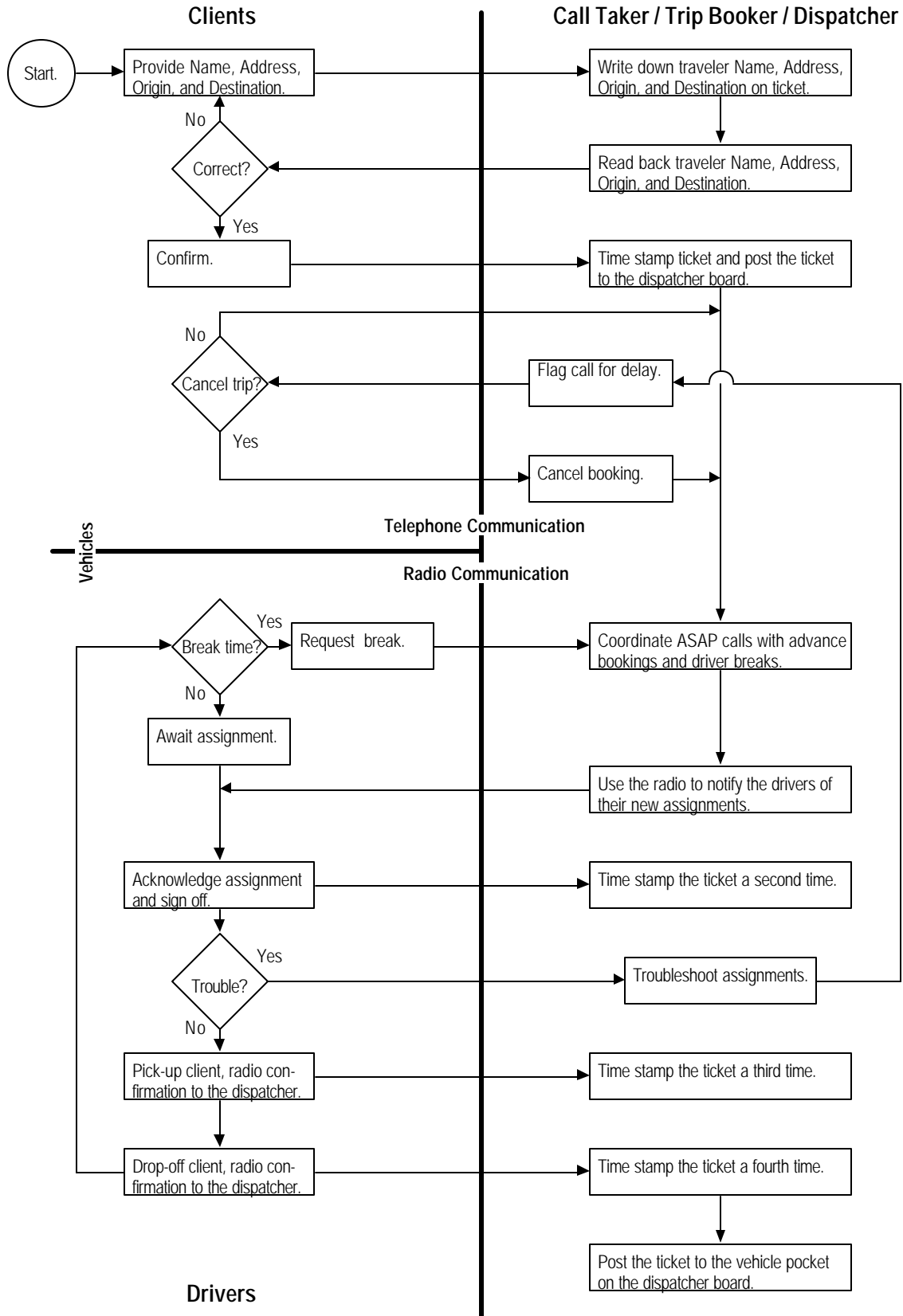
Drivers

Figure 4.2   Pre-FOT Call Taking, Trip Booking, and Dispatching Activities Executed
by the Monrovia Service Contractor.

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reporting capability of SGVSS could be satisfactorily demonstrated. The time stamped tickets could not be retained, because the dispatcher and call taker would not be able to fill out tickets and enter data into the computer at the same time.

The Monrovia service contractor hoped to replace these paper records with electronic records. This would provide management information, and might enable operations decisions that would improve service or reduce costs. The new system captured transactions electronically, but ultimately did not summarize these transactions in a report format relevant to the service operator or the City of Monrovia.

In addition to the general objectives described previously, the Monrovia operations manager provided a list of features desired as part of the SGVSS:

1) GPS tracking: to keep track of where the vehicles are, because drivers often do not reveal where they are, and to enhance safety.

2) Capability for a caller ID linked to street locations, to reduce errors in pick-up information.

3) Information links to Arcadia, Duarte and Foothill Transit, but no sharing of operational data.

4) Capability for all dispatch process information to be visible to dispatcher.

5) A semi-automated dispatching system that gives assignment options but can be easily overridden.

Items 1 and 3 were part of the deployed SGVSS. Items 2 and 4 were not feasible. Item 5 was achieved, because the dispatchers figured out how to override the system.

4.2   DEPLOYING SGVSS AT MONROVIA CONTRACT OPERATOR

The automated dispatching and scheduling system was installed at the Monrovia service contractor relatively early in the FOT. The service contractor and the system vendor used this period to accomplish training and establish procedures.

Having identified Monrovia as the operation where SGVSS would likely have the most impact, the evaluation team conducted extensive field observations of all aspects of the system installation. Table 4.2 lists all field visits conducted from the beginning of training in January 1999 to the demonstration of transfer capability conducted in February 2000. In addition to these field visits, the Monrovia operations manager was contacted regularly via telephone to obtain status reports on the operation of the system.

No similar observations were feasible at Duarte or Foothill Transit. Both are fixed route operators, but the Duarte system is small enough that it has no dispatcher, and

Table 4.2   Evaluation Team Field Observations at the Monrovia Service Contractor

Date	Purpose
Dec 16 1998	Administrator training
Jan 4 1999	Static training
Jan 5	Static training
Jan 7	Operator training
Jan 8	Operator training
Jan 11	Operator training
Jan 12	Operator training
Jan 13	Operator training
Jan 14	Operator training
Jan 15	Operator training
Feb 17	Dispatching observation
Feb 20	Dispatching observation
Feb 22	Dispatching observation
May 27	On-site interview
June 28	MDT training
June 29	MDT training
June 30	Observation
Nov 11	On-site interview
Nov 11-14	Driver observation
Nov 16-17	Driver observation
Dec 4	Driver observation
Jan 6 2000	Dispatching observation
Feb 9	Transfer test

thus the new FOT workstations installed there were unstaffed. Sporadic training was
provided to Foothill Transit staff, but the Foothill Transit dispatcher had no operational
use for the system unless communication with the Monrovia service contractor was
required. Such communication would have been the case if coordinated transfers had
become standard procedure.

4.2.1   Installing Dispatching Software

Half-day workshops were held for each of the operators in February 1998, and
operator comments and requests were solicited at that time. However, contracting
problems and equipment purchasing and delivery problems continually delayed the
project. See Chapters Two and Three. In October the system integrator reported that

the system design was finalized, and installation and training was expected to begin shortly thereafter. Additional problems delayed things until January 1999. The software trainer met with the project team and Monrovia contract employees in mid-December to prepare for training. It was at this meeting that the operations manager was informed that the software system required names and addresses for all passengers. In addition, it was apparent that the software trainer was unaware of the nature of the operation with its emphasis on on-demand requests rather than advanced reservation service.

The system integrator decided to install the dispatching software first and install the MDTs later. Software (dispatching) training took place at the Monrovia contractor in January, and at the end of January the operation migrated to the automated dispatching system. Three dispatcher/call takers were staffing the dispatch room in an effort to maintain a reasonable level of service operation while the staff was getting used to the new system.

The training process took longer than anticipated for several reasons. These include

1) lack of technical training of contractor employees;
2) lack of user manuals or other software documentation;
3) requirement for passenger names and addresses, which required collecting this information as call requests came in;
4) problems with inputting fare codes, addresses, vehicle specifications, etc.;
5) problems with maps and geo-coding; and
6) computer and software performance problems.

In February the contractor lost several drivers. Problems with the computer and software continued, with the system "crashing" on a regular basis. The operations manager returned to manual operation, stating that he would not go back to the automated system until it was reliable and he had his labor problems solved. The operation remained on manual until late March. During this period the operations manager made several inquiries regarding reporting capability and the ability to track County trips.

The operations manager and dispatchers identified the following problems during this phase of the FOT.

1) The driver shortage caused long wait times and generated much frustration among passengers, drivers and dispatchers. The system had to be constantly

over-ridden since it cannot handle queued demand. Morale was affected as
drivers and dispatchers bore the brunt of customer complaints.

2) Passengers resisted giving their names and felt that the system had become too
impersonal.

3) And, the operations manager was frustrated by the lack of response on the issue
of reporting, and concerned about the need for a second dispatcher.

In late March preparations began for installation of the MDTs. Testing of the
MDTs resulted in more computer system problems, and the system integrator decided to
keep Monrovia off-line until the Go-Live date. That is, the MDTs were installed in
Monrovia vehicles but not activated. Monrovia was now using the software for
dispatching on a regular basis, but without communications capability, the system was
no more than a hi-tech trip assignment package that had the distinct disadvantage of
requiring two people in the dispatch office at all times.

The FOT system was intended to function as shown in Figure 4.3. The software
provider claims that the system can be operated by one person, and that it was the way
that the Monrovia contractor was using the system that required two people. However, it
was genuinely difficult for one person to handle incoming calls, radio communications,
and the two separate computer screens required by the system. As a result, the
Monrovia service contractor had to separate the call taking / trip booking and dispatching
functions into two personnel assignments. See Figure 4.4. This reduced the workload
per person, but increased coordination requirements, because two people now had to
coordinate their functions.

Comparing Figure 4.4 with Figure 4.2 illustrates the greater complexity of the
automated system. The FOT system is designed to support dispatcher decisions, and to
accomplish more than the original system. To do so, the new system must capture the
information necessary to automate support of trip assignment and dispatching decisions.
This decision support has potential to reduce the cognitive load imposed on personnel
and simplify work, but it comes at an operations cost, and in this case the trade-off did
not lead to a net reduction in personnel requirements.

The net impact was an increase in the number of tasks managed centrally by the
Monrovia service contractor, and an increase in the total cognitive load associated with
dispatching. As noted above, the new system required that new travelers, which
included everyone at the point the system was initially installed, be logged into a
database along with a geo-coded record of each traveler's residence. This database

Figure 4.3 Planned Call Taking, Trip Booking, and Dispatching Activities Executed by the Monrovia Service Contractor as a Result of the FOT Installation.

had to be accumulated as operations proceeded, and this substantially increased the burden associated with call taking. The trip assignments suggested by the FOT system were generally credible, but not consistently better than the assignments generated by an experienced dispatcher. As a result these assignments had to be evaluated. In the pre-FOT system, drivers tracked their break time and requested break assignments from the dispatcher. The need to evaluate and compare and evaluate prospective assignments created a need to better anticipate driver availability, and thus track driver break times centrally.

