SWIFT

Seattle Wide-area Information For Travelers

Deployment Cost Study

Contract Number: WSDOT Y-5908

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EXECUTIVE SUMMARY

The Seattle Wide-area Information For Travelers (SWIFT) project was a highly successful Intelligent Transportation System (ITS) Field Operational Test (FOT) that was conducted over a four-year period from 1993 to 1997. The purpose of the project was to test the efficacy of a High Speed Data System (HSDS), or FM Sub-carrier, to disseminate incident, bus and speed/congestion information via three different end-user devices: pager watch, portable computer and in-vehicle navigation device. Six hundred ninety (690) commuters, many with route- or mode-choice options, participated in the FOT and provided user-acceptance evaluations. Other evaluation components examined the system architecture, communications coverage, institutional issues, and consumer acceptance.

The primary purpose of the *SWIFT Deployment Cost Study* was to provide an independent Life Cycle Cost Estimate (LCCE) of an operational and fully deployed SWIFT system. Moreover, it is intended to provide both the SWIFT participants and the FHWA with a measure of the commercial viability of "SWIFT-like" systems nationwide. Table ES-1 shows the organizations that were included in the *SWIFT Deployment Cost Study* LCCE and commercial viability analysis.

Table ES-1. Deployed SWIFT Participants (Cost/Revenue Participants).

Industry	Government/Institutional
• Seiko Communications Systems, Inc. (SCS) • Metro Networks • Etak, Inc. • IBM (FOT Development Only) • Delco Electronics (FOT Development Only)	• King County Metro Transit • University of Washington (UW)

The methodology for the *SWIFT Deployment Cost Study* LCCE relied on standard proven cost estimation and data collection and analysis techniques to provide cost estimates for each SWIFT participant shown above across the following three life-cycle phases:

1) FOT development (costs of current SWIFT Test)
2) Commercial Development (additional development and procurement costs for fully deploying an operational SWIFT system (follows the completion of the SWIFT test)
3) Annual Commercial Operations (annual operations costs for a fully deployed SWIFT system)

A summary of the resulting life cycle cost estimate (LCCE) for the deployed SWIFT system is presented in Table ES-2. Here, the FOT Development phase (based on SWIFT test actuals) was estimated to cost $6.4 Million, the Commercial Development phase was estimated to cost $1.5 Million, and the Annual Commercial Operations costs were estimated to be $0.8 Million.

Table ES-2. SWIFT LCCE Summary.

Participant	FOT Development				Commercial Development				Annual Commercial Operations				Life Cycle Cost (5 years of Ops.)			
	Hours	Labor	ODC's	Total	Hours	Labor	ODC's	Total	Hours	Labor	ODC's	Total	Hours	Labor	ODC's	Total
SCS	19,137	$1,605K	$500K	$2,105K	1.005	$64K	$82K	$147K	804	$51K	$66K	$117K	24,162	$1,926K	$911K	$2,837K
Metro Networks	4,348	$264K	$320K	$584K	8,249	$493K	$11K	$504K	6,188	$370K	$2K	$371K	43,536	$2,604K	$340K	$2,944K
Etak	7,760	$639K	$248K	$887K	3,840	$254K	$0K	$254K	1,920	$134K	$0K	$134K	21,200	$1,565K	$248K	$1,813K
UW	32,136	$857K	$220K	$1,077K	10,998	$442K	$81K	$522K	1,922	$105K	$30K	$135K	52,741	$1,822K	$450K	$2,272K
Metro Transit	1,751	$73K	$2K	$75K	2,060	$86K	$0K	$86K	1,545	$65K	$0K	$65K	11,536	$483K	$2K	$485K
IBM	5,123	$342K	$194K	$536K	0	$0K	$0K	$0K	0	$0K	$0K	$0K	5,123	$342K	$194K	$536K
Delco	14,101	$750K	$344K	$1,093K	0	$0K	$0K	$0K	0	$0K	$0K	$0K	14,101	$750K	$344K	$1,093K
TOTAL	84,356	$4,529K	$1,828K	$6,357K	26,151	$1,339K	$174K	$1,513K	12,379	$725K	$97K	$822K	172,401	$9,493K	$2,488K	$11,981K

As shown in Figure ES-1, when viewed across the life cycle time period (1995-2003), the cost estimate followed the expected traditional life cycle curve of high initial development costs tapering down to lower annual operations costs as the years progressed – this was true for both labor and ODC's.

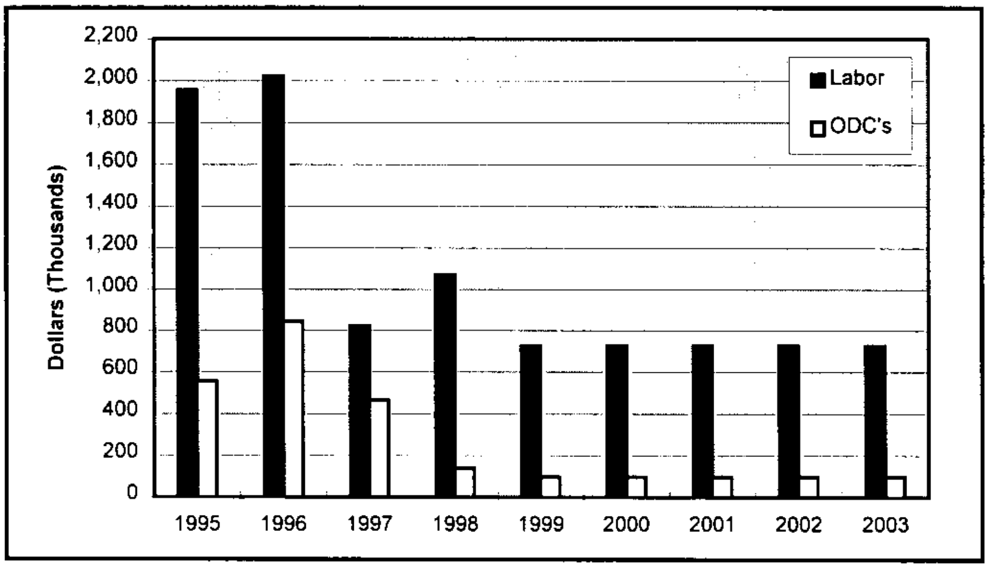

Figure ES-1. SWIFT LCCE Overview by Life Cycle Phase Total Cost.

As can been in Figure ES-2, as the life cycle progressed from the FOT Development phase to Commercial Deployment and then to Commercial Operations, the SWIFT team member's role and their share in the effort changed significantly, with SCS providing for the largest share of costs (for hardware and software development tasks) in the FOT Development phase, and Metro networks providing for the largest share of costs (for SWIFT TWS operations) by the Commercial Operations phase.

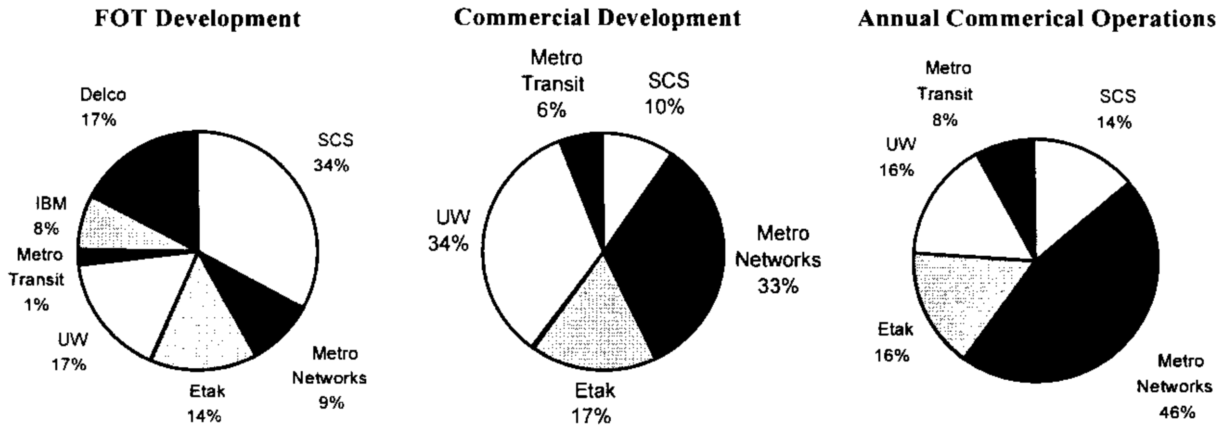

Figure ES-2. LCCE Overview by SWIFT Participant Share.

A summary of the methodology for the *SWIFT Deployment Cost Study* commercial viability analysis (CVA) is presented in Figure ES-3. This methodology was largely focused on developing consumer market penetration estimates for SWIFT user subscription. The methodology incorporated "willingness to pay" results from SWIFT user surveys conducted in the *SWIFT Consumer Acceptance Study.* The methodology results in a comparison of an estimate for annual SWIFT revenues with the Annual Operations cost estimate from the LCCE above.

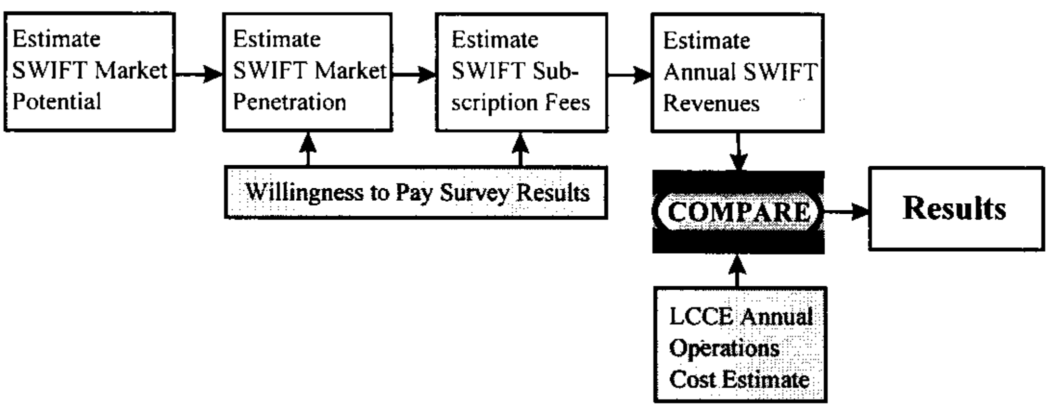

Figure ES-3. SWIFT Deployment Cost Study CVA Methodology.

As shown below in Figure ES-4, the commercial viability analysis (CVA) found that a deployed SWIFT can be expected be a viable commercial enterprise. Even under the most conservative market penetration scenario, the CVA analysis still showed that annual revenues exceeded annual operations costs by a factor of more than 3 to 1. This provides the result that in terms of operations, and noting the assumptions and calculations made in this report, that a fully deployed SWIFT system as defined in this study would have a high likelihood of being commercially viable.

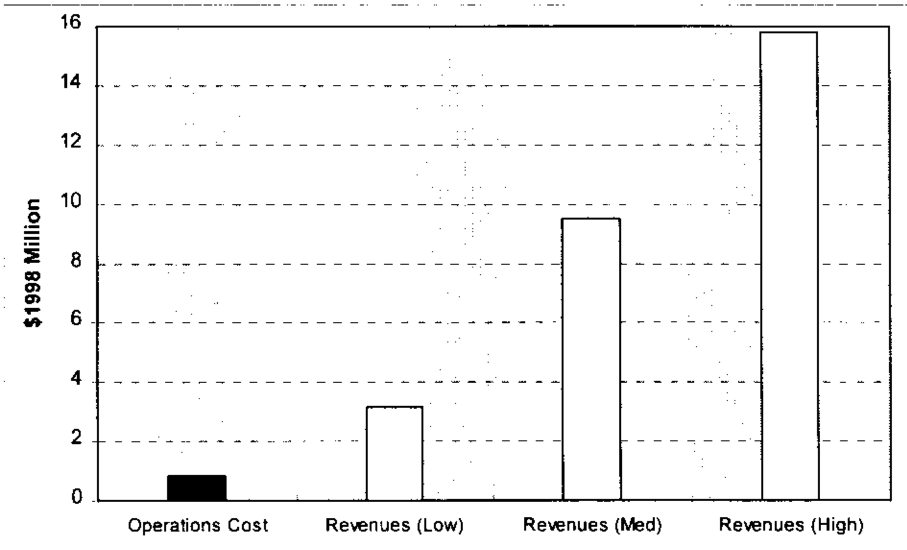

Figure ES-4. SWIFT CVA Results Summary.

Based on the results of the CVA, it would seem that if the deployed SWIFT were addressed as an investment opportunity, that it would have been seen as a reasonable investment. Moreover, based on the most conservative market penetration scenario (annual revenues of $3.1M), and assuming a bank corporate loan rate of 6%, if the entire SWIFT development cost of $7.9 had been financed by a loan from an investment bank, then the "payback period" on the loan (i.e., the "break-even" point on the investment) would be about 4½ years. This lies within the typical "5 year return on investment" that many large companies use to analyze potential investment projects. Note that after the 4½ year point, the deployed SWIFT Team members under this scenario would divide approximately $2.3M annually in profits!

Conclusions of the *SWIFT Deployment Cost Study* were largely focused on application of the results to other potential metropolitan areas. Specifically, in developing SWIFT as a commercial enterprise in other metropolitan areas where SCS operates an HSDS and Metro Networks/Etak are involved, dramatic savings should be realized in the development costs of a SWIFT-like system:

- SCS and Metro Networks/Etak would apply results (e.g., the expertise, software, and the hardware designs) of the SWIFT deployment (i.e. a substantial reduction in the "learning curve")
- A much shorter test period would likely be required (i.e., "validated" SWIFT technologies would be used)

- The lack of government oversight could facilitate reductions in labor costs -- according to Metro Networks SWIFT Project Manager Joan Ravier: "Some projects we're involved with would be a lot cheaper to run if we were doing them for ourselves, because following government procedure requires us to do all kinds of things we wouldn't do normally."[1]

In terms of "lessons learned," the potential development of SWIFT-like ATIS systems as commercial ventures in other metropolitan areas where different commercial enterprises would implement a similar system, the following should be considered:

- The deployment of an FM-subcarrier ATIS in other cities may require the expenditure of up-front "infrastructure" costs (i.e., costs associated with developing the required HSDS hardware and software and integrating it with available FM radio stations)
- Significant FM-subcarrier ATIS deployment costs are likely to be encountered during the development phase, where software development, integration and test costs are incurred
- Operations costs for FM-subcarrier ATIS projects should be fairly stable, and will center on the human element of managing and inputing traffic information into the ATIS system (eg., Metro Networks TWS operators)
- Successful commercial deployment of FM-subcarrier ATIS projects should be based upon the development of sound market-penetration scenarios
- Future ITS public-private joint ventures should stipulate in their teaming agreements that the private-sector partners will provide full details of their development costs to the evaluation team, with appropriate non-disclosure agreements set up as required.
- Future ITS public-private joint ventures should stipulate in their teaming agreement that all costs will be invoiced according to an activity-based Work Breakdown Structure (WBS) of at least three (3) levels of detail for each Team Member in order to allow costs to be tracked by activity throughout the project.

[1] Nancy Johnson and Christina Steffy, "What will it Take to Create a Profitable Business in the Market for In-Vehicle ITS Systems and Services," ITS World, September/October 1997, p. 39.

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1. INTRODUCTION

The United States (U. S.) Congress passed the Inter-modal Surface Transportation Efficiency Act (ISTEA) in 1991. The purpose of this legislation was to re-invigorate the country's transportation infrastructure by providing needed repairs to the highway system, encouraging the development of inter-modal transportation facilities and applying information technology (IT) solutions to transportation problems.

The Intelligent Transportation Systems (ITS) initiative grew out of ISTEA's interests to apply IT solutions to transportation problems. Specifically, the U. S. Department of Transportation (USDOT) developed the *National Program Plan for ITS* (1994) in order to guide the deployment of ITS around the country. The goals of the USDOT ITS program are to:

- Improve the safety of surface transportation
- Increase the capacity and operational efficiency of the surface transportation system
- Enhance personal mobility and the convenience and comfort of the surface transportation system
- Reduce the environmental and energy impacts of surface transportation
- Enhance the present and future productivity of individuals, organizations and the economy as a whole
- Create an environment in which ITS can flourish

Operational tests present opportunities to develop, deploy and evaluate specific implementations of ITS. According to the Federal Highway Administration (FHWA) document, *Generic ITS Operational Test Guidelines* (1993), prepared by The MITRE Corporation, an ITS Field Operational Test (FOT) is a "joint public/private venture, conducted in the real world under live transportation conditions..." that "...serve[s] as [a] transition between Research and Development (R&D) and the full-scale deployment of [ITS] technologies." Thus, FOTs represent a significant step in accelerating the deployment of ITS in North America.

Conducting FOTs results in feedback from the public regarding the viability and perceived usefulness of a specific ITS implementation. This information can be used by the public and private organizations involved to determine the best approach toward full-scale implementation after the FOT is completed. Also, lessons are learned during the conduct of an FOT that will enable the Federal, State and Local governments in partnership with industry and non-profit, academic institutions to bear, conceive, design, develop and deploy an ITS that provides the best possible services to the traveling public.

1.1. SWIFT Project

On September 8, 1993, the Federal Highway Administration (FHWA) published a request for ITS FOTs. The concept for the SWIFT project was submitted in response to this request on January 6, 1994 by the SWIFT Project Team. The SWIFT Project Team proposed to partner with the FHWA to perform an operational test of a wide-area ITS communications system in the

Seattle area. The proposed system incorporated a flexible FM sub-carrier High Speed Data System (HSDS) that had been developed and commercially deployed in the Seattle area by one of the SWIFT Project Team members. The HSDS would be used to transmit traveler information to three receiving devices provided by other SWIFT Project Team members. It was anticipated that the SWIFT Operational Test would provide valuable information regarding the viability of these devices for traveler information systems. SWIFT Project Team members included:

- Delco Electronics Corp., a subsidiary of General Motors Corporation (Delco)
- Etak, Inc. (Etak)
- Federal Highway Administration (FHWA)
- International Business Machines, Inc. (IBM)
- King County Department of Metropolitan Services (Metro Transit)
- Metro Traffic Control, Inc. (Metro Traffic Control)
- Seiko Communications Systems, Inc. (Seiko)
- Washington State Department of Transportation (WSDOT).

On April 6, 1994, the SWIFT proposal was accepted by the FHWA contingent upon the filing of a signed Memorandum of Understanding (MOU) by all SWIFT Project Team members and a Teaming Agreement between the Washington State Department of Transportation (WSDOT) and the FHWA. The SWIFT MOU was signed on October 18, 1998 and the SWIFT Teaming Agreement was completed on January 10, 1995. Following the fulfillment of these requirements by the SWIFT project team, construction of the SWIFT system was initiated.

In addition to guiding the signing of the SWIFT MOU and Teaming Agreements, WSDOT also negotiated separate contracts with the University of Washington (UW) and Science Applications International Corporation (SAIC) to participate in the SWIFT project. The University of Washington was retained to provide data gathering and fusion services for the project, while SAIC was retained as the independent evaluator. In this regard, SAIC signed their contract with WSDOT on September 13, 1994 and UW on November 17, 1994.

As part of the their contract with WSDOT, the University of Washington also developed and demonstrated a dynamic ride-share matching system called Seattle Smart Traveler (SST). SST used the UW Intranet to match ride requests with drivers. Participants registered and requested/offered rides using a web-like page, and riders would be notified of pending rides by email. The project also used 65 SWIFT Seiko MessageWatchs, or pagers, to let riders know where to call to set up a ride. These SST users also participated in SWIFT and received traffic incidents and general information messages. A separate evaluation of SST was conducted by the Texas Transportation Institute and, thus, the SWIFT evaluation did not address the SST project.

1.2. SWIFT System Description

An overview of the SWIFT system is shown in Figure 1-1, while Table 1-1 lists the primary types of information that were delivered by SWIFT. Each SWIFT receiving device regularly scanned the FM airwaves to identify, retrieve and display the information/messages intended for it.

The SWIFT system was divided into five (5) data components:

- Generation— gathering of the information to be transmitted
- Processing— formatting of the information to be transmitted
- Transmission— broadcast of the information to travelers
- Reception— receipt of the transmitted information by SWIFT devices
- Interpretation— use of the transmitted information by operational test participants.

Each of these are described in the following sections.

Table 1-1. Information Delivered by SWIFT.

Device/Information Received	Traffic Incidents, Advisories, Scheduled Events and Road Closures	Route Guidance	Traveler-Service Information	Freeway Loop-Sensor Information	Bus Locations and Schedules	Time and Date, Personal Paging and General Information Messages
Seiko MessageWatch	Yes	--	--	--	--	Yes
Delco In-vehicle Navigation Device	Yes	Yes	Yes	--	--	Yes
SWIFT Portable Computer	Yes	--	Yes	Yes	Yes	Yes

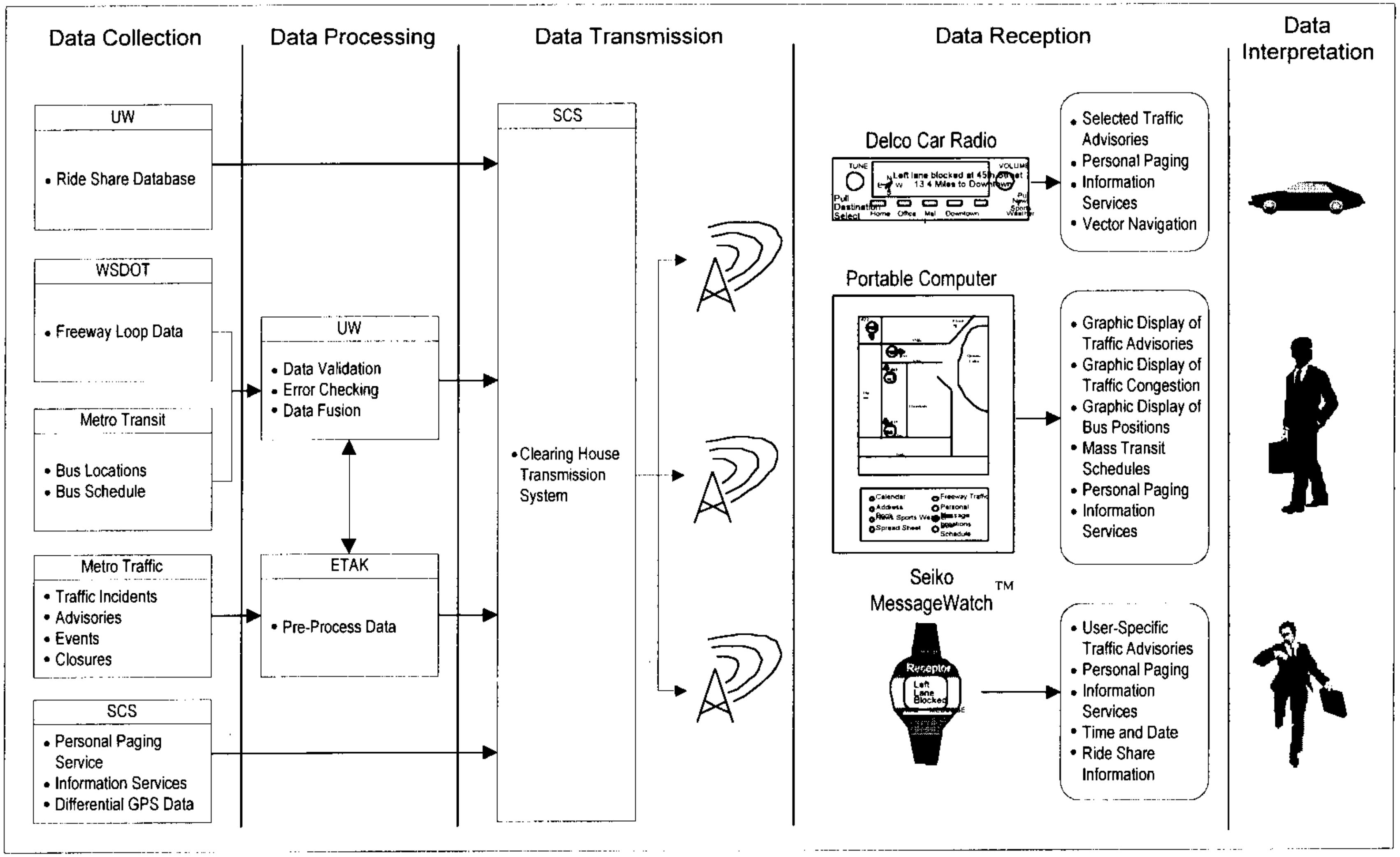

Figure 1-1. SWIFT System Description.

1.2.1. Generation

Table 1-2 provides a listing of the information that was provided to SWIFT FOT participants. This information was generated by Metro Traffic Control, Etak, Delco, WSDOT, Metro Transit and Seiko.

Table 1-2. SWIFT Data Generation.

Data Generator	Data Generated
Metro Traffic Control, Inc.	Traffic Incidents, Advisories, Scheduled Events and Closures
Delco and Etak	Route Guidance
Etak	Traveler-Service Information
WSDOT	Freeway Loop-Sensor Information
Metro Transit	Bus Locations and Schedules
Seiko Communications Systems, Inc.	Time and Date, Personal Paging and General Information Messages

Traffic Incidents, Advisories, Scheduled Events and Closures

This information was generated by Metro Traffic Control personnel who routinely compiled incident information for use in traffic reports delivered to several Seattle-area radio stations. Information, consistent with the International Traveler Information Interchange Standard (ITIS), was entered into a Traffic Work Station (TWS) developed by Etak, Inc. The TWS located the incident and the operator added descriptive information about the incident, such as "truck overturned" or "right lane closed." The TWS then formatted the message for transmission and forwarded it to Seiko.

Route Guidance

As part of the in-vehicle device they developed for the SWIFT project, Delco supplied a route-guidance system that assisted local drivers by providing a directional pointer to pre-selected destinations. This system incorporated a Global Positioning System (GPS) antenna that was placed on the roof of the SWIFT FOT participant's vehicles that participated in this portion of the test, and was tied into a Geographic Information System (GIS) that Etak supplied. Users would select destinations from an "Etak Guide" which contained the latter's geographic coordinates. Users could also enter latitude/longitude coordinates as destinations, save the current positions of their vehicles as destinations and select to receive estimated time of arrival (ETA) information based upon the current speed of their vehicles. The route guidance provided by the directional pointer was static— no turn-by-turn directions were provided, only an arrow pointing in the direction the driver needed to go to reach the destination.

Traveler-Service Information

As indicated, the in-vehicle device for SWIFT provided traveler-service information (i.e., Etak Guide) to its users. This same information was also presented as a "Yellow Pages" directory on the SWIFT portable computers. Users could select the name of local-area businesses or organization by category (e.g., service stations, restaurants, colleges and universities, tourist destinations, etc.) and receive a display of the appropriate address and telephone number in order to guide their travel. Portable computer users could also select to have the locations of their selections presented on the map of Seattle that accompanied the SWIFT application.

Freeway Loop-Sensor Information

Traffic congestion information was derived from the existing WSDOT freeway management system in Seattle. Vehicles were detected with a network of 2,200 standard traffic loops, and UW used the loop information to estimate speeds, which were then expressed as a percentage of the posted speed limit. The speed information was compared to freeway bus speeds to detect any errors. Congestion information was then packaged into a format that could be directly transmitted and sent to Seiko via the Internet.

Bus Locations and Schedules

Bus location and schedule information was provided by King County Metro Transit. Their Automatic Vehicle Location (AVL) system uses small roadside transmitters, wheel (distance) sensors and pattern matching to locate buses in the system. Each location was updated about once every minute and a half. Raw data from Metro Transit's system were sent to UW, where each coach location was converted into latitude and longitude. The UW then generated all of the information including the route and trip number into a format ready for transmission, which was sent to Seiko via the Internet. The SWIFT project included all the fixed routes that Metro Transit operates, or up to 900 buses during peak periods.

Time and Date, Personal Paging and General Information Messages

All SWIFT devices also received and displayed information services currently available to Seiko MessageWatch customers. These included time and date, weather reports, financial-market summaries, sports scores, ski reports and lotto numbers. All SWIFT devices could also function as a personal pager.

