



StarTran Automated Vehicle Location System
CONCEPT OF OPERATIONS

November 2005

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Table of Contents

1	SCOPE	4
1.1	Identification	4
1.2	Document Overview	4
1.3	System Overview	2
1.4	Referenced Documents	3
2	THE CURRENT SYSTEM OR SITUATION	4
2.1	Background, Objectives, and Scope	4
2.2	Operational Policies and Constraints	4
2.3	Description of the Current System or Situation	5
2.4	Modes of Operation for the Current System or Situation	5
2.4.1	Normal Operational Mode	5
2.4.1.1	Customer	6
2.4.1.2	Fleet Management	6
2.4.1.3	Bus Operator	6
2.4.1.4	Fleet Maintenance	6
2.4.1.5	Emergency Personnel	7
2.4.1.6	Administrative Personnel	7
2.4.2	Peak Operational Mode	7
2.4.2.1	Customer	7
2.4.2.2	Fleet Management	8
2.4.2.3	Bus Operator	8
2.4.2.4	Fleet Maintenance	8
2.4.2.5	Emergency Personnel	8
2.4.3	Emergency Operational Mode	8
2.4.3.1	Customer	8
2.4.3.2	Fleet Management	9
2.4.3.3	Bus Operator	9
2.4.3.4	Fleet Maintenance	9
2.4.3.5	Emergency Personnel	10
2.5	User Classes and Other Involved Personnel	10
2.5.1	Organizational Structure	10
2.5.2	Profiles of User Classes	11
2.5.2.1	StarTran Management and Administrative	11
2.5.2.2	Dispatchers/Field Supervisors	12
2.5.2.3	Fleet/Bus Maintenance	12
2.5.2.4	Bus Operator	12
2.5.2.5	Bus Rider/Customer	13
2.5.2.6	Police/Fire/Emergency Management	13
2.5.2.7	IT/Radio/Telecommunications	14
2.5.3	Interactions Among User Classes	14
2.5.4	Other Involved Personnel	15
2.5.4.1	Transport Plus	15
2.5.4.2	StarTran Advisory Board	15
2.5.4.3	City of Lincoln/Mayor/City Council	15
2.5.4.4	Lincoln Metropolitan Planning Organization (MPO)	16
2.5.4.5	Omaha MAT	16
2.6	Support Environment	16

3	JUSTIFICATION FOR AND NATURE OF CHANGES	18
3.1	Justification for Changes	18
3.2	Description of Desired Changes	18
3.2.1	New or Modified Capabilities	19
3.2.2	Operational, Support, and Personnel Changes	20
3.3	Priorities Among Changes	21
3.3.1	Essential Features/Functionalities	21
3.3.2	Desirable Features/Functionalities	21
3.3.3	Optional Features/Functionality	22
3.4	Assumptions and Constraints	23
4	CONCEPTS FOR THE PROPOSED SYSTEM	25
4.1	Background, Objectives, and Scope	25
4.2	Operational Policies and Constraints	25
4.3	Description of the Proposed System	26
4.3.1	Essential Function: Precise Vehicle Location Technology	26
4.3.2	Essential Function: Safety Monitoring Systems	26
4.3.3	Essential Function: Open System Design	27
4.3.4	Desirable Function: Vehicle Tracking Capability	27
4.3.5	Desirable Function: Mobile Data Terminals	27
4.3.6	Desirable Function: Traveler Information System	27
4.3.7	Desirable Function: Traveler Planning System	27
4.3.8	Desirable Function: Traveler Reservation System	27
4.3.9	Desirable Function: Vehicle Component Monitoring	28
4.3.10	Desirable Function: System Statistical Reporting	28
4.3.11	Optional Function: Automated Bus Operator Login	28
4.3.12	Optional Function: ADA Compliant Announcements	28
4.3.13	Optional Function: Automated Fare Payment System	28
4.3.14	Optional Function: Traffic Signal Priority System	28
4.4	Modes of Operation	29
4.4.1	Normal Operational Mode	29
4.4.1.1	Customer	29
4.4.1.2	Fleet Management	29
4.4.1.3	Bus Operator	30
4.4.1.4	Fleet Maintenance	30
4.4.1.5	Emergency Personnel	30
4.4.1.6	Administrative	30
4.4.2	Peak/Degraded Operational Mode	30
4.4.2.1	Customer	30
4.4.2.2	Fleet Management	31
4.4.2.3	Bus Operator	31
4.4.2.4	Fleet Maintenance	31
4.4.2.5	Emergency Personnel	32
4.4.3	Emergency Operational Mode	32
4.4.3.1	Customer	32
4.4.3.2	Fleet Management	32
4.4.3.3	Bus Operator	33
4.4.3.4	Fleet Maintenance	33

4.4.3.5	Emergency Personnel.....	33
4.5	User Classes and Other Involved Personnel.....	34
4.5.1	Organizational Structure.....	34
4.5.2	Profiles of User Classes.....	35
4.5.2.1	StarTran Management and Administrative	35
4.5.2.2	Dispatchers/Field Supervisors.....	36
4.5.2.3	Fleet/Bus Maintenance.....	36
4.5.2.4	Bus Operator	37
4.5.2.5	Bus Rider/Customer.....	37
4.5.2.6	Police/Fire/Emergency Management.....	37
4.5.2.7	IT/Radio/Telecommunications.....	38
4.5.3	Interactions Among User Classes.....	38
4.5.4	Other Involved Personnel	39
4.5.4.1	Transport Plus	39
4.5.4.2	StarTran Advisory Board.....	39
4.5.4.3	City of Lincoln/Mayor/City Council.....	39
4.5.4.4	Lincoln Metropolitan Planning Organization (MPO).....	40
4.5.4.5	Omaha MAT	40
4.5.5	Nebraska Emergency Management Agency (NEMA)	40
4.5.6	Nebraska Department of Roads (NDOR).....	40
4.6	Support Environment	40
5	OPERATIONAL SCENARIOS	42
5.1	Scenario 1: Bus Operator Automated Systems	42
5.2	Scenario 2: Security/Emergency Response	42
5.3	Scenario 3: Trip Planning and Real Time Status Information.....	43
5.4	Scenario 4: Dispatcher Management of Routes and Schedules.....	43
5.5	Scenario 5: Automated Fleet Management	44
6	SUMMARY OF IMPACTS	45
6.1	Operational Impacts	45
6.2	Organizational Impacts	46
6.3	Impacts During Development	47
7	ANALYSIS OF THE PROPOSED SYSTEM.....	48
7.1	Summary of Improvements.....	48
7.2	Disadvantages and Limitations	49
7.3	Alternatives and Trade-offs Considered.....	49
APPENDIX A - DEFINITIONS, ACRONYMS, AND ABBREVIATIONS		51

Table of Figures

FIGURE 1 - STAND-ALONE VS. OPEN SYSTEM ARCHITECTURE.....	3
FIGURE 2 - STARTRAN ORGANIZATIONAL CHART	11
FIGURE 3 - STARTRAN ORGANIZATIONAL CHART WITH AVL SYSTEM.....	35

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1 SCOPE

1.1 Identification

This document applies to the City of Lincoln, Nebraska’s StarTran Automated Vehicle Location (AVL) system. The document control number for this document is contained in the document footer and the file name for the electronic rendition of the document is recorded in the table of contents for the document.

1.2 Document Overview

This document provides a Concept of Operations (ConOps) for the City of Lincoln, Nebraska’s StarTran AVL system. The ConOps document is designed for the system owners, system users, system developers, and system providers. It describes the current system state, establishes the need for system change, and describes the proposed system in terms of features and functionality.

The remainder of this document consists of the following sections and content:

Section 2 (Current System or Situation) of the ConOps describes StarTran’s current situation with respect to the existing system (either automated or manual). When systems or functionality do not currently exist, the document describes the situation that motivates development of the proposed system.

Section 3 (Justification for and Nature of Changes) of the document describes the justification for and nature of the proposed changes. This section identifies deficiencies of the existing situation and the benefits of change.

Section 4 (Concepts for the Proposed System) describes the proposed system that results from the desired changes. This is, necessarily, a high-level description, indicating the operational features of the system when fully deployed. This represents a long-term vision, not a description of the initial deployment.

Section 5 (Operational Scenarios) of the ConOps contains operational scenarios for the system. A scenario is a step-by-step description of how the proposed system might operate and interact with its users and its external interfaces under a given set of circumstances. The scenarios tie together all parts of the proposed system, the users, and other entities by describing how they interact.

Section 6 (Summary of Impacts) of the document describes the operational impacts of the proposed system on the users, the developers, and the support and

maintenance organizations. This section may also identify temporary impacts on participants in the deployment that are a direct impact of transition from the old system(s) to the new system.

Section 7 (Analysis of the Proposed System) provides a discussion on the benefits, limitations, advantages, disadvantages, and alternatives and trade-offs considered for the proposed system. In the context of this document, alternatives are operational alternatives and not design alternatives (which are considered in the Systems Engineering Analysis, part of Task 2.)