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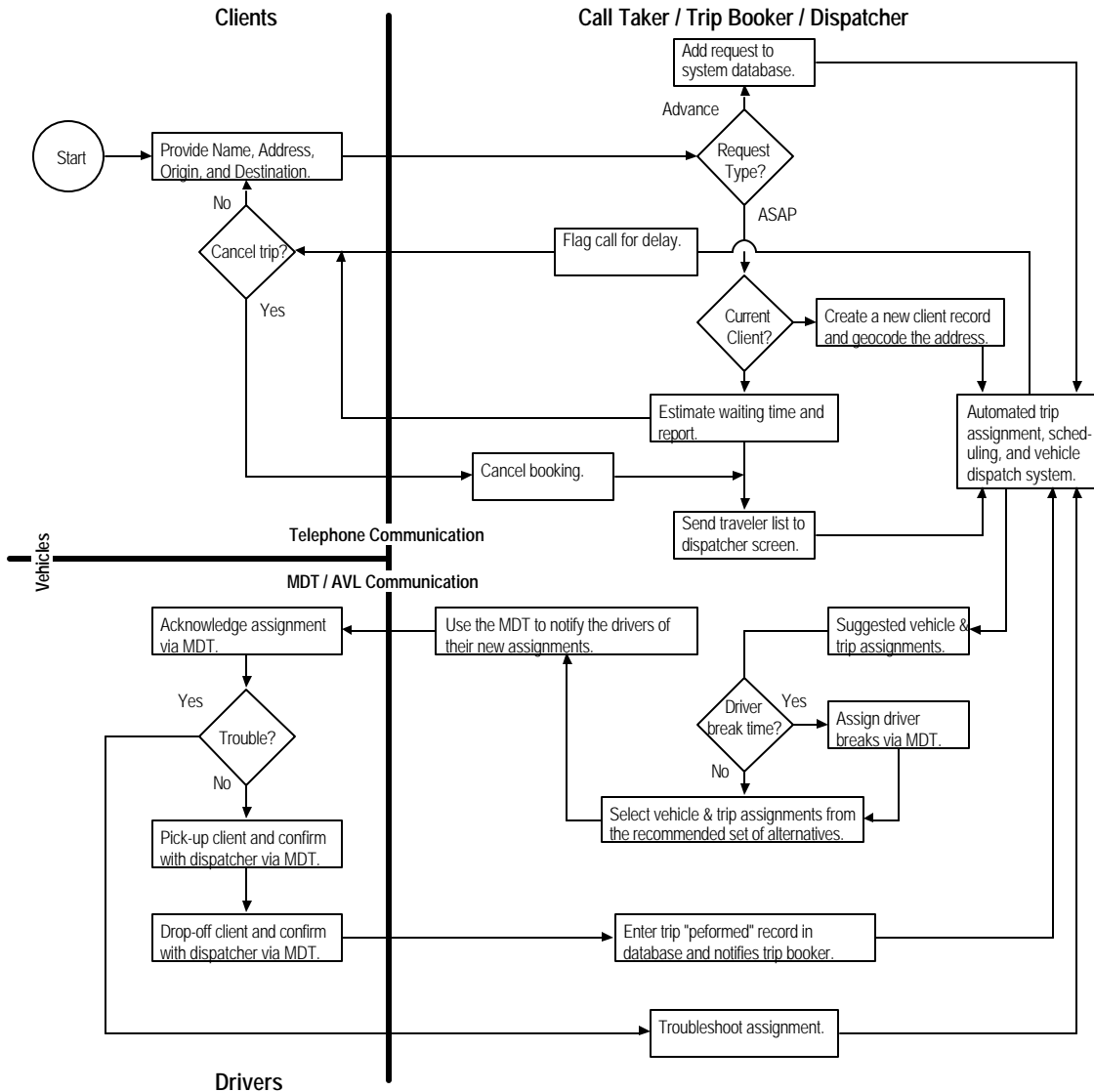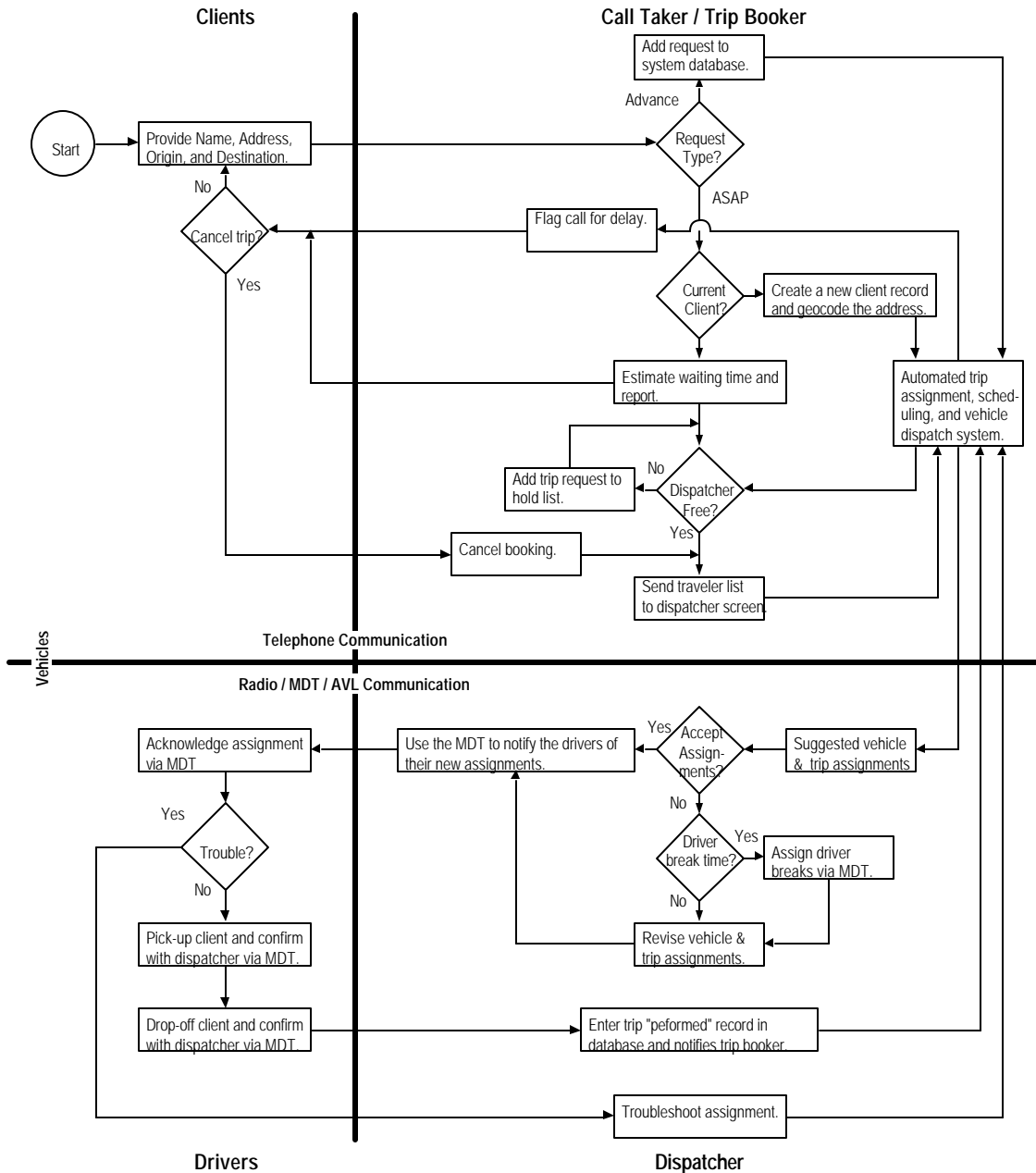**Figure 4.4** Actual Call Taking, Trip Booking, and Dispatching Activities Executed by the Monrovia Service Contractor as a Result of the FOT Installation.

Not only did the automated system require a larger labor commitment than the manual system, the nature of the labor required was different. The new system required computer skills that increased employability, and may have contributed to staff turnover.

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4.2.2 Installing MDTs

Problems with the MDT/software interface continued through June. The system integrator and the subcontractors were on-site frequently trying to solve coding and communications problems that prevented proper working of the MDTs. System integrator staff was traveling in the vehicles testing and troubleshooting the MDTs. The software trainer worked from the dispatching office to do the same.

Installation was complicated by service contractor management problems. The operations manager was spending little time on-site, leaving the dispatchers to run things as best they could. He quit without notice in early June. One of the dispatchers was promoted to operations manager. These problems drew attention away from the reporting issue, as the new manager was overwhelmed with the task of keeping the service running. Moreover, she had not been informed of the contract reporting requirements and did not learn about them until the City asked for its annual report. Her only alternative for obtaining the required on-time performance data was to go back to the manual ticket system for one day.

MDT training took place for the drivers at the end of June, but problems continued through the summer, and as noted in Chapter Three, the Go-Live date continued to be deferred. MDTs were used sporadically by Monrovia drivers throughout the Summer and Fall. The Monrovia dispatcher used both radio and MDTs to communicate with the drivers, but emphasized use of the MDT. By November the end of the FOT was at hand. The extension to March 2000 had not yet been approved, and the system integrator made one last attempt to get the system running reliably. The evaluation team took advantage of this seven day test period to conduct ride-alongs with each driver to observe use of the MDTs.

4.2.3 Drivers' Use of MDTs

The evaluation team conducted ride-alongs with each of the 9 Monrovia drivers. Eight of the ride-alongs took place in the week of November 11 through 17; the last one took place December 4. Each ride-along had a duration of ½ shift, either morning or evening. Students observed the activities of the drivers and asked a small set of open-ended questions.

Drivers had widely divergent views of the reliability of the MDTs, estimating the time they actually were working from most of the time to almost never. All used radio to verify MDT information or as a substitute for the MDTs, and all had experienced

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problems with the MDTs. These ranged from the MDTs simply not working to getting erroneous messages or not getting messages the dispatcher was sending.

Drivers differed in their willingness to use the MDTs, with some drivers using it as much as possible and others using it only to record pick-ups and drop-offs. Even when the MDTs were working properly, evaluation team observers noted that 6 of 8 drivers continued to use the radio. All drivers agreed that MDTs could not replace radios, as radios would always be needed for unusual events and for back-up.

All of the drivers stated that having to use the MDTs and complete the paper logs added 1 to 2 minutes to every pick-up and drop-off. Team observers found that the driver had to stop long enough to both write in the passenger information and do the text messaging.

Drivers also differed in their assessment of the MDTs and of the automated system. One driver said that the route assignment is often ignored, as drivers will try to accommodate passengers with specific time constraints. Another said that with flag-down rides the drivers and dispatchers are able to do a better and faster job of adjusting assignments. A third said that the drivers know shortcuts that the computer doesn't know. The Mobile Data Terminals simplify communications between dispatchers and drivers, but cannot be designed to support all relevant communications. The overall assessment of the drivers was that the MDTs are fine for routine communications (when they work), but the radio is better for everything else.

4.3   CLOSING DOWN THE FOT

As noted in Chapter Two, supporting coordinated transfers became the defining characteristic of the FOT as other features of the system failed to materialize and as Arcadia withdrew from the FOT. The transfer process was to take place entirely via the SGVSS system; drivers would make a transfer request via MDT (radio in case of Foothill Transit), e-mail would be exchanged between the two operators to arrange the transfer, drivers would be informed of a pick-up via MDT or radio in case of Foothill Transit. For the sponsors, it was imperative that some type of functional integration be demonstrated. After much discussion, a one-day test demonstration of transfers between Monrovia and Foothill Transit took place in February 2000, using evaluation team students for the test transfers.

The test demonstration was a limited success; most of the trips were accomplished. (See Chapter Three) However, the demonstration showed that the

automated process was more complicated and time consuming than radio communications and phone calls. It also showed that the Foothill Transit dispatcher had too many other duties to attend to the SGVSS monitor and check for e-mail messages.

The evaluation team tried to determine whether there was any demand for transfers between Monrovia and other transit systems. No records are kept of transfers, and dispatchers or drivers would not necessarily know whether a passenger was making a transfer. Monrovia contractor staff was aware of informal locations where people transferred, e.g., certain Foothill stops, certain shopping centers, and claimed that people manage transfers themselves. It was also noted that as a matter of policy, transferring passengers could not be given priority over other passengers just to get to a bus stop on time. Staff estimated that transfers are very rare; perhaps only a few each month. In order to get at least an approximate idea of transfer demand, the evaluation team developed a short form and requested that Monrovia dispatchers specifically ask each passenger if they were transferring to or from another service. While the operations manager willingly obliged, the dispatchers did not consistently use the forms and the resulting data were unusable.

4.3.1   FOT Completion Problems

By the Fall of 1999 communications between the system integrator and the software consultant had broken down, and morale among all the subcontractors and the project manager was at low ebb. Deliverables were still under discussion, with reporting a major outstanding issue. Monrovia had never gotten the reporting capability it requested and had been promised at the start of the project. While the automated dispatching system could be manipulated and radios could easily replace MDTs, there was no substitute for the lack of reporting information. Monrovia drivers were still using paper logs, and on-time performance data could only be obtained by shutting down the system and reverting to manual dispatching. While drivers could mark an origin or destination in the county area, there was no way to identify trips a County resident might take within the borders of the City. Consequently, there was no way to monitor county trips, save by the paper logs and only in a limited way.