1.2.2. Processing

Data generated by WSDOT, Metro Transit, and UW were collated at UW, where it was validated, converted, corrected and fused. Once these activities had taken place, the data were processed into standardized data packets in order to facilitate ultimate transmission over the HSDS. Information provided by Metro Traffic Control was preprocessed on the TWS. All data from UW and Metro Traffic Control were transmitted to Seiko via the Internet.

1.2.3. Transmission

SWIFT data transmission involved sending the processed data to Seiko which formatted the data packets for transmission over the HSDS transmission network. Once formatted by Seiko, the data were transmitted over an FM subcarrier at a rate of 19,000 bytes per second (19 Kbps). In order to increase the certainty of reception by Seiko MessageWatches, double-level error correction and multiple transmissions were used. Otherwise, asynchronous (or broadcast) message sent to the Delco in-vehicle navigation device and the portable computers were sent only once.

Seiko High Speed Data System

The SWIFT project was based upon the HSDS that is currently used to deliver paging and information services to Seiko MessageWatch customers. The HSDS signal is added to standard FM broadcast transmissions in the form of digital data modulated at a frequency 66.5 khz higher than the standard, or "nominal," FM audio signal. No portion of an FM signal, audio or otherwise, is broadcast below the nominal frequency. FM radio signals are usually broadcast in three frequency groups between the nominal frequency and 55 khz above this frequency. Thus, the SWIFT HSDS signal was presented at a frequency that did not interfere with nominal, or standard FM audio, transmissions.

SWIFT HSDS receivers were "frequency agile," which means they could receive messages from any HSDS-equipped FM station. Seven Seattle-area radio stations transmitted the HSDS protocol to SWIFT devices. Consequently, information was sent from all stations in the area which nearly guaranteed reception of important paging messages.

SWIFT information was transmitted three times (once every 1.87 minutes) from each station for the Seiko MessageWatch. Otherwise, for the portable computers and Delco in-vehicle navigation device, congestion information was transmitted every 20 seconds, incident information every 30 seconds and bus information every 90 seconds. This feature of the Seiko HSDS provided information redundancy which further ensured that SWIFT FOT participants were receiving the most current information provided by their receiving device.

SWIFT Message Formats

All SWIFT information was encoded into a version of the International Traveler Information System (ITIS) message-formatting convention. The North American version of ITIS, which was developed by the Enterprise group, is based on message formats used by the European Radio Broadcast Data System (RBDS). The ITIS codes conserve bandwidth by sending incident and congestion information in a compact form. Some customization of the ITIS formats was necessary for SWIFT in order to adjust for HSDS packet size, which is longer than the RBDS packet. Message formats were also developed to send the SWIFT bus location and speed/congestion data, which are not available in the RBDS.

SWIFT traffic-incident information received by the Delco in-vehicle navigation device was integrated with Global Position System (GPS) location and time/date information received by the same device. The latter capability provided the incident-direction/distance information and the current time of day information presented by the Delco in-vehicle navigation device.

Information transmitted to the three receiving devices used in the SWIFT project is presented below:

- Seiko MessageWatch— incident type/direction, roadway affected and closest intersection. Example: A level 3 incident (i.e., accident) on Southbound I-5 is located near the Mercer intersection.
- Delco In-vehicle Navigation Device— incident type/direction, description, roadway/intersection affected, duration and vehicle-reference (in miles) description. Example: An accident blocking the two outside lanes of Northbound I-5, expected to last for the next 15 minutes, is located 16 miles to the Northwest.
- SWIFT Portable Computer— icon display/text description (including incident type, roadway affected, direction, closest intersection, backup and duration) of incidents, icon display of real-time bus position, timepoint schedule information, icon display of speed information (i.e., closed, 0-19, 20-34, 35-49, 50+ and no data) and speed icon location description. Example: Vehicles are traveling at 50% of normal speed at the Mercer speed sensor.

1.2.4. Reception

Three types of HSDS-capable receiver devices, each developed and manufactured by private entities through consultation with their SWIFT team members, provided SWIFT FOT participants with incident information, traffic speed/congestion information, bus information, informational messages (e.g., forecast weather, sports scores, stock-market information) and personal pages, depending upon the device. The devices were:

- Seiko MessageWatch
- Delco In-Vehicle Navigation Device
- SWIFT Portable Computer

Figures 1-2, 1-3 and 1-4 show examples of the three receiving devices used for SWIFT. Operational features of each of these devices are described in the following sections.

Seiko MessageWatch

These devices are commercially available and widely used in the Seattle area to deliver personal-paging services and "information service" messages. Current information-service messages include weather forecasts, financial market summaries, local sports scores and winning lotto numbers. SWIFT traffic messages were featured as an added information service.

SWIFT test participants who used the Seiko MessageWatch supplied information to the Evaluator about the usual routes, directions, days and times of the day they traveled. Traffic messages indicating the location and severity of traffic problems that the user might encounter were sent based on the resulting travel profile. Because the Seiko MessageWatch stored eight messages, only traffic problems that resulted in a substantial delays were sent.

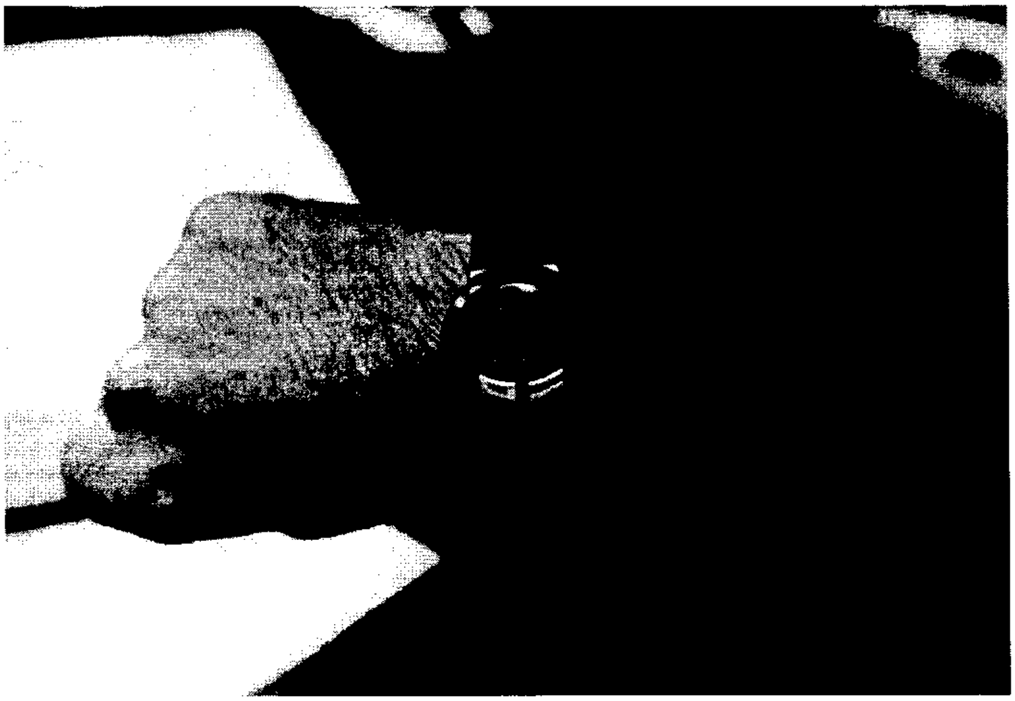

Figure 1-2. Seiko MessageWatch.

Delco In-Vehicle Navigation Device

This device incorporated a route-guidance component, GIS, GPS receiver and the speakers of a radio/compact disc player to present real-time traffic information to users. The whole package was placed into one of four vehicle types: 1995 or newer Buick Regals, Oldsmobile Cutlass Supremes and Saturns, and GMC Rally Vans.

The Delco device included the capability to select destinations from a "Yellow Pages" directory of local landmarks, hotels, restaurants, businesses and street corners selected by the user. The GPS provided the current location of the vehicle and a directional display associated with the route guidance system indicated the direction (relative to the vehicle) and distance to the selected destination. The stereo speakers were used to announce received messages.

Real-time traffic-incident information was transmitted over the Seiko HSDS. The HSDS receiver was built into the Delco in-vehicle navigation unit filtered out any messages that were outside a pre-defined distance (e.g., 20 miles) from the current location of the vehicle. The navigation unit also decoded upon demand the SWIFT traffic messages from text into a "voice" that provided incident details to the driver. Although messages were retransmitted every minute, only new or modified messages were announced to the driver.

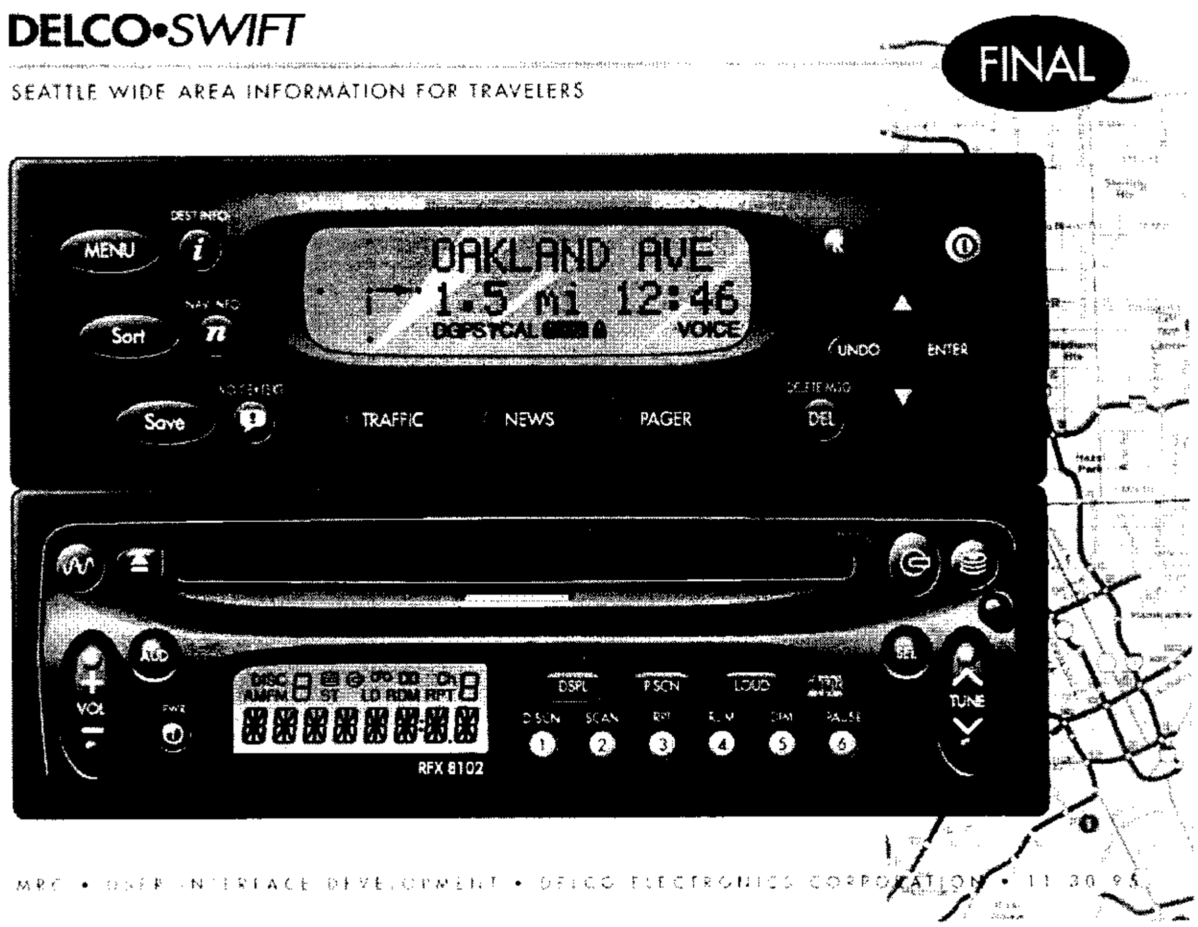

Figure 1-3. Delco In-vehicle Navigation Device.

SWIFT Portable Computer

The SWIFT project primarily used IBM Thinkpad and Toshiba Satellite portable computers. Some Dauphin sub-notebook computers were distributed before they were discontinued due to negative user feedback. The Thinkpads were 486 machines, used Windows 3.1, had a built-in, "butterfly" keyboard and presented information on an active matrix, SVGA color display. The Satellites were Pentium 100 machines, used Windows 95 and also presented information on SVGA color displays.

A separate HSDS receiver unit was attached to the SWIFT portable computer's serial port. This unit had approximately the same footprint as the portable computer and was often attached to the portable computer via Velcro tape. Primary SWIFT information presented on the portable computer included real-time traffic incident, speed/congestion and bus-location information.

All of the traveler information for SWIFT portable computers was displayed using Etak Geographical Information System (GIS) software to show the location of each piece of data. The software allowed the user to select the type(s) of information (i.e., traffic incident, speed/congestion or transit-vehicle location) to be displayed on a map of Seattle. A "Yellow Pages" directory was also installed and linked to the GIS software to show the location of a selected business or point of interest. SWIFT portable computers also offered transit schedule information from static database tables inside the computer.

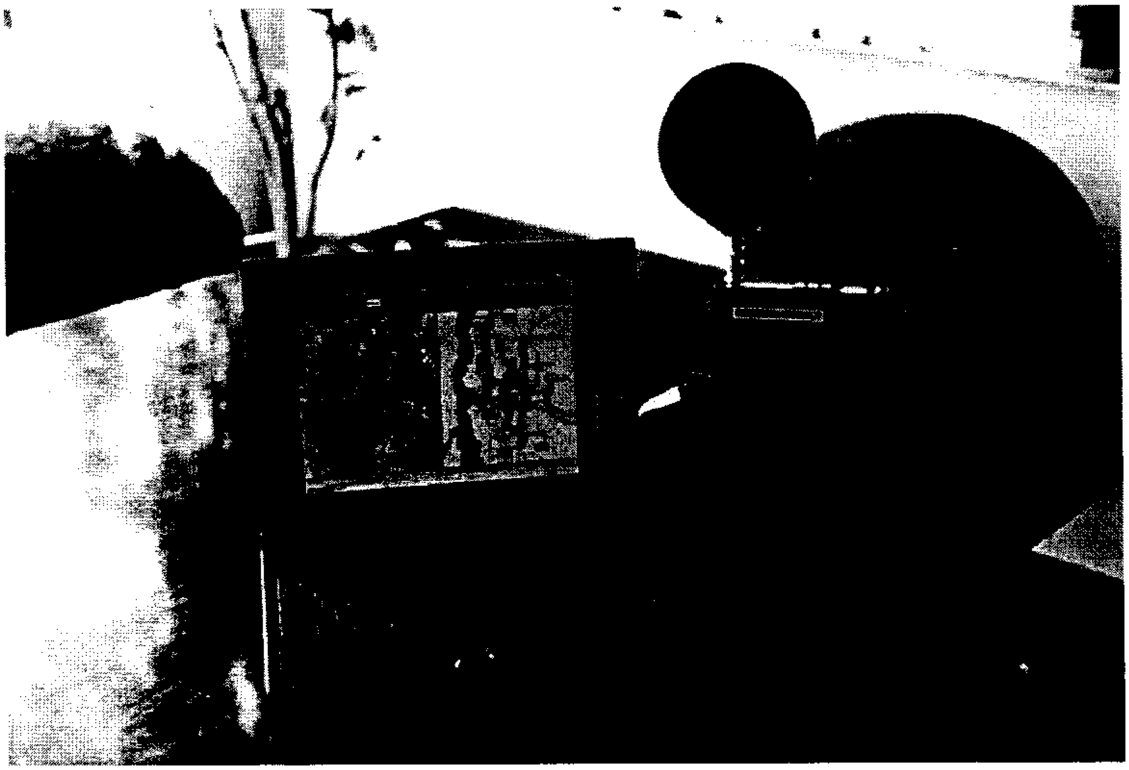

Figure 1-4. SWIFT Portable Computer and RRM.

1.2.5. Data Interpretation

The data interpretation portion of the SWIFT system involved hypothesized processes that affected how users were able to interact with the system. Among those user perceptions that were addressed were the following:

- Data Reception— whether SWIFT information was received
- Data Timeliness— whether SWIFT information was received in a timely fashion
- Data Reliability— whether SWIFT information was regularly received
- Data Display— whether SWIFT information was displayed appropriately
- Data Fidelity— whether SWIFT information was accurate
- Data Validity— whether SWIFT information affected travel behavior.

1.3. SWIFT Field Operational Test Evaluation

Once the SWIFT system was completed, an FOT was conducted with approximately 690 users who were recruited from the community in order to assess the system. With the majority of the SWIFT system completed by June 30, 1996, the SWIFT FOT evaluation was conducted from July 1, 1996 through September 20, 1997. The goals of the SWIFT FOT evaluation, listed in order of priority, were to evaluate:

1. *Consumer Acceptance, Willingness to Pay and Potential Impact on the Transportation System* – determine user perceptions of the usefulness of the SWIFT receiving devices, how much consumers would be willing to pay for such devices and services and assess how SWIFT-induced changes in users' driving behavior might impact the Seattle transportation network if the SWIFT system was fully deployed.
2. *Effectiveness of the HSDS Transmission Network* – determine how well the SWIFT HSDS communications system functions.
3. *Performance of the System Architecture* – determine how well the various SWIFT components work singularly and together.
4. *Institutional Issues That Affected the Operational Test* – identify how institutional factors associated with the SWIFT public-private partnership affected the FOT, with emphasis on implications for deployment.
5. *Deployment Costs* – estimate how much money it would take to deploy and maintain a SWIFT-like system.

Five evaluation studies were conducted as part of the SWIFT FOT evaluation. These studies paralleled the five SWIFT FOT evaluation goals and were implemented at various times during the 15-month test. Table 1-3 provides a summary of SWIFT evaluation information.

Table 1-3. SWIFT Evaluation Information.

Study/ Activity	Study Leader	Test Plan Completion Date	Primary Data Collection Periods	Primary Data Collection Methods	Final Report Completion
Consumer Acceptance	Jeff Trombly	August 19, 1997	Spring, Summer and Fall, 1997	Questionnaires, Telephone Surveys, Focus Groups	March 31, 1998
Communications	Jim Murphy	August 19, 1997	Fall, 1997	Field Tests	June 29, 1998
Architecture	Hesham Rakha	August 19, 1997	Spring, 1997	Data logging and Field Tests	March 31, 1998
Deployment Cost	Mark Jensen	August 19, 1997	Summer, 1997	Data Collection	March 31, 1998
Institutional Issues	Bruce Wetherby, Principal Investigator	August 19, 1997	Spring and Fall, 1997	Questionnaires and Semi-structured Interviews	March 31, 1998

As part of the conduct of the SWIFT FOT evaluation, the Evaluator was responsible for user recruitment. This involved the recruitment of approximately 1,200 individuals before selection of the 690 FOT participants was made. The final breakout of SWIFT participants is shown in Table 1-4.

Table 1-4. SWIFT Participant Breakout.

Device/Condition	Existing	New	Metro Transit Van Pool	SST	Total
Seiko MessageWatch	50	400	--	70	520
Delco In-vehicle Navigation Device	--	65	25	--	90
Portable Computer	--	80	--	--	80
Total	50	545	25	70	690

Selection criteria for each category of SWIFT user varied, primarily depending upon the assumed operational requirements for each device type. As a result, three types of Seiko MessageWatch users (i.e., existing [i.e., those who owned their own watches], new [i.e., those who were given a Seiko MessageWatch for the first time] and SST [i.e., those who participated in the SST program] and two types of Delco in-vehicle navigation device users (i.e., new [i.e., SOV commuters] and Metro Transit Van Pool [i.e., HOV commuters] were recruited. The majority of the eighty (80) SWIFT portable computer users were bus riders with mode-choice options.

The SWIFT FOT Evaluator was also responsible for the following activities:

- Device configuration/software installation
- Device distribution/installation scheduling
- Training/instruction on device usage
- Travel profile entry/maintenance
- SWIFT Help Desk
- User problem analysis/feedback to team members
- Device collection/de-installation
- SWIFT newsletter (writing, publication and mailing; WSDOT responsible for editing and breadboarding)

1.4. Purpose of SWIFT Deployment Cost Study

The overriding purpose of the *Deployment Cost Study* is to provide an independent Life Cycle Cost Estimate (LCCE) of an operational and fully deployed SWIFT system. Moreover, it is intended to provide both the SWIFT participants and the FHWA with a measure of the commercial viability of "SWIFT-like" systems nationwide.

1.5. Objectives

As shown in Table 1-5, the following four evaluation objectives were identified for the *Deployment Cost Study*.

Table 1-5. Objectives of the SWIFT Deployment Cost Study.

Objective
1. Collect relevant cost and pricing data from SWIFT participants (industry & government/institutional) and member vendors
2. Collect relevant cost data on analogous systems and system elements nationwide
3. Develop a LCCE for a fully deployed SWIFT system (recurring and non-recurring costs)
4. Evaluate the commercial viability of a fully deployed SWIFT System

2. METHODOLOGY

The following sections describe the *SWIFT Deployment Cost Study* methodology. This methodology is based on the December 1996 SWIFT *Deployment Cost Study Final Test Plan*[2], with minor modifications as noted. Results of the application of this methodology are presented in Section 3.

Before examining the methods and technical approaches for achieving each of the four *SWIFT Deployment Cost Study* objectives outlined in Section 1, it is first necessary to provide some definition concerning the context and the participants that would make up a credible scenario for a fully deployed SWIFT system.

As shown below in Table 2-1, a fully deployed SWIFT system is defined here to consist of three "life cycle" phases. The *FOT Development* phase is the recently completed SWIFT test, funded by FHWA, WSDOT, and by SWIFT commercial participant matching funds. The *Commercial Development Phase* consists of the current period in which the SWIFT participants continue to operate portions of the SWIFT system, and in which some of the participants are pursuing additional development/refinement of SWIFT systems to support a future operational deployment. The *Annual Commercial Operations* phase consists of the recurring operations activities (costed yearly) for a fully deployed system starting on 1 January 1999. Where necessary for cost estimation purposes, an operations period of five years is assumed in order to bound this analysis.

Table 2-1. Deployed SWIFT System Life Cycle.

Life Cycle Phase	Time Period
FOT Development (SWIFT Test)	1 Jan 1995 to 30 Sep 1997
Commercial Development	1 Oct 1997 to 31 Dec 1998
Annual Commercial Operations	Yearly, Beginning 1/1/99

The SWIFT participants who are assumed in this analysis to be the financial stakeholders in a future operational deployment and subsequent operation of the SWIFT system in the Seattle Metropolitan Area are shown in Table 2-2. Note that it is assumed here that IBM and Delco Electronics will not be involved in the commercial development and operations phases of a deployed SWIFT.[3]

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[2] Mark Jensen, "SWIFT Deployment Cost Study Final Test Plan," SAIC, prepared for the Washington State Department of Transportation, December 16, 1996.

[3] IBM's involvement was limited to initial software development and modeling activities which have now been subsumed by Etak and UW; Delco developed a prototype traveler information car radio/navigation unit for the SWIFT test, and while Delco (and other potential suppliers) may choose to develop a production version of this device for SWIFT, it will be considered a separate product from the SWIFT system.

Table 2-2. Deployed SWIFT Participants (Cost/Revenue Participants).

Industry	Government/Institutional
• Seiko Communications Systems, Inc. (SCS) • Metro Networks • Etak, Inc. • IBM (FOT Development Only) • Delco Electronics (FOT Development Only)	• King County Metro Transit • University of Washington (UW) (All Government/institutional SWIFT team members were contractually responsible to WSDOT for their activities.)

While two of the deployed SWIFT participants are "government/institutional" entities (UW & KCMT), for the purposes of this analysis, they are treated as full business partners with the commercial participants, and it is assumed that they will share in both costs and revenues.

2.1. LCCE Methodology

2.1.1. Methodology Overview

Figure 2-1 provides a composite overview of the Life Cycle Cost Estimate (LCCE) methodology used in the *SWIFT Deployment Cost Study*. Each of the elements of this methodology, along with the technical approaches to the first three study objectives, are addressed in detail in the sections below.

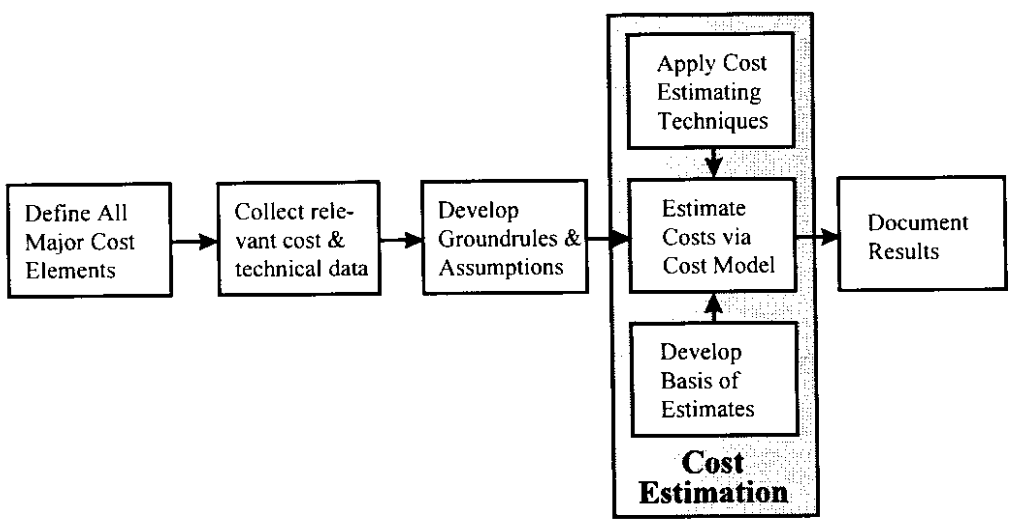

Figure 2-1. SWIFT Deployment Cost Study LCCE Methodology.

2.1.2. Definition of Major Cost Elements

In order to develop this analysis, it was first necessary to outline major cost categories for each deployed SWIFT participant in terms of non-recurring costs, recurring costs and revenues. In this regard, Table 2-3 provides an overview of the major cost categories by participant.

Table 2-3. Deployed SWIFT Major Cost Elements.

Non-Recurring Costs	Recurring Costs	Revenues
• SCS HSDS SWIFT Integration and SWIFT Equipment Development & Testing • Metro Networks TWS Hardware Development & Testing • ETAK SWIFT TWS Software Development & Testing • UW Hardware and Software Development & Testing • Metro Transit Software Development & Testing • IBM PC/PDA Equipment & Software Development &Testing • Delco SWIFT Car Navigation Radio Development & Testing	• SCS SWIFT System Operations & HSDS Leasing • Metro Networks SWIFT TWS Operations • ETAK SWIFT Software Support • UW SWIFT System Support • Metro Transit Service Updates	• SCS Message Watch SWIFT Subscription Prices • PC/PDA-based SWIFT Subscription Prices • Car Navigation Radio SWIFT Subscription Prices

Here, non-recurring costs are defined as "one-time" costs that occur during the FOT development and commercial development phases of the SWIFT system prior to deployment. These costs, which will be incurred by SWIFT industry participants, typically include equipment procurement or development, equipment installation, and software development and testing activities.

Recurring costs are defined as "annual continuous" costs associated with operation of a deployed SWIFT system. For deployed SWIFT participants, these costs will typically include annual general labor costs for operations, annual hardware/software upgrade/maintenance costs, and costs of services such as leases or communications/phone costs. Recurring costs may be incurred in all three SWIFT life cycle phases.

Revenues are defined primarily as revenues or sales to the public of SWIFT hardware or SWIFT user subscriptions by the SWIFT industry participants. This would typically include the gross receipts collected by SWIFT industry participants from the subscriptions to SWIFT Seiko MessageWatch services, SWIFT PC user service subscriptions, and SWIFT Delco in-vehicle navigation device user service subscriptions.

2.1.3. Collection of Relevant Cost and Technical Data (Objectives 1 and 2)

As shown in Table 2-4, the focus of Objective 1 was to collect relevant cost and pricing data from SWIFT participants.