Appendix A (Definitions, Acronyms, and Abbreviations) provides definitions for the terms, acronyms, and abbreviations used throughout the document.

1.3 System Overview

The City of Lincoln's StarTran, as a fixed route and demand-responsive transit provider, wishes to improve the operational efficiency and security of its transit system. These desires can be summarized in three main goals:

- Increased availability of transit information and dissemination;
- Improved overall dispatching and operating efficiency; and
- Increased driver and passenger safety and security.

Like many other transit system operators, StarTran has identified AVL technology deployment as a method to accomplish these goals. Further, the City of Lincoln desires that any StarTran AVL system provide future expandability and interoperability capabilities for other City of Lincoln (or even State of Nebraska) fleets, as well as neighboring transit providers. Given this desire, a stand-alone system is unlikely to satisfy the system requirements. Therefore, StarTran, along with the City of Lincoln and a grant from the Federal Transit Administration (FTA), has undertaken the process to design an open AVL system. The following figure displays a graphical comparison between a stand-alone system and one potential open solution.

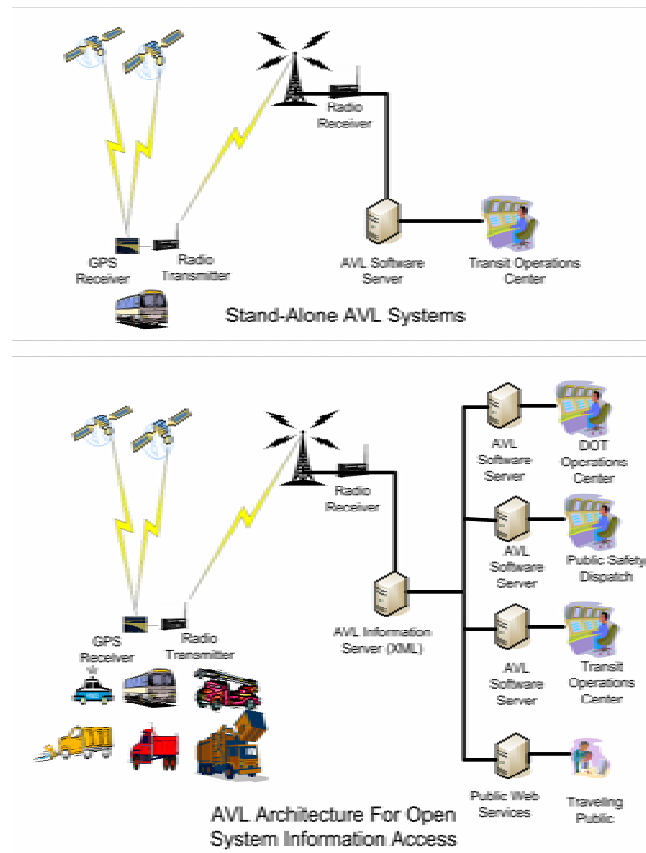


Figure 1 - Stand-Alone vs. Open System Architecture

The remainder of the document provides further details of the proposed project, including functional requirements for the resulting system.

1.4 Referenced Documents

The following documents contain additional information pertaining to this project or have been referenced within this document:

- Request for Proposals, Specification No. 05-053, City of Lincoln, NE, March 2005.
- Consulting Services for Automated Vehicle Location System Proposal, Mixon/Hill, Inc., April 2005.
- “Application for Participation in the Fiscal Year (FY) 2004 Intelligent Transportation System (ITS) Integration Component of the ITS Deployment Program – AVL System for StarTran,” StarTran, January 20, 2005.
- Title 23 Code of Federal Regulations (CFR) §940 (ITS Final Rule), and as referenced in Title 49 CFR §600 (FTA Regulations).

2 THE CURRENT SYSTEM OR SITUATION

2.1 *Background, Objectives, and Scope*

StarTran is the public transit provider for the City of Lincoln, with a mission to provide the citizens of Lincoln a convenient, reliable, comfortable, safe, and affordable public mass transit system. They work to achieve this mission by efficiently serving the public with the highest standards of quality, safety, and responsiveness while working with great commitment to increase the public trust and the community's quality of life.

StarTran provides a combination of fixed route and demand-responsive transit services throughout Lincoln. Using 60 full-size coaches of varying ages and nine (9) 2003 model year HandiVans, StarTran provides service on 20 regular service lines, the downtown circulator, and the various special transportation services. When extraordinary demand arises, the StarTran HandiVan fleet is supplemented by coaches provided by Transport Plus. They supply buses and bus operators on a contract basis as needed. Support for the StarTran bus fleet is provided by three (3) support vehicles, three (3) maintenance vehicles, and one (1) snowplow. Transit service is provided Monday through Friday from 5:15 a.m. – 7:10 p.m. (with special transportation services until 10:00 p.m.) and Saturday from 5:55 a.m. – 7:10 p.m. Service is not provided on Sundays, New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, or Christmas Day.

Operating with a current staff of 112 employees, StarTran served an annual fixed route ridership of 1,508,073 and an annual special transportation service ridership of 44,719 in 2003-2004, for a total 1,719,551 revenue miles. This represented an approximate 3% ridership increase from the previous year. Recognizing the increasing demand, StarTran's objective is to provide for increasing ridership and improved customer safety and satisfaction while minimizing operating expenses.

2.2 *Operational Policies and Constraints*

Currently, StarTran operates as an autonomous unit of the City of Lincoln Public Works/Utilities Department. StarTran operates within the bounds established by the City of Lincoln, as well as guidelines provided by FTA. These include constraints on the hours of operation, days of operation, and the number of staff dedicated to StarTran.

The existing StarTran system is not integrated with any of Lincoln's other city departments (i.e., Engineering Services/Street Maintenance, Police, or Fire). This constrains the flow of information between city departments and can introduce delay into those departments' response to a StarTran emergency, including a possible homeland security incident.

In addition, the current system does not share infrastructure with any of Nebraska's other transit providers, such as Metro Area Transit (MAT) in Omaha, Nebraska. This prevents system redundancy in the event of an emergency, particularly a homeland security emergency. A stated goal of this AVL project is for the StarTran AVL system to examine the potential of leveraging the existing AVL communication infrastructure at MAT. Currently, an intergovernmental

agreement does not exist between the City of Lincoln/StarTran and the City of Omaha/MAT.

2.3 Description of the Current System or Situation

As mentioned previously, StarTran currently provides service to a significant ridership. Because the current systems for dispatching and driver communications are largely manual, real-time schedule and routing information is impractical to provide. Therefore, when one of these riders requests bus information, the StarTran staff must call dispatch, who then calls the bus in question. This can create lengthy communications, which can frustrate customers and increase demand on already limited staff resources.

The lack of real-time schedule and routing information also impacts StarTran's scheduling and operating efficiency. Without such real-time data, schedule adjustments cannot be thoroughly optimized. This can create reluctance among potential customers to utilize the StarTran service, thereby suppressing ridership.

Communication between dispatchers and bus operators currently occurs over a two-way radio network. During peak periods, dispatchers can be inundated with radio communication between various bus operators. Many of these calls are routine. However, the risk exists that the volume of routine communication may delay or prevent the dispatchers from receiving an urgent communication from a bus operator.

Not only can urgent communications be delayed or lost, but if the dispatch center were to fail due to a security issue or a public emergency (fire, flood, etc.), there is no redundant, formal communication channel between the dispatcher and the bus operators. This creates an elevated security risk for each active bus. In addition, the routine communication requirements can distract the bus operator from focusing on his or her primary task; providing safe and efficient transportation for the customers.

One important characteristic of the current system is bus stop annunciation capabilities. Because the current system is essentially manual, bus operators must call out upcoming stops. This is typically done only at major intersections. Not only does this preclude all stops from being announced, it places the burden of compliance with the Americans with Disabilities Act (ADA) for the announcement on the bus operator. Not only can this create inconsistency between bus operators, it is an additional distraction from the bus operator's primary task.

2.4 Modes of Operation for the Current System or Situation

The operational modes for the current system are very basic and display a significant amount of overlap. The modes can be described as normal, peak/degraded, and emergency.

2.4.1 Normal Operational Mode

This is the normal, daily operational mode for the current StarTran system.

2.4.1.1 Customer

Customers have access to a variety of information. This information includes fixed-route geographic and schedule information, demand-responsive reservation service, and bus status information for both fixed- and demand-responsive routes.

Fixed route geographic and schedule information is available on the Internet and is accessible 24 hours-a-day. This information can also be obtained by calling StarTran customer service representatives during normal business hours.

Demand-responsive reservations can be made by phone. During normal business hours, StarTran customer service representatives answer telephone reservation requests. Outside of normal business hours, StarTran employs an answering service to respond to information requests; customers cannot make reservations requests during these hours.

