Artificial Intelligence and Intelligent Transportation Systems

Planning and Administration
# Transportation Research Record 1774

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Foreword

The papers contained in this volume were among those presented at the 80th Annual Meeting of the Transportation Research Board in January 2001. More than 1,700 papers were submitted by authors; more than 1,100 were presented at the meeting; and approximately 600 were accepted for publication in the 2001 series of the Transportation Research Record: Journal of the Transportation Research Board. The published papers also will be issued on CD-ROM, which will be available for purchase in late 2001. It should be noted that the preprint CD-ROM distributed at the 2001 meeting contains unedited, draft versions of presented papers; the papers published in the 2001 Record series include author revisions in response to review comments.

The subtitle of the Record, "Journal of the Transportation Research Board," reflects the nature of the publication series and the peer review conducted in accepting papers for publication. Each paper published in this volume was peer reviewed by the sponsoring committee acknowledged at the end of the text; members of the sponsoring committees for the papers in this volume are identified on page ii. Additional information about the Transportation Research Record: Journal of the Transportation Research Board series and the peer-review process can be found on the inside front cover. The Transportation Research Board appreciates the interest shown by authors in offering their papers and looks forward to future submissions.
Advanced Technology and Integrated Public Transit
San Gabriel Valley Smart Shuttle Field Operational Test

Genevieve Giuliano, James E. Moore II, and Thomas O'Brien

Results of the San Gabriel Valley Smart Shuttle (SGVSS) field operational test (FOT) are presented. Results are drawn from a comprehensive evaluation of the FOT conducted over a 3-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. The history of the project is described, and an analysis of the FOT is presented. Outcomes are explained by the following: (a) origination of the project in a different location and with a different service concept, (b) time and budget constraints imposed by the original FOT, (c) limited commitment on the part of some project participants, (d) lack of clear project goals and objectives, (e) software and hardware technical problems, and (f) problems with contracting and management. The FOT provides many insights into the challenges of service integration. Lessons learned are described.

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 (1, 2). Advanced technologies have been promoted by the U.S. Department of Transportation and the state of California as a way to increase service efficiency and attract new riders (3, 4). 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.

In this paper the results of an evaluation of a new technology field operational test (FOT), the San Gabriel Valley Smart Shuttle (SGVSS), are presented. The SGVSS attempted to integrate the services of three local municipal operators and a regional fixed-route transit operator. The complete system was never fully deployed. Although technical problems were serious and extensive, the outcomes of this FOT were primarily a function of institutional and organizational constraints.

Institutional issues have been addressed in recent evaluations of transit technology deployments; however, it is believed that multiagency technology deployments raise a host of new concerns. This assessment is based on comprehensive monitoring of the FOT from its inception to its conclusion, a period of more than 3 years. The research team conducted repeated in-depth interviews with all project participants. Each stage of the FOT was documented, and representa-

tives of the research team attended all project meetings. Field visits were conducted at critical times during planning and deployment, and extensive observations were conducted during system installation and other critical periods of the FOT.

INTEGRATED PUBLIC TRANSIT

Geographically or functionally segmented services are often not consistent with patterns of travel demand. Hence the traveler must negotiate transfers between systems that do not accept one another's transfers and that 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 (4). In principle, advanced technology makes integration of services easier to accomplish. Advanced communications technology allows the sharing of schedule and passenger information so that transfers between services can be coordinated. Combined with a common fare medium, this would allow seamless transfers between systems, whether across modes or geographic boundaries.

Advanced technology makes much possible, but transit operators determine what is implemented. Cooperation among operators is still required, and information sharing and service coordination across agencies impose 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. Although a degree of technology integration was achieved, there was no functional integration of services.

PRIOR RESEARCH

There have been few FOTs of integrated transit services. Most similar to SGVSS is the Santa Clara County FOT, which used computer-assisted dispatching, a digital geographic database, and automatic vehicle location equipment to provide service mandated by the Americans with Disabilities Act throughout the county (5). The FOT integrates several different service providers, but all are acting under the direction and control of the master contractor. The automated system allowed the county to accommodate rapid increases in demand.