Table 2-4. Technical Approach for Objective 1.

Objective	Data Source	Method of Analysis
1. Collect relevant cost and pricing data from SWIFT participants (industry and government/ institutional) and member vendors	• SWIFT Team Members • WSDOT	• Conduct phone and in-person interviews with relevant SWIFT participants • Request and collect required cost data and price quotes from relevant SWIFT participants via writing • Collect SWIFT Test Cost Actuals from WSDOT

Here, the primary method of data collection involved the following interactions with each SWIFT participant:

1) Initial deployment cost study explanation and request for cost data overview letter provided to each SWIFT participant (2/97)
2) In-person data collection interviews with each SWIFT participant (4/97 to 8/97)
3) Follow-up written/telephone requests for additional data/clarifications (7/97 to 2/98)

As stated in the *SWIFT Deployment Cost Study Final Test Plan*, in conducting the interviews, "the participation and willingness of the SWIFT participants to provide access to all relevant cost and price related data will be critical to the success of the data collection effort." In practice, while the results of the data collection effort from the SWIFT participants succeeded in providing the data required to support the development of the LCCE, the level of detail and the type of data provided was, in general, less than had been desired. This was largely the result of concerns by the commercial participants that providing proprietary cost data for a public study could potentially reduce their competitive advantage.

Data collected via the SWIFT participant interviews and follow-ups typically centered around four data categories:

1) Hours labor estimates by activity and staff for non-recurring activities during the *commercial development* phase (e.g, software development)
2) Equipment non-recurring costs during the *commercial development* phase (e.g., PC servers)
3) Hours labor estimates by activity and staff for recurring operations activities during the *commercial development* phase and the *annual commercial operations* phase (e.g., FM HSDS monthly leasing)
4) Equipment recurring maintenance costs (i.e., estimated annual maintenance costs)

The data collected for the *FOT development* phase, or SWIFT Test, was provided by Larry Senn, WSDOT SWIFT Project Manager. This data included the entire 2.75 year collection of SWIFT quarterly financial invoices and monthly technical reports (which provided hours). A spreadsheet was developed to provide the complete results of the financial and hours data collected from these reports, and is provided in Appendix A, with a summary provided as part of the LCCE in Section 3.

Unfortunately, the required format of the SWIFT FOT financial invoices did not provide a basis for costs to be estimated by activity; rather, they typically provided total labor, overhead, travel and ODC costs per quarter. However, by analyzing the monthly technical reports, it was possible to come up with a reasonably comprehensive list of the major design, development, testing and evaluation activities by participant for the duration of the *FOT development phase*. These activities are listed in their respective *FOT development* LCCE sections in Section 3.

Next, as shown in Table 2-5, the focus of Objective 2 was be to *collect relevant cost data on analogous systems and system elements nationwide*.

Table 2-5. Technical Approach for Objective 2.

Objective	Data Source	Method of Analysis
2. Collect relevant cost data on analogous systems and system elements nationwide	• FHWA & Contractors • IVHS Industry (Transportation, Communications, Information)	• Interviews with appropriate industry or government representatives • Market/University Library Research

Here, while the initial goal was to attempt to collect cost data on some systems being deployed in other regions that were similar to the SWIFT system, in practice this proved problematic due to two factors. First, after surveying the general technical literature available on other U.S. traveler information systems being designed or tested, it became apparent that the SWIFT system was unique among any other systems being tested or deployed in the U.S. Secondly, while it had been planned to work with and collect cost data from FHWA and their SETA support contractor on analogous elements from other ITS deployment tests or designs, it was discovered that the type/level of cost data that would be required was not being collected as part of these tests.[4] Nevertheless, significant cost and related technical data related to some elements of the SWIFT system and in traveler information/ITS system deployments in general were collected in support of developing the discussion on how the results of the SWIFT LCCE and the Commercial Viability Analysis could be applied to other regions nationwide. This discussion is presented in Section 4.

An extensive literature review supporting the above data collection effort was conducted involving market research of trade journals and other publications including numerous ITS America journals and papers, I-95 Corridor Coalition reports, Caltrans future ITS architecture studies, ITS industry stakeholder reports, etc. This review involved data collection from SAIC ITS data sources, collection of reports from ITS America, Internet research, and publication orders. A comprehensive bibliography documenting the literature review is presented in Appendix B.

[4]It had been suggested by FHWA early on that BAH might be able to provide cost and related technical data on the Minnesota Guidestar project, but BAH later determined that significant cost data was, in fact, not being collected

2.1.4. Develop Groundrules & Assumptions

The development of groundrules and assumptions was the third step required to develop the deployed SWIFT LCCE. Essentially, groundrules and assumptions are used: (1) to bound the estimate by limiting/clarifying the estimate scope, and (2) to establish baseline conditions upon which the estimate is premised.

The development of the groundrules and assumptions occurred in parallel with the data collection effort, and was based on discussions with relevant SWIFT participants staff during the data collection interviews, and on the review of the other SWIFT Evaluation Test Plans. A set of draft groundrules and assumptions was then submitted to WSDOT, FHWA and all of the SWIFT participants in August 1997 for comment. Following a period of review and comment, an updated set, shown here, was completed in October 1997:

1) Costs will be estimated for the following three phases:

   a. FOT development (2.75 years: 1 Jan 95 to 30 Sep 97)
      - Costs of current SWIFT Test

   b. Commercial Development (1.25 Years; 1 Oct 97 to 31 Dec 98)
      - Additional development and procurement costs for fully deploying an operational SWIFT system (follows the completion of the SWIFT test)

   c. Annual Commercial Operations (Beginning 1 Jan 99)
      - Annual operations costs for a fully deployed SWIFT system

2) Annual revenues will be estimated for the Annual Commercial Operations phase based on stratification of the following inputs (i.e., results) from 2nd SWIFT Consumer Survey
   - Percentage of test drivers who would consider purchasing SWIFT devices/services
   - Dollar-value average of Willingness to Pay by device/service

3) All of the current SWIFT partners, except IBM and Delco, will form a profit/cost sharing entity to procure and operate a fully deployed SWIFT system. Although UW and King County Metro are public entities, for the purpose of this analysis, they will be considered to function as commercial entities (this will enable extrapolation of the results to other cities as a commercial venture)

4) IBM and Delco costs will only be included for the SWIFT FOT Development (i.e, SWIFT Test) phase

5) All costs will be expressed in 1998 US Dollars, SWIFT test actuals from 1995 through 1997 will be assumed to be equivalent to 1998 US Dollars

6) Where labor rates are not provided, the following unburdened rates will be assumed (in $/hr)

Engineering and Other Professional Technical Disciplines

Junior Engineer: $18
Mid-Level Engineer: $28
Senior Engineer: $35
Engineering Manager: $42

All Other Professional Non-Technical Disciplines

Junior Analyst: $15
Mid-Level Analyst: $23
Senior Analyst: $30
Manager: $35

Technical Specialists (trades)

Junior Tech: $10
Mid-Level Tech: $18
Senior Tech: $25
Clerical: $12

7) Unless specific guidance in provided, all hardware procurement will assume a 10% added factor to account for equipment maintenance

8) Where overhead rates are not available, a standardized industry Overhead/G&A multiplier of 2.5 (150% above labor $/hr) will be applied to all labor costs

2.1.5. Conduct LCCE Cost Estimation (Objective 3)

As shown in Table 2-6, the focus of Objective 3 was to Estimate Life Cycle Costs (recurring and non-recurring) for a fully deployed SWIFT system.

Table 2-6 Technical Approach for Objective 3.

Objective	Data Source	Method of Analysis
3.Develop a Life Cycle Cost Estimate (LCCE) for a fully deployed SWIFT system (recurring and non-recurring costs)	• Inputs from Objectives 1 and 2	• Develop Groundrules & Assumptions • Estimate individual cost elements using proven cost estimating techniques. • Prepare Basis of Estimates (BOEs)

Following the development of the groundrules and assumptions, and using the major cost categories defined in Section 2 as the guideline, the costs of each WBS element were estimated using proven techniques. The techniques that were used to estimate costs for the deployed SWIFT LCCE are described below.

Engineering Build-up. By far the most commonly used approach to estimate deployed SWIFT LCCE costs was by engineering build-up. Here, during the SWIFT participant interviews and follow-ups, the engineer or the technical manager POC would typically provide an estimate of the commercial development phase labor hours required by activity (which were also defined during the interviews), the type of equipment procurement required, and the types of recurring operations costs that could be expected. Following this definition, labor rates and overhead burdens were then to applied to the hours to estimate costs by appropriate labor category. In some instances the participants overhead rates and staffing labor rates by labor category were available. In instances where the overhead rates or staffing definition was not available, the appropriate factors from the groundrules and assumptions were utilized.[5]

Use of "Actuals" For the *FOT development phase*, with the exception of UW, actual incurred cost data (i.e., "actuals") was collected from WSDOT (Larry Senn). This data included the entire 2.75 year collection of SWIFT quarterly finanical invoices and monthly technical reports (which provided hours). A spreadsheet was then created to provide the complete cost estimate/results and summary costs for the *FOT development phase*.

Proposal Analysis. For the UW portion of the deployed SWIFT LCCE, the cost estimate for all three life cycle phases involved a detailed analysis with UW's involvement in going through two proposals, item by item, and making assessments as to which items were SWIFT-related, and then assigning them to the appropriate SWIFT life cycle phase. Following this, costs were developed based on percentages of hours by task, proposal labor rates, and proposal-derived "effective" overhead rates.

Vendor Pricing. Vendor pricing was used in several cases for the deployed SWIFT LCCE to estimate both non-recurring equipment costs and recurring operations costs. Vendor price quotes for computer equipment and T1 Line costs were obtained over the Internet.

Parametric Techniques. Parametric techniques use statistically significant relationships between costs and physical or performance parameters. For the deployed SWIFT LCCE, a parametric cost factor developed by WSDOT was used for the SCS estimate which assumed a direct relationship between the percentage of SWIFT HSDS bandwidth usage and the costs to SWIFT of operating the SCS Network Control Center.

In performing the deployed SWIFT LCCE, a Microsoft Excel multi-level spreadsheet was developed to automate cost estimation for all three deployed SWIFT life cycle phases. The summary-level outputs from this spreadsheet model are provided as results in Section 3. In addition, the output from the model for the *FOT development phase* (SWIFT Test) containing the SWIFT Test "actuals" costs is provided in full in Appendix A.

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[5] In cases where the labor category did not match one of the standardized labor categories in the groundrules and assumptions, the best match was selected based on the perceived requirements of the activity being performed.

Finally, Bases of Estimates (BOEs) supporting the cost estimates are provided in Section 3 within the text of the LCCE. BOE's provide the source, assumptions, methods and calculations utilized to estimate each individual cost item. It is intended that the BOE descriptions provided in the LCCE sections will provide enough information to promote a reasonable degree of confidence in the cost estimate.

2.2. Commercial Viability Analysis Methodology

2.2.1. Methodology Overview

As shown in Table 2-7, the focus of Objective 4 will be to *Evaluate the Commercial Viability of the SWIFT System*. In providing a process for fulfilling this objective and implementing the technical approach, Figure 2-2 provides a composite overview of the Commercial Viability Analysis (CVA) methodology that will be applied. Each of the elements of this methodology are addressed in detail in the sections below.

Table 2-7. SWIFT Deployment Cost Study Technical Approach for Objective 5.

Objective	Data Source	Method of Analysis
5.Evaluate the Commercial Viability of the SWIFT System	• Commuter Statistical data from the Puget Sound Regional Council • Consumer Acceptance Study "willingness to pay" results from SWIFT FOT surveys	• Estimate the Market for SWIFT services • Estimate Annual SWIFT subscription revenues • Compare the estimates of the annual SWIFT revenues with the LCCE annual operations results

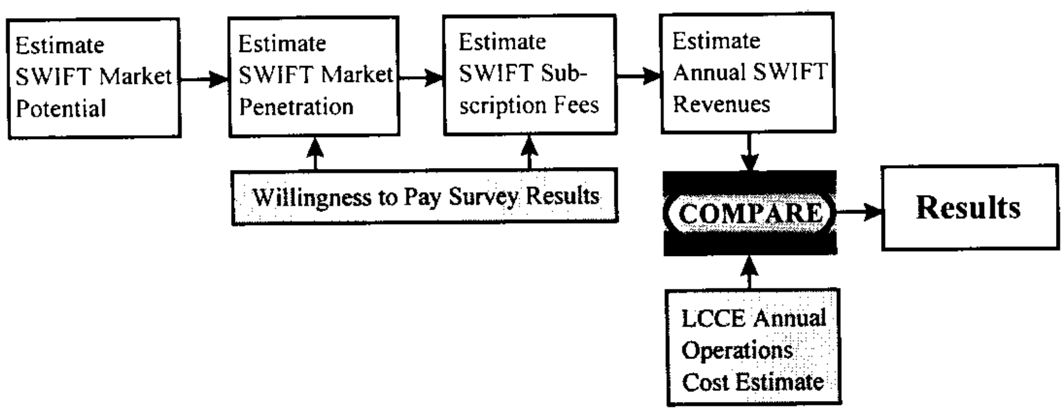


Figure 2-2. SWIFT Deployment Cost Study Commercial Viability Analysis Methodology.

2.2.2. Estimation of SWIFT Consumer Market Potential

The first step in developing the CVA is to estimate the consumer "market potential" of SWIFT services for the Greater Seattle Metropolitan region. Market potential is defined here to the consist of the total number of consumers who would comprise the potential market for SWIFT services. These consumers will heretofore be referred to as "SWIFT consumers."

SWIFT consumers are defined here to be all commuter vehicle drivers of both single occupancy (SOV) and high occupancy vehicles (HOV) who drive more than five miles one-way to work daily. It is assumed here that commuters who drive less than five miles on-way to work daily would not be in the market for SWIFT services due to their short commute to work.

Two steps will be required to estimate the SWIFT market potential.

1) First, it is necessary to estimate the total "commuter vehicle driver" market in the Seattle/Puget Sound Metropolitan region. This is defined here to be the average total number of vehicle drivers, comprising both SOV's and HOV's (but not including HOV passengers), being driven by commuters to work on a daily basis in the Seattle Metro region. It will be assumed here that HOV's consist of an average of 2.5 persons.
2) Secondly, it will be necessary to estimate the percentage of commuter vehicle drivers who drive more than five miles one-way to work daily in the Seattle Metro region, and then multiply this percentage by the total calculated in step 1 above.

Based on the above steps, the following equation can be set up to illustrate the SWIFT market potential calculation[6]:

$$M_{\text{Potential}} = F_{\text{5 Mile}} \times \left(P_{\text{SOV}} + \frac{P_{\text{HOV}}}{2.5} \right) \times N_{\text{Vehcile Commuters}}$$

where: $M_{\text{Potential}}$ = SWIFT Market Potential (in total number of commuter drivers)

$F_{\text{5 Mile}}$ = Factor for Percent of Commuters who drive more than 5 miles one-way to work

P_{SOV} = Percentage of daily commuters in SOVs

P_{HOV} = Percentage of daily commuters in HOVs

$N_{\text{Vehicle Commuters}}$ = Total Number of daily commuters (all travel methods)

The elements which make up this equation can be estimated based on the collection of transportation, employment and census data for the Seattle Metro region. The data collection approach centered on collecting applicable statistical data from the Puget Sound Regional

[6] Based on the relatively small survey sample size and on the type of transportation statistical data available, transit riders have not been included in this calculation. It is believed that including transit riders in the SWIFT market potential equation would result in a market potential increase in the neighborhood of three to ten percent.

Council (PSRC) organization. PRSC is the Metropolitan Planning Organization (MPO), for King, Kitsap,

Pierce and Snohomish counties, and as one of its functions it performs analyses and maintains an extensive statistical database of demographic, economic, travel and geographic data of its member jurisdictions.

2.2.3. Estimation of SWIFT Market Penetration

The second step in developing the CVA is to develop credible estimates/forecasts for what levels of market penetration might be expected by the deployed SWIFT system. In other words, it is necessary to develop an estimate of what percentage or range of percentages (i.e., market penetration) of the SWIFT market potential defined above would be likely for a fully deployed SWIFT system well into its operational phase.

The approach to estimate market penetration centered on an evaluation of the use of a survey tool during the SWIFT FOT to measure SWIFT test user interest in SWIFT products and services in the future. Specifically, Figure 2-3 provides the question that was asked to SWIFT FOT users of each of the three SWIFT devices to determine appropriate levels of market penetration. This question was developed early on and provided to the *SWIFT Consumer Acceptance Study* Manager for implementation in the "Willingness to Pay" portion of the SWIFT FOT surveys. For a detailed discussion of the survey sampling methodology employed here, see Section 2 of the *SWIFT Consumer Acceptance Study* Final Report.

How willing would you be to subscribe to a current system like SWIFT if the current information services were retained?	**(check one response)**
Would definitely subscribe	O
Would probably subscribe	O
Not Sure	O
Would probably not subscribe	O
Would definitely not subscribe	O

Figure 2-3. "Willingness to Pay" Subscription Purchase Interest Survey Question.

Based on the results for the above question, three percentage levels of market penetration are developed for low, medium and high market level penetration, respectively. The "low" level was estimated as the average percentage of responses for the three SWIFT devices to the "would definitely describe" questions. The "high" level was estimated as the average percentage of responses for the three SWIFT devices combining the "would definitely describe" and the "would probably subscribe" response percentages. Finally, the "medium" was selected as the midpoint percentage between the low an high values.

In addition, as a "check" to make sure that consumers willing to subscribe to SWIFT services would also being willing to purchase the equipment up-front, the questions provided below in Figure 2-4 are also asked of SWIFT FOT users.

Would consider purchasing your Seiko Message Watch or a future version of this watch?	(check one response)
No	O
Yes	O

Would you consider purchasing SWIFT software to operate on your own PC?	(check one response)
No	O
Yes	O

Would you consider purchasing a your Delco in-vehicle navigation device or a future version of this device?	(check one response)
No	O
Yes	O

Figure 2-4. "Willingness to Pay" Device Purchase Interest Survey Questions.

2.2.4. Estimation of SWIFT Subscription Fees

Estimation of the appropriate consumer SWIFT subscription fees is conducted by the use of a survey tool during the SWIFT FOT.

Figure 2-5 provides the survey question that is used to directly estimate the average subscription fee that consumers would be willing to pay for SWIFT services for a fully deployed SWIFT system. This question was developed early on and provided to *the SWIFT Consumer Acceptance Study* Manager for implementation in the "Willingness to Pay" portion of the SWIFT FOT surveys. For a detailed discussion of the survey sampling methodology employed here, see Section 2 of the *SWIFT Consumer Acceptance Study* Final Report.

How much per month would you consider to be a fair subscription price for the SWIFT services you currently receive, assuming that the SWIFT system was fully functional and reliable?	(check one response)
$0	O
$5	O
$10	O
$15	O
$20	O
$25	O
$30	O

Figure 2-5. SWIFT Subscription Fee "Willingness to Pay" Survey Question.

2.2.5. Estimation of Annual SWIFT Revenues

The estimation of annual SWIFT revenues is calculated based on the results of the first three steps of the commercial viability analysis methodology as shown in the equation below. Here, annual SWIFT revenues are defined as all subscription fees collected per year from user monthly subscriptions to SWIFT services (i.e., subscriptions to Seiko Message Watches, PC Internet access account, Delco-like devices).

$$R_{\text{Annual}} = S_{\text{Average}} \times P_{\text{Market}} \times M_{\text{Potential}}$$

where: R_{Annual} = SWIFT annual revenues from consumer subscription fees

S_{Average} = Average annual SWIFT subscription fee for a consumer (see Section 2.4.4)

P_{Market} = Percentage of Market Penetration (see Section 2.4.3)

$M_{\text{Potential}}$ = SWIFT Market Potential (see Section 2.4.2)

The above equation is used to estimate annual SWIFT revenues for all three market penetration scenarios (low, medium, high).

2.2.6. Comparison with LCCE Annual Commercial Operations Costs (Objective 4)

The final step in the commercial viability analysis is to quantitatively compare the annual SWIFT revenues calculated above (for all three market scenarios) with the deployed SWIFT annual commercial operations phase costs estimated in the SWIFT LCCE. Based on this comparison, it should then be obvious if the annual revenues will support the overall cost estimate. For each market scenario evaluated, the estimated annual revenues must support the annual commercial operations cost estimate in order to ensure commercial viability of deployed SWIFT operations.

3. RESULTS

The following sections provide the *SWIFT Deployment Cost Study* results of the both the deployed SWIFT Life Cycle Cost Estimate (LCCE) and the deployed SWIFT Commercial Viability Analysis (CVA). The LCCE and CVA results were developed based on the methodology outlined in Section 2. In addition, the results of the LCCE served as an input to the CVA. A discussion on how these results might be applied to other U.S. metropolitan areas is provided in Section 4.

3.1. LCCE Results

3.1.1. LCCE Summary-Level Results

An overview of the results of the deployed SWIFT LCCE is presented below in Table 3-1, and in Figures 3-1 through 3-6. Table 3-1 presents the summary-level spreadsheet which provides all of the total costs by participant and life cycle phase. Figure 3-1 provides an overview of the financial share of each SWIFT participant. Figure 3-2 provides an overview of total life cycle costs by year. Figure 3-3 provides a summary of total labor hours by participant and life cycle phase. Figure 3-4 provides a summary of total loaded (i.e, with overhead and G&A included) labor costs by participant and life cycle phase. Figure 3-5 provides a summary of other direct costs (e.g., equipment, travel, software licensing, etc.) by participant and life cycle phase.

In the following sections, the detailed LCCE estimates by participant are presented. For each participant estimate, the following is provided:

1) A system description provided the technical definition of the relevant SWIFT elements that is required so that the SWIFT participant activities can be analyzed and costed
2) The FOT development phase cost estimate, with supporting basis of estimates
3) The commercial development phase cost estimate, with supporting basis of estimates
4) The Annual Operations cost estimate, with supporting basis of estimates
5) The corresponding LCCE, providing an estimate of the total costs that would be required to develop, test, deploy and operate the participant's portion of a commercial SWIFT system

Table 3-1. Deployed SWIFT Life Cycle Cost Estimate (LCCE) Summary.

Participant	FOT Development				Commercial Development				Annual Commercial Operations				Life Cycle Cost (5 years of Ops.)			
	Hours	Labor	ODC's	Total	Hours	Labor	ODC's	Total	Hours	Labor	ODC's	Total	Hours	Labor	ODC's	Total
SCS	19,137	$1,605K	$500K	$2,105K	1,005	$64K	$82K	$147K	804	$51K	$66K	$117K	24,162	$1,926K	$911K	$2,837K
Metro Networks	4,348	$264K	$320K	$584K	8,249	$493K	$11K	$504K	6,188	$370K	$2K	$371K	43,536	$2,604K	$340K	$2,944K
Etak	7,760	$639K	$248K	$887K	3,840	$254K	$0K	$254K	1,920	$134K	$0K	$134K	21,200	$1,565K	$248K	$1,813K
UW	32,136	$857K	$220K	$1,077K	10,998	$442K	$81K	$522K	1,922	$105K	$30K	$135K	52,741	$1,822K	$450K	$2,272K
Metro Transit	1,751	$73K	$2K	$75K	2,060	$86K	$0K	$86K	1,545	$65K	$0K	$65K	11,536	$483K	$2K	$485K
IBM	5,123	$342K	$194K	$536K	0	$0K	$0K	$0K	0	$0K	$0K	$0K	5,123	$342K	$194K	$536K
Delco	14,101	$750K	$344K	$1,093K	0	$0K	$0K	$0K	0	$0K	$0K	$0K	14,101	$750K	$344K	$1,093K
TOTAL	84,356	$4,529K	$1,828K	$6,357K	26,151	$1,339K	$174K	$1,513K	12,379	$725K	$97K	$822K	172,401	$9,493K	$2,488K	$11,981K

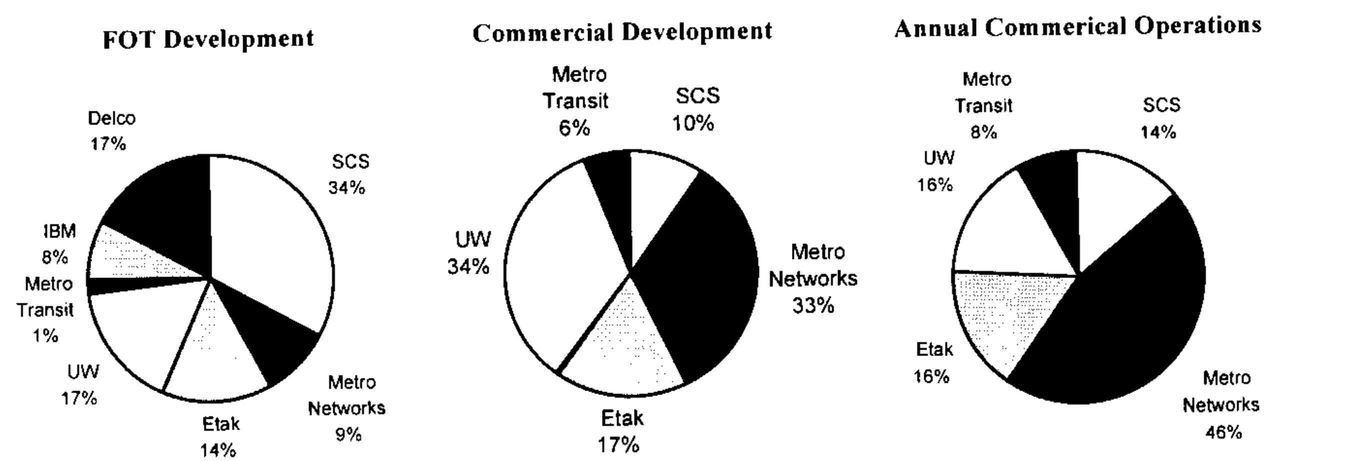


Figure 3-1. LCCE Overview by SWIFT Participant Share.

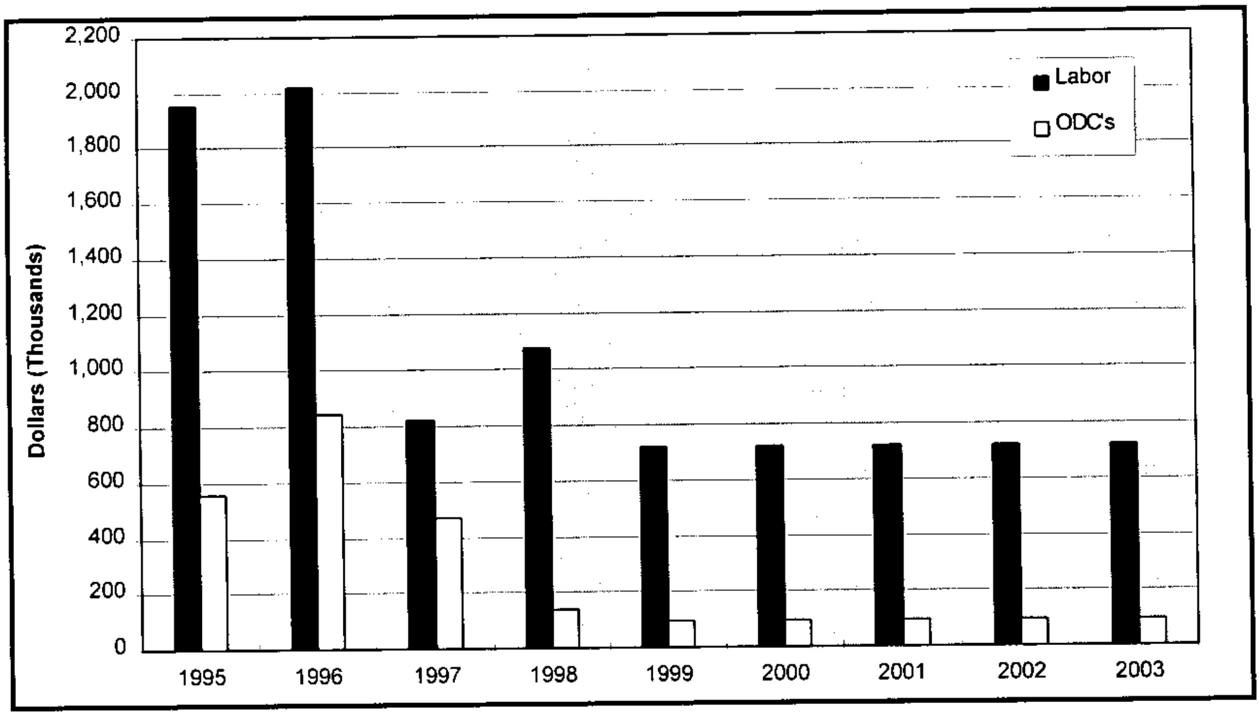


Figure 3-2. LCCE Overview by Year.