Despite the lack of reporting capability, the Monrovia contractor was the only participant that in the end elected to retain SGVSS system. Because the system required a communications server that was located at Foothill Transit, Foothill agreed to house the server on behalf of Monrovia.

As noted in Chapter Two, the Monrovia service contract was ending on June 30, 2000. The City had issued a one-year renewal in 1998 in order to extend the contract through the FOT. In early 2000 the City placed the contract up for competitive bid, per County Transportation Authority regulations. The Monrovia service contractor was one of three to bid on the service, and it did not win the bid. Thus all of the SGVSS FOT equipment ceased to be in use as of June 30.

4.4   IMPACTS

This final section of the case study discusses overall impacts of the FOT on the Monrovia service. The first section discusses service productivity, and the second section discusses overall impacts on the organization.

4.4.1   Productivity

The original evaluation plan called for an analysis of productivity. Did the automated system increase service efficiency, or did it decrease efficiency, either because manual dispatching of a small operation is actually more efficient, or because the SGVSS system somehow affected efficiency? The evaluation team set up a before/after comparison using the data available from the driver logs. We had anticipated having access to automated files generated by the SGVSS system; when these did not materialize, we used the only other available source of data. This limited the extent of our analysis, as all of the data had to be manually entered into spreadsheet data files. We also scheduled the data collection to coincide with a period of steady state operation. We selected the last six months of 1999 as the most likely period of steady state operation. Our before comparison is the last six months of 1997, steady state operation of the manual system, but a year of rather low productivity and high costs See Figure 4.1 and Table 4.1. Of course the last six months of 1999 really were not "steady state" since technical and functional problems continued throughout the period. Therefore our comparisons do not necessarily reflect what might have happened had the system operated as intended.

Table 4.3 gives monthly averages for passengers and for several measures of supply: total vehicle hours, revenue vehicle hours, total vehicle miles, and revenue vehicle miles. It is easily seen that every measure of supply increased, while passengers decreased. This translates to lower productivity, as measured in passengers per mile or passengers per hour. Figure 4.5 gives monthly averages of

Table 4.3   Before / After FOT Monthly Averages

	Passengers	Total Vehicle Hrs.	Revenue Vehicle Hrs.	Total Vehicle Miles	Revenue Vehicle Miles
1997	1,503	1,299	17,408	15,936	7,622
1999	1,629	1,429	18,167	16,941	7,000
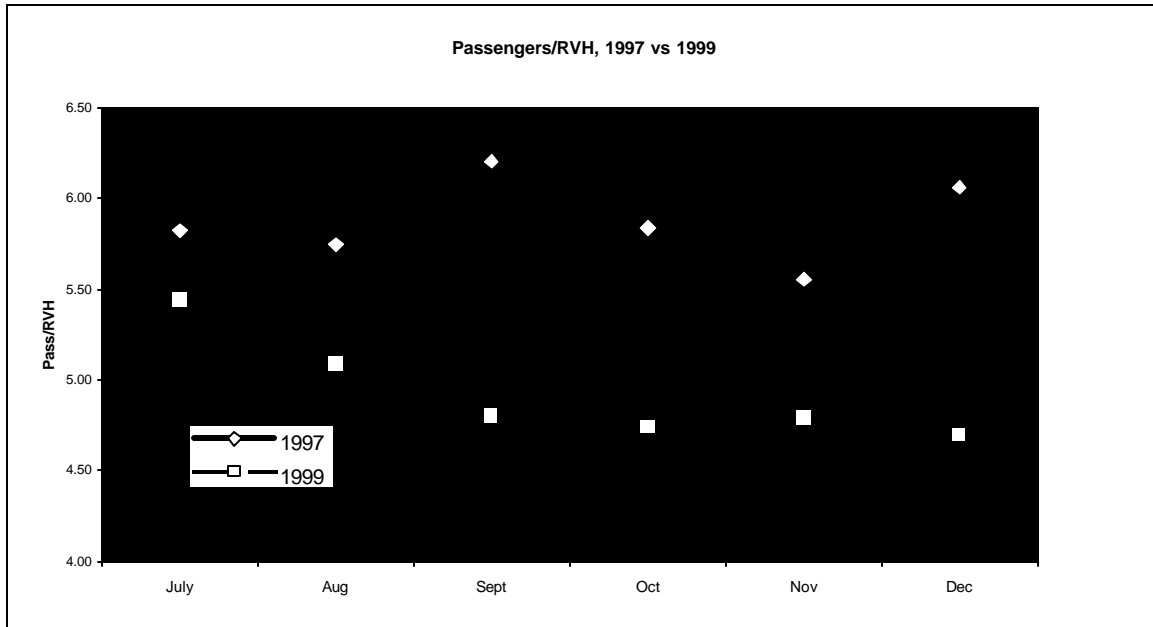
Figure 4.5   Before and After FOT Productivity Comparison.

passengers per revenue vehicle hour; 1999 is lower for every month, and there is a distinct downward trend through the six month period.

We also conducted some simple tests to determine whether these differences are statistically significant. We compared the average of all days in 1997 versus all days in 1999, and we made the same comparisons using weekdays only. For the total day averages, passengers per hour is 6.14 in 1997 and 5.01 in 1999. For the weekday averages, passengers per hour is 5.77 in 1997 and 4.91 in 1999. These differences are statistically significant. Both are significant at a significance level of $p < .01$ in a difference of means tests.

We conclude that the SGVSS system had no positive effects on the productivity of Monrovia Transit service, and likely had a negative effect. Whether these differences were due to the system's technical problems, the inherent inferiority of an automated

system to good manual dispatchers in small systems, the incompatibility of the automated system with the nature of the Monrovia operation, the interference of the FOT in the day-to-day operations of the contract provider, or management and operational problems within the contractor's operation cannot be determined. In our exit interviews, the Monrovia contractor stated that the automated system "is a very inefficient dispatcher," and noted that performance had declined and passengers had been lost. In contrast, the City of Monrovia contract manager thought the system made dispatching more efficient. However, her view was not based on any review of data.

4.4.2 Overall Impacts and Assessment

What can be learned from Monrovia and its contractor's experience in the SGVSS FOT?

1) The City and the contractor were motivated to participate for political reasons. Once it was clear that the Mayor was enthusiastic about the project, they looked for ways to gain benefits from participating.

2) Obtaining more data more efficiently was the expected major benefit of participation for both the City and the contractor. The manual system implied a large effort to obtain basic performance data required by the contract. Any system that would reduce the costs of obtaining such data was viewed as a plus. The issue of County trips was an additional motivating factor.

3) The concept of moving to a state-of-the-art dispatching system was attractive to the contractor. However, contractor staff was completely uninformed on the nature of automated systems, the demand they might place on staff, and the adjustments to operations that might be required.

4) The Monrovia service appears to have been loosely monitored by the City and loosely managed by the contractor. This state of affairs was acceptable given the low visibility of the service prior to the FOT, and given the stability and relative efficiency of the operation. The FOT required much closer supervision, and this was not forthcoming.

5) The automated dispatching software was not compatible with the nature of the Monrovia operation. Most trip requests were on-demand, but the system was designed for a reservation system. Driver assignments were customized to take into account driver preferences regarding where and when breaks were taken, and to allow drivers discretion in pick-up and drop-off sequencing. The system

was designed to assign rides in a specific sequence, and to program breaks in advance. Monrovia passengers were accustomed to flagging down the vans for rides, changing destinations on-board, and getting special treatment if a deadline was critical. None of this flexibility was possible with the automated system.

6) The extensive period of installation problems and troubleshooting likely reduced productivity by interrupting service operations, taking vehicles out of service, slowing down service, and distracting dispatchers and operators. These problems may also have contributed to morale problems.

7) The Monrovia operations manager was a visible spokesperson for the operation. Once he left, there was no advocate to pressure for delivery of the necessary reporting capability.

8) The failure to provide the necessary reporting capability to the Monrovia contractor severely affected the contractor's ability to monitor and manage the operation, and made it impossible to deliver on contractual obligations.

In retrospect, it is easy to conclude that the SGVSS automated system was far too sophisticated and complex to serve the needs of Monrovia Transit. Monrovia, like the other participant operators, had no real desire or need to be integrated with other services; the City and the contractor wanted to use the system to solve their own internal problems. The SGVSS system, however, was designed for integration. Integration required a high level of technology, hence the resulting mismatch between user needs and the designed system.

CHAPTER FIVE

INSTITUTIONAL AND ORGANIZATIONAL ANALYSIS

5.1 APPROACH

This institutional and organizational analysis deals with the non-technical elements of the project. From the outset it was clear that this FOT, involving a great many institutional partners, would require close monitoring and evaluation of institutional issues. Previous experience with the evaluation of technologically challenging multi-agency projects had convinced the study team that effective cooperation of institutional players in such projects could be vital in explaining success or failure of the final outcome.

The object of the institutional analysis was to monitor the actions of the multiple partners, to poll their views and responses at appropriate times, and to gain as deep an understanding as possible of the contributions of the project partners to the project outcomes. We also wanted to understand the various lessons learned by the participants and gain insights for future transit technology deployments.

For a period of over three years the study team attended the regular project meetings that were run by the SCAG project administrator, supported by the project manager and usually attended by a Caltrans Project Monitor. Participant City staff and transit operators were invited to these meetings. The system integrator often made extremely detailed presentations to this group. The evaluation team members attended each of these meetings, documented the planning and implementation process, and monitored the dynamics of the group interactions. Records were kept of attendees, agendas, meeting minutes, hand-outs, and consultant presentations. See Appendix 3.

In addition the evaluation team interviewed all of the major participants individually. Table 5-1 lists the dates and primary subjects of these interviews. Every attempt was made to give the various parties, including the vendors, opportunities to voice their opinions about the project. The critical players were interviewed before, during and at the end of the FOT. Additional sources of institutional information consisted of attendance at training sessions, site observation periods, and informal discussions with the many staff involved in this extensive project.

Table 5.1   List of Interviews

Organization	Interviewee	Nature of Contact	Date
Interviews Before the Project			
City of Duarte	Transit Manager	On-site Interview and bus ride	11/21/97
Monrovia Service Contractor	Service Manager	On-site Interview	11/21/97
Arcadia Service Contractor	Service Manager, 2 assistants	On-site Interview	12/3/97
City of Arcadia	Interim Transit Manager	On-site Interview	12/16/97
City of Monrovia	Transit Manager	Telephone Interview	12/16/97
Interviews During the Project			
System Integrator	Consultant Team Leader	On-site Interview	2/24/98
City of Monrovia	Transit Manager, Asst. Mgr.	On-site Interview	3/19/98
SCAG	Project Administrator	On-site Interview	3/27/98
Foothill Transit	Operations Manager	On-site Interview	3/31/98
Consultant	SGVSS Project Manager	Telephone Interview	4/17/98
Software company	Software company consultants	Software Demo	4/28/98
Monrovia Service Contractor	Service Manager	Telephone Interview	5/4/98
Foothill Transit	Operations Manager	Telephone Interview	5/6/98
Monrovia Service Contractor	Service Manager	On-site Interview	7/8/98
City of Duarte	Transit Manager	On-site Interview	7/15/98
Foothill Transit	Operations Manager	On-site Interview	7/22/98
City of Duarte	Transit Manager	On-site Interview	8/5/98
City of Arcadia	Transit Manager (new)	On-site Interview	12/21/98
Transit Service Contractor	Manager (not part of SGVSS)	Telephone Interview	4/30/99
System Integrator	Consultant Team Leader	On-site Interview	5/10/99
Consultant	SGVSS Project Manager	On-site Interview	5/19/99
Caltrans	Project Monitor	On-site Interview	5/26/99
Monrovia Service Contractor	Service Manager	On-site Interview	5/27/99
Software company	Software trainer	On-site Interview	5/27/99
System Integrator	Consultant Team Member	Telephone Interview	6/2/99
Caltrans	Director of New Technology and Research	On-site Interview	6/8/99
Software company	Implementation Manager	Interview	6/9/99

Table 5.1   Continued

Organization	Interviewee	Nature of Contact	Date
Interviews During the Project			
SCAG	Project Administrator	On-site Interview (SCEP)	6/22/99
SCAG	Project Administrator	Telephone Interview	8/13/99
System Integrator	Consultant Team Member	On-site Interview	8/30/99
Monrovia Service Contractor	Service Manager (new)	On-site Interview	10/14/99
SCAG	Project Administrator	Telephone Interview	10/20/99
Monrovia Service Contractor	Service Manager	On-site Interview	11/11/99
Foothill Transit	Operations Manager (new), Scheduling Manager	On-site Interview	12/15/99
SCAG	Project Administrator	Telephone Interview	1/24/00
Caltrans	Project Monitor (new)	Interview (USC)	2/17/00
Interviews After the Project			
System Integrator	Consultant Team Leader, Team Member	On-site Interview	4/17/00
City of Monrovia	Transit Manager, Asst. Mgr.	On-site Interview	4/20/00
Monrovia Service Contractor	Owner Contractor	On-site Interview	4/20/00
Foothill Transit	Operations Manager, Scheduling Manager	On-site Interview	4/21/00
City of Arcadia	Transit Manager	On-site Interview	4/24/00
City of Duarte	Transit Manager	On-site Interview	4/26/00
SCAG	Project Administrator	On-site Interview	4/28/00
Arcadia Service Contractor (new)	Manager, Asst. Manager	On-site Interview	5/31/00
Caltrans	Project Monitor	On-site Interview (USC)	7/18/00
System Integrator	Independent Subcontractor	Telephone Interview	12/12/00

The evaluation team strove to assume a neutral and objective posture at all times. Team members did not, in general, volunteer information or advice in an effort to avoid biasing decisions or outcomes. Some potentially key observation opportunities, such as when system elements were installed, or when the Monrovia service contractor went-live with the automated dispatching system, were avoided to preclude disruptions or distractions that might be generated by the presence of evaluators.