An example of the complexity of multiagency integration of smart card technologies is reported by Giuliano et al. (6). This FOT included seven small transit operators, and its goal was to implement 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 constraints.
Many FOTs have attempted various types of integration for the highway system, including smart corridor projects intended to coordinate freeway and arterial traffic management and traveler information projects intended to collect traffic data from various sources and provide the data to the public via automated telephone or Internet. Traffic management coordination efforts have had limited success, often because of the difficulties in 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 (7, 8).

SAN GABRIEL VALLEY SMART SHUTTLE FOT

The SGVSS 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 city east of Los Angeles. 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, and the city ceased its sponsorship in July 1996. Institutional and contractual issues played a central role in the decision to suspend ATHENA (9).

ATHENA had a legacy. By the time it was canceled, 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 so that the FOT could continue. Relocating the project was difficult, since 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 1-year period of deployment. Thus the new FOT would have to be up and running by June 1998.

The origin and structuring of the SGVSS FOT influenced project outcomes. First, there were strict time and budget constraints. This motivated decisions to rely on "off-the-shelf" hardware and software, to establish an unrealistic time schedule, and to keep the budget for consulting services to an absolute minimum. Thus any delays or problems would quickly affect the project schedule and the profit margin of the consulting team. Second, the pressure to relocate and get the project started allowed no time to negotiate with the service providers. The decision to participate in the FOT was made by board members and city councils: service providers (three of four: are contract opera-

tors) were informed after the fact. The actual objectives of the FOT (how the four services would be integrated and for what purpose) were left for later consideration. Third, the absence of clear service objectives allowed technical objectives to drive the early decisions of the FOT. The fact that the system technology specifications were the one concrete product of the earlier FOT reinforced the emphasis on technical objectives. Finally, the structure of the new FOT placed the Southern California Association of Governments (SCAG), a regional planning agency, in the position of administering what was effectively a service operations contract, something the agency proved ill prepared to do.

FOT Participants

SCAG worked intensively to recruit participation to retain the project in the region. In mid-1997 the project was relocated to the San Gabriel Valley in northeast Los Angeles County. Four transit operators were recruited:

- City of Monrovia, providing local general public demand-responsive service within the city and the adjacent unincorporated area;
- City of Arcadia, providing local general public demand-responsive service within the city;
- City of Duarte, providing local fixed-route service within the city; and
- Foothill Transit, the regional fixed-route transit operator for the San Gabriel Valley.

Basic information on the services provided by the four transit operators is summarized in Table 1. The relevant governing bodies approved participation in the FOT. However, there were no formal contractual arrangements, and no formal scope of work was defined for participation.

The new FOT included many players in addition to the cities and their contract operators. SCAG became the project administrator on behalf of Caltrans. A project monitor from the New Technology and Research Program represented Caltrans. An independent consultant was retained from the earlier FOT in the ambiguous role of project manager. The system integrator role was put out to bid, and a transportation consulting firm was hired. This firm acted as the master contractor and had responsibility for all aspects of the deployment, including hardware and software procurement, installation, and system operation and maintenance. Contractual relationships were numerous. The system integrator team included two subcontractors:

<table>
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<th>Table 1 Field Operational Test Transit Operators</th>
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<td>City/Agency Name</td>
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<tr>
<td>Monrovia</td>
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<tr>
<td>Arcadia</td>
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<tr>
<td>Duarte</td>
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<tr>
<td>Foothill Transit</td>
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^ Duarte is free fare system.

* Foothill Transit Route 187 only; ridership for calendar year 1996.
an independent consultant who had authored the original system technical specifications and a transit software concept design specialist. Subcontracts were issued for the project software and for mobile data terminals (MDTs). Service agreements were established with a wireless communications service provider and a communications equipment installer. Other equipment and services were purchased directly from vendors.