Information regarding bus location and schedule is provided to fixed-route and demand-responsive customers by StarTran staff. After receiving a customer's call, StarTran customer service representatives obtain the current information by contacting the appropriate dispatcher who then contacts the bus operator via two-way radio. The information then retraces the route back to the bus rider. Bus location and schedule information is generally accurate, but can sometimes take a significant amount of time for the customer to obtain.

2.4.1.2 Fleet Management

Dispatchers, field supervisors, and management have three methods of monitoring individual bus performance. First, the dispatchers can communicate with the bus operator via two-way radio. This system is constrained by the physical limits of dispatcher, the bus operator, and the radio communication system.

Second, field supervisors can drive throughout the City on recognized routes. By observing routes from a vehicle, they can monitor actual field performance. This method limits the field observations to one-at-a-time observations, limited by their desired mobility from the observation vehicle.

Third, field supervisors can ride along a given route. This provides them with in-depth information about the individual bus operator and route/schedule adherence. However, it limits the observation to a single route, unless the field supervisor transfers to another line.

2.4.1.3 Bus Operator

The bus operators for both fixed- and demand-responsive routes drive their vehicles on the assigned routes. They maintain schedules and provide announcements of upcoming stops. When requested, they provide location and schedule status information to the dispatchers.

2.4.1.4 Fleet Maintenance

The fleet maintenance personnel get reports from the bus operators documenting the updated odometer readings and any failed or failing components. From this

information, the fleet maintenance personnel schedule preventive maintenance and major repairs.

2.4.1.5 Emergency Personnel

Under normal operational mode, emergency personnel are not actively involved.

2.4.1.6 Administrative Personnel

Administrative personnel gather the necessary data to support the program. Examples of this data are ridership numbers, revenue miles, and financial information. This data is used to report program accomplishments and status to FTA as well as City of Lincoln decision makers, as well as support subsequent capital and operating budget requests. This information is gathered by generally manual means, including manual entry into tracking software.

2.4.2 Peak Operational Mode

This is the operational mode experienced during periods of peak usage. Information regarding bus location and schedule may or may not be provided to customers by StarTran staff. This can result from staff overload due to multiple customer requests or from the inability to obtain accurate information from the bus operator due to heavy two-way radio traffic. This operational mode is characterized by communication needs exceeding system capabilities. Either way, customer satisfaction will decrease as a result of this operational mode.

2.4.2.1 Customer

Customers have access to a variety of information. This information includes fixed-route geographic and schedule information, demand-responsive reservation service, and bus status information for both fixed- and demand-responsive routes.

Fixed route geographic and schedule information is available on the Internet, and is accessible 24 hours-a-day. This information can also be obtained by calling StarTran customer service representatives during normal business hours. Under peak conditions, however, the wait time to speak with a customer service representative may be excessive. Under extremely heavy call loads, the customer may be unable to get through to speak with a customer service representative.

Demand-responsive reservations can be made by phone. During normal business hours, StarTran customer service representatives answer telephone reservation requests. During peak conditions, call volumes may exceed available phone lines or customer service representatives. Therefore, they may be unable to take a customer's reservations request.

Information regarding bus location and schedule may or may not be provided to fixed-route and demand-responsive customers by StarTran staff. This can result from staff overload due to multiple customer requests or from the inability to obtain accurate information from the bus operator due to heavy two-way radio traffic. This operational mode is characterized by communication needs exceeding system capabilities. Either way, customer satisfaction decreases as a result of this operational mode.

2.4.2.2 Fleet Management

Dispatchers, field supervisors, and management utilize the same three methods of monitoring individual bus performance discussed under normal operation mode. However, because of the increased demand on the two-way radio system, communication between dispatchers and bus operators may be delayed or not occur at all. This can limit the amount of effective monitoring the dispatchers and field supervisors can perform.

2.4.2.3 Bus Operator

The bus operators for both fixed- and demand-responsive routes drive their vehicles on the assigned routes. They attempt to maintain schedules due to increased traffic congestion and provide announcements of upcoming stops. When requested, they attempt to provide location and schedule status information to the dispatchers. This may be limited by the physical capabilities of the two-way radio system, as well as the bus operator's ability to multi-task.

2.4.2.4 Fleet Maintenance

The fleet maintenance personnel get reports from the bus operators identifying the updated odometer readings and any failed or failing components. From this information, the fleet maintenance personnel schedule preventive maintenance and major repairs.

2.4.2.5 Emergency Personnel

Under peak operational mode, emergency personnel are not actively involved.

2.4.3 Emergency Operational Mode

This is the operational mode experienced during an emergency event. Such an event may result from a fire or medical emergency in the StarTran dispatch center, an obstruction to the scheduled path such as an accident or road closure, an emergency on an active bus, or an initiated homeland security alert. During an event in the dispatch center, communication may be non-existent, leaving bus operators with no access to schedule, route, or emergency contact information. During a bus operator-related event, required communication with the dispatch center may unnecessarily delay police, fire, or emergency management response. This operational mode is characterized by higher risk exposure for the bus operator and riders.

2.4.3.1 Customer

Customers may have limited access to the information discussed previously. This information includes fixed-route geographic and schedule information, demand-responsive reservation service, and bus status information for both fixed- and demand-responsive routes.

Fixed route geographic and schedule information is available on the Internet, and is accessible 24 hours-a-day. This information may also be obtained by calling StarTran customer service representatives during normal business hours.

However, customer service representatives may be directed to other activities as a result of the emergency. If so directed, customer calls may go unanswered.

Demand-responsive reservations can be made by phone. During emergency operational mode, customer service representatives may be directed to other activities as a result of the emergency. If so directed, customer calls may go unanswered. Therefore, demand-responsive customers may be temporarily unable to take place a reservation request.

Information regarding bus location and schedule may or may not be provided to fixed-route and demand-responsive customers by StarTran staff. This can result from staff overload due to the emergency situation or from the inability to obtain accurate information from the bus operator due to heavy two-way radio traffic. This operational mode is characterized by communication needs exceeding system capabilities. Either way, customer satisfaction decreases as a result of this operational mode.

2.4.3.2 Fleet Management

Dispatchers, field supervisors, and management utilize the same three methods of monitoring individual bus performance discussed under normal operation mode. However, because of the increased usage of the two-way radio system, communication between dispatchers and bus operators may be delayed or not occur at all. This can limit the amount of effective monitoring the dispatchers and field supervisors can perform.

Dispatchers do not have access to the cameras within the buses, further limiting their ability to assess the situation. Without real-time location, direction, and speed data, directing emergency response to the bus is also difficult. In the case of a hostile bus takeover, this information may be nonexistent as the bus operator may be prevented from communicating with the dispatcher.

2.4.3.3 Bus Operator

The bus operators for either fixed or demand-responsive routes must continue to drive the bus, while addressing the emergency situation, as needed. In this situation, the bus operator will be communicating with dispatch via two-way radio. If the emergency situation involves a bus other than the one they're operating, the bus operator may have to continue the route with limited to no communication with dispatch. This results from the necessary use of the radio to communicate with the bus experiencing the emergency.

Under situations involving criminal activity, the bus operator may be forced to drive the bus off route, and may not have the ability to communicate this fact to the dispatcher. This increases risk of harmful actions being taken upon the bus operator and bus riders with no immediate method to recognize danger and send emergency responders.

2.4.3.4 Fleet Maintenance

During a bus breakdown, fleet maintenance personnel are involved. Currently, the bus operator makes an assessment of the situation based on his or her

knowledge of the bus' mechanical systems. The bus operator then relays that information, along with a geographic position, to the dispatcher via two-way radio. The dispatcher then notifies the fleet maintenance personnel.

Fleet maintenance personnel then gathers the necessary emergency equipment and responds to the site of the disabled bus; they may be unaware of bus' direction and/or location within the travel way. The fleet maintenance personnel may attempt to perform repairs or may arrange to tow the bus back to the garage. If towing is required, the fleet maintenance personnel notifies the dispatcher who then arranges for an alternate bus to continue the route. The inherent delay in this process impacts the normal traffic flow in the immediate area.

2.4.3.5 Emergency Personnel

Emergency personnel will be involved in health and safety emergencies, and may be involved during a bus breakdown for traffic control. Emergency personnel learn of the situation from the dispatcher who has received the information from the bus operator. The emergency personnel may not have precise geographic information for the bus, particularly if the bus is continuing to move. This introduces response time delay, which could further endanger lives.

Further, the emergency personnel have no direct way to assess the situation on the bus. There is no direct communication with the bus operator and the bus provides neither the emergency personnel nor the dispatcher with visual confirmation of the situation on the bus. Not only does this increase the risk for the bus operator and the bus riders, it may endanger the safety of the responding emergency personnel as well.

2.5 User Classes and Other Involved Personnel

This section describes the stakeholders of the existing StarTran system. It includes not only those groups/individuals that directly interact with the system, but also those groups/individuals that provide support to ensure the system's operational status. Each group/individual will be described below.