5.2   PROJECT ORGANIZATION AND MANAGEMENT

Chapters Two and Three present a detailed history of the FOT. With that as background, this section presents our observations on the function, roles and objectives of the project participants.

5.2.1   Project Goals and Staff Roles

SCAG became the project administrator on behalf of Caltrans. The structure of the new FOT placed SCAG – a regional planning agency – in the position of administering what was effectively a service operations contract. On occasion the project administrator referred to the project as "turn key." This should have implied that for a fixed price the system integrator would deliver a fully tested working product. However the administration of the project proved to be a frustrating and demanding task. A project monitor from the New Technology and Research Program represented Caltrans. This role minimized project involvement and was concentrated on offering background and budgetary support. The project manager, an independent consultant, was retained from the ATHENA FOT. The role of this individual was poorly defined, and the project manager lacked authority to assume a leadership role.

The system integrator had a fixed price contract and acted as the master contractor. They had responsibility for all technical aspects of the deployment, including hardware and software procurement, installation, and system operation and maintenance. Contractual relationships were numerous, as discussed in Chapter Two. The system integrator included two subcontracts, one with an independent consultant who had authored the original system technical specifications for the defense firm involved in the ATHENA project, and another with a transit software concept design specialist. Purchase and licensing arrangements were established for the project software and for Mobile Data Terminals. Service agreements were established with a wireless communications service provider and a communications equipment installer. Other equipment and services were purchased directly from vendors.

The Request for Proposals issued for the system integrator identified three goals for the restructured FOT. These were

1) "To develop, integrate, and test the integration of emerging technologies"....;
2) "To identify and mitigate any institutional barriers that might interfere with the implementation of the new services"..."Once the system is installed, the agencies

will be able to cooperate in ways not now possible, such as coordinating transfers and providing back-up services to one another." ...; and

3) "To test the public acceptance of the new services provided" (Southern California Associations of Governments, 1997, pp 1-2).

The RFP included a project description that identified required technical capabilities (automatic vehicle location, mobile communications, computer-assisted dispatching) and provided a list of service capabilities that participating agencies might choose to implement. These included route deviation, inter-agency passenger transfers, and computer-based passenger trip requests.

SCAG 's Vision statement for the project was delivered to and discussed with the evaluation team in March of 1998 (SCAG Memorandum, March 1988). This was not an item of discussion with the other project participants. The goals were

1) "To apply and test vehicle location, tracking, dispatching, and communications technologies on fixed-route, variable route, and demand responsive transit systems to test the operational possibility of 'seamless' transit (allowing and facilitating transfers)." …;

2) "…. to assess whether improved operational efficiencies might be achieved from both an operator and a user perspective"…;

3) "To take"…"operators with varied states of existing technology and install, overlay and integrate new technologies with those [of the] existing system and achieve a functional integration"…; and

4) "To create a legacy APTS system that can serve as a model and test bed for other potential APTS deployments in the I-5 ITS Priority Corridor"…."and as a possible future 'real-time' transit Advanced Traveler Information link."

This final regional goal is also related to the use of so-called legacy systems. As can be seen from these statements, the project focus was testing technology, not addressing either transit user needs or operator requirements.

5.2.2   Agency Participants and Objectives

Each participant was interviewed at the outset of the project. They were asked what benefits they expected from the FOT and why they chose to participate in the FOT. It should be noted that there were no formal written agreements between the parties that would have defined objectives, roles, and responsibilities.

Local municipal public transit is quite common in Los Angeles County, because cities receive a portion of a local county sales tax for support of public transit. These services are designed specifically to serve city residents; they do not serve trips outside the city limits, except by special agreement or special request from city residents. Arcadia and Monrovia share a common border, but service in each case is restricted to the city limits (and a portion of unincorporated area for Monrovia). Passengers traveling between the two cities on city-run services must transfer at the border. Informal transfer points are designated for this purpose, and transfers are on occasion coordinated via telephone between the dispatchers. Duarte and Monrovia share a common border, and the Duarte stops serve as informal transfer points between the two city services.

Given common borders and overlapping services, the three-city area may seem like an obvious candidate for service integration, save for the clear community orientation these services reflect. However, the operators involved revealed little interest in service integration. When the issue of transfers between services was brought up, participants responded that transfers have never been an issue with passengers, and that the few transfers that do occur are managed either via dispatchers or by the passengers themselves. Given that the three local operations were city funded services, any more elaborate type of integration, e.g., providing back-up services to one another, was beyond consideration. They were looking for solutions to problems specific to their own operation.

5.2.2.1 Southern California Association of Governments and the Southern California Economic Partnership

The evolution of the FOT from real-time ridesharing in Ontario to integrated transit in the San Gabriel Valley was due to the efforts of SCAG to keep the FOT in the region. As noted in Chapter Two, the actual goals and objectives of the FOT were ill-defined from the start. The evaluation team asked many times about the transit service objectives that were to be demonstrated, but neither SCAG nor others described anything beyond service options that would be possible with the technology system, nor did they consider specific functional goals and objectives critical to the FOT. In response to the evaluation team's request, a set of objectives was presented in a March 1998 memo. It was apparent to the evaluation team that the project focus was testing technology, rather than addressing either transit user needs or operator requirements.

SCAG's stated goals were more about promoting advanced technology in public

transit more generally. As MPO for the Los Angeles region, SCAG is required to produce a series of federally mandated planning documents. These include waste management plans, regional housing needs assessments, demographic projections and regional transportation plans (RTPs). The RTP has a minimum 20-year planning horizon and is updated every three years. The agency also produces a Regional Transportation Improvement Program every two years. The RTP is a performance-based plan aimed at providing long-range transportation goals, objectives, policies and strategies to improve transportation within the region, and must be coordinated with the South Coast Air Quality Management District's (SCAQMD) Air Quality Management Plan (AQMP).

Smart shuttles are part of wider planning strategy focusing on Intelligent Transportation Systems (ITS). The 2001 RTP goals include transportation investments that are cost-effective; and the plan seeks to promote transportation strategies that are innovative and market-based, and which encourage new technologies. Along with freight improvements, advanced transportation technology, airport ground access and traveler info services, smart shuttles are specifically mentioned as a means of implementing transit restructuring, and the project administrator was a strong proponent of advanced technology for transportation system management.

In February 1999, SCAG transferred its ITS planning projects and the FOT's administrator from its own planning group to the Southern California Economic Partnership (SCEP). SCEP was established by SCAG and the SCAQMD in 1994 to foster public/private efforts leading to the deployment of advanced transportation technologies. SCEP is an independent, non-profit corporation and coordinates, among other things, SCAG's Clean Cities and Alternative Fuel Vehicle Programs.

One of the primary efforts undertaken by SCAG and SCEP is the Southern California Priority Corridor (SCPC). The Corridor is an attempt to integrate ITS research, planning and deployment activities in an area stretching from Ventura County to the US/Mexico border. It proposes a hierarchy of participation, beginning with independent ITS operations, moving to cross-jurisdictional coordination and ending with central traffic management systems. The Southern California Corridor was one of four specifically identified in the Intermodal Surface Transportation Efficiency Act (ISTEA). As a result, SCAG shares oversight of the Corridor's activities with the federal government (FHWA), the State (Caltrans), and other regional agencies.

For SCAG and SCEP, the San Gabriel Valley Smart Shuttle FOT was an opportunity to test the concept of cross-jurisdictional coordination, using both transit and

paratransit. Also, as noted previously, from Caltrans' perspective, the FOT was conditional on achieving some level of "system integration;" technical integration was not sufficient. SCAG was committed to integration to comply with the Caltrans' conditions, and therefore when route deviation proved infeasible, the agency eventually settled on inter-agency transfers as the one concrete demonstration of integration, despite the lack of interest among the operators. The demonstration of the complexity of systems integration was considered to be important. It was acknowledged that the project represented a substantial challenge in terms of getting the legacy systems already in place to communicate with one another and with new elements of the installation.

5.2.2.2 City of Arcadia

The Monrovia and Arcadia service contractors were competitors. Arcadia's contractor was therefore reluctant to reveal too many specifics about the company's system, particularly since it was already automated.

Arcadia had little expectation of benefits, as its contractor was already automated. However, the possibility of gaining access to more information for monitoring purposes was initially identified as a potentially attractive outcome. The City did not identify service integration as a potential benefit of taking part in the FOT. In fact, Arcadia's city-funded service effectively precludes any more extensive integration. Since ridership on the system was in decline, the City was concerned about the performance of the original contractor.

The City of Arcadia had an interim transit manager at the start of the FOT who was an experienced paratransit consultant employed to oversee the DAR service. There was no permanent staff in place. The same transit service contractor had run the service for twenty years, and it had never been competitively re-bid. The City was reported to be happy with the service and had no great expectations for improvements resulting from the FOT. The interim transit manager held very different views. He suggested that the software system used by the Arcadia service contractor was inappropriate for transit use, that neither the MDTs nor AVL were being used correctly, that there was little valuable data capture occurring. The existing contractor was collecting little data, and had no interest in using the software reporting features. The City's consultant was most concerned with improving productivity and reporting for the service as a whole. He did not expect SGVSS to achieve much in these regards.

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The interim transit manager commented on the dearth of information available about SGVSS from SCAG. He suggested that informing the cities about all that was currently known about Smart Shuttles would be a good place to start. SCAG had sponsored an earlier Smart Shuttle study. He further stated that there was no data available about the demand for transfers. The relationships with the other transit operators were virtually non-existent and there was no active coordination. The project had not been presented as involving formal cooperation with the other cities. He was not optimistic about using technology to tie the existing system to transit services operated by neighboring cities. The consultant was a passive participant in the FOT throughout 1997 and early into 1998.

The evaluation team returned to Arcadia after the interim manager had been replaced. The new permanent manager also had a transit background. He reported that in March 1998 he had sought information about why Arcadia was not receiving the same software and hardware as the other operators in the demonstration. At the same time he informed the Project Administrator (SCAG) that the service was to be bid out, and he was hoping to find a contractor with a compatible automated dispatch system. The expectation was to have a new contractor in place by July 1999. The transit manager was anxious that Arcadia -- as the largest general public dial-a-ride in the Greater Los Angeles area -- be fully included in the project. He also commented that the project had thus far failed to address the issue of transfers, an issue that had been stressed by the Caltrans project monitor.