Goals of the FOT

The core of the former FOT was retained: "a computer system to match ride requests and vehicles" (10). Instead of matching private individuals and private vehicles, it would match private individuals with public transit vehicles. However, a straightforward application of computer-assisted dispatching, even with state-of-the-art communications technology, did not meet the full criteria for an FOT. FOTs require some form of innovation, and the Santa Clara FOT was already investigating various aspects of computer-aided dispatching (5). In this case integration became the innovation. The request for proposals (RFP) issued for the system integrator identified three goals for the restructured FOT:

- "To develop, integrate, and test the integration of emerging technologies";
- "To identify and mitigate any institutional barriers that might interfere with the implementation of the new services" so that "once the system is installed, the agencies will be able to cooperate in ways not now possible, such as coordinating transfers and providing backup services to one another"; and
- "To test the public acceptance of the new services provided" (10, pp. 1–2).

Service capabilities that participating agencies might choose to implement included route deviation, interagency 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 1998 (SCAG memorandum, March 4, 1998). The goals were

- "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)";
- "To assess whether improved operational efficiencies might be achieved from both an operator and a user perspective";
- "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
- "To create a legacy APTS system that can serve as a model and test bed for other potential APTS deployments in the I-710 ITS Priority Corridor . . . and as a possible future ‘real-time’ transit Advanced Traveler Information link."

In short, the project focus was on testing technology, not on addressing either transit user needs or operator requirements.

Description and Motivations of FOT Participants

The three cities are close to one another in an area northeast of the city of Los Angeles and are all served by Foothill Transit. The three cities are described in Table 2. Local municipal public transit is 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. One contractor had operated the city of Monrovia’s dial-a-ride (DAR) service for many years. Before the FOT, the system was completely manual; the call taker/dispatcher processed ride requests via hand-stamped tickets placed on a dispatching board. Drivers and dispatchers communicated via radio. The service is heavily used, and productivity averaged 5.8 passengers per vehicle service hour.

The Arcadia DAR also had been in existence for many years and was still being operated by the original contractor at the beginning of the FOT. The contractor was using computer-assisted dispatching, and all vehicles were equipped with automated vehicle location (AVL) and MDTs. Arcadia is a large operation by DAR standards. Fares are low and, like Monrovia, demand for the service is high, often creating long wait times for passengers. Arcadia and Monrovia share a 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 must transfer at the border. Informal transfer points were designated for this purpose, and transfers were coordinated via telephone between the dispatchers.

Duarte operates its own free community fixed-route service, consisting of two routes (one in each direction) that form an approximate circle through the city. The service is heavily used. It is operated out of the Public Works Department. The Duarte shuttle connects with several Foothill Transit bus stops. Duarte and Monrovia share a border, and the Duarte stops serve as informal transfer points between the two city services.

Foothill Transit serves 20 member cities within an 847-km² (327-mi²) service area and operates 26 routes. Two of Foothill’s routes were initially included in the FOT: Route 187, a regional intercity route traversing all three participating cities, and Route 721, a local feeder route to a commuter rail station.

Given common borders and overlapping services, the three-city area provided seemingly obvious opportunities for service integration. However, the operators involved indicated little interest. They were looking for solutions to problems specific to their own operations. Monrovia saw an opportunity to upgrade its operation to state-of-the-art computerized dispatching at no cost to the city or the contract operator and a potential means for tracking trips in unincorporated areas for reimbursement by the county. The Monrovia contractor saw the potential benefits of upgrading its system and simplifying data collection, and it saw the possibility of expanding its DAR business. Arcadia had little expectation of benefits, since its contractor was already automated. However, the city was concerned about the performance of the contractor and was interested in the possibility of