2.5.1 Organizational Structure

The Transit Manager serves as the head of StarTran. He reports to the Director of Public Works & Utilities, who reports to the Mayor. The StarTran Advisory Board provides advice on the StarTran system to the Mayor, the Director of Public Works & Utilities, and the City Council. The following figure graphically displays the StarTran organization as well as the reporting chain within the City.

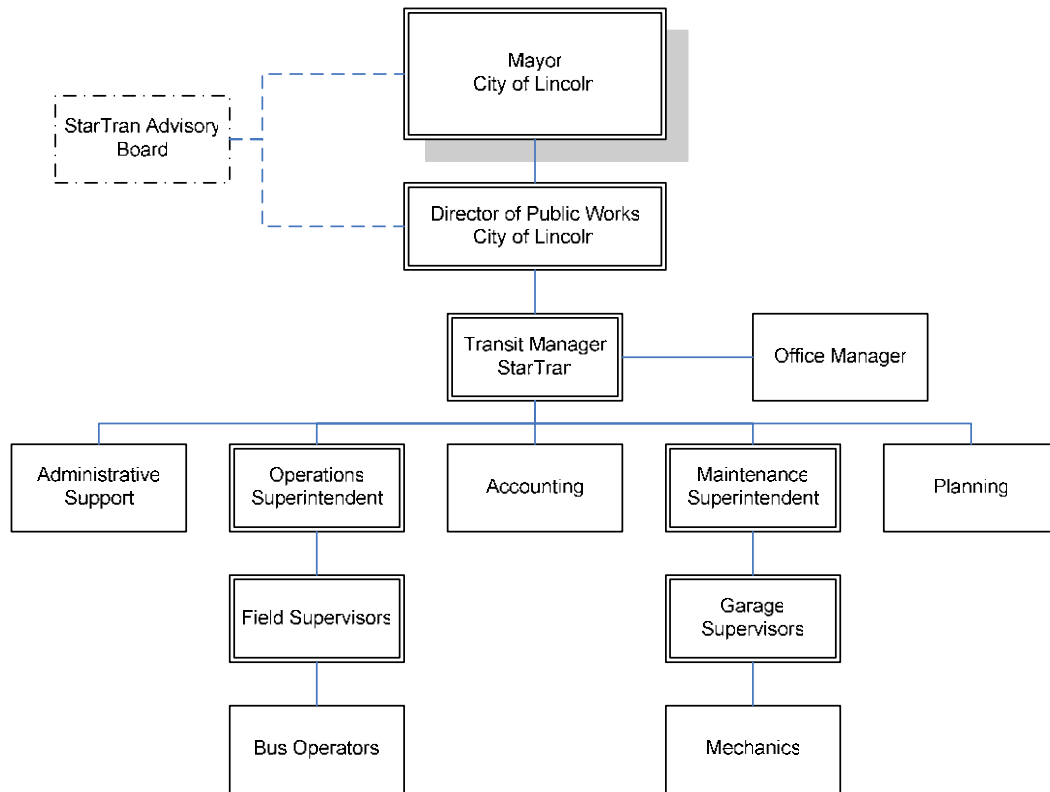


Figure 2 - StarTran Organizational Chart

2.5.2 Profiles of User Classes

The following subsections describe each of the user classes for the current StarTran system. Each description also includes system responsibilities and existing interactions with the system.

2.5.2.1 StarTran Management and Administrative

StarTran management and administrative staff are characterized as personnel who work primarily in the StarTran office. This includes program supervisors, office managers, customer service representatives, and accounts personnel. Their responsibilities include:

- Establishing budgets;
- Providing supervisory oversight;
- Responding to customer requests;
- Aggregating and reporting financial information; and
- Aggregating and reporting ridership information.

These responsibilities are executed with limited access to real-time data, and reporting functions are largely a manual assembly of pertinent data. This user class directly interacts with the system, dispatchers/field supervisors, fleet maintenance, bus operators, and customers daily. They also interact with

information technology (IT) (including radio and telecommunications) and emergency management personnel as needed.

2.5.2.2 Dispatchers/Field Supervisors

StarTran dispatchers are characterized as personnel who manage the StarTran bus operators. This includes the Operations Superintendent and Field Supervisors. Their responsibilities include:

- Ensuring fixed route service schedule adherence;
- Providing communication between bus operators and customer service representatives;
- Determining location of currently active buses;
- Scheduling demand-responsive or special transportation service requests; and
- Communicating assistance requests from the bus operator to the appropriate emergency or fleet maintenance personnel.

These responsibilities are executed with access to real-time data that is limited by the physical capabilities of the dispatcher and the two-way radio system. This user class directly interacts with the system, customer service representatives, and bus operators daily, and interacts with fleet maintenance, IT, radio, telecommunications, and emergency personnel as needed.

2.5.2.3 Fleet/Bus Maintenance

StarTran fleet maintenance personnel are characterized as those individuals that directly maintain fleet equipment. This includes the Maintenance Superintendent, the Garage Supervisors, and the mechanic staff. Their responsibilities include:

- Preventative maintenance of StarTran buses and other vehicles;
- Emergency repair of StarTran buses and other vehicles;
- Scheduling preventative fleet maintenance; and
- Maintaining and managing parts inventory for the fleet.

These responsibilities are executed with limited access to real-time data. Generally, maintenance scheduling is based on manual reports from bus operators or periodic inspections of fleet equipment. This user class directly interacts with the system, dispatchers, and bus operators daily, and interacts with IT, radio, telecommunications, and emergency personnel as needed.

2.5.2.4 Bus Operator

StarTran bus operators are characterized as those individuals that directly operate the buses and other vehicles that carry bus riders. This includes both StarTran bus operators, paratransit vehicle operators, and Transport Plus bus operators. Their responsibilities include:

- Safely operating their individual buses and vehicles;

- Providing customer service to bus riders;
- Ensuring route and schedule adherence; and
- Providing bus/equipment repair notification.

These responsibilities are executed with access to real-time data while operating their vehicles, providing customer service, and ensuring route and schedule adherence. The ability to execute these responsibilities is limited by the physical capabilities of the bus operator and the two-way radio system. Bus operators report their location via two-way radio to the dispatchers, including information related to schedule delays. This user class directly interacts with the system, dispatchers, and bus riders daily, and interacts with emergency personnel as necessary.

2.5.2.5 Bus Rider/Customer

StarTran bus riders are characterized as those individuals that utilize StarTran for public transportation within the City of Lincoln. This includes those individuals who use the fixed service, the demand-responsive service, and the special transportation services such as during University of Nebraska – Lincoln (UNL) football games. Their responsibilities include:

- Safely using the StarTran service;
- Obtaining appropriate route and schedule information; and
- Providing the appropriate payment for service.

These responsibilities are executed with extremely limited access to real-time data. Bus riders can only obtain such information by calling a StarTran customer service representative, who then contacts a dispatcher, who then contacts the bus operator. Obviously, this system is not direct and offers multiple opportunities for the information to become corrupted. This user class directly interacts with the bus operators daily, and interacts with emergency and customer service personnel as necessary.

2.5.2.6 Police/Fire/Emergency Management

Emergency personnel are characterized as those individuals who respond to emergency events within the City of Lincoln and Lancaster County. This includes the Lincoln Police Department, Lincoln Fire and Rescue, UNL Police Department, Lancaster County Sheriff, Lincoln-Lancaster County Emergency Management, Nebraska Emergency Management Agency, and Nebraska State Patrol (NSP). Their responsibilities include:

- Ensuring public safety;
- Responding to health emergencies, including bus operators and riders;
- Responding to vehicle accidents, including those with StarTran buses; and
- Responding to crime scenes, including those on StarTran buses.

These responsibilities are executed with limited access to real-time data. Generally, requests for assistance are generated by the bus operator via two-way radio to the StarTran dispatcher; the StarTran dispatcher then contacts the appropriate emergency personnel via 911 or direct line. These multiple steps can introduce unnecessary delay to response times and allows additional opportunities for information corruption. This user class directly interacts with the dispatchers, bus operators, and bus riders as necessary.

2.5.2.7 IT/Radio/Telecommunications

IT, radio, and telecommunications personnel are characterized as those individuals that install, maintain, and operate the various information systems used by StarTran. This includes computer personnel, network engineers, radio technicians, and telecommunications specialists. Their responsibilities include:

- Installing new computer networks, and radio and telecommunications systems;
- Maintaining and operating existing computer networks, and radio and telecommunications systems; and
- Supporting City of Lincoln and Lancaster County agencies in their use of computers and networks, radio systems, and telecommunications systems.

These responsibilities are executed with access to real-time data about the information systems, and generally limited real-time data about the activities the information systems support. System maintenance scheduling is based on planned preventive system maintenance, as well as reaction to unforeseen system failures. This user class directly interacts with the system and management/administrative personnel daily, and with dispatchers/field supervisors and fleet maintenance personnel as needed.