After Arcadia brought on the new contractor in the summer of 1999, the original contractor's proprietary system was no longer a consideration. However, the uncertainty of the bid process and the time lost in the transfer of the contract proved unsettling to the FOT project managers. They could ill afford additional delays. Money was also a concern. While the proposed interface with Arcadia would cost $25,000, the system integrator reported that making the City a full participant in the demonstration – outfitting the City's new contractor with software, and data terminals for vans and the dispatch office- would require more than $280,000. A second option was also rejected. This alternative would have allowed for partial integration without MDT/AVL components, using instead the addresses of pick-up and drop-off locations to update vehicle locations. This option did not preclude adding MDT/AVL at a later date, but at a cost of over $160,000 still proved too expensive.   Arcadia, seeing no benefits from the FOT, formally ended its participation in November 1999.

5.2.2.3 City of Monrovia

Chapter Four described in detail the motivations and objectives of the City of Monrovia and the Monrovia service contractor. To summarize, the City was motivated by the Mayor's desire to participate. The main objective for the City was the documentation of County trips. The City hoped that accurate ridership data would allow it to identify trips made by residents of the unincorporated portion of Los Angeles County. Obtaining reimbursement from the County for trips within the unincorporated area was a problem; and a computerized system was to allow the City to identify and track these trips. Doing so would also allow Monrovia to pursue more accurate reimbursements.

Performance monitoring was a secondary objective. Monrovia viewed the FOT as an opportunity to upgrade its operation to state of the art computerized dispatching at no cost to either the City or the service contract operator. The Monrovia service contractor saw the potential benefits of upgrading its system, simplifying the collection of ridership data, and the possibility of expanding its DAR business by acquiring the additional dispatching, operations, audit and planning capacity a computerized system would provide.

The City transit managers requested that the project administrator give them a list of the possible data options and specifications, and they in turn would indicate what they felt was relevant to their needs. They were never given such a list. They had some expectation that the project might result in better dispatching and some productivity increases. They noted that there is not much happening with regard to potential cooperation and connectivity between services. Passengers complain that they have to be dropped off to wait for another service when they are already close to their destination. This is a function of the individual funding of local city services. There is no pooling of resources across city boundaries to create larger integrated service areas.

The contract service manager was computer literate, but was concerned about the ability of his drivers to learn to use the equipment. Most had never had formal computer training. He asked whether the issue of driver training for the project had yet been discussed. Overall, he was optimistic that the operation would benefit from the FOT. Commenting on the on-time performance manual ticket analysis he had to conduct, he stated, "If the demo does nothing else it ought to be able to improve on this system." He also anticipated increased efficiency in the use of the vehicles.

5.2.2.4 Duarte Transit

The transit supervisor's background was in school bus management, and he is a licensed State Driving Instructor. This enables him to personally give the drivers their statutory eight hours of annual update training. The City's two fixed routes operate in alternate directions. When the FOT began, the full circuit took one hour and fifteen minutes, making the schedule difficult to remember. The service is free and is a valued community resource. The ability to hail and stop at unmarked locations is built into the system. The adopted goals for service improvements were to reduce the route time to one hour, to improve commuter service, and to tie into Foothill and MTA service at an existing stop at Huntington and Highland with a timed transfer.

At a preparatory workshop, the transit supervisor expressed the desire to use the FOT to reduce operating time to achieve a one-hour run time on each route. This might be accomplished by selectively skipping low demand stops. The transit supervisor was asked about route deviation as a way to achieve the one-hour schedule. He made it clear that there were no plans for route deviation. However, it would be useful if westbound drivers could be informed if there were pickups at the senior center, one of the low demand stops. If not, the driver could avoid the diversion and reduce run time. The solution however could not involve a dispatcher, because the Duarte system has no dispatcher. A short commuter run to the transfer point at Huntington and Highland was also mentioned as a possibility by the transit supervisor.

The system integrator asked about automatic vehicle location and its importance. With no real-time dispatching it did not appear important. Sharing vehicles with other operators in the event of breakdowns was also not seen as important as Duarte operates with 100 percent spare capacity. Automated passenger counting and other operating data would not provide anything new since scheduled and actual miles are almost identical in the Duarte operation. Monitoring speed was also considered unnecessary. Panic alarms were thought to be a nice feature. The system integrator did not ask about the issue of transfers. The transit supervisor asked about expandability of the tracking system and possible application to the city emergency service fleet.

The evaluation team traveled on Duarte Transit. We found a well-used service, running on time with polite professional drivers who stopped to wait for latecomers. Buses were equipped with radios, but they appeared to be reserved for emergency use.

The major trip attractions were a supermarket, shopping center, dairy, and hospital. Passengers are counted with a tally device, and total riders are noted at the end of each run when the counters are re-set. Because the service is free, no transfers are issued, hence there was no data source to check the demand for transfers to Monrovia, MTA or Foothill. The supervisor showed little interest in the topic of transfers, with the exception of timed transfers.

The City's main interest appeared to be in tying together the buses with its other city vehicles on a wireless communications system. The City was also interested in vehicle tracking technologies for eventual application to the city emergency service fleet. The City showed little interest in transfers to Monrovia Transit.

There is some indication that the City Duarte had an interest in modifications to transit service that were initially envisioned as part of the FOT. In July, 1997 a report was released entitled "Duarte: Vision for the 21st Century," (City of Duarte, 1997). This project was a joint effort of the City Council, the School Board, and the Chamber of Commerce. It includes the recommendations of five issue-specific task forces that were turned over to the three agencies for adoption. One task force dealt with Telecommunications, Transportation, and Municipal Services. The report's recommendations included that statement that:

The City should continue to test, and if appropriate, deploy so-called "smart shuttle" technology as a means of improving the scheduling and routing of its bus and other transit services. It should also investigate the possibility of using technology to develop a local service similar to "commuter computer."

In the end however, the FOT offered little to Duarte. As "dates on which the fully deployed system was to be in operation" regularly slipped, the City implemented its own route changes at the beginning of 1999 to reduce headways and improve service. Duarte decided to limit the number of buses serving the senior center where delays often occurred, independent of the MDT deployment. The City also introduced a limited commuter route in the early mornings, serving northern Duarte, an area not reached by the buses during normal runs. In March 2000, SCAG announced officially that Duarte had decided to not continue its involvement in the FOT due to cost considerations. The reality is that the City made that decision much earlier in the test.

5.2.2.5 Foothill Transit

The interviewee was the Operations Manager. He was asked about the significance of the project for the agency and what they hoped to learn from it.

Foothill wanted to experiment with pro-active responses to dealing with schedule adherence problems, particularly on one route that is very long and subject to congestion delays. Foothill saw the FOT as a means of testing real-time information applications. Drivers are supposed to call in when they are running five minutes late, but don't always do so. They were thinking of developing a list of strategies for dealing with the problems as they are identified. These could involve such things as sending supervisors out into the field, operating a closed-door strategy for catch up purposes, or even adding buses. Foothill used scheduling software but did not have access to a vehicle locator system. The data could also be useful for making schedule adjustments. Such a system might allow dispatchers to make schedule adjustments when vehicles are running late. Further into the future they were interested in the linking real-time vehicle location to passenger information at bus stops. They wanted to learn about the capability of AVL and what Foothill might be able to do with it.

It is likely that Foothill and SCAG included Route 184 in the test because it traverses the three participating cities. However, schedule adherence was not a concern with this route. The monthly schedule adherence tests conducted between July of 1998 and February of 1999 indicated that Route 184 was on time most of the time, scoring 94% or above in most months and in both directions. The score was often 100%. See Appendix 2. The greater concern with this route was under loaded buses, particularly in Arcadia, along with low utilization during peak periods in Monrovia and Duarte.

Route 721 was a peak period Metrolink shuttle service that was attracting few passengers. Route deviation might increase ridership. Deviation would be limited by the need to supply on-time service to meet the trains, and by the streets the buses could navigate. It would be critical to market the service through employers if the idea of route deviation was to mean much in practice. At this stage the idea was in its infancy. There had been no discussions of how deviation might work e.g. automated dispatching, or anything else associated with the service.

The Foothill spokesman declared general interest in the project and wanted to be helpful to the evaluation. At the preparatory workshop for Foothill, a number of issues were raised. It was agreed that there was interest in AVL technology and how well it

works. They would expect to get improved schedule adherence data and pro-active dispatch with the ability to make on-line (real-time) adjustments in the system. A question was raised as to whether it might be possible to link the data to a signal priority system. This was considered outside the scope of the project. The system integrator asked how often it would be necessary to poll the vehicles. Twice a minute was the first response, but this was followed by a discussion of the relationship of cost to polling frequency. It was clear that such questions had not been considered in detail by any party.

There was also concern that increased communication between the driver and dispatcher, whether by radio or MDT, was an unnecessary distraction for drivers already charged with operating fareboxes and radios. A Foothill representative at the meeting asked if they could use the same keypad as the farebox MDT. They already have two in use. A third could not be added. Route deviation was discussed in passing but was agreed to be dependent on route surveys. The topic of vehicle exchanges was dismissed as being unworkable given Foothill's full size buses. Transfers did not receive a warm response from the Foothill representatives, and a comment was made to the effect that the dial-a-ride services compete with the fixed route services. There were no data on the number of transfers being made to and from the Dial-A-Ride services, but all of the participants presumed the volume to be small. The major conclusion was that schedule adherence information was of primary importance.

Foothill Transit maintained active involvement throughout the FOT, but the ultimate focus of the FOT, inter-agency transfers, was never a priority for Foothill Transit. As for riders, the results of a 1997 Foothill Transit Attitude and Awareness Survey suggested that riders wanted the agency to improve its efforts in three areas: running buses at convenient times of day, running buses on-time, and keeping bus stops well-lit at night.

5.2.3   Summary of Agency Objectives

This review of participant expectations is a snap shot from the first few months of the project. It is clear that the various parties all had very different views and expectations of what was important.

1) *SCAG* had extremely broad policy and technology oriented goals. These included testing the concept of "seamless transit" through facilitating transfers. Productivity increases from the use of AVL were expected.

2) *Arcadia* under the original staff expected little from the project. Subsequent staff wished to join the project, but to what end was not clear.

3) *Monrovia* had explicit reporting needs to be fulfilled through the automated systems. The operator expected increased vehicle efficiency through the use of AVL and improved reporting.

4) *Duarte* expected little from the project, and was pursuing service improvements that did not involve technology.

5) *Foothill Transit* wanted an evaluation of the benefits of real-time schedule adherence. The possibility of route deviation was to be reviewed.

There was, in short, no unity of purpose declared among the SGVSS project partners. The operators identified possible applications that would aid their own services, but saw no utility in any type of functional service integration. There was no data available on the significance of transfers, and it was not a topic embraced by the operators. It was just a policy statement by a policy agency. Such topics as vehicle sharing had been dismissed as irrelevant to the operating environment, and the practicality of incorporating route deviation had yet to be investigated. Cities such as Duarte and Arcadia appeared involved merely to show political good will towards SCAG.

5.2.4 The Role of System Integrator and the Subcontractors

The system integrator's role was affected by

1) strict time and budget constraints,

2) contractual arrangements that placed all the risk for project delivery on the system integrator, and

3) project complexity.

The project as defined, relied on off-the-shelf hardware and software, had an unrealistic time schedule (established out of budgetary necessity), and had adopted a fixed price budget format that kept the budget for consulting services to an absolute minimum.

The consensus among the project managers and the system integrator was that problems with the software company were the primary constraint on final FOT outcomes. Of course, the software company disagreed, arguing that many apparent software problems were in fact hardware or communications problems. The software firm attributes FOT outcomes to the lack of commitment by the operators, which was compounded by the tight timeline and technical problems. The question of reporting came down to a disagreement about what was promised in the contract. Regrettably,

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the service contractors and Monrovia passengers suffered the consequences of the these problems, whatever their source.

The complexity of the project requirements were greatly underestimated by the sponsoring agency, and were not challenged by the systems integrator. Integrating fixed route and general public dial-a-ride operations at so many levels, as well as delivering such specialized procurements as an integrated scheduling and on-time performance module, required new and highly customized software products. The lack of market response, i.e., in the form of software bidders, to the project as specified and budgeted should have raised a large red flag for all concerned. It would appear that the software vendor either did not read the project specifications closely, or assumed something "close enough" would be acceptable. Similarly, the systems integrator either failed to appreciate that they were being sold an inappropriate product, or assumed that with detailed project specifications and close attention they could obtain the software the project required.