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<td>Population 1996 (est.)</td>
<td>Monrovia</td>
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<tr>
<td>37,550</td>
<td>52,100</td>
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<tr>
<td>Race/Ethnicity (1990, %)</td>
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<tr>
<td>White</td>
<td>57.1</td>
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<tr>
<td>Hispanic</td>
<td>28.5</td>
</tr>
<tr>
<td>Asian</td>
<td>4.3</td>
</tr>
<tr>
<td>Black</td>
<td>9.6</td>
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<tr>
<td>Median HH income 1989</td>
<td>$35,684</td>
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Note: HH = household.
monitoring. Duarte wanted to reduce operating time to achieve a 1-h run time on each route, perhaps by selectively skipping low-demand stops. The city was also interested in vehicle-tracking technologies for eventual application to the emergency service fleet. Foothill Transit briefly considered using the FOT to experiment with route deviation but decided to focus on using the AVL to monitor schedule adherence on Route 187.

None of the participants identified any type of service integration as a potential benefit of participating in the FOT. 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 by 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 backup services to one another) was beyond consideration. However, from Caltrans’s 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 Caltrans conditions, and therefore when route deviation proved infeasible, the agency eventually settled on interagency transfers as the one concrete demonstration of integration, despite the lack of interest among the operators.

**HISTORY OF THE FOT**

The RFP for the system integrator was issued in July 1997, but contract negotiations were not concluded until January 1998. This delay reduced the FOT operation period to 10 months, forcing the consultant to move quickly. Site visits and workshops were conducted with project participants in February, since finalizing the design of the technical system was a top priority. The mismatch between the consultant’s objective (finalize the design and start purchasing equipment) and the participants’ lack of understanding of the FOT quickly became apparent. Finalizing the system design became a process of linking potential system functions on the basis of the pre-existing system specifications to each operator. These functions were presented to participating agency staff as “subsystem user requirements”—for example, vehicle sharing, remote monitoring, and data reporting. Agency staff members were asked to identify their set of user requirements. However, the question of what they were going to do with the system had not progressed beyond vague ideas. In addition, agency staff were not familiar with systems development and did not have the technical knowledge to understand the process. They therefore had little to contribute, and agency staff participation in project meetings steadily dwindled. Most key design decisions were made by the system integrator and the various project monitors. In March it was announced that there would be no actual interface with the Arcadia system; only information on vehicle location would be exchanged.

**SGVSS System Design**

The SGVSS system network as envisioned by the system integrator is illustrated in Figure 1. The four participating operators and their contractors would share communications via a wide-area network. Dispatch centers would be located at the Monrovia contractor and at one of Foothill Transit’s contractor locations. Dispatch centers would include a geographic information system 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 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 MDTs, wireless communications equipment, vehicle location equipment, and an onboard microcomputer.

The technology concept was to have interchange of information 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 and to communicate with both vehicles and dispatchers across operations. Dispatching software had to be combined with communications software to accomplish these functions, as well as perform computer-assisted dispatching.

A critical design review was held in April 1998 to formalize the SGVSS technical system plan and proceed to hardware and software procurement. There were many alternatives available for the various hardware components, but software was another matter. Only two bids were received for the software component, and only one bidder was willing to meet the project schedule. The software was used routinely to operate more than one service but had never been used to coordinate or communicate between services. Although the consultant, project monitors, and one of the operators expressed reservations, this bidder was selected. It was the only way to keep the project on schedule and within budget.

Delays Due to Contract Arrangements

The process of negotiating and executing the various subcontracts led to several months of delay, and the project start (“Go Live”) date was shifted to January 1999, reducing the FOT performance period to 6 months. Contracts were finally signed in September and October 1998. However, by December it was apparent that Go Live was still months away. Equipment installation was delayed to the end of December, and training could not begin until January. As problems intensified, Caltrans managed a contract change that extended the FOT to December 1999.