2.5.3 Interactions Among User Classes

Interaction among each of the user classes has been identified in the particular user class. However, the types of interactions among the user classes will be discussed here.

Routine fleet operations are generally provided by the dispatchers and the operators. The operators drive the buses and paratransit vehicles and work to maintain route and schedule adherence. They communicate via two-way radio with their supervisors and the dispatchers to report any variance from the schedule or need for emergency assistance. Requests for health, safety, or equipment emergencies are provided by the bus operators to their dispatcher via two-way radio, who then relays the request to emergency personnel or to StarTran maintenance or field support personnel. Routine equipment repair requests are provided to fleet maintenance personnel via manual reporting methods such as daily reports.

Route or schedule variance is provided to bus riders primarily when they call customer service and request such information. Long-term route or schedule adjustments are provided via the StarTran website, but temporary adjustments are typically provided as requested. Bus rider requests for this information begin

with the bus rider and are routed through the customer service representatives, the dispatchers, and the bus operators; the information then retraces the route back to the bus rider.

IT, radio, and telecommunications personnel interact with each unit within StarTran. They receive requests for system upgrades and repairs, perform those activities, and provide feedback to the appropriate unit regarding system changes. They support the system's electronic infrastructure, providing the system that allows the various user classes to communicate between each other. The IT, radio, and telecommunications personnel also support the information systems that gather StarTran financial and statistical information for reporting to the appropriate political oversight bodies. This information is also used to project necessary system improvements and upgrades.

Management and administrative interaction with dispatch and fleet management supervisors is typically limited to oversight. They ensure the respective groups are managing budgets and performing acceptably, as well as providing feedback regarding future system needs. They also interact with the various City of Lincoln and Lancaster County groups, including the political bodies representing the area's constituents, providing reports about system performance and requesting funds for system modifications and upgrades.

2.5.4 Other Involved Personnel

2.5.4.1 Transport Plus

Transport Plus is a private transit company that supports StarTran. Through a contract with StarTran, they provide vehicles to supplement StarTran's HandiVan fleet for large special transportation service events or in the event an inordinate amount of StarTran's normal fleet is undergoing maintenance. In this capacity, Transport Plus may operate as bus operator and fleet maintenance among others. Therefore, they have an interest in any existing or proposed StarTran system.

2.5.4.2 StarTran Advisory Board

The StarTran Advisory Board makes initial review of and acts upon matters related to the operation of the system, including transit related studies and plans, route studies and evaluations, performance indicators, rates, fares, and schedules. They meet monthly with the StarTran staff and as needed during committee meetings.

2.5.4.3 City of Lincoln/Mayor/City Council

The region's political bodies provide the vast majority of the financial support for the StarTran system. The City of Lincoln provides approximately two-thirds of StarTran's annual operating budget. This budget is authorized by the City's political bodies on behalf of the area's constituents. These bodies have a direct interest in ensuring StarTran operates as efficiently and effectively as possible.

2.5.4.4 Lincoln Metropolitan Planning Organization (MPO)

The Lincoln MPO is the region's overall planning organization. This agency studies the region's growth patterns, specifically how they relate to the transportation system. Based on this information, and coupled with system needs provided by the Department of Public Works & Utilities, the Lincoln MPO prepares a five-year Transportation Improvement Plan (TIP) as well as a 20-year Long Range Transportation Plan (LRTP). The projects listed in these documents are intended to reflect the community values and visions for improving the overall transportation system, including StarTran projects.

2.5.4.5 Omaha MAT

Omaha MAT is the transit provider in the Omaha, Nebraska metropolitan area. Because of the close proximity between Lincoln and Omaha, interest naturally exists in the adjacent region's public transportation system. Administrative components of the Omaha MAT could provide redundancy for StarTran (or vice-versa) in the event of a homeland security or other large-scale emergency. Because of these situations, Omaha MAT has an interest in StarTran's existing system and any potential modifications.

2.6 Support Environment

The current system is primarily a human-based system, utilizing two-way radio and plain old telephone system (POTS) infrastructure to share information between various user classes.

As mentioned previously, the IT, radio, and telecommunications user class supports the existing information and communication systems according to accepted industry practices. This includes regularly scheduled maintenance, along with accepted capital replacement cycles. The support activities for the information and communication systems are performed within the existing StarTran, City of Lincoln, and Lancaster County facilities utilizing existing equipment.

The vehicle fleet (buses and paratransit vehicles) is supported by the fleet maintenance user class. This includes regularly scheduled maintenance according to manufacturer recommendations, as well as daily vehicle washing. Capital replacement is performed on an as-needed basis, utilizing increasing support expenditures as an indicator for scheduling replacement vehicles. The support activities for fleet maintenance are performed within the existing StarTran facilities utilizing existing repair equipment.

Route maps and schedules are available 24 hours-a-day via the Internet. This information is found several layers below the City of Lincoln's main portal. For each of StarTran's routes, the pages provide schedules and Graphic Interchange Format (GIF) images that graphically depict the route. Each route's page also provides a link to downloadable Portable Document Format (PDF) documents containing this information.

Transit services are provided Monday through Friday from 5:15 a.m. – 7:10 p.m. (with special transportation services until 10:00 p.m.) and Saturday from 5:55

a.m. – 7:10 p.m. except holidays. StarTran’s normal office hours are Monday through Friday from 8:00 a.m. – 4:30 p.m. However, an answering service responds to customer information requests outside of the normal business hours. The combination of phone response provides the customers with information 24 hours-a-day; reservations can only be made during normal business hours.

3 JUSTIFICATION FOR AND NATURE OF CHANGES

This section describes the gaps between the existing system and the system to be created by this project. It will identify the shortcomings of the current system and the desired system capabilities that are motivating the new system's development.

3.1 *Justification for Changes*

As mentioned in the System Overview, StarTran wishes to improve the operational efficiency and security of its transit system. These desires can be summarized in three main goals:

- Increased availability of transit information and dissemination;
- Improved overall dispatching and operating efficiency; and
- Increased driver and passenger safety and security.

StarTran is tasked with providing these improvements while minimizing additional expenditures or personnel. The existing system, because of the inherently manual nature of its data sharing, precludes the ability to increase system efficiency without the application of additional resources.

StarTran has identified the use of technology as a cost-effective method to achieve operational improvement and accomplish the three main goals. Specifically, the appropriate implementation of ITS technology to improve data accuracy and reduce communication delays offers the potential to meet the three main goals without additional personnel resources, and with minimal, if any, increase in recurring operational costs.

In November 2003, funding for the implementation of a StarTran ITS system was included in the FY 2004 Federal Transportation Appropriations bill. This funding provides the ability to implement an ITS system that will help StarTran more efficiently and effectively accomplish the three main goals above.

3.2 *Description of Desired Changes*

StarTran has identified AVL technology as an ITS system with the capability of meeting the system goals. For the purpose of this ConOps, AVL is used as a generic term to represent a collection of transit ITS technologies. Many of these technologies may be packaged together in a single application. The set of technology components and applications may comprise:

- Differential Global Positioning System (GPS) – providing satellite-based location tracking of transit vehicles (buses and service vans), maintenance vehicles, and field supervisor vehicles with reporting capabilities to a central dispatch facility;
- Fleet management software – utilizing GPS location data and other information to support real-time schedule and route adherence monitoring, dispatching, communications management, and alerts monitoring;
- Mobile data terminals (MDT) – on-vehicle devices to manage two-way messaging between operators and dispatchers, and to gather vehicle and

route performance data for subsequent download into maintenance management systems and for future route and schedule planning activities;

- Vehicle component monitoring – onboard sensors to monitor critical vehicle components and systems, and to provide information via the MDT (either in real-time or through end-of-day download) about imminent equipment failures or for routine maintenance monitoring;
- Safety and security systems – including onboard cameras and silent alarms for real-time alerts and situational monitoring for dispatchers and supervisors;
- Onboard annunciators – ADA-required components providing visual and audible presentation of stops and other service announcements;
- Automated fare payment systems – supporting fare collection through a variety of contact or contactless media, including tickets, swipe cards, and smart cards;
- Traffic signal priority – equipment installed onboard vehicles and at signalized intersections that provides the capability to extend signal green times to allow passage of a transit vehicle; and
- Passenger information systems – providing linkages to web sites, and displays and kiosks at boarding locations that provide passengers with information about routes and schedules, service interruptions and delays, and, potentially, real-time wait times.

By following a strict systems engineering process, StarTran can design and procure a system that will allow the most future flexibility and expandability, while meeting the current needs cost effectively.

3.2.1 New or Modified Capabilities

The desired system changes are centered around the increased capabilities that an AVL system can provide without increasing the burden on existing personnel or systems. One such change is the ability of an AVL system to improve overall scheduling and operating efficiency. It is anticipated that an AVL system's vehicle tracking capabilities will allow development of more efficient route schedules that can have a positive impact on ridership.