As noted in Chapter Four, the automated dispatching software was inappropriate for the nature of the Monrovia service, and the lack of report capability turned out to be serious problem. Investigations by the evaluation team during the project revealed that the complexity and difficulty of manipulating the software data for reporting purposes was well known among software users. The April 1998 demonstration of the reporting features of the product by the vendor was cursory, but implied that all reporting needs could be met. When this later proved not to be the case, the responsibility to provide the necessary specialized reporting features reverted to the system integrator. The system integrator and the software vendor disagreed on what the contract required. There was no contractual means of binding the software vendor to the delivery of this product to the full extent required by the City of Monrovia reporting requirements.

The product delivery problems reflect more than purely technical issues. They reflect more fundamental organizational problems. First, the software vendor was in the midst of a period of explosive growth. Between 40 and 50 installations were taking place simultaneously, and the vendor was having problems recruiting sufficient numbers of installation managers. The job calls for an unusual combination of skills, including computer expertise and transit management expertise, and requires intensive travel. The software product itself is very complicated. The SGVSS project was just one of many, and thus did not receive consistent priority from the vendor.

Second, the software vendor was not comfortable with working with a third party master contractor. They believed that working directly with a client provides them with a much clearer understanding of requirements, and an opportunity to influence requirements in a reasonable way. They cited as an example a project specification that was for "free text messages." This is something they provide so they had not foreseen a problem. It only later transpired that the free text messaging in question had to be two-way. This had never done before and required new programming.

All such communication problems cost additional time and resources. Communication difficulties went extremely deep. Both sides claimed that they were misunderstood. The software vendor claimed the system integrator did not understand what was required to meet their specifications, and suggested that in some cases the specs were a wish list rather than a realistic expectation of what could be accomplished. The systems integrator believed that the bidder had never read the specifications for the project, and had not thought through the requirements. When the reality of what the specifications required became apparent, the software vendor refused to do the work necessary to meet them.

When asked about the customization required for SGVSS, the software vendor noted that all transit installations required an element of customization, and problems in software development are routine rather than exceptional. Although they expected to encounter time consuming problems, they felt that the systems integrator's expectations were unrealistic. Such a complex system could not be delivered without encountering development difficulties. Of course, the system's integrator's expectations reflected the unrealistic project time schedule.

Problems in product delivery also reflect a more fundamental mismatch between the nature of the software product and the requirements of SGVSS. It retrospect it became evident to the evaluators that the software is a rather rigid product, designed to be used in specific ways. The software vendor prefers to work directly with clients in part to explain what the software can and cannot do, and therefore how the software will be used. In contrast, the SGVSS was a project that was to use existing products in new ways, and the software vendor was asked to change the product to serve the project – just the opposite of the vendor's usual approach. Making things more difficult was the software vendor's practice of constantly changing the software. The vendors saw this as a plus – each new client gets a better product. The system integrator saw this as a great disadvantage. Every new software patch introduced the possibility of creating problems

somewhere else in the code, and frequent did. The lack of documentation made it impossible for others to troubleshoot these problems.

Organizational problems and the software mismatch problem were evident in training. Training and training support in particular for Monrovia proved to be a major difficulty for the systems integrator as the various products were installed.   This was due, in part, to the incompatibility between the software and the way the Monrovia system operated. For example, there was no client database to input, because Monrovia never collected such information. Training could not begin without the database, so valuable training (and dispatcher practice) time was spent constructing the database, including geo-coded addresses.   The software trainers had no understanding of the details of the operation, the system integrator and project manager had limited understanding of the details of the software, and Monrovia service contractor employees had no understanding of the complexities of the software. Neither the system integrator nor the project managers had prepared either party for the conversion. All parties suffered from inadequate communications between the systems integrator and the software vendor. The Monrovia service suffered from the consultants' and the project managers' understanding of how the service operated.

The same mix of problems was evident at Foothill Transit. As noted in Chapter Two, it became apparent that the Foothill MDTs would serve no useful purpose. However, technology had priority over any discussions of goals, objectives or operational functionality. The MDTs were installed on Foothill vehicles, but they were placed far out of the driver's reach, clearly indicating that they were never intended to be used. The one function that Foothill really wanted, real-time schedule adherence, was not delivered. Once again communications problems were evident. The software vendor claimed that they did deliver on schedule adherence, and the real problems were in network communications. The system integrator had no way to force delivery of a satisfactory product.

Training and installation difficulties were the subject of discussion with many of the participants interviewed. The view of the software vendor trainer was that committed leadership and buy-in from everyone involved is necessary for successful installation and deployment, and these conditions did not exist in SGVSS. Problems were compounded for the software vendor by the complete absence of information about the Monrovia contractors operation and having to work with computer illiterate staff. One comment was that with hindsight the estimated time required for training should have

been doubled.

Blame for training difficulties was passed around between the several parties. Ultimately it became obvious that the integrated system that had been put together with so much difficulty did not meet participant requirements. The products were not user friendly, and in most cases were not making tasks quicker, easier, or more reliable than manual methods. The lack of easily retrievable data from all of the systems was a major shortcoming that ultimately had serious business impacts for the Monrovia service contractor, as they could not provide reports that were contractually required. The Monrovia contract was put up for bid under stressful circumstances at the end of the project. Unfortunately, the lack of performance data and qualitative indications that the service quality had been slipping weakened the contractor's ability to bid successfully.

Delayed payment of invoices by the administering agency constitute a final set of institutional problems encountered by the systems integrator. The system integrator had to pay the subcontractors to keep the FOT on track, but it took six months or more to get their own invoices paid. The systems integrator was effectively acting as a banker for a public agency, but with no opportunity to charge interest. Thus the systems integrator experienced unbudgeted opportunity costs. If the administrative agency had been responsible for paying the subcontractor invoices and imposed such delays, the subcontractors would simply have terminated service. Another payment problem for the system integrator was that the largest expenditures were for hardware, and these had to be made up front. Thus the delays represented significant costs for the system integrator. A more general financial problem was the insufficient budget for this project. The system integrator and some of the subcontractors claimed that they had lost money. The relationship between the system integrator and the software vendor was particularly strained, as each sought to minimize their losses over months of installation and operation problems.

5.3   PARTICIPANTS' ASSESSMENT OF THE SGVSST PROJECT

In this section we discuss project outcomes from the perspective of each of the participants. Participants were queried at the end of the project and asked to comment on the project, and what they had learned from the experience.

5.3.1　City of Arcadia

Arcadia never became part of the system, but they learned a great deal by bidding out their system to a new contractor. This contractor services multiple operations in the region from a single dispatch center. They use the same paratransit software vendor and products as those used for SGVSS. The new contractor is now delivering good service and complete reporting for the Arcadia dial-a-ride. Success has been achieved by using the software as a base level dispatching system only and by supporting it with a second dispatcher. They have invested in their own data retrieval systems and have a high level of technical and computer expertise available to fine-tune the operation. They have long experience with the vendor and understand the strengths and weaknesses of the products.

Arcadia staff had formed their own views on service integration. A view was expressed that having just one Regional service provider for both fixed route and DAR would make a lot of sense and help with the integration of services. The mistake made in the project was trying to invent so much that was technical. If transfers really were to have been the central theme, a great deal more thought would have been required to examine what this would mean in practice. For example, the Arcadia policy for pickups is first come first served. To give priority to those transferring would have required substantial changes. Scheduled buses could be expected to wait, say, 90 seconds at most. More fundamentally, service and transfer agreements would be needed to substantially increase transfers.

5.3.2　City of Duarte

From the outset, Duarte had doubts that there would be any benefits from the project. They had no need to know where their buses were, and the polling interval of 5 to 6 minutes made AVL even less useful. The dedicated computer and screen were restricted to use on the project, but could have been more useful if they could have been used for multiple functions. As it was, the equipment merely tied up needed space and telephone lines. The one thing they had learned from the experience was that equipping the public service fleet with AVL and paying the communication costs would be too expensive. There was clearly a need for a computer knowledgeable city liaison staff person to assist with communications between the city and the system integrator. The Duarte representative felt overwhelmed by all of the technical information, which had little meaning for him. It should be noted that during the project period the city re-

scheduled the service to one hour by dropping low rider stops and serving their senior center less frequently, and added commuter runs to a transfer point with Foothill and MTA service. They did not employ any advanced technology to solve their route schedule problem.

5.3.3   City of Monrovia

City staff believed that there had been considerable improvement in the operation of their contracted system as a result of moving from manual to automated dispatching. They appeared to have no real evidence for this, but cited the example that using computer generated lists of regular users had allowed them to call people to see if they needed their normal ride when the dispatch center had unexpectedly lost phone service. They were also prepared to be patient, and fully expected to receive the reporting features they had been promised. They were not particularly interested in the failure of the transfer side of the demonstration, and did not consider it an important objective. It should be noted that staff members responsible for the service had many other responsibilities and were only intermittently involved with the project. They had neither transit nor paratransit experience.

The (former) Monrovia service contractor was justifiably angry at the conclusion of the project. They were in desperate need of on-time performance data to use in their new bid for the service, and were unable to extract it from the system database. They had been really looking forward to having daily performance data. In particular they had expected to be able to rely on it to refine their vehicle and driver schedules. They had never been able to revert to dispatching with one person in the off-peak periods, and the drivers were still manually filling in their logs. The service contractor stated, "There should have been some interim plan put in place to insure minimal disruption to the service."   Despite this sorry state of affairs the contractor remained positive about the attractions of the technology, intended to retain the automated system, and referred to the project as a learning experience. However, the exit interview took place before the contractor lost the Monrovia service contract.

5.3.4   Foothill Transit

In response to the question, "Why did Foothill choose not to continue with the project?," staff representatives gave the following reasons.

1) Foothill did not receive a system that would improve operations. The schedule adherence capability was not delivered, and there was no access to system data.

2) The system was partial. It was installed on only 30 vehicles out of a fleet of 259, and so would have had limited utility even if it had worked.

3) Its costs could not be justified. It would have doubled communications costs to $3,000 per month or $100 per bus per month, and there would be additional maintenance costs.

Foothill, perhaps of all the participants, seems to have learned the most from this experience. Their lessons learned were summarized as follows.

1) Tying the technology together became the goal of the project to the exclusion of all else. The system integrator and SCAG were interested in taking the technology pieces and make them work together. What was forgotten was what it would take in terms of dispatchers, field supervisors and drivers. Foothill had no power to influence the project as it was going along, and as a result their goals were sidelined. The operations manager said, "with hindsight, we built the specs backwards instead of first finding out what the needs are and building from that."

2) Introducing new technology into the transit industry takes time and training. Computers are foreign to most transit workers. Training manuals are absolutely essential, preferably before staff even see the equipment. There weren't any manuals for this project. The operations manager realized that neither Foothill nor the systems integrator had paid enough attention to the technology users. If they had, the project participants probably would have gained a lot of knowledge and learned a lot of lessons. They failed to think about the complexity of transit location and schedule information. Foothill realized that, in order for technology to work, the software providers must understand operational needs, rather than providing a fixed product that may not meet these needs.

3) New technology may be useful, but it requires resources. Appropriate space and equipment, proper installation, and more manpower and training would be required.

4) The FOT assisted them in learning about their own operation and what they might do to improve it. For example, Foothill now believes that they should give more attention to transfers within their own system.

5) The FOT assisted them in defining what they wanted in the way of new technology and how they should go about obtaining it. They decided that they would not involve third parties, but rather deal with vendors themselves. They were now well enough informed to be effective procurers of technology.

5.3.5 The Systems Integrator

This participant endured a painful and costly learning experience. With hindsight they had learned the dangers of being overly compliant with schedule constraints. Perhaps even more importantly, the need to be more risk averse with cutting edge development projects was now clear. Allowing the client to place all of the risk for a state of the art project on the contractor had been a mistake. In any future project, SCAG would not only have to share more risk, they would also have to be directly responsible for the payment of vendors.

At a technical level they believed it would have been preferable to have split off the AVL and schedule adherence part of the project and bid it out separately. There are more and larger companies competing in this field. The interface software could then have been done separately, and this would have made for a better product. However, there simply was not enough money in the project to do the job correctly, and this explained why the more sophisticated companies operating in the transit sector had shown no interest in bidding.

5.3.6 Southern California Association of Governments

The project administrator also endured a bitterly frustrating experience with the project. They learned the significance of trying to do too much, and the importance of staying away from integration "for integration's sake." They remain supportive of the use of technology integrators in particular for oversight, testing, writing specifications, developing needs and identifying options. In retrospect it was also thought that it would have been better to focus on combining one dial-a-ride service with one fixed route property. With hindsight the administrator concluded that the Los Angeles Smart Shuttles rather than SCAG should have lead the project. It was acknowledged that they erred with respect to what could be accomplished for the budget and time available.