By late 1998 several changes had occurred. Caltrans assigned a new contract monitor to the FOT. Arcadia hired a new transportation manager, who recommended, after an evaluation of the current contractor, that the service be put out to bid and a new contractor hired by July 1, 1999. Duarte was no longer participating in meetings. The staff representative for Foothill Transit left the agency, and several months passed before new representatives appeared. Because of the schedule delays, the system integrator decided to Go Live in two phases, starting with computer-assisted dispatching at Monrovia and later deploying AVL and interagency communications. Thus in early 1999 all efforts were focused on getting the dispatching software up and running at Monrovia.

Deployment Difficulties

As the new software was installed at Monrovia and training began, it became obvious that the software was not compatible with the way the Monrovia system operated. In particular, Monrovia receives mostly real-time ride requests, but the dispatching software is designed for a reservation system. Consequently DAR staff were informed at the last minute that they would have to construct a database (including geocoded addresses) of system users for the software to work.

In addition, during off-peak times Monrovia had operated with just one dispatcher/call taker, but the new system (as used in this case) effectively required two persons at all times. Third, training was more costly than anticipated. 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 the Monrovia contractor staff had no understanding of the complexities of the software. Neither the lead consultant nor the project managers had prepared either party for the conversion. It was anticipated that installation of equipment would take only a few weeks and training would be completed in a matter of a few sessions at each site. In fact, numerous technical problems were encountered, and the installation process dragged on for months. In March the Go Live date was pushed to June 1.

Software problems intensified when the customized portions of the system were attempted. Numerous problems were encountered when the MDTs were connected to the system. The system could not be made to work reliably. The Go Live date was continually pushed back. MDTs were added to the Monrovia system in summer 1999. However, frequent failures and the absence of adequate messaging capability resulted in limited and sporadic use.

Problems were also encountered at Foothill Transit, both with MDTs and with the software package intended to provide schedule adherence information. Although Foothill had agreed to the installation of AVL units and MDTs, it expressed concerns about actually using the MDTs. Their function in fixed-route service was unclear, and there was no agreed policy on the transfer requirements. Nevertheless, the project called for functioning MDTs at Foothill, and they were installed; but they were placed far out of the driver’s reach and clearly were never intended to be used.

More serious problems were encountered with schedule adherence. Foothill Transit was already using an earlier DOS version of the project software for vehicle and driver run scheduling that was not compatible with the new Windows version being used in the FOT. Shifting to the new version made it necessary to input detailed bus and driver schedule data manually. As the installation proceeded, it became evident that this new module did not have the capability of providing real-time vehicle location information sufficient to allow the monitoring of schedule adherence desired by Foothill Transit.

By the end of summer 1999, Go Live was pushed back to mid-September. Problems continued, and the FOT was once again extended to March 2000 to allow for a minimal period of Go Live operation. Other changes took place. A new contractor was operating the Arcadia service, and start-up problems put its participation on indefinite hold. The manager of the Monrovia contract operation quit the company without notice. The project manager’s contract ended in June (the original FOT end date), leaving the SCAG administrator to take over day-to-day management.

Winding Down of the FOT

The system was plagued with various forms of operational failures; in addition, the software failed to deliver on two key functions. First, real-time schedule adherence capability acceptable to Foothill Transit was not provided. Second, reporting capability sufficient to provide required Federal Transit Administration Section 15 data, identify outside city trips for Monrovia, and provide on-time performance data was not possible within the standard reports provided by the software. This was a serious problem for the Monrovia contractor. Drivers were still filling out daily reports by hand, but the automated dispatch sys-
tem eliminated the hand-stamped tickets used for on-time performance reporting. With neither a manual nor an automated system for this essential purpose, the contractor had no means of providing reports required by its contract with the city. Ultimately, the contractor resorted to shutting down the automated system for 2 days and reverting to manual dispatch to collect the required performance data.