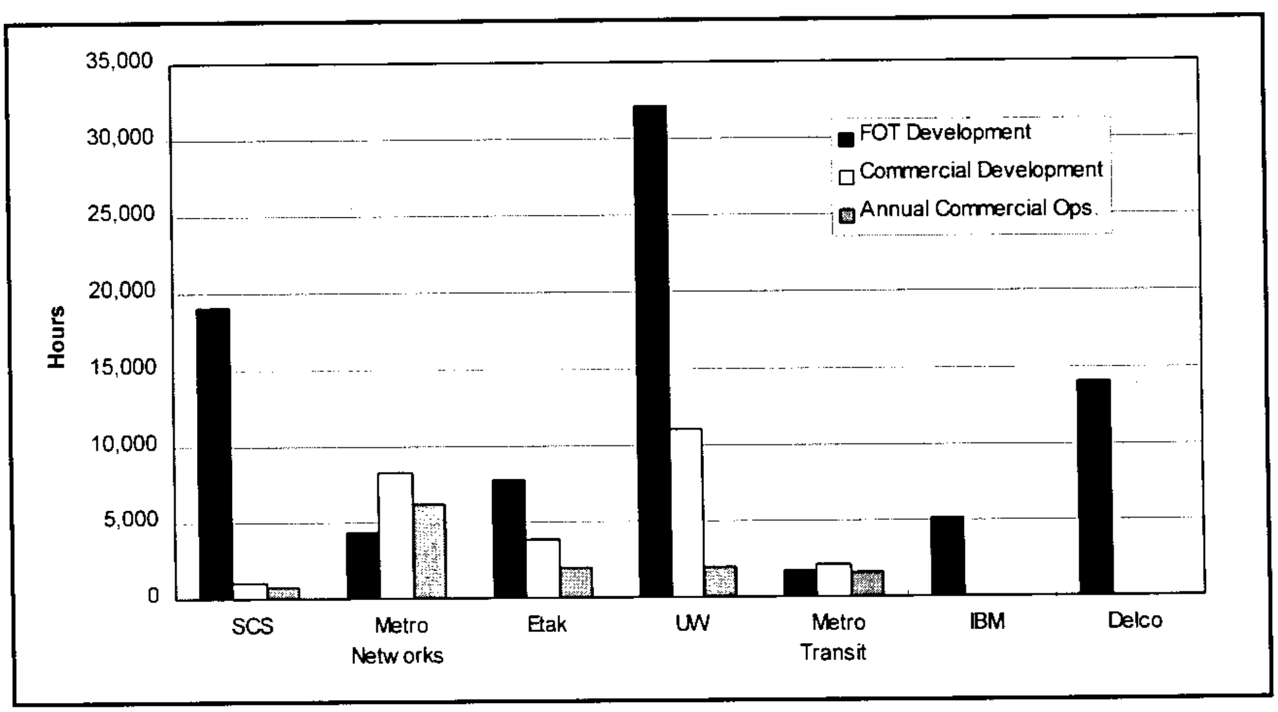


Figure 3-3. LCCE Hours Overview.

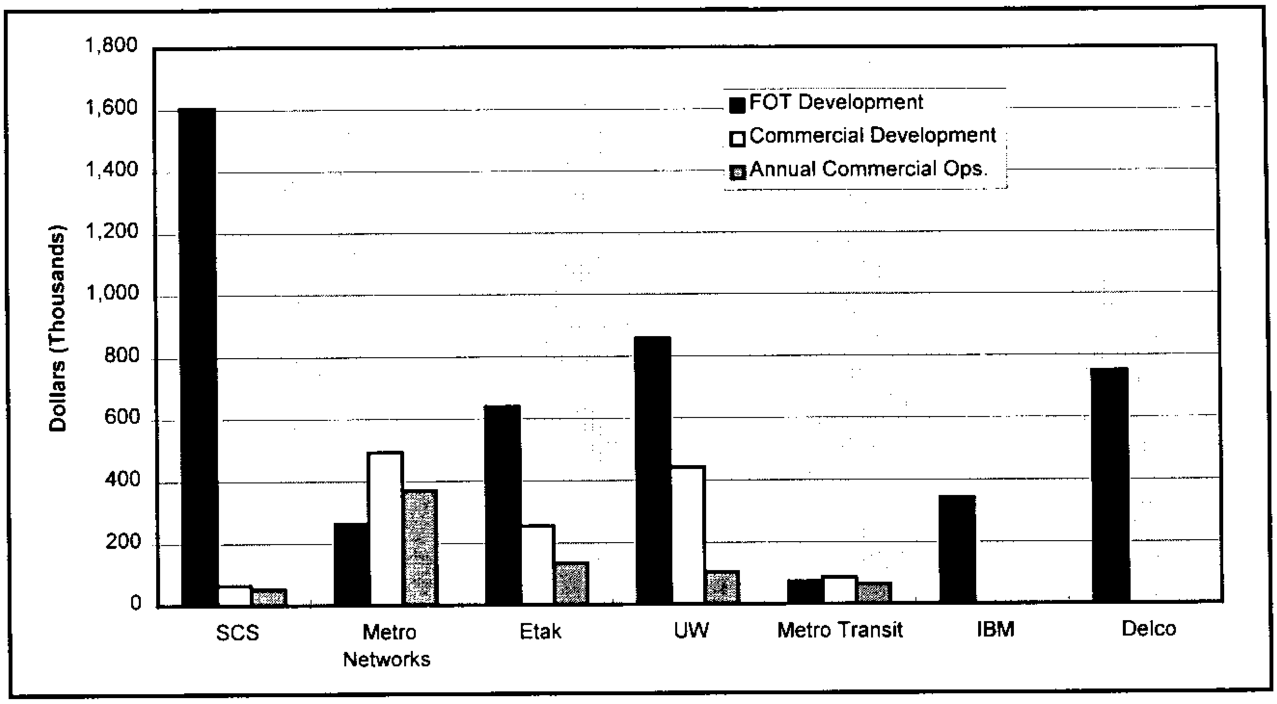


Figure 3-4. LCCE Labor Costs (Loaded) Overview.

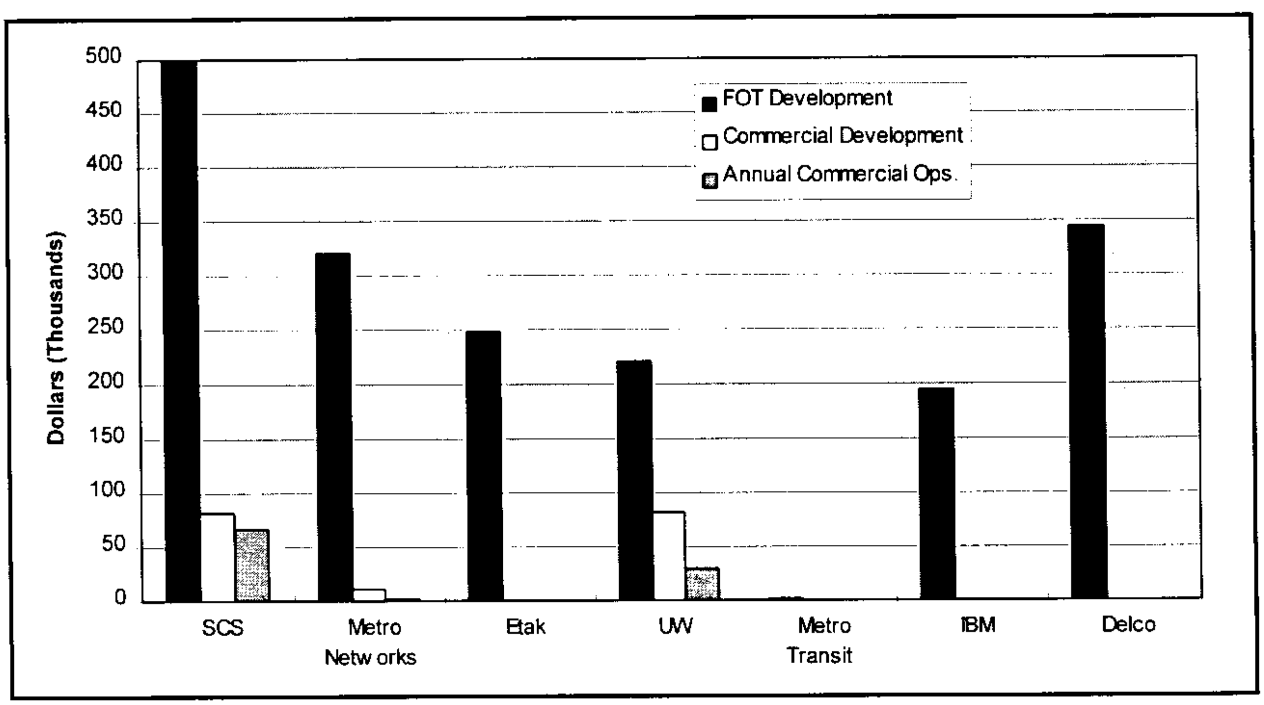


Figure 3-5. LCCE Other Direct Costs (ODC's) Overview.

3.1.2. SCS Cost Estimate

System Description

The core of the SWIFT system is utilization of the Seattle area FM sub-carrier High Speed Data System (HSDS) that was developed by Seiko Communications Systems (SCS), a member of the Seiko Group of companies. The HSDS was developed as a means of creating a network for delivering personal communication information services. HSDS has been commercially deployed by SCS in Portland, Seattle, Los Angeles, New York, San Diego, Las Vegas and in the Netherlands, and is the result of an SCS investment of more than $50 million.

HSDS takes advantage of the un-utilized spectrum available in the non-audio region of commercial FM transmitters in the 75-108 kHz frequency band. In particular, by using the existing worldwide FM broadcast infrastructure, HSDS technology dramatically decreases the cost basis of delivering personal communication services to the consumer. Any FM broadcast transmitter can be enabled to carry the HSDS sub-carrier. HSDS can be transmitted in conjunction with other sub-carrier services such as Radio Data Systems (RDS).

The HSDS protocol is a one-way communications protocol that permits the use of very small receivers. HSDS can operate as a stand-alone single station (channel) system, or as multiple systems operating independently in a geographical area with each system including multiple stations. The HSDS data rate is 19 kbps in a bandwidth of 19 kHz, which is symmetric and centered at 66.5 kHz (i.e. between 57 kHz and 76 kHz). The HSDS sub-carrier is added on to the FM station's baseband signal before being FM modulated onto the Radio Frequency (RF) carrier.

In Seattle, the SCS HSDS had previously been used to transmit both standard pager information (i.e., telephone numbers and short messages) and value-added services (e.g., sports scores, stock market data) from seven radio stations which provide broad coverage of the entire metro area. For SWIFT, traffic information was provided as another value-added service available to a special set of SWIFT receivers including Seiko Message Watches, in-vehicle receivers such as the Delco SWIFT test device, and laptop computers equipped with a special receiver/antenna.

Conceptually, the SWIFT SCS Message Data System (MDS) information flow and transmission operations consist of several input streams each entering via a Message Entry (ME) unit, as illustrated below in Figure 3-6. The relevant data then passes through a Message Processor (MP) which routes the data to a multiplicity of Transmission Equipment (TREQ) units where each TREQ unit prepares the data for transmission. The data are then transmitted from the SCS HSDS control center in Portland, Oregon via satellite to the seven FM stations in the Seattle area, which in turn broadcast the data via an FM sub-carrier to be received by the three receiver types.

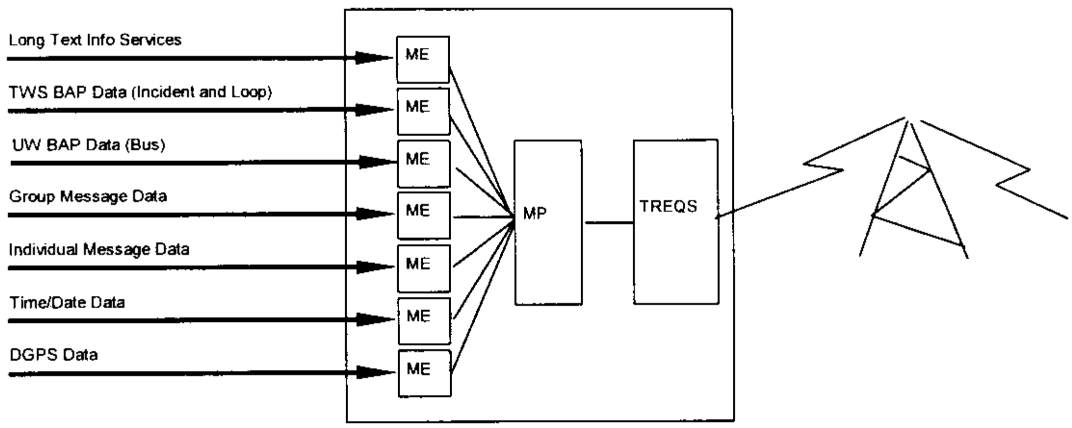


Figure 3-6. Message Date System (MDS) Information Flow at the SCS Network Node.

The SWIFT MDS can receive data from a variety of potential traffic information input sources including telephone/voice/modem inputs, GPS time/date and location verification data, Metro Network processed freeway loop (originated at WSDOT) and incident data via the Internet, Metro Network generated traffic incident data for Message Watches via the Internet, bus location data from UW via the Internet, and confirmation of rideshare data from UW via the Internet.

FOT Development Phase Cost Estimate

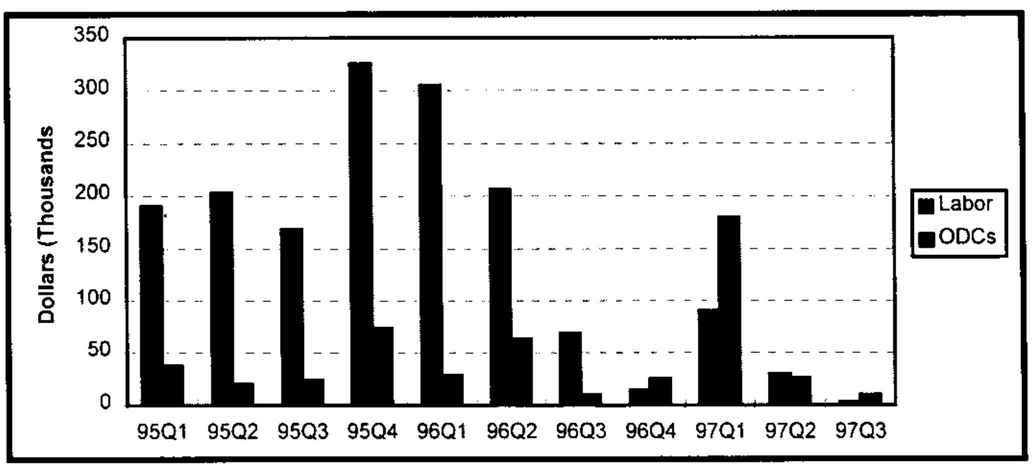
The SCS SWIFT FOT development cost estimate includes all actual costs accrued during the SWIFT Test from 1 January 1995 through 30 September 1997. While the total breadth of SCS SWIFT activities performed during the SWIFT test is beyond the scope of this report, the following SCS design, development, testing and evaluation activities provide a broad description of what elements contributed to SCS FOT development costs:

- SCS assumed leadership of all major SWIFT architecture development activities, and led the development of all major SWIFT system requirements
- Served as the lead system engineer and integrator of hardware and software for all SWIFT participants
- Developed receiver system requirements for the PDA and Car Radio for IBM and Delco, respectively; subsequently assisted in development of respective specifications
- Assisted Metro Networks in developing Traffic Workstation (TWS) system requirements and specification
- Developed and installed improved HSDS communications equipment and antennas
- Developed HSDS/SWIFT over-the-air protocols for SCS and other SWIFT participants

- Developed, tested and fielded improved technology SCS receivers for SWIFT
- Developed and tested numerous software code items for SCS and other SWIFT participants
- Developed computer simulations for HSDS and SWIFT communications/operations which involved extensive use of mathematical modeling and algorithm development
- Developed system for HSDS and SWIFT hardware and software and testing
- Installed SWIFT-specific hardware at the SCS HSDS Network Operations Center
  - ⇒ 1 SWIFT Server & 1 Firewall Computer ($20,000 total)
  - ⇒ 1 Clearinghouse Processor and associated Routers ($25,000 total)
- Supported Alpha, Beta and Final Evaluation testing of the HSDS system and the overall SWIFT system
- Provided management functions, coordination and meetings with the SWIFT team, supported the evaluation team, and provided other support to the SWIFT project as required

The result of the SCS SWIFT FOT development cost estimate is presented in Table 3-2. The costs and hours shown are all "actuals," and have been collected from the corresponding Quarterly SWIFT Invoice Summaries and the SWIFT Monthly Progress Reports. The complete detailed spreadsheet breakout is presented in Appendix A.

Table 3-2. SCS FOT Development Cost Estimate.



Hours	Labor (Loaded)			Other Direct Costs			Total		
(Total)	Public	Private	Total	Public	Private	Total	Public	Private	Total
19,137	$1,073K	$532K	$1,605K	$332K	$168K	$500K	$1,405K	$700K	$2,105K

Commercial Development Phase Cost Estimate

The SCS SWIFT commercial development cost estimate is an estimate of the additional costs that would necessary to complete development and testing of SCS's portion of the SWIFT system prior to the full deployment of a commercial SWIFT system. The time period assumed for the commercial development phase cost estimate is 1 October 1997 through 31 December 1998.

In an interview conducted with SCS SWIFT Project Manager it was stated that SCS did not anticipate that any further development costs would be required to enable the full deployment of a commercial SWIFT system. Moreover, SCS stated that the existing SCS SWIFT architecture would be able to support a total of between 400,000 and 600,000 users in the Seattle Metro Area.

Based on interviews with SCS, it appears that the only costs that would be incurred during the commercial development phase are the SWIFT-related labor and equipment maintenance portions of the SCS Network Operations Center, and the SWIFT portion of the FM station leasing fees for HSDS transmission.

In a June 1997 memo, WSDOT estimated that the SWIFT portion of the HSDS bandwidth was 14.6%.[7] [8] The assumption was then made that the SWIFT percentage of HSDS bandwidth would be directly related to the percentage of SCS labor costs spent on SWIFT operations, which are conducted in the SCS Network Operations Center. Following this assumption, based on an estimated total staffing of 3 full-time employees at the Network Operations Center, the memo allowed for the estimation of SCS SWIFT-related monthly labor costs as follows:

$$\boxed{Labor(loaded) = 3 \text{ FTE @ } \$9{,}779\,/\,month \times 14.6\% = \$4{,}283\,/\,month}$$

Note that applying this equation to hours yields an estimate of a total of 67 labor hours/month.

In addition to the above monthly labor costs, annual equipment maintenance costs are calculated by applying a 10% factor, based on the generalized groundrules provided in Section 2, to the original SWIFT server/firewall/clearinghouse processor toal cost of $45,000 (estimated above), to yield an annual maintenance cost estimate of $4,500, equivalent to a monthly maintenance cost of $375.

In interviews, SCS provided an average estimate of FM station HSDS leasing costs to be $5000 per station per month.[9] Applying the WSDOT 14.6% SWIFT bandwidth-based

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[7] Larry Senn, "SWIFT Supplement 4 – Clarification of Scope and Cost/Memo to Paul DePalma", Washington State Department of Transportation, June 20, 1997.

[8] Note that the HSDS bandwidth of 14.6% includes that bus data stream, which takes up more than 50% of the total bandwidth.

[9] Note that HSDS leasing rates vary significantly across the nation depending on market size and local demand.

usage factor to this yields a SWIFT-related cost estimate of $730 per station per month. Thus for all seven FM stations, the combined FM monthly leasing cost is estimated to be $5,110.

Combining the labor and ODC cost/hour estimates, and multiplying by the 15 month period of the commercial development phase, yields the cost estimate for the SCS SWIFT FOT development phase, which is presented in Table 3-3.

Table 3-3. SCS SWIFT Late Deployment Cost Estimate.

Hours (Total)	Labor (Loaded)	Other Direct Costs	Total Cost
1,005	$64K	$82K	$147K

Annual Commercial Operations Cost Estimate

The SCS SWIFT annual commercial operations cost estimate is an estimate of the cost of operations of a commercially deployed SWIFT system per year following the full deployment of a commercial SWIFT system on 1 January 1999.

SCS SWIFT operations costs are as based on the monthly operations cost estimates calculated in the above commercial development cost estimate, namely:

- Monthly SWIFT-related labor cost (loaded) = $4,283 (67 hours)
- Monthly SWIFT-related HSDS FM stations leasing cost = $5,110
- Monthly SWIFT equipment maintenance cost = $375

Thus, these costs extended to 12 months make up the SCS SWIFT annual operations cost estimate, which is presented in Table 3-4.

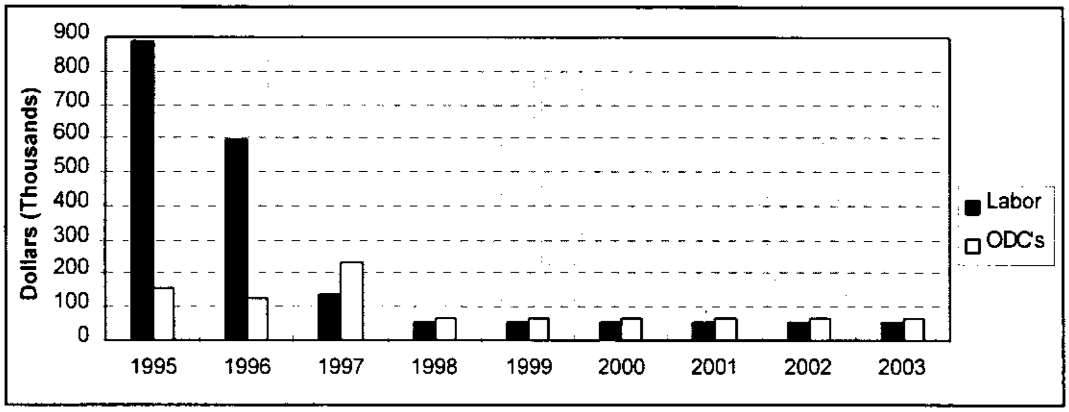
Table 3-4. SCS SWIFT Annual Operations Cost Estimate.

Hours (Total)	Labor (Loaded)	Other Direct Costs	Total Cost
804	$51K	$66K	$117K

Life Cycle Cost Estimate

Based on the above, the SCS SWIFT LCCE, presented in Table 3-5, provides an estimate of the total costs that would be required to develop, test, deploy and operate the SCS portion of a commercial SWIFT system. For analysis purposes, the LCCE assumes a five year period of operations.

Table 3-5. SCS SWIFT Life Cycle Cost Estimate.



Cost Estimate	Time Period	Hours (Total)	Labor (Loaded)	ODC's	Total Cost
FOT Development	Jan 95 thru Sep 97	19,137	$1,605K	$500K	$2,105K
Commercial Development	Oct 97 thru Dec 98	1,005	$64K	$82K	$147K
Annual Commerical Operations	Annual from 1/1/99	804	$51K	$66K	$117K
Life Cycle Cost (5 yrs. Ops.)	Jan 95 thru Dec 03	24,162	$1,926K	$911K	$2,837K

3.1.3. Metro Networks Cost Estimate

System Description

Metro Networks, at its downtown Seattle traffic information control center, receives traffic information from a number of sources, including: two spotter aircraft, police reports, state and local DOTs, special event operators, cellular phone calls and loop detector data from the University of Washington. In addition, Metro Networks operators phone state patrols three times every hour during peak traffic conditions and two times every hour during off-peak traffic conditions. Most of the data is received orally over telephone and radio, and is manually keyed into text to be communicated to, and read by, traffic reporters, radio and television broadcasters, and law enforcement personnel.

For SWIFT functions, the SWIFT Traffic Work Station (TWS) allows the Metro Networks operator to conveniently convert the information into a highly compressed, georeferenced form which is then communicated via the Internet to the SCS broadcast server for FM sub-carrier HSDS transmission. The SWIFT TWS was developed jointly by Metro Networks and Etak, with Metro Networks responsible for TWS hardware and operations, and Etak responsible for the software development, installation and maintenance.

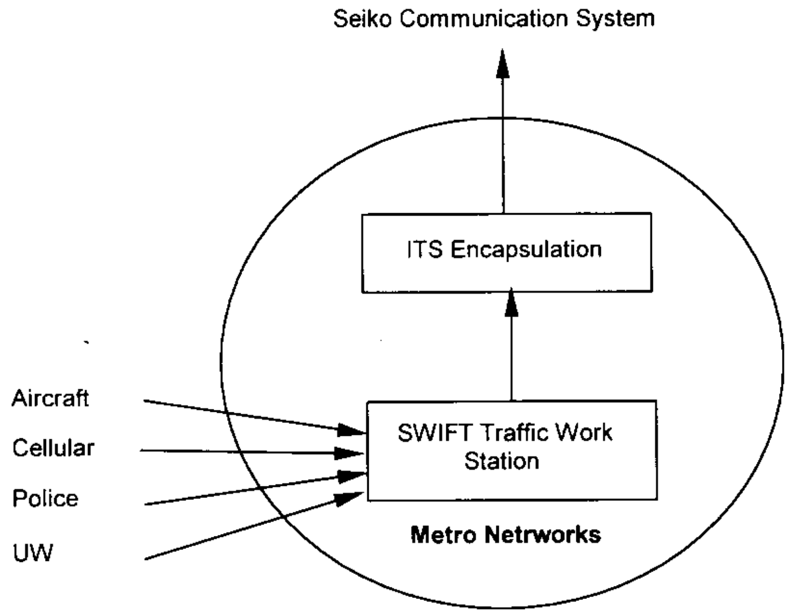


Figure 3-7. SWIFT Data flow at Metro Networks.

The SWIFT TWS can communicate entered incidents or events via the Internet to SCS in one of two ways, namely: (a) as a reference location (16 bit code), or (b) as a latitude/longitude location (32 bit code). The reference location selects the location from a Location Reference Table which consists of 65,536 locations. The SWIFT TWS event descriptions are based on the ITIS standard which provides 2,048 standard messages for describing traffic and road conditions, and other common traveler information.

Because Seiko Message Watches cannot interpret location or message codes, short text messages must be independently developed for the pager watches. In addition, due to limited memory and battery capacity, the watches can handle only a fraction of the messages sent to the PCs and Delco in-vehicle navigation devices. Hence, the SWIFT TWS message table contains watch messages only for the most important "high impact" incidents. Furthermore, the Location Reference Table includes abbreviated road and location descriptions that are suitable for pager watch display. In addition, the pager watch users provide the TWS with a list of most frequently used freeway road sections (user profile).

The SWIFT TWS automatically produces pager watch messages, but the operator can select from a message-list which messages he/she wants to be sent. In addition, the SWIFT TWS operator can create custom messages for transmission to the watches (and to the other devices). The advantage of the message-list approach is that it provides a compressed format by which detailed descriptions of incidents and events can be transmitted with relatively little channel capacity compared to sending the descriptions themselves.

The SWIFT TWS also receives loop data from the University of Washington. The loop data is sent in the High Speed Data System-Bearer Application Protocol (HSDS-BAP) format from UW so that the data received by the SWIFT TWS is already properly formatted for transmission and broadcast. Edited loop data are then sent via the Internet to SCS for final HSDS broadcast.