It is clear that abundant lessons were learned by everyone connected with SGVSS. The following chapter presents our analysis of the FOT and our summary of lessons learned.

CHAPTER SIX

CONCLUSIONS

The previous chapters have described the SGVSS FOT, discussed the technical and functional performance of the system that was deployed, and presented an institutional analysis. Special attention has been paid to Monrovia because of the significant impacts SGVSS had on the service and the service contractor. This chapter presents our overall conclusions generated by the SGVSS evaluation.

6.1 EXPLAINING PROJECT OUTCOMES

With the benefit of hindsight, a number of reasons can be identified that explain why the FOT was not successful in the integration of transit systems. The failure to achieve a functioning level of technical integration, or any type of service integration, and the abandonment of the SGVSS system at the end of the FOT is explained by six major factors. These are

1) relocation and recasting of the FOT,
2) time and budget constraints,
3) lack of commitment to or interest in system integration by project participants,
4) lack of clear goals and objectives,
5) software/hardware technical problems, and
6) weak project management.

6.1.1 Relocation and Recasting of the FOT

The original FOT concept (quasi-informal real-time ridesharing) failed because it could not be implemented. It was technically possible to build a communications and dispatching system to perform such a function, but regulatory, institutional and safety problems could not be resolved. The result was a highly developed technical system design that had no practical application. SGVSS inherited the technical system design. As noted earlier, conditions for relocating the project were that the new FOT would have to fit within the general description of the original project. The general description of the system's function was extremely vague. However, the technical specifications were highly detailed and published in a four-volume set of project technical documents. The technical specifications were the only tangible product from the original FOT.

Relocating the FOT meant finding an application that would conform to the general description of the original project, and yet fulfill the general requirement of an FOT to demonstrate a new application of technology. There were few choices available, and potential participants had to be convinced that taking on the FOT had some benefits. SCAG wanted the FOT to remain in the region, and therefore was motivated to find a suitable location. Ties between SCAG upper management and the political leadership in the San Gabriel Valley ultimately made it possible to recruit the participation of the three cities and Foothill Transit. The decision to participate was made by political leaders and passed down to the Foothill Transit contractor, city staff, and the city contractors to carry out. It appears that participation was a political decision made in the interest of cooperating with SCAG, and to show support for SCAG's stated commitment to expanding the market for public transit via advanced technology. It was relatively easy for management to accept a test of "system integration," given the vagueness of the concept, and given that the funds were coming from and through Caltrans.

6.1.2 Time and Budget Constraints

The reality of the relocated FOT was a far more complex project to be accomplished with less time and a smaller budget than the original ATHENA project. At the time of the relocation, all parties were told that June 1999 was an absolute, fixed deadline for completing the FOT. This put great pressure on SCAG to get the new FOT started and minimize changes to the technical work that had already been done. However, in relocating the FOT, a far more complicated project emerged. The FOT required integration across different transit operations and anticipated several different functional applications. Time and budget constraints made it impossible to conduct the analysis that would have been necessary to develop a project acceptable to four different operators as well as the project sponsors.

The system integrator had to rely on vendors perfectly executing their delivery of the required products to be able to keep the project on schedule and within budget. The only vendor available refused to accept a liability clause for delivery of a product to meet all of the specifications. An abundance of projects and lack of competition in this niche transit market appears to have supported this stance. Under tremendous time pressure to conclude contracts for software delivery it became necessary for the system integrator to accept an inferior risk avoidance solution. This was to hold back 25 percent of the

vendor final payment as a guarantee for product delivery. The lack of risk sharing by the sponsoring and administering agencies became a serious burden as the project proceeded.

The time pressure meant that there was no time to negotiate with project participants and no time for developing clear project objectives. The details could be worked out later, but the real focus was on getting a system integrator on board, and then on getting the system built. Neither the project managers nor the system integrator viewed the lack of service objectives as a problem. From their perspective, deploying the integrated system (the software and hardware) *was* the objective.

Time and budget pressure also meant that the system would have to be built from off-the-shelf hardware and software, that deviations from the original technical specifications would be strongly discouraged, and that all delays would have critical impacts on the FOT. Using off-the-shelf hardware and software is incompatible with design principles that in effect required extensive customization. The many months of installation problems that resulted frustrated participating operators and project monitors and drained project resources.

Finally, time pressure prevented the project sponsors from doing basic due diligence to determine whether the service integration concept was feasible in this context. Had a needs assessment been conducted, the sponsors would have learned something about the four transit services. They would have known that transfers were not a problem from anyone's perspective, and that other forms of integration were not feasible. They would also have learned that there was no compelling reason to integrate the operations of these services.

6.1.3   Commitment of Participants

Participant commitment to the project was lukewarm at the start and eroded as the FOT progressed. The various operators involved were informed of a decision by management. A logical response in such a situation is passive acceptance: Do what is necessary, but minimize the time and effort required. This was clearly the strategy adopted by Arcadia and Duarte. The cities involved seemed to be motivated to participate mostly as a goodwill gesture to SCAG. As noted above, only Monrovia and Foothill had identified specific attributes of SGVSS that would be useful to their own operations, and none of the participants desired or expected any benefits from service integration.

The declining commitment and refusal to continue to support the FOT concept should have been clear to all at a much earlier stage in the project.   In early 1998, when participants were pressured to quickly identify their set of "user requirements" so that the final design of the SGVSS system could be completed, they reacted passively, in part because they did not understand the technical approach being used, and in part because they had few ideas about how the system could possibly benefit their operation. As noted above, time pressure made it difficult for the system integrator and the project manager to spend the time that would have been necessary to learn the details of the various operations and develop useful plans. Rather, components were bought and the system integrator team went about building a system. The system was a first priority for the system integrator, but a low priority for the participants.

Lack of commitment and growing frustration with the problems experienced with SGVSS were evident in a number of ways. First, it was evident in the treatment of SGVSS equipment. The network server and Foothill monitor were placed in a small room just off the driver lobby in the service operator's bus garage. The room was part telecommunications closet and part storage closet. The hardware was placed on a metal rack, and people using the computer had to stand up while doing so. The room had no windows or ventilation, so the door had to remain open when someone was using the system, despite the noise and milling around of drivers waiting for their shifts. The operations people (who were to use the equipment for schedule adherence) were located at the other end of the building. We have already mentioned the Foothill MDTs, mounted in the buses far out of the driver's reach.

Second, management support of the project was polite but lukewarm. City council members or board members did not solicit information on the FOT, participate in meetings, or otherwise lend support to the effort. On the contrary, political leaders received no substantive information on the FOT until it was time to decide on keeping the system. The FOT really had little relevance to the day to day operations of the various services. Caltrans was providing the funds, and, in the worst case, the participants would be left with some aging computer equipment.

Third, passive support evolved to effective withdrawal for Duarte and Arcadia. From the beginning it was evident that SGVSS had nothing to offer either city, but Caltrans and SCAG desired several participants. The Duarte representative did not attend another technical meeting after August 1998. When asked by the evaluation team about his lack of participation, the Duarte manager replied that he did not

understand the technology, felt he had little to contribute to technical meetings, and did not know what SGVSS could do for Duarte. Representatives from Arcadia attended no meetings between August 1998 and August 1999. It was apparent that, with the adjustment issues associated with a new contractor and the ongoing MDT problems, neither Arcadia nor the system integrator had any intention of keeping Arcadia in the project. Still, Arcadia was listed as a participant until December 1999.

Passive withdrawal was not an option for the Foothill Transit and Monrovia contractors. At Foothill, frustration with the software reached a boiling point in October 1999. They were facing a presentation to their Board on the project, and were beginning to realize that they were not going to get what they wanted from SGVSS. At that point it became obvious that they would cut their own losses by exiting the project as soon as diplomatically possible.

A good illustration of the decline in participant commitment and the loss of morale among consultants, managers, and operators is provided by the SGVSS technical team meetings. In the early stages of the FOT, all stakeholders were present, meetings had an agenda, and minutes were recorded by the project manager. As installation problems wore on, agendas and minutes disappeared, and the number of participants dwindled. At several meetings the FOT consultants outnumbered participants. The technical meeting chronology appears in Appendix 3.

6.1.4   Project Goals and Objectives

The concept of third party systems integrators for Intelligent Transportation Systems innovations was popular at the time of the commencement of the project. However, in this case it can be seen that it only helped to mask the basic institutional shortcomings of the project. Technically integrating systems that did not need to be integrated was the wrong answer to the question, "how can we make transit seamless?" Service integration requires institutional and political solutions, and these were not a part of the project. Other research questions such as whether computer aided dispatching increases productivity, increases quality of service, and leads to satisfaction for customers and operators would also have required a different approach.

The participating agencies never had a chance to participate in project development. They were not asked how the integrated system should be used until the FOT was well underway. At that point they were under pressure to merely support decisions so that the project could go forward. Moreover, the entire discussion took

place in the context of system design and development, a completely foreign concept to agency staff. The possibilities for service integration (route deviation, transfers) were ideas fielded in casual discussions between SCAG, project monitors, and project participants. There was never a serious discussion of integration goals and objectives, or of what it would take for the agencies involved to achieve any type of functional integration. The tight schedule allowed no time for such deliberations, and once the project was underway, the technical challenge of integration overwhelmed all other considerations.

The participating operators behaved rationally; they tried to figure out what benefit they could realize from the project. Hence the technology applications were oriented to agency specific problems (schedule adherence for Foothill, reducing run time for Duarte, and improving dispatch capability for Monrovia). Those who saw no benefit (Arcadia, and later Duarte) simply ceased participating. When it became apparent that schedule adherence monitoring would not be possible, Foothill withdrew from the project, effectively ending the deployment. None of the participants had anything to gain from deploying and using the transfer capability. Passengers did not complain about transfers, and a simple telephone call accommodated transfers when they occurred.

6.1.5   Software/Hardware Problems

While there is no question that software was a major source of operational problems, the larger question is why this happened. One answer is that given the time and cost pressure, it made sense to go with existing software, rather than contracting to develop something new. This proved to be a serious problem, because the software company's approach is to fit the operation to the software, rather than customizing software to fit the operation. There was a fundamental incompatibility between the software company and the intended SGVSS system.

As noted in Chapter Five, our assessment of the software package (after many hours of observation) is that while it has some powerful features, it is rigid, complicated, unintuitive, and not user-friendly. It was clearly far too complex for the Monrovia operation, a case of technical overkill for a small scale operation that had no need for automated dispatching, but certainly could have benefited from a simpler decision support/data collection system. The software does not provide the operations information that most agencies desire or require. Installation and start-up problems were extensive, even for the standard package. Problems were complicated by unresponsive

technical support, continuous software updates, and a total lack of documentation, though the firm claims that documentation has been improved dramatically since the end of the FOT. The software firm also states that they have now developed a "lite" version of the software for small operations.

It became apparent that the software firm was either unwilling or incapable of doing the customization required for system integration, or that the desired system integration was simply not possible.   As noted in Chapter Five, the software is designed for rather specific functions, and was inappropriate for the type of system operated by Monrovia and the type of integration called for by the system specifications. It is possible that the system integrator, not knowing enough about the software early on, thought detailed specs and aggressive management would be enough to get the job done.

We noted in Chapter Five that the lack of software bidders should have provided a clear indication that the system requirements were unrealistic, given the time and budget constraints.   The requirements of this FOT were ahead of the market, and the funds available to the project were apparently not sufficient to gain the attention of the major players developing new products for the transit industry. Additional evidence was provided by the software company's refusal to accept a liability clause for delivery of a product that fully met all specifications. Nevertheless, the project moved forward. As problems were encountered, the moving target nature of the software, the lack of documentation, and the changing list of software company technicians surely contributed to the ultimate outcome of this FOT.

The ultimate software problem was that it did not meet the needs of the end user in the dispatch office or in the vehicle. The trip-booking component of the software permitted Monrovia to organize a valuable rider database; but the more complex vehicle scheduling and locator system was unnecessary in a small city with knowledgeable dispatchers. In the end, an effective concept of technological operations is dependent on an effective concept of overall operations.