By fall 1999, interagency transfer capability was the defining feature of the FOT. Arcadia’s participation formally ended in November 1999, when the software upgrades necessary to link the new contractor’s equipment with the SGVSS were found to be infeasible given the FOT’s schedule and budget constraints. Although Duarte had not officially withdrawn from the FOT, problems at City Hall had prevented installation of the monitoring computer. Duarte had no reason to continue participation. Foothill Transit was openly frustrated with not achieving real-time schedule adherence monitoring. As problems continued, SCAG shifted its emphasis from integration to “interoperability” and “legacy systems.” A demonstration that the SGVSS system could successfully process transfers between operators would illustrate the interoperability of the system.

At this point SCAG was acting alone. The Caltrans project monitor had left, and a replacement had not yet been assigned. The system integrator had effectively removed all staff from the project. Plans for a short demonstration of transfer capability between Monrovia and Foothill Transit were developed. A transfer test using student volunteers was conducted in February 2000. In the end, Foothill decided against a public demonstration, stating that the formal transfer process required too much effort for the already overworked bus dispatcher, was not sufficiently reliable, and could lead to customer complaints. There was no evidence of agency demand for transfer capability.

The FOT officially ended in March 2000. Retaining the legacy system would require that one of the participants assume the role of system administrator and that all participants share the communications operating costs and system maintenance costs. In addition, participants would have to renew the annual software license. The participants elected not to retain the system. Only Monrovia elected to keep the computer-assisted dispatch system. Foothill agreed to retain the server so that Monrovia could continue to use the system. The reporting issue became moot in May 2000. The Monrovia contract went out to bid in April, and the contractor failed to win the new contract.

EXPLAINING PROJECT OUTCOMES

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 are explained by six major factors: (a) relocation and recasting of the FOT, (b) time and budget constraints, (c) lack of commitment to or interest in system integration by project participants, (d) lack of clear goals and objectives, (e) technical (software) problems, and (f) weak project management.

Relocation and Recasting of the FOT

The original FOT concept failed because it could not be implemented. It was technically feasible, but regulatory, institutional, and safety problems could not be resolved. The result was a highly developed technical system design that had no practical application. 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 canceled FOT, and they set the tone for the orientation of the relocated 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. Few choices were available, and potential participants had to be convinced that accepting the FOT had some benefits. SCAG wanted the FOT to remain in the region. Ties between SCAG upper management and political leaders in the San Gabriel Valley ultimately made it possible to recruit 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 is surmised that participation was a political decision made in the interest of cooperating with SCAG and to show support for SCAG’s 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 Caltrans.

Time and Budget: Constraints

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, a far more complicated project emerged. The relocated FOT required integration across different transit operations and anticipated several different functional applications.

The time pressure meant that there was no time to negotiate with project participants or to develop clear project objectives. 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 resulting installation problems 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, that other forms of integration were not feasible, and that there was no compelling reason to integrate the operations of these services.

Commitment of Participants

The participating agencies were not strongly committed to the FOT. They were informed of a decision made by management, and it was their job to carry it through. A logical response in such a situation is passive acceptance: do what is necessary, but minimize the time and effort involved. This was clearly the strategy adopted by Arcadia and Duarte, and to some extent by Foothill as well. Only the Monrovia contract operator expressed real commitment: the opportunity to
migrate to computer-assisted dispatching was perceived as a business opportunity.

Management support of the project was polite but lukewarm. 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. 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 whether to keep the system.

Project Goals and Objectives

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, as opposed to technological integration, were ideas fielded in casual discussions between SCAG, project monitors, and project participants. There was never a serious discussion of the structural changes required to move toward the goal of seamless regional transit. The tight schedule allowed no time for such deliberations, and once the project was under way, the challenge of technology integration overwhelmed everything else.

The participating operators behaved rationally. They tried to determine what benefit they could realize from the project. Those who saw no benefit simply ceased participating. The end came when it became apparent that schedule adherence monitoring would not be possible, and Foothill withdrew from the project.