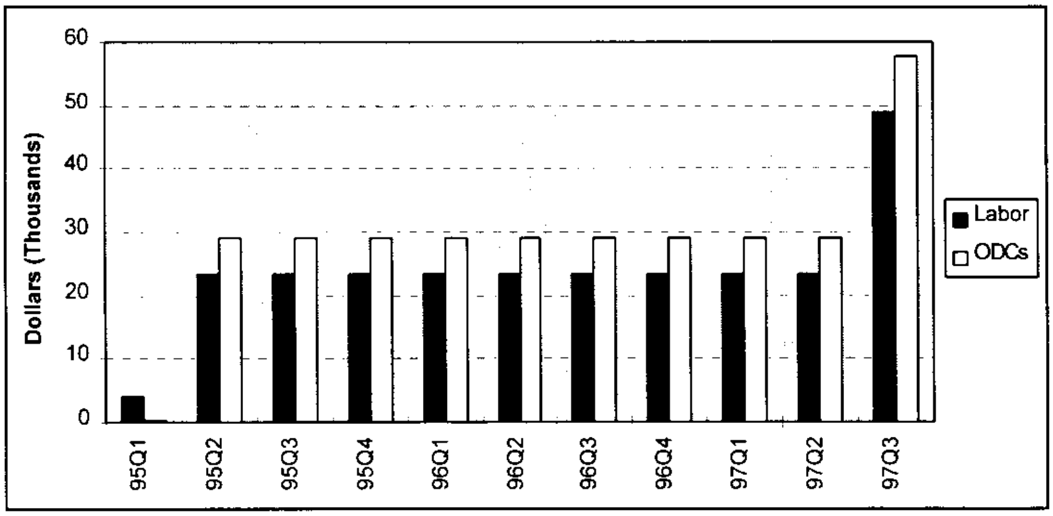
FOT Development Phase Cost Estimate

The Metro Networks SWIFT FOT development cost estimate includes all actual costs accrued during the SWIFT Test from 1 Jan 1995 to 30 Sept 1997. These costs include all SWIFT design, development, testing and evaluation activities performed by Metro Networks as shown here:

- Supported architecture development of SWIFT system with focus on Metro Networks user interface to the SWIFT system; worked with SCS, IBM, UW and Etak in support of user interface developments, issues and modifications
- Worked with Etak to develop, test, install, and maintain, and upgrade the prototype SWIFT Traffic Work Station (TWS) at Metro Networks
- Worked with Etak to install "spare" SWIFT TWS at Metro Networks
- Operated the prototype SWIFT TWS at Metro Networks in support of "running" the SWIFT system
- Supported Alpha, Beta and Final Evaluation testing of the SWIFT system, and provided feedback from SWIFT TWS operators
- Provided management functions, coordination and meetings with the SWIFT team, supported the evaluation team, and provided other support to the SWIFT project as required

The result of the Metro Networks SWIFT FOT development cost estimate is presented in Table 3-6. While the total costs and hours for the SWIFT test shown in the table below are all "actuals," since Metro Networks only provided three invoices during the 2.5 year SWIFT test, the costs from 95Q2 through 97Q2 had to derived based on an average of the total costs from the invoice that Metro Networks provided in 97Q2 (i.e, this was the first invoice Metro Networks provided since 95Q1). The complete spreadsheet breakout is presented in Appendix A.

Table 3-6. Metro Networks FOT Development Cost Estimate.



Hours	Labor (Loaded)			Other Direct Costs			Total		
(Total)	Public	Private	Total	Public	Private	Total	Public	Private	Total
4,348	$43K	$220K	$264K	$52K	$268K	$320K	$96K	$488K	$584K

Commercial Development Phase Cost Estimate

The Metro Networks SWIFT commercial development cost estimate is an estimate of the additional costs that would necessary to complete development and testing of Metro Networks's portion of the SWIFT system prior to the full deployment of a commercial SWIFT system. The time period assumed for the commercial development phase cost estimate is 1 October 1997 through 31 December 1998.

In interviews conducted with Metro Networks, it was determined that the costs incurred during the commercial development phase would consist of the continued costs of the Metro Networks operations of the SWIFT TWS, the upgrade of the existing SWIFT TWS computer systems, and the cost of an ISDN line for improved Internet connectivity with the other SWIFT team members.

The weekly cost of Metro Networks operations of the SWIFT TWS are shown below in Table 3-7. Based on interviews with Metro Networks, it was determined that the labor hours would consist of a full time Project Manager to oversee all SWIFT TWS and other SWIFT-related activities, and two or more TWS operators available for the following hours: 6 am to 7 pm Monday to Friday; 10 am to 6 pm Saturday, and 12 am to 6 pm Sunday. The labor rates and overhead rates used below were based on the generalized groundrules provided in Section 2.2.4, with the assumption that a TWS Operator is equivalent to a Mid-Level Technical Specialist (trades).

Table 3-7. Metro Networks SWIFT TWS Weekly Operations Cost Estimate.

Labor Category	Hours	Rate ($/hr)	Labor Cost	Overhead/G&A	Labor (Loaded)
Project Manager	40	35	$1,400	$2,100	$3,535
TWS Operators (2)	79	18	$1,422	$2,133	$3,573
Total	119				$7,108

Based on interviews with Metro Networks, it was also determined that at upgrade/ replacement of the existing SWIFT TWS computer and spare would be desirable during the commercial development phase. Based on a price quote from Gateway 2000[10], a 300 MHz Pentium II "NT workstation class" system with 128 MB Ram, large monitor, and significant additional features, would cost $4,925. Thus replacing both the existing SWIFT TWS computer and the spare SWIFT TWS computer would extend the cost to **$9,850 total**. Note that it is assumed here that Etak would be responsible for configuring the machine with the necessary TWS software. Note also that it is assumed here that the warranty would cover any computer maintenance costs through the commercial development period.

Metro Networks also expressed the desire to move to ISDN-based Internet connectivity for its SWIFT TWS's. Based on a typical ISDN installation and service price quote[11], ISDN costs per SWIFT TWS computer would be a one time fee or $196 for installation, and $435 in total monthly service charges for the commercial development phase ($29 monthly x 15 months). Extending this cost for both SWIFT TWS's (to include the spare) provides a total ISDN installation and service cost of $1262.

Combining the labor and ODC cost/hour estimates detailed above yields the cost estimate for the Metro Networks SWIFT commercial development phase, which is presented in Table 3-8.

Table 3-8. Metro Networks SWIFT Commercial Development Cost Estimate.

Hours (Total)	Labor (Loaded)	Other Direct Costs	Total Cost
8,249	$493K	$11K	$504K

Annual Commercial Operations Cost Estimate

The Metro Networks SWIFT annual commercial operations cost estimate is an estimate of the cost of operations of a commercially deployed SWIFT system per year following the full deployment of a commercial SWIFT system on 1 January 1999.

Metro Networks SWIFT operations costs are as largely based on the monthly operations cost estimates calculated in the above commercial development cost estimate, namely:

[10] Gateway 2000 Price Quote #10214224, 2/14/98, Model E-5000 300, 300 MHz Pentium II, 128 MB RAM, Windows NT, 19" Monitor, 8 MB Video Care, 9GB SCSI HD, 32X CD-ROM, 56.6 Modem, 10/100 Ethernet Card, Zip Drive, Tape Backup, LAN software, Uninterrupted Power Supply, Gold Warranty

[11] Pacific Bell "FasTrak Business ISDN" price quote, 2/14/98

- Weekly SWIFT-related labor cost (loaded) = $7,108 (119 hours)
- Monthly ISDN Service = $58

In addition, annual equipment maintenance costs are calculated by applying a 10% factor, based on the generalized groundrules provided in Section 2, to the SWIFT TWS computer cost of $9,850 (estimated above), to yield an annual maintenance cost estimate of $985. Thus, the these costs extended to 12 months make up the SCS SWIFT annual operations cost estimate, which is presented in Table 3-9.

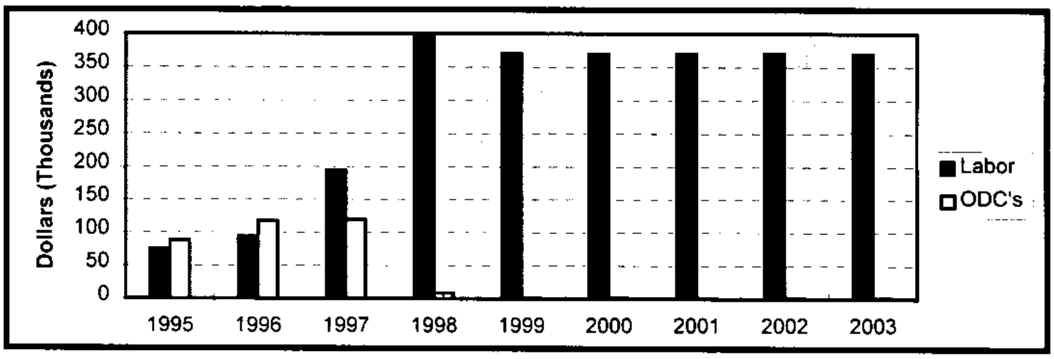
Table 3-9. Metro Networks SWIFT Annual Operations Cost Estimate.

Hours (Total)	Labor (Loaded)	Other Direct Costs	Total Cost
6,188	$370K	$2K	$371K

Life Cycle Cost Estimate

Based on the above, the Metro Networks SWIFT LCCE, presented in Table 3-10, provides an estimate of the total costs that would be required to develop, test, deploy and operate the Metro Networks portion of a commercial SWIFT system. For analysis purposes, the LCCE assumes a five year period of operations.

Table 3-10. Metro Networks SWIFT Life Cycle Cost Estimate.



Cost Estimate	Time Period	Hours (Total)	Labor (Loaded)	ODC's	Total Cost
FOT Development	Jan 95 thru Sep 97	4,348	$264K	$320K	$584K
Commercial Development	Oct 97 thru Dec 98	8,249	$493K	$11K	$504K
Annual Commerical Operations	Annual from 1/1/99	6,188	$370K	$2K	$371K
Life Cycle Cost (5 yrs. Ops.)	Jan 95 thru Dec 03	43,536	$2,604K	$340K	$2,944K

3.1.4. Etak Cost Estimate

System Description

Over the last decade, Etak has been on the forefront in developing digital geographic maps and related technologies. For SWIFT, in addition to serving as the georeferencing consultant, and assisting with the overall design of the SWIFT system, Etak provided:

1) SWIFT software for Metro Networks Traffic Workstations (TWS's)

2) Geocoded business listings and address files for destination finding with the Delco in-vehicle navigation device

3) Software, map database, and business listings to display real-time traffic and bus positions and to find destinations with portable computers

4) Software that sends personalized traffic alerts to Seiko MessageWatch pagers based on individual travel profiles stored in the Metro Networks TWS's

For PC use on SWIFT, Etak map-based software allows the user to show the location of each piece of data and to select the type of information (i.e., traffic incident, congestion or transit vehicle location) to be displayed. Each type of information is updated or re-sent at regular intervals. A "yellow pages" directory is also installed and linked to the map-based software to show the location of a selected business. The software also offers transit schedule information from static database tables inside the computer.

FOT Development Phase Cost Estimate

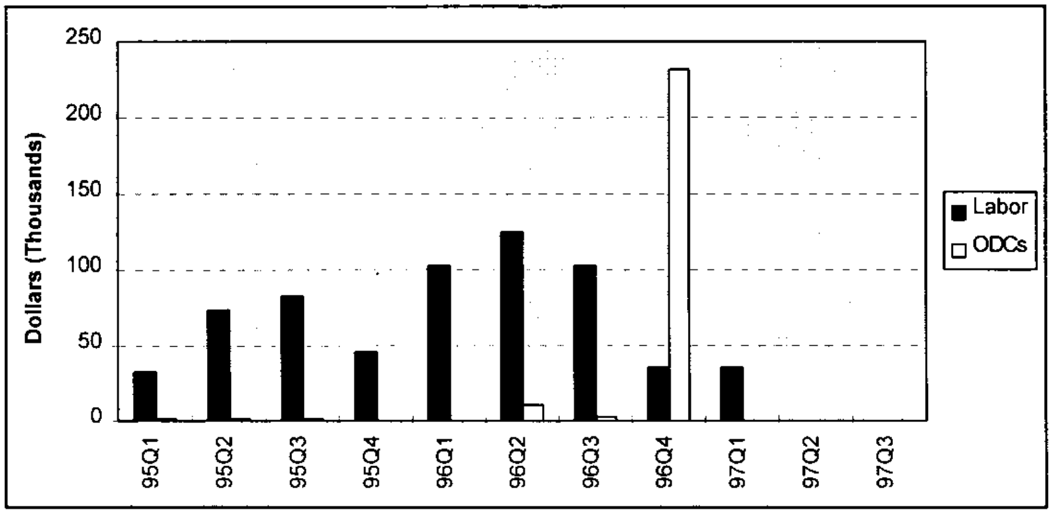
The Etak SWIFT FOT development cost estimate includes all actual costs accrued during the SWIFT Test from 1 January 1995 through 30 September 1997. These costs include all SWIFT design, development, testing and evaluation activities performed by Etak as shown here:

- Supported architecture development of the SWIFT system
- Worked with Metro Networks to develop, test, install, and maintain, and upgrade the prototype SWIFT Traffic Work Station (TWS) at Metro Networks; developed software for Metro Networks user interface
- Worked with Metro Networks to install "spare" SWIFT TWS at Metro Networks
- Developed a map software tool which allowed developers to rapidly create a map (based on Etak's global map libraries) for any windows software application
- Developed updated digital map of Seattle Metro area for use on PDA's and Laptops, and in support of Metro Transit AVL system
    - ⇒ Provided a licensed version of Seattle Metro area digital map for the SWIFT system at a cost of about $230K (see ODC "spike" in table below for 4th Quarter 1996)
- Worked with SCS, UW and IBM to develop various SWIFT software tools; developed components of incident database and user profile software
- Supported Alpha, Beta and Final Evaluation testing of the SWIFT system

- Provided management functions, coordination and meetings with the SWIFT team, supported the evaluation team, and provided other support to the SWIFT project as required

The result of the Etak SWIFT FOT development cost estimate is presented in Table 3-11. The costs and hours shown are all "actuals", and have been collected from the corresponding Quarterly SWIFT Invoice Summaries and the SWIFT Monthly Progress Reports. The complete detailed spreadsheet breakout is presented in Appendix A.

Table 3-11. Etak FOT Development Cost Estimate.



Hours	Labor (Loaded)			Other Direct Costs			Total		
(Total)	Public	Private	Total	Public	Private	Total	Public	Private	Total
7,760	$579K	$60K	$639K	$16K	$232K	$248K	$595K	$292K	$887K

Commercial Development Phase Cost Estimate

The Etak SWIFT commercial development cost estimate is an estimate of the additional costs that would necessary to complete development and testing of Etak's portion of the SWIFT system prior to the full deployment of a commercial SWIFT system. The time period assumed for the commercial development phase cost estimate is 1 October 1997 through 31 December 1998.

In interviews conducted with Etak, it was determined that the only costs that would likely be incurred by Etak during the commercial development phase would consist of the additional software development that would be required to develop "commercial" versions or upgrades of it's prototype SWIFT-related software, namely:

- Integrate new Seattle Metro Area digital map (being developed separately by Etak)
- Re-engineer PC user SWIFT Windows-based software to make it into a viable commercial product – requires additional features and an improved user interface

- Upgrade SAIC-developed user profile software to be a robust and sophisticated "operational" product that can support large-scale public use
- Update and improve "yellow pages" database of Seattle Metro Area businesses

Based on interviews with Etak, it was determined that about two staff-years of software development labor would be required during the commercial development phase to complete these activities. As shown below in Table 3-12, it is assumed here that this would consist of one staff-year by a Senior Software Engineer and 1 staff-year by a Junior Software Engineer. The labor rates and overhead rates used below were based on the generalized groundrules provided in Section 2.

Table 3-12. Etak SWIFT Software Development Labor Cost Estimate.

Labor Category	Hours	Rate ($/hr)	Labor Cost	Overhead/G&A	Labor (Loaded)
Senior Software Engr.	1,920	35	$67,200	$100,800	$168,035
Junior Software Engr.	1,920	18	$34,560	$51,840	$86,418
Total	3,840				$254,453

The above yields the cost estimate for the Etak SWIFT commercial development phase, which is presented in Table 3-13.

Table 3-13. Etak SWIFT Commercial Development Cost Estimate.

Hours (Total)	Labor (Loaded)	Other Direct Costs	Total Cost
3,840	$254K	$0K	$254K

Annual Commercial Operations Cost Estimate

The Etak SWIFT annual commercial operations cost estimate is an estimate of the cost of operations of a commercially deployed SWIFT system per year following the full deployment of a commercial SWIFT system on 1 January 1999.

Based on interviews with Etak, it was determined that Etak costs during the operations phase would be based on having the equivalent of one full-time software support person available for consulting and for performing troublshooting and minor upgrades to the Etak SWIFT hardware as required. The estimate of this labor cost is shown below in Table 3-14. Note that the actual staffing for these hours would likely consist of a be mix of senior, mid-level junior personnel. The labor rates and overhead rates used below were based on the generalized groundrules provided in Section 2.

Table 3-14. Etak SWIFT Software Support Labor Cost Estimate.

Labor Category	Hours	Rate ($/hr)	Labor Cost	Overhead/G&A	Labor (Loaded)
Mid-Lvl Software Engr.	1,920	28	$53,760	$80,640	$134,428

The above yields the cost estimate for the Etak SWIFT commercial development phase, which is presented in Table 3-15.

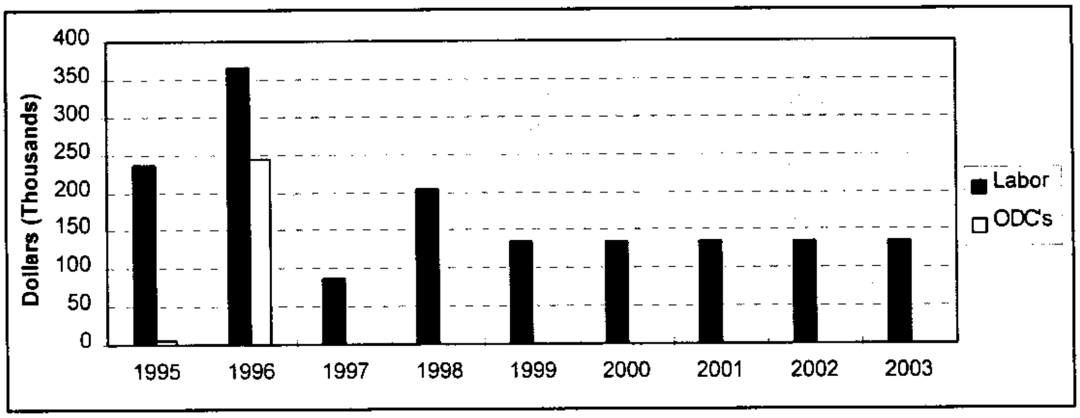
Table 3-15. Etak SWIFT Annual Operations Cost Estimate.

Hours (Total)	Labor (Loaded)	Other Direct Costs	Total Cost
1,920	$134K	$0K	$134K

Life Cycle Cost Estimate

Based on the above, the Etak SWIFT LCCE, presented in Table 3-16, provides an estimate of the total costs that would be required to develop, test, deploy and operate the Etak portion of a commercial SWIFT system. For analysis purposes, the LCCE assumes a five-year period of operations.

Table 3-16. Etak SWIFT Life Cycle Cost Estimate.



Cost Estimate	Time Period	Hours (Total)	Labor (Loaded)	ODC's	Total Cost
FOT Development	Jan 95 thru Sep 97	7,760	$639K	$248K	$887K
Commercial Development	Oct 97 thru Dec 98	3,840	$254K	$0K	$254K
Annual Commerical Operations	Annual from 1/1/99	1,920	$134K	$0K	$134K
Life Cycle Cost (5 yrs. Ops.)	Jan 95 thru Dec 03	21,200	$1,565K	$248K	$1,813K

3.1.5. UW Cost Estimate

System Description

The University of Washington's role on SWIFT was to develop the necessary data processing capabilities, in the form of software and hardware, to allow for the fusion of data from three sources, namely:

(a) Loop detector data from WSDOT indicated by volume, occupancy and speed in the case of dual loop detectors.

(b) AVL data from Metro Transit indicated as routes (a series of geographical locations placed sequentially in a file), and status (a code indicating such parameters as type of route, type of vehicle, schedule adherence, etc.).

(c) Rideshare data from the World Wide Web (WWW) about potential participants in dynamic car pools.[12]

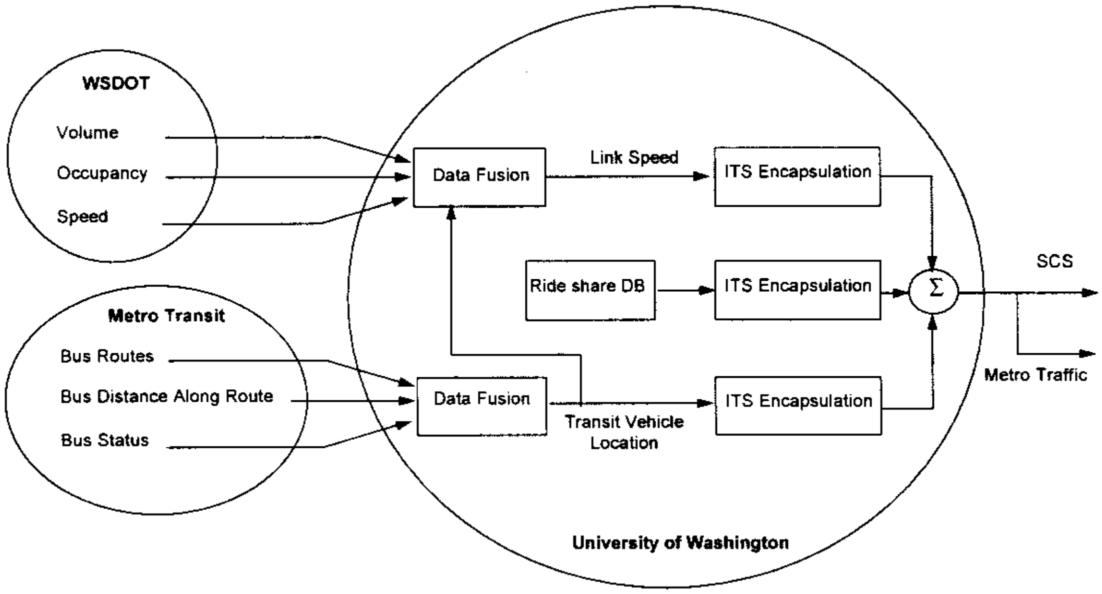


Figure 3-8. UW SWIFT Functions.

As shown in Figure 3-8, these data sources are then encapsulated and fused to generate three types of data streams for eventual transmission via the HSDS. These data streams include the following:

(a) Measured and estimated travel speeds on regional freeways.

(b) Estimated current locations of Metro buses.

(c) Selected elements from a database of information on potential rideshare participants.

FOT Development Phase Cost Estimate

The UW SWIFT FOT development cost estimate includes all actual costs accrued during the SWIFT Test from 1 January 1995 through 30 September 1997. These costs include all SWIFT design, development, testing and evaluation activities performed by UW as shown here:

- Supported selection of SWIFT base data elements (i.e., traveler information inputs)

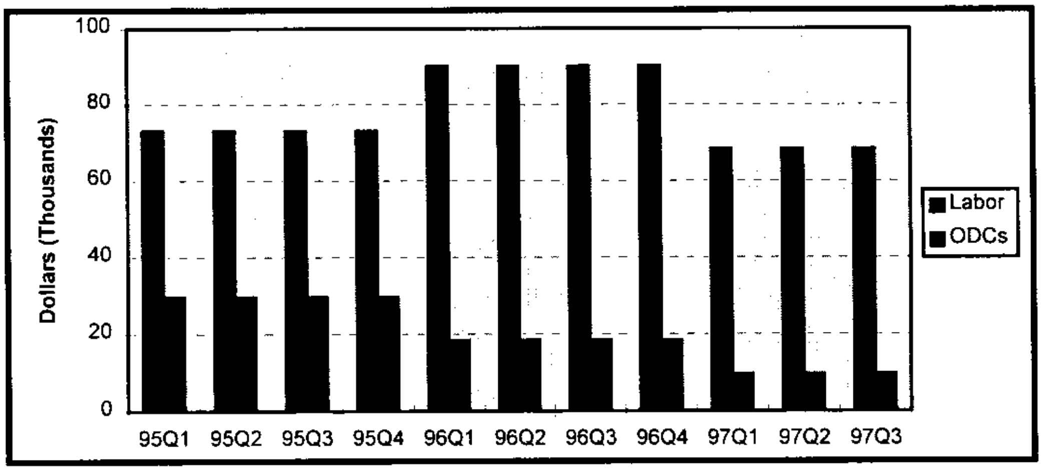
[12]Although it's related, the rideshare project is not technically part of SWIFT -- only a relatively small number of SWIFT participants could use this service.

- Defined data package formats for each selected base data element
- Worked with SWIFT Team members to plan system architecture and data flow data needs (IBM for PC & PDA services, Delco for radio services, Seiko for Message Watch services)
- Worked with providers of base data elements (WSDOT, Metro Transit & Metro Networks) to secure robust data streams for the life of the SWIFT project.
- Enhanced the regional "backbone" data network to make the data obtained from the providers as well as the appropriate bandwidth is available for each
    - ⇒ Hardware costs for the backbone were determined (based on UW invoices) to be $44.2K and consisted of 9 personal computers/servers and a laser printer
- Designed and implemented prototype software to validate source data elements prior to delivery to the Seiko HSDS
- Designed and implemented prototype software to fuse source data elements into desired format prior to delivery to the Seiko HSDS
- Provided technical assistance and design specifications (format and bandwidth) to Seiko for integrating the data on the regional backbone with the HSDS network
- Supported Alpha, Beta and Final Evaluation testing of SWIFT by providing validated, fuzed data to the Seiko HSDS network
- Provided management functions, coordination and meetings with the SWIFT team, supported the evaluation team, and provided other support to the SWIFT project as required

The result of the UW SWIFT FOT development cost estimate is presented in Table 3-17. Since "actuals" were not available from UW, this estimate was instead created based on the costs detailed in the Budget Estimate in the original UW proposal that was submitted to WSDOT in October 1994. [13] It has been verified with WSDOT that the total value of this proposal Budget Estimate ($1.076M) was equal to the total amount spent by UW at the end of the SWIFT test on 30 September 1998.

[13] D.J. Dailey, "Research Task Order #37: SWIFT - Seattle Wide Area Information for Travelers", submitted to WSDOT, October 1, 1994

Table 3-17. UW FOT Development Cost Estimate.



Hours	Labor (Loaded)			Other Direct Costs			Total		
(Total)	Public	Private	Total	Public	Private	Total	Public	Private	Total
32,136	$857K	$0K	$857K	$220K	$0K	$220K	$1,077K	$0K	$1,077K

In order to create this estimate, the UW proposal Budget Estimate was converted from fiscal years to calendar years, and actual equipment dollars ($44.2K) available from UW invoices were substituted for the estimated equipment costs ($100K), with the difference ($55.8K) applied to labor in 1997 since the SWIFT test was extended through September. The complete detailed spreadsheet breakout is presented in Appendix A.

Commercial Development Phase Cost Estimate

The UW SWIFT commercial development cost estimate is an estimate of the additional costs that would be necessary to complete development and testing of UW's portion of the SWIFT system prior to the full deployment of a commercial SWIFT system. The time period assumed for the commercial development phase cost estimate is 1 October 1997 through 31 December 1998.