Another new capability provided by an AVL system is improved quality, timeliness, and availability of route and schedule information. The ability to quickly access such accurate information will not only assist in attracting new riders, it will reduce the delay in providing existing customers with this information and will reduce the demand on the customer service staff. Further, the use of MDT can reduce the demand on the two-way radio system. Such capabilities can also have a positive impact on ridership.

A third capability provided by an AVL system is increased bus operator and bus rider safety and security. Because of the detailed location information, as well as the ability to remotely monitor activities on the buses in real time, such a system can help reduce passenger assaults and other criminal acts on the buses. Further,

the location information provided by the AVL system can be quickly and accurately provided to emergency responders. This could not only help law enforcement apprehend any criminals perpetrating acts on the buses, but can also help emergency responders more quickly provide first aid to victims of criminal acts or medical emergencies.

A fourth capability provided by an AVL system is the ability to better monitor and manage fleet operations. Given the dispatchers' overlapping responsibilities between the fixed-route and demand-responsive transit services, this capability can ease the transitions between management shifts. Also, by providing accurate information about vehicle location, an AVL system can identify when buses are on- and off-route and alert dispatchers to off-route buses. This function can be used to alert new bus operators if they have made a mistake or notify dispatchers of bus operators taking shortcuts to get back on schedule. The fleet operations capabilities could be extended through the use of traffic signal prioritization as well, further reducing travel times through signalized intersections.

A fifth capability offered by an AVL system is improved bus fleet maintenance operations. By collecting accurate information about each bus, an AVL vehicle component monitoring system can provide automated information to fleet maintenance personnel about the vehicle's status. This can include data about required preventive maintenance, potential upcoming equipment failures, and equipment operational characteristics such as fuel mileage. Further, accurate location information will aid maintenance staff to quickly reach buses with mechanical breakdowns.

A sixth capability provided by an AVL system is improved system administrative functions. A fully functional AVL system can automate many of the reporting functions currently performed by administrative staff, including assembling ridership and revenue mile data, as well as bus operating data. This streamlines the FTA reporting process, and can provide the City and County decision makers with accurate system data more quickly. An additional administrative function is an automated fare payment system. Such a system can enable bus riders to utilize an automated card for fare transactions, can help reduce administrative expenses for fare collection, and reduces the amount of cash stored on the bus. This can extend StarTran's budget by minimizing the amount of expenditures on administrative overhead.

3.2.2 Operational, Support, and Personnel Changes

An AVL system, if implemented, will introduce operational changes to StarTran. This document has discussed the efficiencies offered by automating the vehicle location function. Automating the vehicle location functionality will reduce the need to communicate using the two-way radio system, and shift that operational function to the new AVL system. It will also introduce operational changes to the way dispatchers monitor the bus operators, as they will be provided with real-time location information for all buses under their responsibility. Finally, such information can be used to readily provide status to bus riders, eliminating the need to utilize the customer service representative-dispatcher-bus operator communication chain referenced earlier.

Additional operational changes involve reporting functions. The required ridership and revenue mile reports can be automated, thus changing the way this data is gathered. The daily reporting that allows preventive maintenance to be scheduled can also be automated, thus providing the bus operators with more operational time and providing the fleet maintenance personnel with more timely, accurate information.

The IT, radio, and telecommunications support function will also change. This user class will be responsible for ensuring the system hardware and software remains operational. While this could increase the workload, the additional responsibilities are incremental in nature and will likely not require additional IT, radio, and telecommunications personnel. Depending upon the full build-out over the system life cycle, the AVL system may present the opportunity to reallocate administrative personnel within StarTran.

3.3 *Priorities Among Changes*

Several system changes have been previously discussed. These include new system capabilities along with improvements of existing system capabilities. This section will identify the essential features/functionalities, the desirable features/functionalities, and the optional features/functionalities for which the new system will be designed.

3.3.1 Essential Features/Functionalities

Essential features/functionalities are those that shall be provided by the new system. First and foremost, the system must include precise vehicle location technology and an automated method of transmitting that location data from the bus to the dispatcher. Without automated vehicle locating capabilities, the previously discussed operational efficiencies will not be realized.

Secondly, the system must include safety-monitoring systems. This includes the ability to automatically convey emergency request information from the bus to the dispatcher, and may include incorporation of video cameras that broadcast real time images or video from the buses. Without automated emergency requests and real time images/video, passenger safety and security risk is not improved.

Third, the system must be designed in such a way as to maximize future system expansion/modification. One critical step to meet this need is an effective systems engineering process that thoroughly defines the system's functionality. An additional important step is focusing, to the extent possible, on maintaining an open system design utilizing accepted standards that maximizes the potential for system component suppliers.

3.3.2 Desirable Features/Functionalities

Desirable features/functionalities are those that should be provided by the new system. This represents the vast majority of the ultimate system's capability. Fully implementing every desirable feature/functionality may be cost prohibitive for the initial deployment. Therefore, the system design will provide the ability for these features/functionalities to be added to the system as funding becomes available.

First, the system may incorporate vehicle-tracking capabilities. Such features/functionality allow utilization of a computer-aided dispatch (CAD) system; this can electronically display route information and help determine schedule adherence. Vehicle-tracking capabilities can also provide customer service staff with tools to assess and address customer questions and concerns.

Second, the system may incorporate MDT's that allow two-way messaging between the dispatchers and the bus operators. This feature/functionality can be viewed as an extension of the safety-monitoring system previously mentioned as well as a means of routine communications. Such a system can reduce the use of the two-way radio system, allowing its capacity to be used more effectively.

Third, the system may incorporate traveler information functionality. This functionality can take many forms, including providing real time routing and scheduling information to customers through the Internet, email, text messaging, pagers, phones, and kiosks at key boarding locations. It may also include a trip-planning component that can provide a customer with routing and scheduling information for an upcoming trip, including bus transfer locations. This functionality can directly impact customer satisfaction and may increase ridership.

Fourth, the system may incorporate vehicle component monitoring functionality. This functionality can provide notification when a bus' engine, drive train, or braking systems are not within tolerance, as well as provide notification of upcoming required preventive maintenance. By providing this notification, preventive maintenance can be better planned and bus system failures can be reduced. This leads to reduced downtime for the StarTran fleet and can extend the service life of each individual bus and its systems; this directly impacts StarTran's operational costs.

Fifth, the system may incorporate reporting features/functionality. As discussed previously, a fully functional AVL system can automate many of the reporting functions currently performed by administrative staff, including assembling ridership and revenue mile data as well as bus operating data. This streamlines the FTA reporting process, and can provide City decision makers with accurate system data more quickly. Ultimately, this leads to better decisions regarding the system while allowing existing administrative staff to perform additional duties.

3.3.3 Optional Features/Functionality

Optional features/functionality are those that might be provided by the new system. They are characterized by those features/functionality that are desired by the ultimate system, but ones without which the system still retains the majority of its operational advantages.

First, the system could automate many of the in-bus traveler information functions. By automating the bus operator login process, the bus's head sign and fare structure may be automatically adjusted. With the bus route automatically recognized by the bus' AVL system, automated bus stop announcements can be provided. Not only do these systems help reduce the risk of errors, prerecorded bus stop announcements offer the opportunity to ensure the announcement meets Federal and state ADA requirements.

Second, the system could automate the fare payment system. By enabling bus riders to utilize an automated card for fare transactions, StarTran can provide a cashless mechanism for regular riders. This can reduce the delay at stops while bus riders pay their fares and can help reduce administrative expenses for fare collection. The obvious benefits are bus schedule adherence and reduced expenditures on administrative overhead.

Third, the system could be integrated with traffic signal priority system. Such a system would require close coordination with the City of Lincoln's Public Works & Utilities Department, specifically the Engineering Services Unit. If implemented, this functionality could help further ensure bus schedule adherence by reducing travel times through signalized intersections.

3.4 Assumptions and Constraints

Several assumptions and constraints were considered during the ConOps development. This includes both internally and externally imposed considerations.

First, the initial development of this system is funded under a fiscal year (FY) 2004 FTA §5208 Federal-aid earmark. The total value of the earmark, and thus system cost, is \$1,723,164 comprised of \$861,582 from the subject earmark and an \$861,582 match from the City of Lincoln general funds. This constrains the initial AVL system's capabilities, and increases the need to design and procure a system that provides for future system expansion/modification.

Second, because this project includes FTA funds, it must comply with FTA Policy, which incorporates 23 CFR §940, otherwise known as the Federal Highway Administration (FHWA) ITS Final Rule. These regulations require subject projects to utilize an ITS architecture, appropriate National ITS Standards, and a systems engineering process commensurate with the project size and scope.

Third, the system will be in place for many years, and thus must be able to accommodate increased ridership through capability expansion/modification. System expansion/modification will likely be conducted with StarTran operational funds, and must therefore be performed in an extremely cost-effective manner. On balance, the system must be able to perform its functions with no net increase in StarTran support staff.