Software Problems

Project managers and the system integrator identified problems with the software as the primary cause of the final FOT outcome. The software firm disagreed, attributing FOT outcomes to the lack of commitment by the operators, which was compounded by the tight timeline and technical problems. There is no question that software was a major source of operational problems, but the larger question is why this happened.

The fundamental software problem was one of mismatch: it is oriented to a specific set of applications, not to customization. In addition, it does not provide the operations information that most agencies desire or require, and installation and start-up problems are extensive, even for the standard package. Problems are complicated by unresponsive technical support, continuous software updates, and a lack of documentation. Integration and customization added to problems. The various consultants differ concerning the role of the dispatching software versus the software required to operate the communications equipment versus hardware problems. In any case, the result was failure to deliver a system that performed at a level acceptable to anyone.

In the end, an effective concept of technological operations is dependent on an effective concept of overall operations, clearly expressed in project goals and objectives. The software 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.

Project Management

Management problems resulted from the selection of SCAG 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, and it had no prior experience in managing the uncertainties in new technology demonstrations. Its template for contracts is payment based on deliverables and proof of performance. SCAG had no experience in dealing with licensing, proprietary products, or operating agreements, nor was it capable of quick processing. Every contract negotiation generated months of delay, despite the best efforts of the project administrator, as issues of performance, liability, and so forth were encountered and deliberated.

SCAG did not have the resources for managing such a project, hence a system integrator was essential. SCAG referred to the project as a "turnkey" operation. However, contract arrangements placed the system integrator in a very difficult position. It had all the responsibility and risk for delivering the project but was dependent on subcontractors to get the job done. The contract proved to be unenforceable. SCAG was particularly constrained, given its role as an intermediary acting on behalf of the ultimate overseers at Caltrans in Sacramento.

The system integrator's already thin profit margin disappeared early as a result of months of troubleshooting and active management. The more effort invested in getting the software firm to deliver, the greater the loss. Subcontractors were in similar circumstances. Hence the reasonable strategy was to minimize effort and see the project through to the end of the contract period. This is what happened.

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. Although this FOT did not accomplish system integration, it provides many useful lessons for future advanced technology applications.

- 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. 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 also cooperative efforts among the participants, strong leadership, and enough time to achieve consensus agreements.

- Institutional arrangements should be formal, should be 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 short of litigation.
The system integrator had responsibility for delivery but had no
effective means for demanding subcontractor performance. There
were no formal agreements for participating agencies. It was there-
fore possible for them to drop in and out of the project and to change
decisions on key matters as the FOT progressed.

- 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.

- The technology should fit with the problem being solved. The
  SGVSS hardware and software were far more sophisticated and
  complicated than required to share basic operating information, or
even to accommodate transfers. Technical complexity contributed
to the software problems and the associated delays.

- Delays are inevitable in FOTs and should be built into the sched-
  ule. 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.

- New technology tests should be as simple and incremental as
  possible. The difficulties of developing even incrementally new appli-
cations are generally underestimated. Public transit is a highly com-
plex operation. Each service is unique in some way, and unpredictable
people 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.

- Basic technical knowledge and computer literacy of participants
cannot be assumed. Technical knowledge is important for two rea-
sons. First, participants with limited technical knowledge cannot
communicate effectively with highly 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 back-
ground. At Monrovia, some dispatchers and drivers simply could not
work effectively with the new system. Furthermore, training took
many times longer than anticipated, because these workers were so
unfamiliar with computer technology.

Seamless public transportation is not a reality because of the insti-
tutional barriers inherent in the way transit is organized and financed.
These barriers are far more difficult to overcome than the technical
problems involved. In the case of SGVSS, it was possible to accom-
modate passenger transfers with "old technology." The dispatchers
could call one another or the DAR dispatcher having the Foothill
fixed-route schedule on hand. There was no need for complex operat-
ing agreements, protocols, AVL, e-mail, and automated messaging
for such a simple task. In an exit interview, the researchers 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 coopera-
tive action. This would be the correct environment for applications
of advanced technology.

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