UW activities during commercial development consist of both non-recurring development activities and recurring operations activities. The non-recurring development activities consist of the following:

- Development of an ITS/IEEE standards proposal for a self-defining data standard
- Implementation of the ITS/IEEE self-defining data standard reference
- Interaction with IEEE/SAE standards bodies to both contribute to standards, and to guarantee that the SWIFT project is aligned with ITS national standards
- Systems Integration support to provide software and interface definitions that will allow SWIFT consortium members to receive and use data from the ITS

backbone; this includes any consulting required to support consortium use of ITS backbone data

- Purchase, Installation and configuration of fiber optic communications hardware and backup hardware

Cost estimates for both labor and ODC's associated with these non-recurring development activities are presented below in Tables 3-18 and 3-19. These estimates are based on a detailed analysis and breakout, in consultation with UW and WSDOT, of elements of two recent proposals submitted to submitted to WSDOT from UW related to the completion of development of the UW SWIFT system – the *STS Backbone Infrastructure Expansion*[14] proposal and the *STS Backbone Infrastructure*[15] proposal.

Table 3-18. Cost Estimate of UW Non-Recurring Labor.

Labor Category	Hours	Rate ($/hr)	Labor Cost	Overhead/G&A	Labor (Loaded)
Principal Investigator	537.6	46	$24,461	$19,079	$43,586
Programmer	2419.2	30	$72,271	$56,372	$128,673
Grad Student	4838.4	11	$53,496	$41,727	$95,234
Total	7795.2				$267,492

Table 3-19. Cost Estimate of UW Non-Recurring ODCs.

Category	Cost
Equipment	$37,000
Fiber Optic/T1 Line Service	$25,500
TRAC	$6,803
Travel	$7,140
Supplies & Materials	$4,121
Total	$80,565

Most of these non-recurring labor and ODC costs shown above were estimated based on the *"Infrastructure Expansion"* proposal, with the addition of the fiber optic installation equipment and line service ODC costs taken from the *"Infrastructure"* proposal. Based on interviews with UW, the labor hours were estimated based on the assumption that 84% of the activities (i.e., hours assigned to each task) defined in the *Infrastructure Expansion* proposal were SWIFT related, with the other activities being related to other ITS elements. The UW "Overhead/G&A" rate was derived from the cost section of the proposals. Note that while there were differences between period of performance of the *Infrastructure Expansion* proposal and the commercial development phase (18 months vs.

[14] Daniel J. Dailey & Mark P. Haselkorn, "STS Backbone Infrastructure Expansion", a proposal submitted to WSDOT, UW ITS Research Program, November 1996.

[15] Daniel J. Dailey & Mark P. Haselkorn, "STS Backbone Infrastructure", a proposal submitted to WSDOT, UW ITS Research Program, November 1996.

15 months), it was assumed here that the non-recurring labor hours and ODCs would remain the same.

As mentioned above, UW activities during commercial development also consist of recurring operations activities. The non-recurring development activities consist of the following activities which allow the continued operations of the SWIFT system during the commercial development phase:

- Hardware and software maintenance for the existing backbone infrastructure
- Continued maintenance of external communications links in conjunction with WSDOT, including new and replacement hardware as required
- Lease of fiber optic interconnect between UW and WSDOT
- Provide documentation, example source code and consulting to allow ISPs access to any of the data flows available on the ITS backbone; respond to ISP requests for additional services

A cost estimate for the monthly labor associated with these recurring operations activities is presented below in Table 3-20. This estimate is based on the labor hours presented in the *Infrastructure* proposal.

Table 3-20. Estimate of UW Monthly Recurring Operations Costs.

Labor Category	Hours	Rate ($/hr)	Labor Cost	Overhead/G&A	Labor (Loaded)
Principal Investigator	27	46	$1,214	$947	$2,207
Research Manager	27	19	$519	$405	$943
Programmer	107	30	$3,189	$2,488	$5,706
Grad Student	53	29	$1,527	$1,191	$2,746
Total	214				$11,602

In the above, the monthly hours were calculated based on dividing the total hours by category contained in the *Infrastructure* proposal by the proposal period of performance of eighteen months. As mentioned previously, the UW "Overhead/G&A" rate was derived from the cost section of both proposals.

Combining the non-recurring labor and ODC cost estimates with the monthly recurring operations cost estimate, (multiplied by 15 months for the commercial development period of performance) yields the cost estimate for the UW SWIFT FOT development phase, which is presented in Table 3-21.

Table 3-21. UW SWIFT Commercial Development Cost Estimate.

Hours (Total)	Labor (Loaded)	Other Direct Costs	Total Cost
10,998	$442K	$81K	$522K

Annual Commercial Operations Cost Estimate

The UW SWIFT annual commercial operations cost estimate is an estimate of the cost of operations of a commercially deployed SWIFT system per year following the full deployment of a commercial SWIFT system on 1 January 1999.

In interviews conducted with UW, it was suggested by UW that the labor costs of operations during the operations phase would be more efficient than the labor costs of operations during the commercial development phase by a factor of about a 25% reduction. Thus, applying a 25% reduction to these costs yields the following estimate of UW operations costs shown in Table 3-22.

Table 3-22. Estimate of UW Monthly Operations Costs.

Labor Category	Hours	Rate ($/hr)	Labor Cost	Overhead/G&A	Labor (Loaded)
Principal Investigator	20	46	$911	$710	$1,667
Research Manager	20	19	$389	$304	$712
Programmer	80	30	$2,392	$1,866	$4,287
Grad Student	40	29	$1,145	$893	$2,067
Total	160				$8,733

An analysis of the *Infrastructure* proposal provided the elements with which to estimate annual ODC costs as shown here in Table 3-23. Note that the Equipment Maintenance cost ($900/month) was calculated as a 10% factor applied to the purchased equipment cost ($9,000/month) contained in the *Infrastructure* proposal.

Table 3-23. Estimate of UW SWIFT Annual ODC's.

Category	Monthly Cost	Annual Cost
Fiber Optic/T1 Line Service	$1,417	$17,000
Equipment Maintenance	$900	$10,800
Supplies & Materials	$165	$1,980
Total	$2,482	$29,780

Combining the annual labor and ODC cost estimates yields the UW SWIFT annual operations cost estimate, which is presented below in Table 3-24.

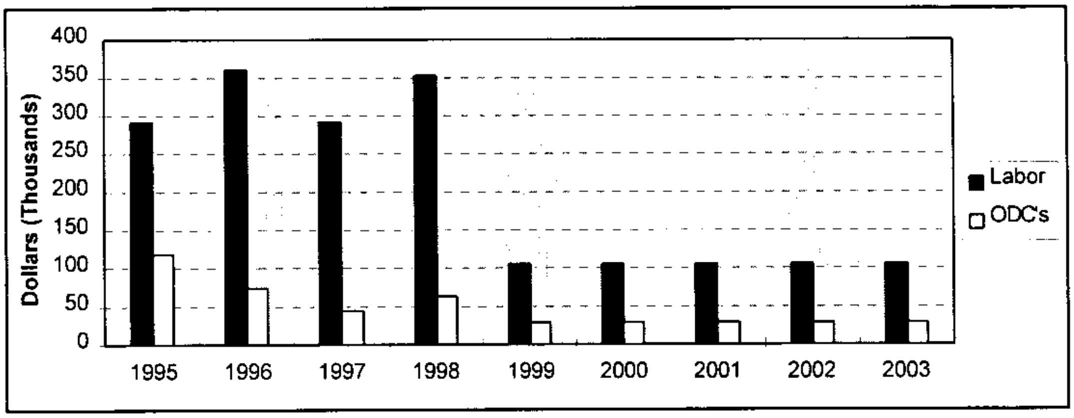
Table 3-24. UW SWIFT Annual Operations Cost Estimate.

Hours (Total)	Labor (Loaded)	Other Direct Costs	Total Cost
1,922	$105K	$30K	$135K

Life Cycle Cost Estimate

Based on the above, the UW SWIFT LCCE, presented in Table 3-25, provides an estimate of the total costs that would be required to develop, test, deploy and operate the UW portion of a commercial SWIFT system. For analysis purposes, the LCCE assumes a five-year period of operations.

Table 3-25. UW SWIFT Life Cycle Cost Estimate.



Cost Estimate	Time Period	Hours (Total)	Labor (Loaded)	ODC's	Total Cost
FOT Development	Jan 95 thru Sep 97	32,136	$857K	$220K	$1,077K
Commercial Development	Oct 97 thru Dec 98	10,998	$442K	$81K	$522K
Annual Commerical Operations	Annual from 1/1/99	1,922	$105K	$30K	$135K
Life Cycle Cost (5 yrs. Ops.)	Jan 95 thru Dec 03	52,741	$1,822K	$450K	$2,272K

3.1.6. King County Metro Transit Cost Estimate

System Description

Metro Transit implemented an Automatic Vehicle Location and Computer-Aided Dispatch (AVL/CAD) system in 1993 in order to improve fleet management and operator security. The vehicle location and schedule adherence for the 1,150 buses is based on a less sophisticated signpost technology as opposed to the use of the Global Positioning System (GPS), since GPS was not widely available when the contract for the project was released in 1989.

The AVL system is composed of a central computer, 255 signpost transmitters that are located throughout the 5000 square kilometer service area, an odometer sensor on each bus, a Mobile Electronic Tracking System (METS) located on each bus, and a two-way radio system on each bus. The system's main computers are loaded with the current bus schedules and routings, including the identity of each signpost transmitter on the route, and the distance between signposts. The bus driver identifies his or her assignment number when leaving the base. When the bus passes each battery-powered signpost, a small receiver on the bus captures the signpost signal and stores it in the memory of an on-board processor. This information, together with the current odometer reading, is sent back to the central computer each time the bus is polled via the data radio system. Polling occurs nominally every 1 to 2 minutes during the peak when up to 900 buses are in service, and more frequently during off-peak periods. Once the polling data is received by the central computer, it calculates whether the bus is on schedule based on time stamps for each scheduled time point along the route and it estimates the bus location on the network based on the location of the last signpost encountered and the odometer reading since the last signpost.

For SWIFT, Metro Transit worked with UW to develop software and interfaces which would allow transmission of real time AVL data on the Seiko HSDS, thus allowing transit riders with access to personal computers the ability to determine real-time bus locations at home or at work. The elements of Metro Transit's SWIFT system and inter-connectivity to the overall SWIFT data flow are shown below in Figure 3-9.

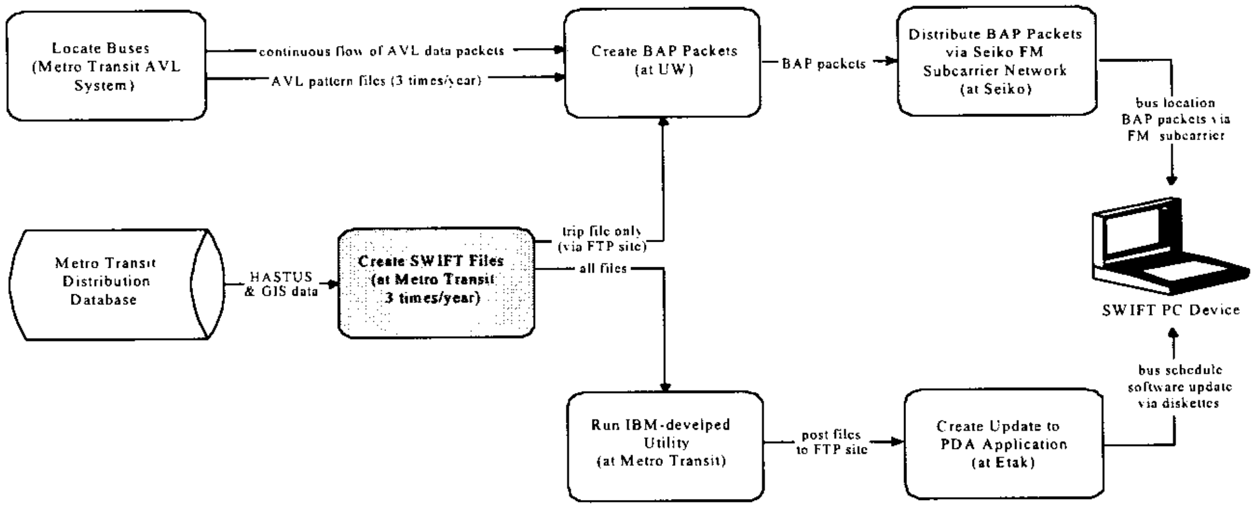


Figure 3-9. Metro Transit SWIFT Functions.

In the above, the primary activities of Metro Transit which are SWIFT-specific (as shown in the shaded box) include the initial software development activity (with Etak and IBM) to create eight SWIFT data file types (2 files for bus locations and 6 files for revisions to laptop software), as well the corresponding continual update (3 times/year) of these eight SWIFT data files when Metro Transit's bus schedules are revised during a "service change."

FOT Development Phase Cost Estimate

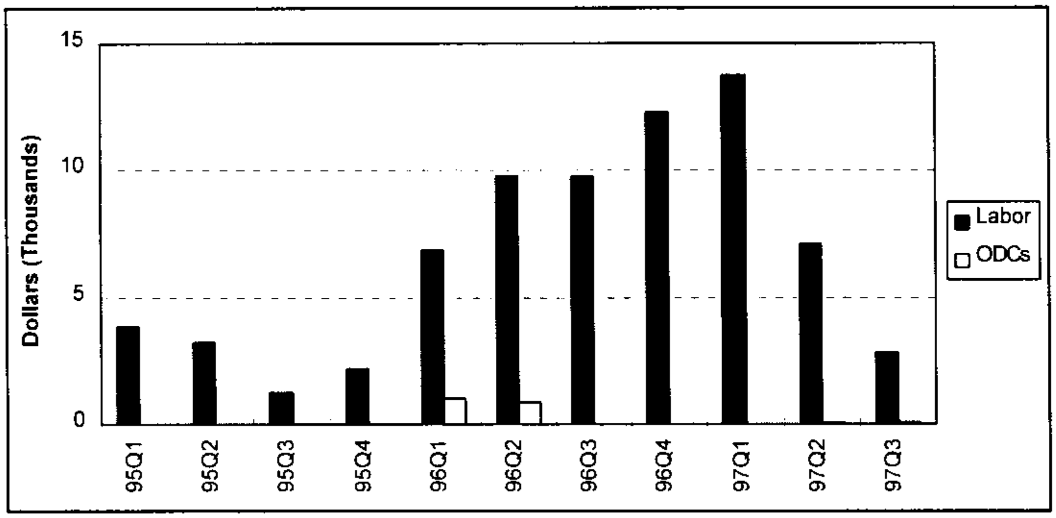
The Metro Transit SWIFT FOT development cost estimate includes all actual costs accrued during the SWIFT Test from 1 January 1995 through 30 September 1997. These costs include all SWIFT design, development, testing and evaluation activities performed by Metro Transit as shown here:

- Finalized Metro Transit SWIFT system requirements
- Developed Metro Transit portions of the SWIFT architecture
- Completed an initial software development activity (with Etak and IBM) to create 8 SWIFT data file types (2 files for bus locations and 6 files for revisions to laptop software)
    - ⇒ Estimated labor includes 100 hours for a Project Manager and 100 hours for a Systems Analyst

- Supported Alpha & Beta testing of SWIFT bus AVL inputs to PC devices through the Seiko HSDS
- Supported system integration (with Etak and Seiko) of MT portions of the SWIFT bus AVL input
- Provided one update of the 8 MT SWIFT data files in June 1997
  - ⇒ Estimated labor includes 100 hours for a Project Manager, 120 hours for a Computer Scientist, 30 hours for a Systems Analyst, and 250 hours for a Junior Engineer
- Supported Final Evaluation testing of SWIFT Bus AVL Inputs to PC devices through the Seiko HSDS
- Provided management functions, coordination and meetings with the SWIFT team, supported the evaluation team, and provided other support to the SWIFT project as required

The result of the Metro Transit SWIFT FOT development cost estimate is presented in Table 3-26. The costs and hours shown are all "actuals", and have been collected from the corresponding Quarterly SWIFT Invoice Summaries and the SWIFT Monthly Progress Reports. In the case of Metro, all funding was from public sources. The complete detailed spreadsheet breakout is presented in Appendix A.

Table 3-26. Metro Transit FOT Development Cost Estimate.



Hours	Labor (Loaded)			Other Direct Costs			Total		
(Total)	Public	Private	Total	Public	Private	Total	Public	Private	Total
1,751	$73K	$0K	$73K	$2K	$0K	$2K	$75K	$0K	$75K

Commercial Development Phase Cost Estimate

The Metro Transit SWIFT commercial development cost estimate is an estimate of the additional costs that would necessary to complete development and testing of Metro

Transit's portion of the SWIFT system prior to the full deployment of a commercial SWIFT system. The time period assumed for the commercial development phase cost estimate is 1 October 1997 through 31 December 1998.

In interviews conducted with Metro Transit, it was determined that the only costs incurred during the commercial development phase would be the costs of the Metro Transit service changes, in which they update their 8 SWIFT database files three times per year. The cost of a single service change is estimated below in Table 3-27, based on hour data and labor descriptions provided by Metro Transit. The labor rates used were based on the generalized groundrules provided in Section 2. Following this, based on the actual hours and labor dollars accrued during the FOT development phase, an overhead rate of 56% was calculated so as to calibrate the labor costs to be consistent with the actual loaded labor costs in the FOT development cost estimate above.

Table 3-27. Cost Estimate of a Single Metro Transit SWIFT Service Change.

Labor Category	Hours	Rate ($/hr)	Labor Cost	Overhead/G&A	Labor (Loaded)
Manager	115	42	$4,830	$2,705	$7,577
Systems Analyst	30	35	$1,050	$588	$1,673
Computer Scientist	120	28	$3,360	$1,882	$5,270
Junior Engineer	250	18	$4,500	$2,520	$7,038
Total	515				$21,557

During the commercial development timeframe, four service changes would be required: October 1997, February 1998, June 1998, and October 1998. The costs of these four service changes make up the cost estimate for of the Metro Transit SWIFT FOT development phase, which is presented in Table 3-28.

Table 3-28. Metro Transit SWIFT Late Deployment Cost Estimate.

Hours (Total)	Labor (Loaded)	Other Direct Costs	Total Cost
2,060	$86K	$0K	$86K

Annual Commercial Operations Cost Estimate

The Metro Transit SWIFT annual commercial operations cost estimate is an estimate of the cost of operations of a commercially deployed SWIFT system per year following the full deployment of a commercial SWIFT system on January 1, 1999.

In interviews conducted with Metro Traffic, it was determined that the only annual operations costs that would be incurred by Metro Transit would be the costs of the Metro Transit service changes, in which they update their eight SWIFT database files three times per year. The cost of a service change was previously estimated above. Thus, the costs of three service changes make up the Metro Transit SWIFT annual operations cost estimate, which is presented in Table 3-29.

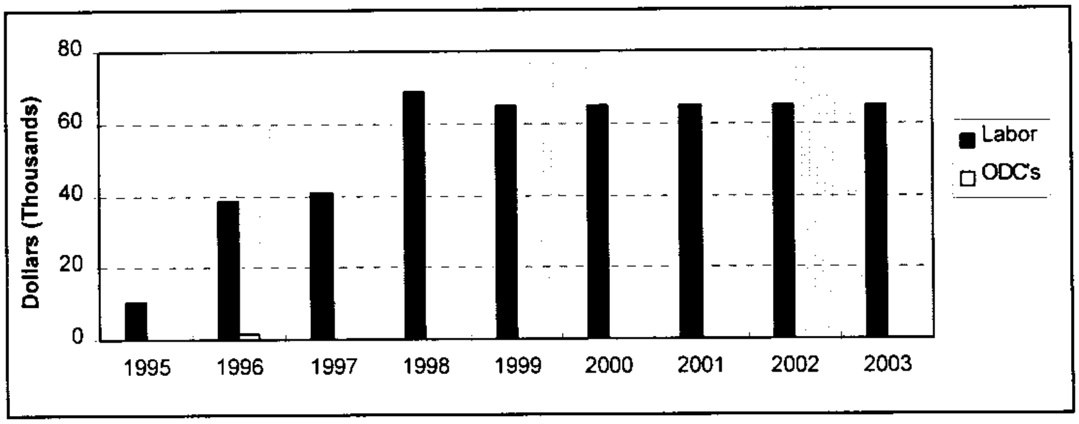
Table 3-29. Metro Transit SWIFT Annual Operations Cost Estimate.

Hours (Total)	Labor (Loaded)	Other Direct Costs	Total Cost
1,545	$65K	$0K	$65K

Life Cycle Cost Estimate

Based on the above, the Metro Transit SWIFT LCCE, presented in Table 3-30, provides an estimate of the total costs that would be required to develop, test, deploy and operate the Metro Transit portion of a commercial SWIFT system. For analysis purposes, the LCCE assumes a five year period of operations.

Table 3-30. Metro Transit SWIFT Life Cycle Cost Estimate.



Cost Estimate	Time Period	Hours (Total)	Labor (Loaded)	ODC's	Total Cost
FOT Development	Jan 95 thru Sep 97	1,751	$73K	$2K	$75K
Commercial Development	Oct 97 thru Dec 98	2,060	$86K	$0K	$86K
Annual Commerical Operations	Annual from 1/1/99	1,545	$65K	$0K	$65K
Life Cycle Cost (5 yrs. Ops.)	Jan 95 thru Dec 03	11,536	$483K	$2K	$485K

3.1.7. IBM Cost Estimate

System Description

IBM's activities during the SWIFT tested consisted of being a equipment supplier of laptop PC's and PDA's, developing SWIFT software for these laptops and PDA's, and providing system performance modeling and simulation consulting support for the overall SWIFT architecture.

The SWIFT test utlized IBM supplied Dauphin PDA's, IBM Thinkpad laptop computers, and Toshiba Satellite laptop computers as user interface devices. All the applications ran under Windows 3.1 in the case of the Dauphins and Thinkpads and under Windows 95 in the case of the Toshiba Satellite laptops. The Thinkpads had a built-in, "butterfly" keyboard and an active matrix, SVGA color display. The Dauphins use a pen for command entry and have a backlit, VGS black and white display. The Toshiba laptops were Pentium 100s with 16 Megabytes of RAM. One hundred portable computers, with a mix of the three PC's, were used in the FOT in order to test the SWIFT system for different PC hardware and software environments.

A separate HSDS receiver unit, provided by SCS, was attached to each PC in order to receive the traveler information and to send the information to the portable computer's serial port. The data is sent in the HSDS ITIS format.

IBM, working closely with Etak and Metro Transit, developed the information processing portion of the pc/pda SWIFT traveler information software, including data storage organization, display and processing of freeway loop and bus data, trip planning, ride sharing database, route guidance information, and traffic flow analysis. Traveler information for the computer includes traffic incident, congestion and bus-location information. The portable computers also support personal paging, other existing Seiko information services (e.g., weather, financial reports and sports scores) and ASCII text messages to support more detailed presentations of Seiko information services and any other message not specified by ITIS.

In addition, IBM contributed to the overall SWIFT design by providing communications modeling and simulations, including modeling pda/pc and Delco car navigation radio performance, determination of optimum protocol usage for transmission of loop and bus data, and end-to-end system model analysis.

FOT Development Phase Cost Estimate

The IBM SWIFT FOT development cost estimate includes all actual costs accrued during the SWIFT Test from 1 January 1995 through 30 September 1997. These costs include all SWIFT design, development, testing and evaluation activities performed by IBM as shown here:

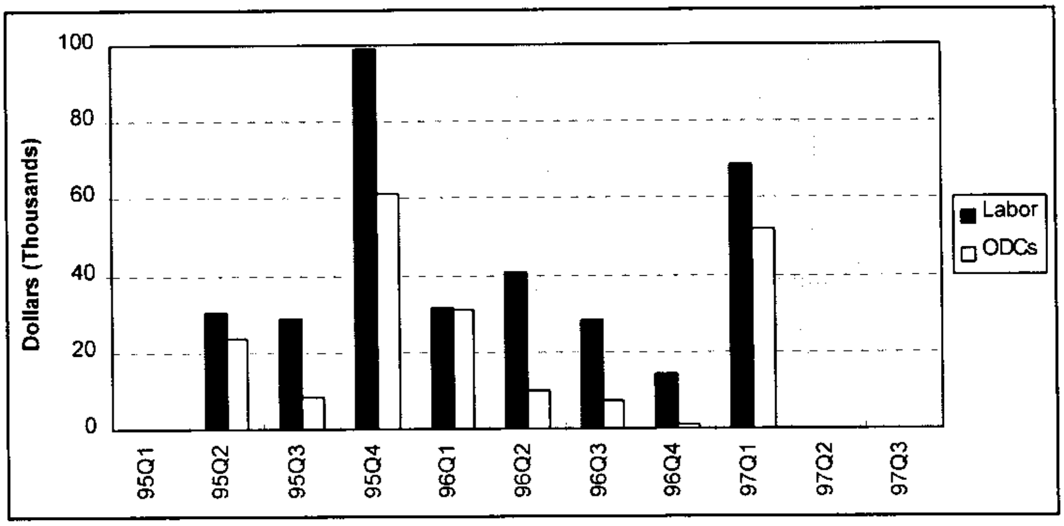
- Provided PDA's and laptop comupters in support of the SWIFT Test
  - ⇒ 100 Dauphin PDA's at a total cost of about $26,000
  - ⇒ 24 IBM Think Pad laptop computers at a total cost of about $48,000[16]
- Supported overall SWIFT architecture development by providing communications modeling and simulations, including modeling PC and Delco in-vehicle navigation device performance, determination of optimum protocol usage for transmission of loop and bus data, and end-to-end system modeling analysis
- Worked with Etak, Metro Transit and UW to develop information processing portions of SWIFT software tools; developed software components of data storage organization, display and processing of freeway and loop data, trip planning, ride sharing database, route guidance information, and traffic flow analysis.

[16] Note that 40 Toshiba laptop computers at a total cost of about $60,000 were also provided for the SWIFT FOT under the SAIC cont

- Supported Alpha, Beta and Final Evaluation testing of the SWIFT system
- Provided management functions, coordination and meetings with the SWIFT team, supported the evaluation team, and provided other support to the SWIFT project as required

The result of the IBM SWIFT FOT development cost estimate is presented in Table 3-31. The costs and hours shown are all "actuals", and have been collected from the corresponding Quarterly SWIFT Invoice Summaries and the SWIFT Monthly Progress Reports. The complete detailed spreadsheet breakout is presented in Appendix A.

Table 3-31. IBM FOT Development Cost Estimate.



Hours	Labor (Loaded)			Other Direct Costs			Total		
(Total)	Public	Private	Total	Public	Private	Total	Public	Private	Total
5,123	$261K	$81K	$342K	$164K	$30K	$194K	$425K	$111K	$536K

Commercial Development Phase Cost Estimate

It is assumed here that IBM will not be involved in additional development of the SWIFT system.

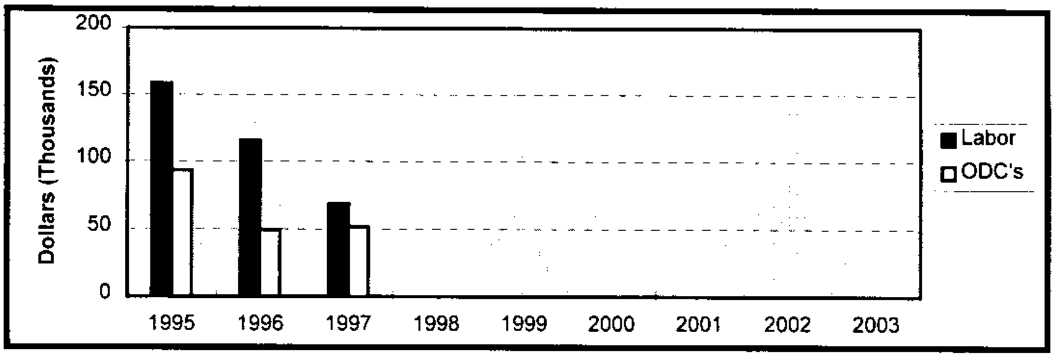
Annual Commercial Operations Cost Estimate

It is assumed here that IBM will not be involved in the operations of a fully deployed SWIFT system.

Life Cycle Cost Estimate

Based on the above, the IBM SWIFT LCCE, presented in Table 3-32, provides an estimate of the total costs that would be required to develop, test, deploy and operate the IBM portion of a commercial SWIFT system. As noted above, IBM's involvement is assumed to be limited to the FOT development (SWIFT test) portion of the SWIFT life cycle.