Fourth, the system must be designed in such a way as to allow future interconnection with other regional systems. For example, the StarTran AVL system may interconnect with the Omaha MAT system, at least allowing for system redundancy in the event of a homeland security or other emergency situation. It may also integrate with the following systems operated by the Lincoln MPO.

- Arterial Management System
- Incident Management System
- Management and Operations System
- Information Management/Data Archiving System

Finally, future enhancements to the StarTran AVL system may integrate with the Lancaster County Emergency Management systems, as well as management, payment, traveler information systems, and maintenance systems operated by the City of Lincoln, the State of Nebraska, and Nebraska Department of Roads (NDOR).

4 CONCEPTS FOR THE PROPOSED SYSTEM

This section describes the proposed system that results from implementing the previously discussed changes. The proposed system's description is provided in a high-level manner, indicating the operational features/functionalities to be provided without specifying design details or technology-specific solutions.

4.1 *Background, Objectives, and Scope*

Operating with a current staff of 112 employees, StarTran served a fixed route ridership of 1,508,073 and a special transportation service ridership of 44,719, for a total 1,719,551 revenue miles during the most recent reporting year. This represented an approximate 3% ridership increase from the previous year. StarTran management anticipates this rate of increase to continue, and wishes to implement systems that can handle not only the projected growth, but can also increase customer satisfaction and safety while minimizing operating expenses.

StarTran, and the City of Lincoln, have identified three goals for their new AVL system. It must:

- Increase availability of transit information and dissemination;
- Improve overall dispatching and operating efficiency; and
- Increase bus operator and bus rider safety and security.

The proposed system must accomplish these goals within the financial constraints of the FY 2004 FTA §5208 Federal-aid earmark, including design and deployment of the initial system. Due to the initial financial constraints, some system capabilities will likely require deployment at a later date.

Therefore, the system must employ an open, standardized design to provide the opportunity for maximum flexibility and minimal expenditures to achieve the system's ultimate functionality. Further, the system might require some not-yet-available capability in the future. This reinforces the need for a standardized and open system design.

4.2 *Operational Policies and Constraints*

StarTran operates as an autonomous unit of the City of Lincoln Public Works/Utilities Department, and utilizes the information system support services from the City of Lincoln Finance Department. StarTran operates within the bounds established by the City of Lincoln, as well as guidelines provided by FTA. These policies, including ADA compliance, may impact the design and development of the StarTran AVL system. Further, the capabilities of the information system support services group may impact the final system design.

Capabilities introduced by the StarTran AVL system may also allow for future integration with the City of Lincoln's other departments (i.e. Engineering Services/Street Maintenance, Police, Fire), as well as other public agencies such as Lancaster County Emergency Management and NDOR. While not part of this project, such future integration must be considered during the design process. These considerations may constrain the final system design.

In addition, the proposed system may share infrastructure with the City of Omaha MAT. Such an arrangement may allow the StarTran AVL system to leverage the existing AVL communication infrastructure at MAT, if possible. Currently, an intergovernmental agreement does not exist between the City of Lincoln/StarTran and the City of Omaha MAT. As a result, for this functionality to be implemented, an intergovernmental agreement must be implemented between the City of Lincoln/StarTran and the City of Omaha MAT.

StarTran's defined hours of operation, days of operation, and the number of staff will impact the final system design. The system may provide functionality such as automated scheduling capabilities. By providing bus riders with the ability to request service via the Internet or other automated methods, this will reduce demands on customer service staff and will provide 24 hour-a-day scheduling capabilities for customers.

In order for the AVL system to offer traffic signal priority capabilities, the City's Engineering Services Unit, specifically the Traffic Operations group, would have to agree with the concept. Then, the work of integrating this capability into the City's existing signal system would fall on the Traffic Operations group.

4.3 Description of the Proposed System

The following section provides a description of the features/functionality for StarTran's AVL system. The essential functions are those defined as critical to the system's success. These functions shall be included in the design and deployment of the initial system.

The remaining capabilities are envisioned in the fully developed, mature AVL system. StarTran will prioritize the development and deployment of these capabilities subsequent to the essential functions. Their inclusion in the initial system deployment will primarily be a function of available funding and existing infrastructure capabilities. Otherwise, they may be scheduled for subsequent deployment phases.

4.3.1 Essential Function: Precise Vehicle Location Technology

The StarTran AVL system is based on the ability to precisely determine the location of the active buses within StarTran's fleet. This includes the ability to automatically transmit this data from the bus to the dispatcher. The data may include location, direction of travel, and travel speed. The system shall be able to monitor the entire StarTran fleet, and provide enough capacity for system redundancy with other regional AVL systems.

4.3.2 Essential Function: Safety Monitoring Systems

The StarTran AVL system will provide improved bus operator and bus rider safety and security. This requires the ability to automatically convey alarms and emergency request information from the bus to the dispatcher; this information will include precise location data. It may also include the ability to transmit real-time images and/or video from the buses to the dispatchers. The exact data type (still, moving images, image quality, frame rate) must be determined during the design process.

4.3.3 Essential Function: Open System Design

The StarTran AVL system must be based on an open system design utilizing accepted standards. This allows various hardware components and potential systems from multiple providers to share information. It must allow for future integration with various regional information and management systems. This will reduce the risk of building a stove-piped system that restricts interaction and future expansion. It also ensures future system changes can be accomplished cost effectively.

4.3.4 Desirable Function: Vehicle Tracking Capability

The StarTran AVL system shall have the capability of implementing vehicle tracking. This will allow dispatchers to not only observe real-time data regarding a particular bus; it will also allow utilization of more sophisticated dispatching systems. The vehicle tracking capability shall provide a CAD system with route and schedule information, and provide customer service staff with the ability to review actual routes/schedules to assess and address customer questions and concerns.

4.3.5 Desirable Function: Mobile Data Terminals

The StarTran AVL system shall have the capability of implementing MDT's. This will allow two-way communication between the dispatchers and the bus operators, while leaving valuable radio capacity for more urgent communication. These MDT's shall provide the ability to convey messages between the dispatcher and the bus operator, and may include the ability to convey information between the bus operator and the fleet maintenance staff. The MDT's may also serve as the mechanism to transmit real-time on-board images to the dispatcher.

4.3.6 Desirable Function: Traveler Information System

The StarTran AVL system shall have the capability to provide real time schedule and route information to customers. The data may include location, direction of travel, and estimated arrival times at planned bus stops. This information will be disseminated automatically through a variety of methods that may include the Internet, phone, email, text messaging, wireless devices, etc. The system design shall provide for the future addition of traveler information devices not yet identified.

4.3.7 Desirable Function: Traveler Planning System

The StarTran AVL system shall have the capability to provide trip-planning services to potential customers. By entering a beginning and ending location, the system will provide the customer with estimated travel times, starting and ending bus stops, transfer locations and times, and estimated fare costs. This system may be provided through the Internet, phone, wireless devices, or other devices not yet identified.

4.3.8 Desirable Function: Traveler Reservation System

The StarTran AVL system shall have the capability to automate trip requests for demand-responsive customers. By entering a beginning location, an ending

location, and an ending time, the system will provide the customer with the ability to automatically schedule a trip. The customer will be provided a pick up time and an estimated fare cost for the scheduled trip.

4.3.9 Desirable Function: Vehicle Component Monitoring

The StarTran AVL system shall have the capability to monitor various vehicle components. This information will be automatically provided to the bus operator, the dispatcher, and fleet maintenance personnel. The notification system will include alerts when predetermined thresholds are exceeded. The data may include real-time engine, drive train, braking status, and fuel usage rate, as well as advance notification of required preventive maintenance such as oil and transmission fluid changes.

4.3.10 Desirable Function: System Statistical Reporting

The StarTran AVL system shall have the capability of automatically generating required system statistical reports. These reports are required by FTA, the City of Lincoln, and others. These reports can include a wide variety of data such as rider counts, revenue miles, peak usage times for specific routes, percent capacity utilization, on time performance, and cost per rider/mile among others. The exact data and reports desired by this functionality shall be determined during the design process.

4.3.11 Optional Function: Automated Bus Operator Login

The StarTran AVL system shall have the capability of allowing the bus operator to login to the bus' AVL system. By logging in and providing a route identifier, the AVL system shall automatically adjust the bus' head sign and fare structure for the bus operator's prescribed route. Necessary data will include route and fare data as well as bus operator identification and security authorization.

4.3.12 Optional Function: ADA Compliant Announcements

The StarTran AVL system shall have the capability of providing automated, ADA-compliant announcements. This includes advanced notification of upcoming stops, fare changes, and route changes. It may include announcements with real-time schedule data, including estimated travel times and bus transfer information.

4.3.13 Optional Function: Automated Fare Payment System

The StarTran AVL system shall have the capability of implementing an automated fare payment system. Such a system may include an automated card for fare payment that is linked to the bus rider's account data. The system will automatically adjust for different routes and different rate schedules. Necessary data will include route identifiers, rate schedules, bus rider automated card identification, and security authorization for account access.