6.1.6   Project Management

Serious management problems resulted from the selection of a planning agency as the project administrator, and from the contracting arrangements that imposed all risk and responsibility on the system integrator. SCAG is a planning agency, not an operating agency. Its template for contracts is payment based on deliverables and proof

of performance. Performance in an FOT is uncertain; no one knows in advance whether the concept will work as planned, or whether the schedule can be maintained. As a planning agency, SCAG had no experience in dealing with licensing, proprietary products, or operating agreements. Nor did it have the internal capability of quick processing. As a result, every contract negotiation generated months of delay, despite the best efforts of the project administrator, as issues of performance, liability, etc., were encountered and deliberated.

SCAG did not have the capability of managing such a project, hence a system integrator-consultant was essential. SCAG referred to the project as a "turnkey" operation. However, the administration of the FOT proved to be a demanding task. The project administrator ended up playing the role of enforcer in an effort to get vendors to deliver, and playing the role of coordinator/advocate as participant support declined.

The role of a system integrator for so complex a project operating with too little time or money also exposed weaknesses in using a third party for procurements and design. Both the software vendor and Foothill Transit expressed dislike of such arrangements because they led to misunderstandings of needs and tasks. In the case of Foothill, their complaints of having their interests "sidelined" are also a reflection of their lack of active involvement in the management of the project areas that affected their operations. Similarly, the Monrovia contract operator was incredulous when told that the details of the reporting package they needed had not been included in the contract specifications for the software vendor. This is not to imply that the project could have been successful without the systems integrator, it clearly could not. However procuring specific products for specific purposes by professionals familiar with the operations of their own systems could be expected to have resulted in greater satisfaction.

Contractual arrangements were unsatisfactory for two reasons. First, there was no real enforcement leverage. Contract arrangements placed the system integrator in a very difficult position. As noted above, the system integrator had all the responsibility and risk for delivering the project, but was dependent upon subcontractors to get the job done. As a practical matter, long-term business considerations precluded any serious enforcement efforts on subcontractors by the system integrator. In theory, the consultant could hold back payment or even threaten to sue; but, in reality, the consultant had to consider its long-term business interests within the industry. SCAG had limited authority, given its role as an intermediary acting on behalf of the ultimate

overseers at Caltrans in Sacramento. Caltrans had ultimate authority, but only with the prime contractor. It could be argued that SCAG or Caltrans would have had more influence had contractual arrangements been structured differently.

Having no real authority to enforce delivery, the system integrator engaged in months of troubleshooting and active management. As problems persisted, communications broke down and all sides tried to minimize losses. Under the circumstances, the reasonable strategy was to minimize efforts and see the project through to completion. This is effectively what happened.

Second, the lack of contractual arrangements for project participants was also a problem. There were no signed agreements regarding what would be expected of managers and operators. Thus Duarte could simply disappear, and the software trainer could arrive at Monrovia not knowing the required passenger data did not exist. There were also no formal agreements regarding what would be delivered to project participants, or what protections they might have in the event of problems. Thus at the end of the FOT the City of Monrovia could still believe that reporting capability was forthcoming, the Monrovia service contractor could be surprised that his specific reporting requirements (explicitly described at the beginning of the FOT) never found their way into contract specifications, and the service contractor could end up absorbing the added costs of a second off-peak dispatcher.

6.2   LESSONS LEARNED

The purpose of an FOT is to determine whether the given technology application is appropriate for large-scale application. Consideration of the institutional context is inherent in the test. There is no such thing as an FOT failure; because there is much to be learned from tests that did not work as anticipated. While this FOT did not accomplish system integration, it provides many useful lessons for future advanced technology applications.

1) *Goals and objectives should be clear, appropriate, understood by all parties, and agreed upon by all parties, especially those charged with carrying out the FOT.* In this case the goal of an "integrated system" became an "integrated technical system." Such a system served no useful purpose for the participants. If the end users of the system (dispatchers, drivers, etc.) had been consulted as part of the initial project design, the design team would have better perceived potential flaws in the chosen technology. As a result, and faced with a fait accompli, participants

tried to use the system to address their own service objectives. True integration would have required not merely technological interoperability, but cooperative efforts among the participants, strong leadership, and enough time to achieve consensus agreements.

2) *Institutional arrangements should be formal, clearly specified, and should allocate responsibility and risk appropriately.* In SGVSS there were formal contracts for the various key consultants, but product delivery could not be enforced. The lead system integrator had responsibility for delivery, but had no effective means for demanding subcontractor performance. There were no formal agreements such as MOUs for the project participants. It was therefore possible for them to drop in and out of the project, and to change decisions on key matters as the FOT progressed.

3) *Any FOT should pass a basic test of reasonableness before it is allowed to go forward.* A commitment to the project on the part of participants and a market for the product should be demonstrated as necessary conditions. Had a thorough investigation of the services been conducted, it would have become apparent that there was no real market for service integration in this case.

4) *The technology should fit with the problem being solved.* The SGVSS hardware and software was far more sophisticated and complicated than required for sharing basic operating information or even accommodating transfers. Technical complexity contributed to the software problems and the associated delays.

5) *Delays are inevitable in FOTs and should be built into the schedule.* The tight schedule added to the difficulties of SGVSS by driving decisions that ended up generating more delays and ultimately the failure to produce a functioning integrated system.

6) *New technology tests should be as simple and incremental as possible.* The difficulties of developing even incrementally new applications are generally underestimated. Public transit is a highly complex operation. Each service is in some way unique, and unpredictable humans are involved, both as consumers and as service providers. SGVSS turned out to be a bundle of numerous different applications, greatly adding to its complexity.

7) *Basic technical knowledge and computer literacy of participants cannot be assumed.* Technical knowledge is important for two reasons. First, participants with limited technical knowledge cannot effectively communicate with highly

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technical consultants, yet such communication is essential if the technology deployed is to do the job the participants want. Second, interacting with computers, MDTs, and other technologies is intimidating for those with little technical background. At Monrovia, some dispatchers and drivers simply could not work effectively with the new system. And training took many times longer than anticipated, because these workers were so unfamiliar with computer technology.

6.3   FINAL COMMENTS

This FOT was an example of a technology application in search of a problem, rather that a problem searching for a technology solution. In this case project sponsors and participants somehow believed that the policy problem of how to provide "seamless transit" could be answered through technology. "Seamless transportation" is not a reality because of the institutional barriers inherent in the way public transit is organized and financed. These barriers are far more difficult to overcome than the technical problems involved. In the case of SGVSS, for example, it was quite possible to accommodate passenger transfers with old technology, e.g., the dispatchers calling one another, or the dispatcher having the Foothill route schedule on hand. There was no need for complex operating agreements, protocols, AVL, and automated messaging for such a simple task. In our exit interview, we asked one of the operators what it would take to achieve interagency cooperation on such an issue. The answer was acknowledgment that a problem existed and could be solved to the benefit of all parties by cooperative action. Such problems are where advanced technology applications should be explored. The needs of transit consumers and operators should drive service requirements, and the selection and specification of the technologies to be used to meet those needs.

Our final comments must also include some discussion of the damage done by this FOT. FOTs and their managers ought to have as a primary objective the avoidance of damage to their partners and the public interest. Protective guidelines need to be established to avoid injury to the business interests, especially in cases where the private sector participants volunteer to act as a guinea pig. Literature and practice include frequent discussion of public-private partnerships and how they should be fostered. The private sector complains consistently that employees of public agencies have no appreciation of the need for businesses to be profitable, nor what it takes to insure that they remain so.

In the case of the Monrovia contractor, operating without productivity and service data over such an extended period became a serious business liability, yet the project managers showed no appreciation of this. Staff turnover increased, customers were unhappy, costs were increased, and the disruptions to operations continued for months. As a result of the failure to provide the promised reporting features, the contractor was largely unprepared to compete when the service was bid out. They received no auxiliary project support in trying to extract data from the system, and their contract was lost. In retrospect, protective guidelines should have been in place, which would have insured that the contract would not be bid out until the project was over and essential features such as a reporting system restored for a working period of recovery.

The systems integrator also suffered from the FOT. When things were proceeding so badly with attempts to "go live" there was ample evidence to suggest that the project should have been cancelled. Instead the project was extended and the emphasis changed from integration to transfers in a last ditch attempt to produce something tangible from the FOT. Duarte and Arcadia were effectively out of the FOT many months before it became official. Although Caltrans had concerns about the FOT and had made it clear that the continued participation of all parties was critical, it was reticent to take the drastic step of canceling the FOT.

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APPENDIX 1 SGVSS COST SUMMARY

	Total Budget	Budget Expended as of June, 1998	Budget Expended as of June, 1999	Funds Available for June 1999 – March 2000
SCAG Project Administration and Marketing	$195,771.00	Unknown to the Evaluation Team	Unknown to the Evaluation Team	$153,695.00
Project Manager	$130,297.00[a]	$74,846.00	$130,297.00	$0.00
System Integrator Project Management	$62,671.00	$19,729.00	$62,671.00	$0.00
System Design	$120,077.00	$113,694.00	$120,077.00	$0.00
System Test Plan	$22,767.00	$17,980.00	$22,767.00	$0.00
System Procurement	$935,128.00	$9,988.00	$758,858.00	$176,270.00
Integration and System Test Plan	$105,520.00	$0.00	$105,520.00	$0.00
Installation and Field Testing	$69,737.00	$0.00	$69,737.00	$0.00
System Support	$40,048.00	$98.00	$28,227.00	$11,821.00
Other System Integrator Direct Costs	$41,214.00	$3,198.00	$40,000.00	$1,214.00
Total	$1,723,230.00	Unknown to the Evaluation Team	Unknown to the Evaluation Team	$343,000.00

Note: a. This figure is the sum of $46,883 remaining from the Ontario ATHENA project and $83,414 budgeted as part of the SGVSS FOT. The former covered billings through a portion of December 1997.

APPENDIX 2 FOOTHILL SCHEDULE ADHERENCE DATA

Foothill Transit saw the FOT as a means of testing real-time information applications. Drivers are directed to call in when they are running five minutes behind schedule, but do not always do so. Foothill used scheduling software but did not have access to a vehicle locator system. Such a system might allow dispatchers to make schedule adjustments when vehicles are running late. In the absence of a vehicle locator system, Foothill Transit obtains on-time performance data using employee surveyors at identified time points. Average monthly data for Foothill Routes 184 and 187 using this method are provided below. The figures represent schedule adherence at the Huntington/Highland time point located in the City of Duarte.

The evaluators performed a one-day on-time performance test using in-vehicle surveyors along the entire length of Route 187. This test was conducted on March 16, 1999; and findings support the data below. The evaluators aborted an in-process survey of Route 184 in April 1999 due to rain. The test was not rescheduled as a result of preliminary findings from the aborted test and driver comments suggesting that 184 buses were consistently on-time (i.e. greater that 90%) even with the inclement weather. The evaluators did not pursue other on-time performance data for either of these routes since vehicle locator systems, if fully tested as part of the FOT, would have had a greater impact on other routes in the Foothill Transit system.

FOOTHILL TRANSIT ON-TIME PERFORMANCE
(Huntington and Highland Time Point)

184 Monthly Schedule Adherence		**187 Monthly Schedule Adherence**	
Jul 98 E/bound	94%	Jul 98 E/bound	88%
Jul 98 W/bound	100%	Jul 98 W/bound	82%
Aug 98 E/bound	93%	Aug 98 E/bound	90%
Aug 98 W/bound	100%	Aug 98 W/bound	92%
Sep 98 E/bound	100%	Sep 98 E/bound	95%
Sep 98 W/bound	100%	Sep 98 W/bound	100%
Oct 98 E/bound	100%	Oct 98 E/bound	100%
Oct 98 W/bound	100%	Oct 98 W/bound	100%
Nov 98 E/bound	82%	Nov 98 E/bound	83%
Nov 98 W/bound	100%	Nov 98 W/bound	81%
Dec 98 E/bound	100%	Dec 98 E/bound	74%
Dec 98 W/bound	100%	Dec 98 W/bound	69%
Jan 99 E/bound	88%	Jan 99 E/bound	84%
Jan 99 W/bound	94%	Jan 99 W/bound	84%
Feb 99 E/bound	88%	Feb 99 E/bound	88%

Feb 99 W/bound   94%   Feb 99 W/bound   84%