Table 3-32. IBM SWIFT Life Cycle Cost Estimate.



Cost Estimate	Time Period	Hours (Total)	Labor (Loaded)	ODC's	Total Cost
FOT Development	Jan 95 thru Sep 97	1,751	$73K	$2K	$75K
Commercial Development	Oct 97 thru Dec 98	2,060	$86K	$0K	$86K
Annual Commerical Operations	Annual from 1/1/99	1,545	$65K	$0K	$65K
Life Cycle Cost (5 yrs. Ops.)	Jan 95 thru Dec 03	11,536	$483K	$2K	$485K

3.1.8. Delco Cost Estimate

System Description

For the SWIFT test, Delco Electronics developed a prototype "proof of concept" device that incorporated an in-vehicle navigation unit with the SWIFT HSDS-based real-time traffic information system. The Delco device test unit came with a radio/compact disc player and replaced an existing car radio in one of four vehicle types: Buick Regal, Oldsmobile Cutlass Supreme, Saturn, as well as in 25 Metro Transit Vanpool GMC Rally Vans. 90 Delco in-vehicle navigation units and radio/compact disc players were used in the SWIFT FOT.

The device utilized a GPS receiver to provide a very accurate estimate of the current location of the vehicle. An LCD display indicated the direction (relative to the vehicle) and distance to the selected destination. In addition, common travel destinations such as local landmarks, hotels, restaurants, businesses and street corners could be selected from a "yellow pages" directory database.

The traveler information component of the device utilized the SWIFT real-time traffic incident information that is transmitted over the Seiko HSDS system using an International Traveler Information System (ITIS) format. The HSDS receiver was built into the Delco in-vehicle navigation unit. The navigation unit filtered out any messages beyond a user-prescribed radius which incorporated and HSDS receiver. The navigation unit also decoded the ITIS messages into text, which were converted to voice and announced to the driver. Although messages were retransmitted in regular intervals (20 seconds for speed data and 30 seconds for incident data), only new or modified messages were announced. The Delco in-vehicle navigation device also supported personal paging and other existing Seiko information services (weather, financial and sports information).

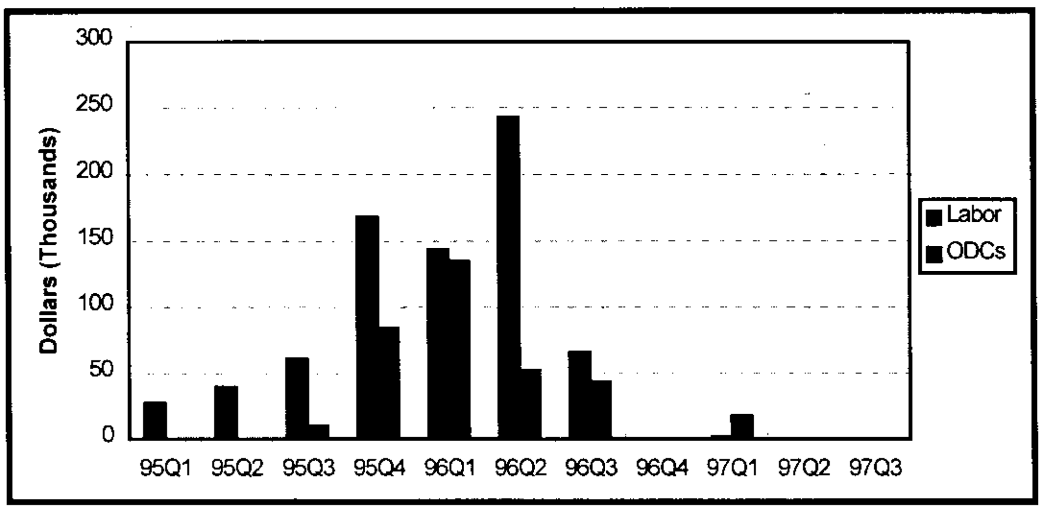
FOT Development Phase Cost Estimate

The Delco SWIFT FOT development cost estimate includes all actual costs accrued during the SWIFT Test from 1 January 1995 through 30 September 1997. These costs include all SWIFT design, development, testing and evaluation activities performed by Delco as shown here:

- Finalized Delco device SWIFT system requirements; worked closely with SCS and other SWIFT participants to define transmission inputs to the Delco device
- Developed, tested, produced and delivered 100 Delco devices to WSDOT for use in the SWIFT test
- Supported Alpha, Beta and Final Evaluation testing of the Delco device and its performance within the SWIFT system
- Provided management functions, coordination and meetings with the SWIFT team, supported the evaluation team, and provided other support to the SWIFT project as required

The result of the Delco SWIFT FOT development cost estimate is presented in Table 3-33. The costs and hours shown are all "actuals," and have been collected from the corresponding Quarterly SWIFT Invoice Summaries and the SWIFT Monthly Progress Reports.[17] The complete detailed spreadsheet breakout is presented in Appendix A.

Table 3-33. Delco FOT Development Cost Estimate



Hours	Labor (Loaded)			Other Direct Costs			Total		
(Total)	Public	Private	Total	Public	Private	Total	Public	Private	Total
14,101	$388K	$362K	$750K	$197K	$147K	$344K	$585K	$508K	$1,093K

[17] Note that the Delco invoices stopped reporting expenditures once they hit the contract dollar value ceiling. As a result, any subsequent Delco SWIFT costs rare not captured here.

Commercial Development Phase Cost Estimate

It is assumed here that Delco will not be involved in additional development of the SWIFT system.

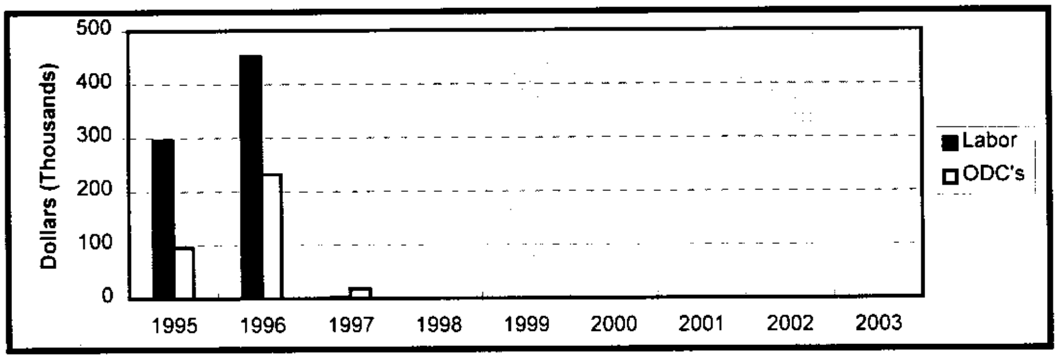
Annual Commercial Operations Cost Estimate

It is assumed here that Delco will not be involved in the operations of a fully deployed SWIFT system.

Life Cycle Cost Estimate

Based on the above, the Delco SWIFT LCCE, presented in Table 3-34, provides an estimate of the total costs that would be required to develop, test, deploy and operate the Delco portion of a commercial SWIFT system. As noted above, Delco's involvement is assumed to be limited to the FOT development (SWIFT test) portion of the SWIFT life cycle.

Table 3-34. Delco SWIFT Life Cycle Cost Estimate



Cost Estimate	Time Period	Hours (Total)	Labor (Loaded)	ODC's	Total Cost
FOT Development	Jan 95 thru Sep 97	14,101	$750K	$344K	$1,093K
Commercial Development	Oct 97 thru Dec 98	0	$0K	$0K	$0K
Annual Commerical Operations	Annual from 1/1/99	0	$0K	$0K	$0K
Life Cycle Cost (5 yrs. Ops.)	Jan 95 thru Dec 03	14,101	$750K	$344K	$1,093K

3.2. Commercial Viability Analysis Results

The results of the deployed SWIFT commercial viability analysis (CVA) are presented below in Figure 3-10. This estimate has been developed based on the methodology outlined in Section 2, and utilizing inputs from the LCCE results provided in Section 3.1.

The purpose of the CVA is to estimate and then to quantitatively compare annual SWIFT revenues for varying market scenarios with the deployed SWIFT annual operations phase costs estimated in the SWIFT LCCE. For each market scenario evaluated, the estimated annual revenues must support the annual operations cost estimate in order to ensure commercial viability of deployed SWIFT operations.

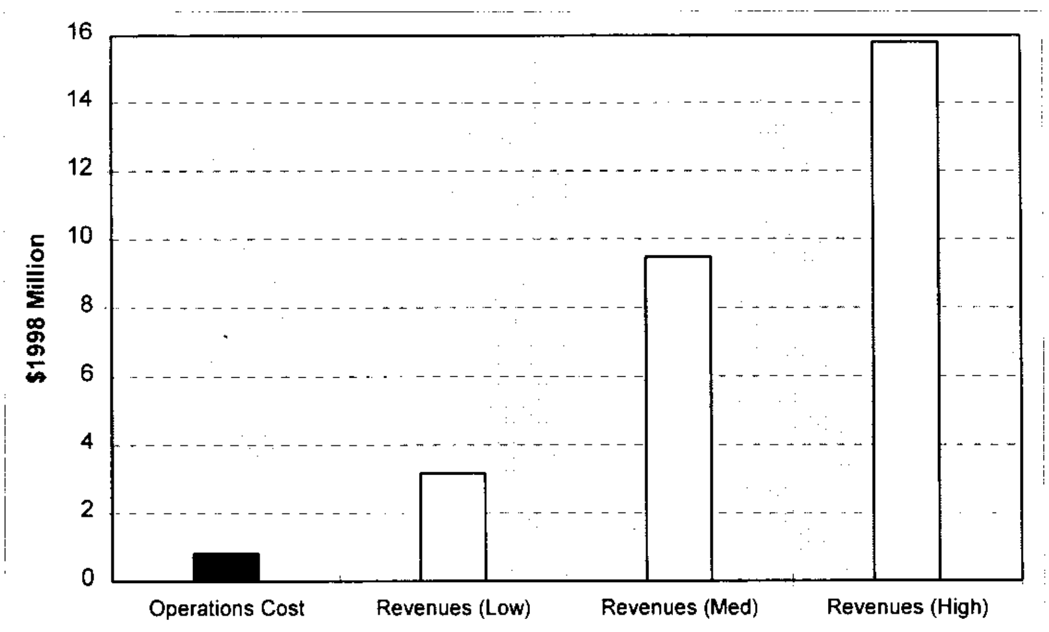


Figure 3-10. SWIFT Commercial Viability Analysis Results.

As can be seen in the above graph, the annual deployed SWIFT revenues estimated in this analysis, provided for three different market penetration levels, comfortably exceed the deployed SWIFT annual operations cost estimated in Section 3.1. Thus, even for the "Low" market penetration case of 4%, revenues still exceed operations costs by a factor of more than 3 to 1. This provides the result that in terms of operations, and noting the assumptions and calculation made in this report, that a fully deployed SWIFT system as defined in this study would have a high likelihood of being commercially viable.

In the following sections, the results of the detailed calculations and derived inputs that went into developing this commercial viability analysis are provided, namely:

1) Estimation of SWIFT consumer market potential
2) Estimation of SWIFT consumer market penetration
3) Estimation of SWIFT consumer subscription fees
4) Estimation of annual SWIFT revenues
5) Comparison of annual SWIFT revenues with LCCE Annual Operations Costs (provided above in Section 3.1)

3.2.1. Estimation of SWIFT Consumer Market Potential

In Section 2.3.3, the following equation was presented as the means to estimate SWIFT market potential. As detailed previously, market potential is defined here to the consist of the total number of consumers who would comprise the potential market for SWIFT services.

$$M_{\text{Potential}} = F_{\text{5 Mile}} \times \left(P_{\text{SOV}} + \frac{P_{\text{HOV}}}{2.5} \right) \times N_{\text{Vehcile Commuters}}$$

where: $M_{\text{Potential}}$ = SWIFT Market Potential (in total number of commuter drivers)

$F_{\text{5 Mile}}$ = Factor for Percent of Commuters who drive more than 5 miles one-way to work

P_{SOV} = Percentage of daily commuters in SOVs

P_{HOV} = Percentage of daily commuters in HOVs

$N_{\text{Vehicle Commuters}}$ = Total Number of daily commuters (all travel methods)

The values for each of these equation elements were determined by analysis of statistical data provided by the the Puget Sound Regional Council (PSRC) organization. PRSC is the Metropolitan Planning Organization (MPO) for King, Kitsap, Pierce and Snohomish counties, and as one of its functions it performs analyses and maintains an extensive statistical database of demographic, economic, travel and geographic data of its member jurisdictions. These values and their sourcse are provided here:

$F_{\text{5 Mile}}$ = 76.2 %; provided by PSRC via a data request – based on 1990 U.S. Census data[18]

P_{SOV} = 75.5 %; PSRC "Puget Sound Trends" report – based on 1990 U.S. Census data[19]

P_{HOV} = 12.5%; PSRC "Puget Sound Trends" report – based on 1990 U.S. Census data[20]

$N_{\text{Vehicle Commuters}}$ = 1,651,927 people; PSRC "Puget Sound Trends" report – based on 1996 data from the Washington St. Employment Security Department, extra-polated to 1998 based on the 2.4% employment growth rate provided[21]

Plugging in these values into the above equation provides for a SWIFT consumer market potential value of 1,013,309 people.

3.2.2. Estimation of SWIFT Market Penetration

As detailed in Section 2.4.4, the second step in developing the commercial viability analysis was to develop credible estimates/forecasts for what levels (low, medium, high) of market penetration might be expected by the deployed SWIFT system. The estimation of SWIFT market penetration centers on an evaluation of willingness to pay survey results.

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[18] Extracted for SWIFT use from 1990 Censu data by Larry Blain of PSRC, February 1998.

[19] "1980 and 1990 County-Level Journey to Work", "Puget Sound Trends," Number T1, PSRC, October 1993, p. 2.

[20] Ibid.

[21] "Growth in Traffic and Vehicle Miles Traveled", "Puget Sound Trends," Number T2, PSRC, August 1997, p. 4.

In 1997, during the SWIFT FOT, the *SWIFT Consumer Acceptance Study* Task Leader developed and implemented a series of consumer surveys for the SWIFT FOT user population. These surveys included the "willingness to pay" questions developed for the *SWIFT Cost Deployment Study* (see Section 2.3.4). The results of these surveys provide a key measure which can aid in the development of market penetration levels.

Market penetration rates are calculated based on the results of the third SWIFT FOT user survey provided below in Figure 3-11. Here, respondents of users of all three SWIFT devices were asked to evaluate their willingness to subscribe to SWIFT services.

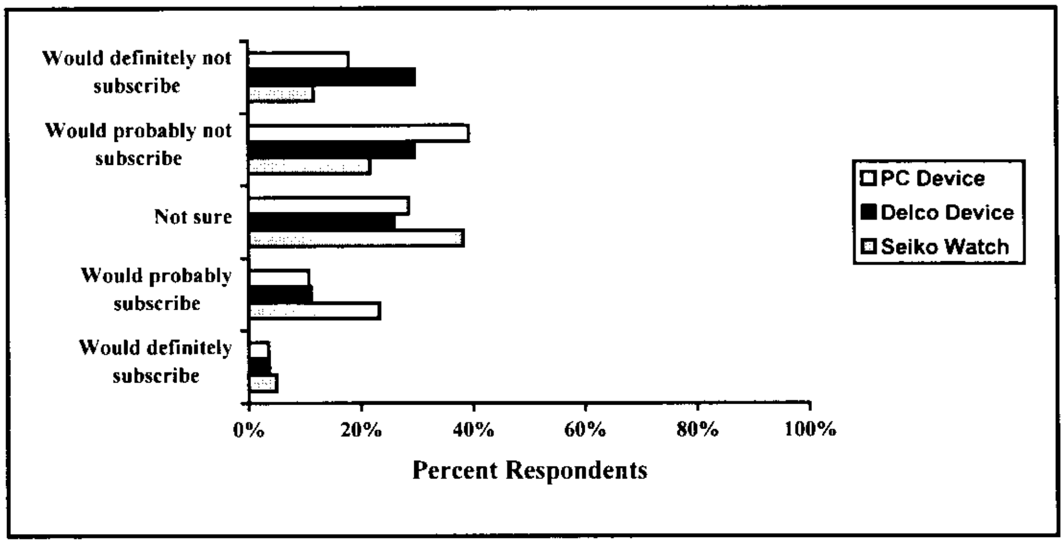

Figure 3-11. Willingness to Subscribe if Current Services Retained.

Based on the results for the above question, three percentage levels of market penetration were developed for low, medium and high market level penetration, respectively. The "low" level was estimated as the average percentage of responses for the three SWIFT devices to the "would definitely describe" questions – this was estimated to be about 4%. The "high" level was estimated as the average percentage of responses for the three SWIFT devices combining the "would definitely describe" and the "would probably subscribe" response percentages – this was estimated to be about 20%. Finally, the "medium" was selected as the midpoint percentage between the low an high values – this is 12%. In summary, the following market penetration levels were thus determined for this analysis[22]:

- LOW = 4%
- MEDIUM = 12%
- HIGH = 20%

[22] Of note, in discussions with SCS, the SCS SWIFT Project Manager stated that he believed that market penetration levels for a deployed SWIFT of up to 30% would be a reasonable expectation for the next 5-10 years.

In addition, as a "check" to make sure that consumers willing to subscribe to SWIFT services would also being willing to purchase the equipment up-front, as part of the second survey, device users were asked to indicate whether they would be willing to consider purchasing SWIFT devices or services. Figure 3-12 summarizes the results. Here, it can be seen that, across the devices, about 38% to of the SWIFT FOT users indicated a willingness to consider purchase of a future version of a SWIFT device, well above the levels of market penetration estimate from the SWIFT subscription question above.[23]

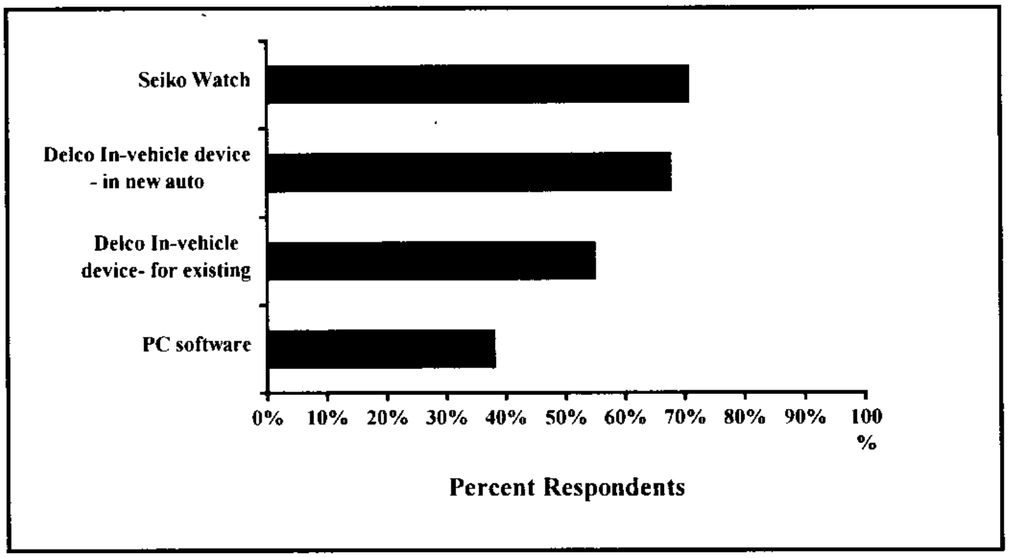

Figure 3-12. Percent of Respondents Willing to Consider Purchasing SWIFT Device.

3.2.3. Estimation of SWIFT Subscription Fees

As detailed in Section 2.4.4, the estimation of the SWIFT subscription fees was conducted by use of a survey tool during the SWIFT FOT. In particular, during the 1997 SWIFT FOT, the SWIFT *Consumer Acceptance Study* Task Leader developed and implemented a series of consumer surveys for the SWIFT FOT user population. These surveys included the "willingness to pay' questions developed for the SWIFT Cost Deployment Study (see Section 2.4).

As part of the second survey, device users were asked to indicate how much per month they would be willing to pay to receive the SWIFT travel information. Figure 3-13 summarizes the results. Approximately 20% of respondents were not willing to pay any amount to receive the services. Over 50% of users of all devices were willing to pay in

[23] Note also that approximately 88% of respondents cited cost of service as a factor that would influence their decision to continue use of the SWIFT service. About two-thirds of respondents cited improved device features and messages as factors influencing continued use. Finally, about half indicated that easier to understand messages would influence their decision to continue use and approximately 44% cited a desire to have more routes covered.

the range of $5 to $10 per month. Seiko MessageWatch respondents reported a willingness-to-pay approximately $ 6.00 per month while users of the Delco Device and PC device reported a willingness to pay around $ 8.00 per month. Combined, all device users reported a willingness-to-pay of approximately $ 6.50 per month. This average value of $6.50 per month, annualized to $78 per year, serves as the estimate for SWIFT subscription fees.

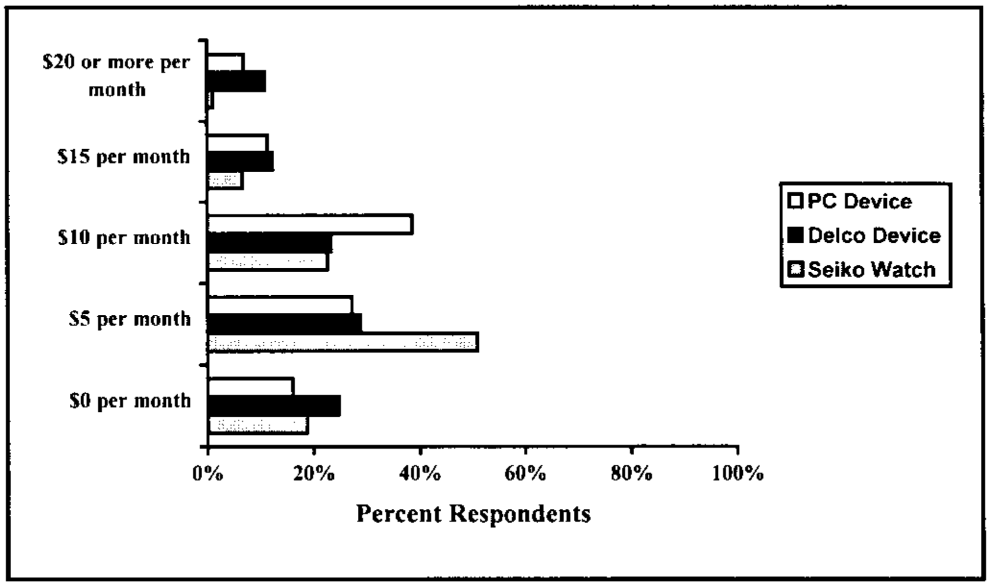

Figure 3-13. Amount Willing to Pay Per Month for SWIFT Travel Information.

3.2.4. Estimation of Annual SWIFT Revenues

As detailed in Section 2, the estimation of annual SWIFT revenues was calculated based on the results of the first three steps of the commercial viability analysis methodology as shown in the equation:

$$R_{\text{Annual}} = S_{\text{Average}} \times P_{\text{Market}} \times M_{\text{Potential}}$$

where: R_{Annual} = SWIFT annual revenues from consumer subscription fees

S_{Average} = Average annual SWIFT subscription fee for a consumer: <u>$78</u>

P_{Market} = Percentage of Market Penetration: <u>4% or 12% or 20%</u>

$M_{\text{Potential}}$ = SWIFT Market Potential: <u>1,013,309 people</u>

From the above equation, the deployed SWIFT annual revenue projections for all three market penetration scenarios are as follows:

- For the LOW case of 4% market penetration, annual revenues are estimated here to be $3.2 Million.
- For the MEDIUM case of 12% market penetration, annual revenues are estimated here to be $9.5 Million
- For the HIGH case of 20% market penetration, annual revenues are estimated here to be $15.8 Million

The above results are presented graphically in Figure 3-10 (see Section 3.2).

4. DISCUSSION

SWIFT *Deployment Cost Study* findings are discussed in this section with respect to their overall implications for ATIS projects elsewhere. This discussion is organized as follows:

- Analysis of Life Cycle Cost Estimate (LCCE)Results
- Analysis of Commercial Viability Analysis (CVA) Results
- Application of LCCE and CVA Results to Other Metropolitan Areas
- Lessons Learned
- Other Discussion

4.1. Analysis of LCCE Results

The life cycle costs of the deployed SWIFT system were estimated to be:

- FOT Development: $6.4 Million
- Commercial Development: $1.5 Million
- Annual Commercial Operations: $0.8 Million

The life cycle costs plotted across the years (1995-2003) followed the expected traditional life cycle curve of high initial development costs tapering down to lower annual operations costs as the years progressed – this was true for both labor and ODC's

As the life cycle progressed from the FOT Development phase to Commercial Deployment and then to Commercial Operations, the SWIFT team member's role and their share in the effort changed significantly:

- Early in the life cycle during the FOT Development phase the largest share of costs (34%) were assigned to SCS for hardware and software development tasks
- Late in the life cycle during the Commercial Development phase that largest share of costs (46%) were assigned to Metro Networks for SWIFT TWS operations

In terms of total hours spent during FOT Development, UW spent in excess of 30,000 hours, more than 60% above the nearest Team Member's (SCS) total. In terms of labor costs spent during FOT Development, SCS spent in excess of $1.6 million, more than 75% above the nearest Team Member's (UW) total. Analysis suggests that this disparity highlights the radically different labor practices of UW and SCS, with UW utilizing a labor pool largely consisting of student and grad student support and SCS utilizing a labor pool consisting largely of senior engineering and management professionals.

The Commercial Development phase estimate showed that the likely additional development costs that will be required to complete an operational SWIFT system will be centered mostly in three areas:

1) Full-time SWIFT operations at Metro Networks
2) Etak SWIFT software upgrades/improvements
3) UW SWIFT backbone infrastructure software/hardware upgrades and operations

The largest single ODC cost for the life cycle occurred when Etak provided a licensed version of it's Seattle Metro area digital map to SWIFT at a cost of $231,000.

4.2. Analysis of Commercial Viability Analysis (CVA) Results

The CVA found that a deployed SWIFT can be expected be a viable commercial enterprise. Even under the most conservative market penetration scenario, the CVA analysis still showed that annual revenues exceeded annual operations costs by a factor of more than 3 to 1. This provides the result that in terms of operations, and noting the assumptions and calculations made in this report, that a fully deployed SWIFT system as defined in this study would have a high likelihood of being commercially viable.

Based on the results of the CVA, it would seem that if the deployed SWIFT were addressed as an investment opportunity, that it would have been seen as a reasonable investment. Moreover, based on the most conservative market penetration scenario (annual revenues of $3.1M), and assuming a bank corporate loan rate of 6%, if the entire SWIFT development cost of $7.9 had been financed by a loan from an investment bank, then the "payback period" on the loan (i.e., the "break-even" point on the investment) would be about 4½ years. This lies within the typical "5 year return on investment" that many large companies use to analyze potential investment projects. Note that after the 4½ year point, the deployed SWIFT Team members under this scenario would divide approximately $2.3M annually in profits!

In discussing the market penetration levels developed in the study (4%, 12% and 20% of vehicle commuters who drive more than 5 miles to work), it is important to note that these levels fit within the bounds of market penetration levels developed in other ITS studies. For example, the *ITS National Investment & Market Analysis*[24] report estimated a market penetration rate (for total drivers in an urban scenario) for "Personal Route Guidance" systems of five percent by 2005.

Moreover, previous studies from other U.S. regions also lend support to the market penetration levels and subscription fees estimated in this report via the SWIFT FOT user surveys. For example, surveys recently completed for the I-95 Corridor Coalition already provide some evidence as to the extent of the commercial potential of ITS traveler

[24] Intelligent Transportation Systems National Investment and Market Analysis: Task C – Identification of Investment Requirements, Apogee Research, Inc., May 1997, p. 46.

information. According to these surveys, anywhere from 44% to 60% of local auto travelers would be willing to pay "something" for pre-trip travel information, and of those, about one-quarter would be willing to pay anywhere from $3 to $5 per information "session."[25] Additionally, an FHWA study conducted by Ng, Barfield, and Mannering (1995) at the University of Washington, and supported by the Battelle Seattle Research Center found that in nationwide mailback questionnaire, 87.7 percent of respondents in the private vehicle drivers category would use an advanced traveler information system.[26]

One issue that was raised in developing the market penetration levels from the SWIFT user survey results dealt with the concern of how SWIFT users related to the public at large. Specifically, concerns were raised that the SWIFT population was likely to be more "technologically inclined" than the general population. Mitigating these concerns are data from other surveys which show that an ever-increasing high percentage of the adult population in the U.S. is becoming familiarized with advanced high tech products and computers. For example, an *I-95 Coalition* report (1996) provided that 72 percent of the adult population in the I-95 corridor are now users of high tech products (i.e., at least on of: fax, cellular phone, has PC, uses PC, has on-line PC service), and correspondingly, 64 percent of the adult population are users of at least two travel information sources during or before trips.[27] Moreover, CNN recently reported that by the year 2000, about 2/3 of U.S. households will own a personal computer.

One final note, while the *SWIFT Deployment Cost Study* did not estimate the consumer costs of the capital equipment required to access SWIFT services, the following pricing ranges can be expected for a deployed SWIFT system:

- Seiko MessageWatches and Personal Pagers: $75 - $200 (2nd Generation devices due in 1998)
- Future In-Vehicle Navigation Systems with Integrated Traveler Information (i.e., Delco device follow-on): perhaps around $2000 by 2000, falling to perhaps around $500 by 2010[28]
- PC software: Free with subscription to SWIFT services[29]

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[25] Ira Hirschman, and Raman Patel, "The Economic Impact of Intelligent Transportation Systems in the Northeast Corridor, ITS America Seventh Annual Meeting, June 2-5, 1997.

[26] I-95 Coalition Organization, "Task 1 -- Develop Market Research Program," Technical Report: I-95 CC 6-95-01, June 1995, page 2.

[27] I-95 Coalition Organization, "Project 6 – User Needs and Marketability," Technical Report: I-95 CC 6-96-09, June 1996, page 2.

[28] The CARIN system recently debuted (available through order from Circuit City) as the first mass-distributed vehicle navigation system in the United States. It's initial selling price is $2,400, but it does not include a traveler information component.

[29] Note that the cost of the Web site and administration could be offset by allowing paid advertising on the web site. Typical current prices are about $200 per thousand click-throughs.

4.3. Application of LCCE and CVA Results to Other Metropolitan Areas

In developing SWIFT as a commercial enterprise in other metropolitan areas where SCS operates an HSDS and Metro Networks/Etak are involved, dramatic savings should be realized in the development costs of a SWIFT-like system:

- SCS and Metro Networks/Etak would apply results (e.g., the expertise, software, and the hardware designs) of the SWIFT deployment (i.e. a substantial reduction in the "learning curve")
- A much shorter test period would likely be required (i.e., "validated" SWIFT technologies would be used)
- The lack of government oversight could facilitate reductions in labor costs – according to Metro Networks SWIFT Project Manager Joan Ravier: "Some projects we're involved with would be a lot cheaper to run if we were doing them for ourselves, because following government procedure requires us to do all kinds of things we wouldn't do normally."[30]

In developing SWIFT as a commercial enterprise in other metropolitan areas where different commercial endeavors would implement a SWIFT-like system, a combination of additional major costs and some significant savings would likely be realized in the development of a SWIFT-like system:

- A major cost would be the development of an HSDS backbone infrastructure. SCS had already had an HSDS transmission system in place for its MessageWatch and pager services in the Seattle Metro area prior to SWIFT. Costs for HSDS transmission systems and the required control facilities and associated software could be expected to be measured somewhere between $5 Million to $10 Million, as SCS has invested about $50 million total in development and deploying its HSDS system into seven cities.
- Significant savings in development costs could potentially still be realized by applying the publicly available results of the SWIFT FOT to these new SWIFT-like deployments elsewhere; in addition, much of the communications protocols for use in SWIFT have now been standardized by UW as ITS protocols

In deploying SWIFT-like systems in other metropolitan areas, it is important to note that the SWIFT enterprise is based on allowing free access of industry to WSDOT, King County Metro, and other public agencies. This was the consensus deployment model suggested by SWIFT participants in *SWIFT Consumer Acceptance Study* focus groups, and this model would allow the SWIFT enterprise modify and utilize public information in a commercial venture. This approach would also be similar to that taken with other

[30] Nancy Johnson and Christina Steffy, "What will it Take to Create a Profitable Business in the Market for In-Vehicle ITS Systems and Services," ITS World, September/October 1997, p. 39.

recent traveler information deployments such as the SmartRoutes projects in Boston and Cincinnati, and FASTLINE/CITYLINE in the San Francisco Bay area.

4.4. Lessons Learned

The following were the major lessons learned during the conduct of the SWIFT *Deployment Cost Study*:

- The deployment of an FM-subcarrier ATIS in other cities may require the expenditure of up-front "infrastructure" costs (i.e., costs associated with developing the required HSDS hardware and software and integrating it with available FM radio stations)
- Significant FM-subcarrier ATIS deployment costs are likely to be encountered during the development phase, where software development, integration and test costs are incurred
- Operations costs for FM-subcarrier ATIS projects should be fairly stable, and will center on the human element of managing and inputing traffic information into the ATIS system (eg., Metro Networks TWS operators)
- Successful commercial deployment of FM-subcarrier ATIS projects should be based upon the development of sound market-penetration scenarios
- Future ITS public-private joint ventures should stipulate in their teaming agreements that the private-sector partners will provide full details of their development costs to the evaluation team, with appropriate non-disclosure agreements set up as required.
- Future ITS public-private joint ventures should stipulate in their teaming agreement that all costs will be invoiced according to an activity-based Work Breakdown Structure (WBS) of at least three (3) levels of detail for each Team Member in order to allow costs to be tracked by activity throughout the project.

4.5. Other Discussion

One area that was not addressed in the SWIFT evaluation was the quantification of the expected benefits that would be generated by a deployed SWIFT system. These benefits, which are listed here, could provide incentives for continued public support of a deployed SWIFT system:

- <u>Reduced Travel Delay</u>. A recent Caltran's study estimated that pre-trip or enroute traveler/driver information would result in a 5-10 percent reduction in travel time and a 5-10 percent increase in speed.[31]

[31] "Caltrans – Advanced Transportation Systems Program Plan: 1996 Update – Benefits and Costs," The California Department of Transportation, 1996, p. 126

- Reduction in Emissions. This is based on the reduced travel time defined above. As an example, a reduction in the average automobile speed from 30 mph to 20 mph will result in an almost 60% increase in Carbon Monoxide emission.[32]
- Vehicle Operating Cost Savings. Up to 55 mph, the cost of vehicles operations (i.e., gas and maintenance) decrease with increasing highway operating speeds.
- Avoided Infrastructure Costs. By rerouting a significant portion of congested traffic, en-route traveler information systems such as SWIFT have the potential to marginally reduce or delay the need for increased lanes on major highways.
- Economic Benefits. This includes indirect benefits such as improved business efficiency and more efficient movement of goods and services.

32 Ira Hirschman and Raman Patel, "The Economic Impact of ITS in the Northeast Corridor," presented at the ITS America 7th Annual Meeting, June 1997, p. 6.

5. CONCLUSIONS

The life cycle cost estimate (LCCE) for the deployed SWIFT system is presented in Table 5-1. Here, the FOT Development phase (based on SWIFT test actuals) was estimated to cost $6.4 Million, the Commercial Development phase was estimated to cost $1.5 Million, and the Annual Commercial Operations costs were estimated to be $0.8 Million.

Table 5-1. SWIFT LCCE Summary.

Participant	FOT Development				Commercial Development				Annual Commercial Operations				Life Cycle Cost (5 years of Ops.)			
	Hours	Labor	ODC's	Total	Hours	Labor	ODC's	Total	Hours	Labor	ODC's	Total	Hours	Labor	ODC's	Total
SCS	19,137	$1,605K	$500K	$2,105K	1,005	$64K	$82K	$147K	804	$51K	$66K	$117K	24,162	$1,926K	$911K	$2,837K
Metro Networks	4,348	$264K	$320K	$584K	8,249	$493K	$11K	$504K	6,188	$370K	$2K	$371K	43,536	$2,604K	$340K	$2,944K
Etak	7,760	$639K	$248K	$887K	3,840	$254K	$0K	$254K	1,920	$134K	$0K	$134K	21,200	$1,565K	$248K	$1,813K
UW	32,136	$857K	$220K	$1,077K	10,998	$442K	$81K	$522K	1,922	$105K	$30K	$135K	52,741	$1,822K	$450K	$2,272K
Metro Transit	1,751	$73K	$2K	$75K	2,060	$86K	$0K	$86K	1,545	$65K	$0K	$65K	11,536	$483K	$2K	$485K
IBM	5,123	$342K	$194K	$536K	0	$0K	$0K	$0K	0	$0K	$0K	$0K	5,123	$342K	$194K	$536K
Delco	14,101	$750K	$344K	$1,093K	0	$0K	$0K	$0K	0	$0K	$0K	$0K	14,101	$750K	$344K	$1,093K
TOTAL	84,356	$4,529K	$1,828K	$6,357K	26,151	$1,339K	$174K	$1,513K	12,379	$725K	$97K	$822K	172,401	$9,493K	$2,488K	$11,981K

When viewed across the life cycle time period (1995-2003), the cost estimate followed the expected traditional life cycle curve of high initial development costs tapering down to lower annual operations costs as the years progressed – this was true for both labor and ODC's.

As can been in Figure 5-1, as the life cycle progressed from the FOT Development phase to Commercial Deployment and then to Commercial Operations, the SWIFT team member's role and their share in the effort changed significantly, with SCS providing for the largest share of costs (for hardware and software development tasks) in the FOT Development phase, and Metro networks providing for the largest share of costs (for SWIFT TWS operations) by the Commercial Operations phase.

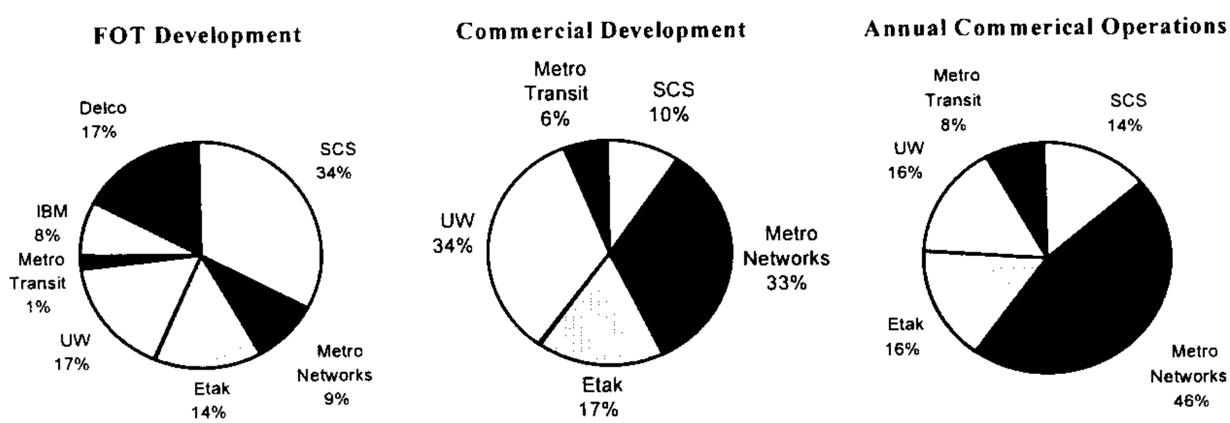

Figure 5-1. LCCE Overview by SWIFT Participant Share.

As shown in Figure 5-2, the commercial viability analysis (CVA) found that a deployed SWIFT can be expected be a viable commercial enterprise. Even under the most conservative market penetration scenario, the CVA analysis still showed that annual revenues exceeded annual operations costs by a factor of more than 3 to 1. This provides the result that in terms of operations, and noting the assumptions and calculations made in this report, that a fully deployed SWIFT system as defined in this study would have a high likelihood of being commercially viable.

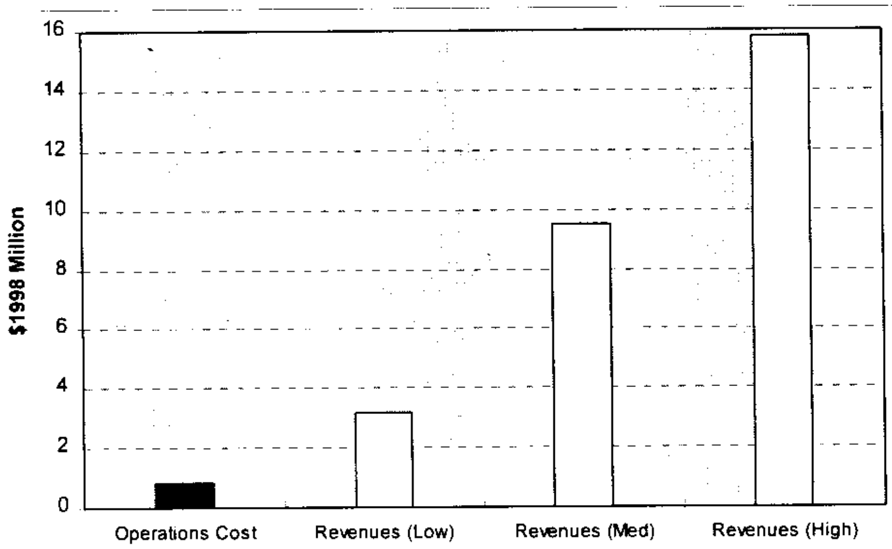

Figure 5-2. SWIFT CVA Results Summary.

Based on the results of the CVA, it would seem that if the deployed SWIFT were addressed as an investment opportunity, that it would have been seen as a reasonable investment. Moreover, based on the most conservative market penetration scenario (annual revenues of $3.1M), and assuming a bank corporate loan rate of 6%, if the entire SWIFT development cost of $7.9 had been financed by a loan from an investment bank, then the "payback period" on the loan (i.e., the "break-even" point on the investment) would be about 4½ years. This lies within the typical "5 year return on investment" that many large companies use to analyze potential investment projects. Note that after the 4½ year point, the deployed SWIFT Team members under this scenario would divide approximately $2.3M annually in profits!

In developing SWIFT as a commercial enterprise in other metropolitan areas where SCS operates an HSDS and Metro Networks/Etak are involved, dramatic savings should be realized in the development costs of a SWIFT-like system:

- SCS and Metro Networks/Etak would apply results (e.g., the expertise, software, and the hardware designs) of the SWIFT deployment (i.e. a substantial reduction in the "learning curve")

- A much shorter test period would likely be required (i.e., "validated" SWIFT technologies would be used)
- The lack of government oversight could facilitate reductions in labor costs -- according to Metro Networks SWIFT Project Manager Joan Ravier: "Some projects we're involved with would be a lot cheaper to run if we were doing them for ourselves, because following government procedure requires us to do all kinds of things we wouldn't do normally."[33]

In developing SWIFT as a commercial enterprise in other metropolitan areas where different commercial enterprises would implement a SWIFT-like system, the following SWIFT "lessons learned" can be applied:

- The deployment of an FM-subcarrier ATIS in other cities may require the expenditure of up-front "infrastructure" costs (i.e., costs associated with developing the required HSDS hardware and software and integrating it with available FM radio stations)
- Significant FM-subcarrier ATIS deployment costs are likely to be encountered during the development phase, where software development, integration and test costs are incurred
- Operations costs for FM-subcarrier ATIS projects should be fairly stable, and will center on the human element of managing and inputing traffic information into the ATIS system (eg., Metro Networks TWS operators)
- Successful commercial deployment of FM-subcarrier ATIS projects should be based upon the development of sound market-penetration scenarios
- Future ITS public-private joint ventures should stipulate in their teaming agreements that the private-sector partners will provide full details of their development costs to the evaluation team, with appropriate non-disclosure agreements set up as required.
- Future ITS public-private joint ventures should stipulate in their teaming agreement that all costs will be invoiced according to an activity-based Work Breakdown Structure (WBS) of at least three (3) levels of detail for each Team Member in order to allow costs to be tracked by activity throughout the project.

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[33] Nancy Johnson and Christina Steffy, "What will it Take to Create a Profitable Business in the Market for In-Vehicle ITS Systems and Services," ITS World, September/October 1997, p. 39.

APPENDIX A: SWIFT FOT COST SUMMARY

SWIFT FOT ROLL-UP (TOTAL COST)

	Hours	Labor (Loaded)			Other Dircect Costs			Total Cost ($K)		
		Public	Private	Total	Public	Private	Total	Public	Private	Total
1995, Q1	5,259	205	127	332	38	31	69	243	158	401
1995, Q2	7,283	402	44	446	73	31	105	476	75	551
1995, Q3	7,309	386	53	439	72	31	103	458	84	542
1995, Q4	11,347	542	195	738	189	89	279	732	285	1,016
1996, Q1	12,562	454	249	703	176	67	243	630	316	945
1996, Q2	14,518	584	154	738	132	53	185	716	207	923
1996, Q3	9,351	212	177	389	29	81	111	242	258	500
1996, Q4	4,851	141	50	191	23	282	305	164	332	496
1997, Q1	4,947	171	131	302	186	102	288	356	233	590
1997, Q2	3,459	88	40	128	33	32	65	121	72	193
1997, Q3	3,474	89	34	123	32	45	78	121	80	201
Total	84,356	3,275	1,255	4,529	984	844	1,828	4,258	2,099	6,357

DELCO

	Hours	Labor (Loaded)			Other Dircect Costs			Total Cost ($K)		
		Public	Private	Total	Public	Private	Total	Public	Private	Total
1995, Q1	258	15.6	11.5	27.1	0.0	0.0	0.0	15.6	11.5	27.1
1995, Q2	659	24.3	15.1	39.4	0.0	0.0	0.0	24.3	15.1	39.4
1995, Q3	908	36.6	24.4	61.0	5.9	3.9	9.8	42.5	28.3	70.9
1995, Q4	2,680	101.1	67.4	168.4	50.7	33.8	84.6	151.8	101.2	253.0
1996, Q1*	2,581	86.1	57.4	143.5	109.0	26.2	135.2	195.1	83.6	278.6
1996, Q2*	4,028	124.2	118.7	242.9	31.6	21.1	52.6	155.7	139.8	295.5
1996, Q3*	2,895	0.0	65.8	65.8	0.0	43.7	43.7	0.0	109.5	109.5
1996, Q4	92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997, Q1	0	0.0	1.7	1.7	0.0	17.8	17.8	0.0	19.5	19.5
1997, Q2	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997, Q3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	14,101	387.8	362.0	749.8	197.2	146.5	343.7	585.0	508.5	1,093.5

*Adjusted to reflect changes in Delco Invoices

ETAK

	Hours	Labor (Loaded)			Other Dircect Costs			Total Cost ($K)		
		Public	Private	Total	Public	Private	Total	Public	Private	Total
1995, Q1*	300	31.6	1.7	33.3	0.7	0.5	1.2	32.3	2.2	34.5
1995, Q2	500	71.3	2.5	73.8	1.9	0.0	1.9	73.2	2.5	75.7
1995, Q3	756	80.6	2.7	83.4	1.5	0.0	1.5	82.1	2.7	84.9
1995, Q4	581	44.1	1.6	45.7	0.0	0.0	0.0	44.1	1.6	45.7
1996, Q1	992	98.5	3.7	102.2	0.0	0.0	0.0	98.5	3.7	102.2
1996, Q2	2,797	118.4	6.6	125.0	10.4	0.0	10.4	128.8	6.6	135.4
1996, Q3	1,064	86.5	16.6	103.1	1.6	0.4	2.0	88.1	17.0	105.1
1996, Q4^	385	24.0	12.2	36.1	0.0	231.2	231.2	24.0	243.3	267.3
1997, Q1^	385	24.0	12.2	36.1	0.0	0.0	0.0	24.0	12.2	36.1
1997, Q2	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997, Q3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	7,760	578.9	59.8	638.7	16.1	232.1	248.2	595.0	291.9	886.8

*Includes Etak private contributions back to 8/4/94

**95Q1 to 96Q2 adjusted to reflect change in Etak overhead rate

^ Labor costs averaged over two quarters due to combined 96Q4 and 97Q1 Invoice

IBM

	Hours	Labor (Loaded)			Other Dircect Costs			Total Cost ($K)		
		Public	Private	Total	Public	Private	Total	Public	Private	Total
1995, Q1	776	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995, Q2	564	24.1	6.4	30.5	18.7	5.0	23.7	42.9	11.4	54.2
1995, Q3	290	22.7	6.0	28.7	6.5	1.7	8.2	29.2	7.7	36.9
1995, Q4*	870	74.4	24.7	99.1	52.5	8.9	61.4	126.9	33.6	160.5
1996, Q1	899	19.7	11.8	31.5	29.6	1.2	30.9	49.3	13.1	62.4
1996, Q2	803	32.4	8.6	40.9	7.9	2.1	10.0	40.3	10.7	50.9
1996, Q3	497	22.5	6.0	28.5	5.7	1.5	7.2	28.2	7.5	35.7
1996, Q4	196	11.3	3.0	14.3	0.9	0.2	1.1	12.2	3.2	15.4
1997, Q1	228	54.2	14.3	68.6	42.1	9.5	51.6	96.3	23.8	120.1
1997, Q2	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997, Q3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	5,123	261.3	80.8	342.1	164.0	30.1	194.1	425.3	110.9	536.3

*Adjusted to reflect 1995 corrections presented in 1996 Q1 Invoice

METRO NETWORKS

	Hours	Labor (Loaded)			Other Dircect Costs			Total Cost ($K)		
		Public	Private	Total	Public	Private	Total	Public	Private	Total
1995, Q1*	25	0.0	4.3	4.3	0.0	0.4	0.4	0.0	4.7	4.7
1995, Q2	390	3.2	20.2	23.4	3.9	25.2	29.1	7.1	45.4	52.5
1995, Q3	390	3.2	20.2	23.4	3.9	25.2	29.1	7.1	45.4	52.5
1995, Q4	390	3.2	20.2	23.4	3.9	25.2	29.1	7.1	45.4	52.5
1996, Q1	390	3.2	20.2	23.4	3.9	25.2	29.1	7.1	45.4	52.5
1996, Q2	390	3.2	20.2	23.4	3.9	25.2	29.1	7.1	45.4	52.5
1996, Q3	390	3.2	20.2	23.4	3.9	25.2	29.1	7.1	45.4	52.5
1996, Q4	390	3.2	20.2	23.4	3.9	25.2	29.1	7.1	45.4	52.5
1997, Q1	390	3.2	20.2	23.4	3.9	25.2	29.1	7.1	45.4	52.5
1997, Q2	390	3.2	20.2	23.4	3.9	25.2	29.1	7.1	45.4	52.5
1997, Q3	814	14.7	34.2	48.8	17.1	40.7	57.8	31.8	74.9	106.6
Total	4,348	43.3	220.3	263.6	52.5	267.8	320.3	95.8	488.1	583.9

*Includes Metro Networks private contributions back to 8/4/94

NOTE: All costs from 95Q1 to 97Q2 are averaged from Metro Networks 97Q2 Invoice; all hours are estimated based on an average loaded labor rate of $60/hour

METRO TRANSIT

	Hours	Labor (Loaded)			Other Dircect Costs			Total Cost ($K)		
		Public	Private	Total	Public	Private	Total	Public	Private	Total
1995, Q1	95	3.9	0.0	3.9	0.0	0.0	0.0	3.9	0.0	3.9
1995, Q2	72	3.2	0.0	3.2	0.0	0.0	0.0	3.2	0.0	3.2
1995, Q3	36	1.2	0.0	1.2	0.0	0.0	0.0	1.2	0.0	1.2
1995, Q4	70	2.2	0.0	2.2	0.0	0.0	0.0	2.2	0.0	2.2
1996, Q1	217	6.8	0.0	6.8	1.0	0.0	1.0	7.8	0.0	7.8
1996, Q2	222	9.8	0.0	9.8	0.9	0.0	0.9	10.7	0.0	10.7
1996, Q3	228	9.8	0.0	9.8	0.0	0.0	0.0	9.8	0.0	9.8
1996, Q4	273	12.3	0.0	12.3	0.0	0.0	0.0	12.3	0.0	12.3
1997, Q1	312	13.7	0.0	13.7	0.0	0.0	0.0	13.7	0.0	13.7
1997, Q2	162	7.1	0.0	7.1	0.1	0.0	0.1	7.2	0.0	7.2
1997, Q3	64	2.8	0.0	2.8	0.0	0.0	0.0	2.9	0.0	2.9
Total	1,751	73.1	0.0	73.1	2.1	0.0	2.1	75.1	0.0	75.1

SCS

	Hours	Labor (Loaded)			Other Dircect Costs			Total Cost ($K)		
		Public	Private	Total	Public	Private	Total	Public	Private	Total
1995, Q1	1,066	81.0	109.4	190.4	7.4	30.3	37.6	88.3	139.6	228.0
1995, Q2	2,359	203.1	0.0	203.1	19.2	1.0	20.2	222.3	1.0	223.3
1995, Q3	2,190	168.7	0.0	168.7	24.2	0.0	24.2	193.0	0.0	193.0
1995, Q4	4,017	244.4	81.5	325.9	52.6	21.2	73.8	297.0	102.7	399.7
1996, Q1	4,105	149.7	155.6	305.3	13.8	14.3	28.1	163.5	169.9	333.4
1996, Q2	2,900	206.2	0.0	206.2	59.4	4.2	63.6	265.6	4.2	269.7
1996, Q3*	899	0.0	68.5	68.5	0.0	10.2	10.2	0.0	78.7	78.7
1996, Q4	137	0.0	14.4	14.4	0.0	25.5	25.5	0.0	39.9	39.9
1997, Q1*	1,075	7.3	82.9	90.2	130.3	49.3	179.6	137.6	132.2	269.8
1997, Q2	350	9.7	19.6	29.3	19.4	7.1	26.4	29.1	26.7	55.8
1997, Q3	39	3.3	0.0	3.3	5.6	4.7	10.3	8.9	4.7	13.6
Total	19,137	1,073.4	531.8	1,605.2	331.8	167.8	499.6	1,405.3	699.6	2,104.9

*Adjustments were made to reflect unreimbursed contributions which were unreported after 1997Q1; also, $126K in materials contribution from 96Q3 was reimbused in 97Q1

UW

	Hours	Labor (Loaded)			Other Dircect Costs			Total Cost ($K)		
		Public	Private	Total	Public	Private	Total	Public	Private	Total
1995, Q1	2,739	73.0	0.0	73.0	29.6	0.0	29.6	102.6	0.0	102.6
1995, Q2	2,739	73.0	0.0	73.0	29.6	0.0	29.6	102.6	0.0	102.6
1995, Q3	2,739	73.0	0.0	73.0	29.6	0.0	29.6	102.6	0.0	102.6
1995, Q4	2,739	73.0	0.0	73.0	29.6	0.0	29.6	102.6	0.0	102.6
1996, Q1	3,378	90.1	0.0	90.1	18.3	0.0	18.3	108.3	0.0	108.3
1996, Q2	3,378	90.1	0.0	90.1	18.3	0.0	18.3	108.3	0.0	108.3
1996, Q3	3,378	90.1	0.0	90.1	18.3	0.0	18.3	108.3	0.0	108.3
1996, Q4	3,378	90.1	0.0	90.1	18.3	0.0	18.3	108.3	0.0	108.3
1997, Q1	2,557	68.2	0.0	68.2	9.6	0.0	9.6	77.8	0.0	77.8
1997, Q2	2,557	68.2	0.0	68.2	9.6	0.0	9.6	77.8	0.0	77.8
1997, Q3	2,557	68.2	0.0	68.2	9.6	0.0	9.6	77.8	0.0	77.8
Total	32,136	856.8	0.0	856.8	220.1	0.0	220.1	1,076.9	0.0	1,076.9

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