4.3.14 Optional Function: Traffic Signal Priority System

The StarTran AVL system shall have the capability of implementing a traffic signal priority system. Such a system will allow the buses to have priority access

at a signalized intersection. Data required includes the bus routes and schedules with estimated travel times between stops. It will also include integration with the City's existing signal timing plans, including any alternate plans they may have for events, inclement weather, or emergencies.

4.4 Modes of Operation

The operational modes for the proposed system are very basic and display a significant amount of overlap. The modes can be described as normal, peak/degraded, and emergency. While the modes do not change from the existing system, the characteristics of each mode have changed.

4.4.1 Normal Operational Mode

This is the normal, daily operational mode for the current StarTran system.

4.4.1.1 Customer

The AVL system data regarding both fixed- and demand-responsive route and schedule status is provided to customers through a variety of automated means. When the StarTran staff receives inquiries directly, the staff member obtains the needed information from one of the AVL system's automated methods. The customer can also obtain this information directly via the Internet. Bus information is provided in real-time, is substantially more accurate than currently available data, and includes location, direction, and travel speed.

Potential customers can plan trips utilizing StarTran buses, and receive information regarding starting location and time, ending location and time, any required transfers, and estimated fare cost. Demand-responsive customers can also make automated trip reservations.

4.4.1.2 Fleet Management

Dispatchers, field supervisors, and management have multiple methods of monitoring individual and fleet performance. In addition to the three methods discussed in Section 2.4.1.2, these individuals use the AVL system to monitor multiple vehicles, up to the entire active fleet, at one time. This allows the dispatchers and field supervisors to more accurately evaluate bus operator performance, including identifying when buses are on- and off-route, allowing them to correct off-route buses. The AVL system provides off-route or behind schedule alerts to both the dispatcher and the bus operator, helping them to more promptly take corrective action.

Communication between the dispatchers and the bus operators is still conducted over the existing two-way radio system, but at a significantly lower volume. The MDTs are used for routine communication between the dispatcher and the bus operator. In addition, the AVL system has eliminated the need to gather location and schedule information via the two-way radio system.

4.4.1.3 Bus Operator

The bus operator no longer communicates location and schedule information via the two-way radio. The AVL system automatically provides that information to the dispatcher. The MDTs are utilized for virtually all routine communications.

The bus operator logs into the AVL system at the beginning of his or her shift. By identifying the driver and the assigned route, the head sign is automatically adjusted to reflect the route and the automated, ADA-compliant annunciations are loaded into the system as well. The normally reported information such as beginning odometer, ending odometer, and fuel are automatically reported by the bus to the AVL system server. That information is made available to the appropriate StarTran personnel.

4.4.1.4 Fleet Maintenance

Fleet maintenance personnel are provided with vehicle monitoring information, including alerts of impending vehicle system failures. The system also provides the fleet maintenance personnel with accurate vehicle information such as beginning odometer, ending odometer, and fuel.

This information allows the fleet maintenance personnel to better plan preventive maintenance, and distribute workloads more uniformly over time. It also allows fleet maintenance personnel to more accurately plan for the appropriate bus maintenance part and supply inventories.

4.4.1.5 Emergency Personnel

Under normal operational mode, emergency personnel are not actively involved.

4.4.1.6 Administrative

System administrative functions are largely automated, including the implementation of automated fare payment and reporting systems. The automated fare payment system improves system performance as well as streamlining financial processing costs. The automated reporting systems provide up-to-date system data as needed, and provide the information required for the annual FTA and City of Lincoln system reports.

4.4.2 Peak/Degraded Operational Mode

This is the operational mode experienced during periods of peak usage. In comparison to the current system's peak operational mode, the proposed system does not suffer nearly as much performance degradation. The system operates similarly to the normal operational mode, with a few additions. The proposed system continues to provide customer information with no visible delay over the normal operational mode.

4.4.2.1 Customer

The AVL system data regarding both fixed- and demand-responsive route and schedule status is provided to customers through a variety of automated means. When the StarTran staff receives direct inquiries, the staff member obtains the

needed information from one of the AVL system's automated methods. The customer can also obtain this information directly via the Internet. Bus information is provided in real-time, is substantially more accurate than currently available data, and includes location, direction, and travel speed.

Potential customers can plan trips utilizing StarTran buses, and receive information regarding starting location and time, ending location and time, any required transfers, and estimated fare cost. Demand-responsive customers can also make automated trip reservations.

4.4.2.2 Fleet Management

Dispatchers, field supervisors, and management have multiple methods of monitoring individual and fleet performance. In addition to the three methods discussed in Section 2.4.1.2, these individuals use the AVL system to monitor multiple vehicles, up to the entire active fleet, at one time. This allows the dispatchers and field supervisors to more accurately evaluate bus operator performance, including identifying when buses are on- and off-route, allowing them to correct off-route buses. The AVL system provides off-route or behind schedule alerts to both the dispatcher and the bus operator, helping them to more promptly take corrective action.

Communication between the dispatchers and the bus operators is still conducted over the existing two-way radio system, but at a significantly lower volume. The MDTs are used for routine communication between the dispatcher and the bus operator. In addition, the AVL system has eliminated the need to gather location and schedule information via the two-way radio system.

Traffic signal priority systems help the StarTran buses remain on schedule, thus ensuring bus riders arrive at their chosen location when expected. Vehicle tracking gains additional visibility as dispatchers and field supervisors verify their drivers are complying with predetermined routes.

4.4.2.3 Bus Operator

The bus operator no longer communicates location and schedule information via the two-way radio. The AVL system automatically provides that information to the dispatcher. The MDTs are utilized for virtually all routine communications.

The bus operator logs into the AVL system at the beginning of his or her shift. By identifying the driver and the assigned route, the head sign is automatically adjusted to reflect the route and the automated, ADA-compliant annunciations are loaded into the system as well. The normally reported information such as beginning odometer, ending odometer, and fuel are automatically reported by the bus to the AVL system server. That information is made available to the appropriate StarTran personnel.

4.4.2.4 Fleet Maintenance

Fleet maintenance personnel are provided with vehicle monitoring information, including alerts of impending vehicle system failures. The system also provides

the fleet maintenance personnel with accurate vehicle information such as beginning odometer, ending odometer, and fuel.

This information allows the fleet maintenance personnel to better plan preventive maintenance, and distribute workloads more uniformly over time. It also allows fleet maintenance personnel to more accurately plan for the appropriate bus maintenance part and supply inventories.

4.4.2.5 Emergency Personnel

Under peak operational mode, emergency personnel are not actively involved.

4.4.3 Emergency Operational Mode

This is the operational mode experienced during an emergency event. Such an event may result from a fire or medical emergency in the StarTran dispatch center, an emergency on an active bus, or an initiated homeland security alert. During a dispatch center-based event, communication can be provided through both the two-way radio and through the MDT's. This provides a redundant system for delivering any pertinent message.

During a bus operator-related event, automated communication including location information can expedite police, fire, or emergency management response. Because the system expedites communication of event and location data, bus operators' and riders' risk exposure is lessened from the existing system's functionality during this operational mode.

4.4.3.1 Customer

The AVL system data regarding both fixed- and demand-responsive route and schedule status is provided to customers through a variety of automated means. When the StarTran staff receives direct inquiries, the staff member obtains the needed information from one of the AVL system's automated methods. The customer can also obtain this information directly via the Internet. Bus information is provided in real-time, is substantially more accurate than currently available data, and includes location, direction, and travel speed.

Potential customers can plan trips utilizing StarTran buses, and receive information regarding starting location and time, ending location and time, any required transfers, and estimated fare cost. Demand-responsive customers can also make automated trip reservations.

Further, customer safety is increased due to the dispatcher's ability to remotely monitor not only the bus' location, direction, and speed, but also to remotely view real time camera video/images from inside the bus.

4.4.3.2 Fleet Management

Dispatchers, field supervisors, and management have multiple methods of monitoring individual and fleet performance. In addition to the three methods discussed in Section 2.4.1.2, these individuals use the AVL system to monitor multiple vehicles, up to the entire active fleet, at one time. This allows the dispatchers and field supervisors to more accurately evaluate bus operator

performance, including identifying when buses are on- and off-route, allowing them to correct off-route buses. The AVL system provides off-route or behind schedule alerts to both the dispatcher and the bus operator, helping them to more promptly take corrective action.

For the buses involved in an emergency event, the dispatcher utilizes the AVL information to know where the bus is currently located, where it is headed, and the travel speed. The dispatcher also has access to real-time video/images from inside the bus, and can communicate with the bus operator via the MDT if the two-way radio system is unavailable or undesirable. The dispatcher can relay this information to emergency responders in real-time. For a health/safety emergency, these responders may already know treatment protocol upon arriving at the scene; this can save precious response time. In the case of a hostile takeover, the emergency responders have an assessment of the situation, the location of the offender within the bus, and the identification of the offender's weapon, if any.

4.4.3.3 Bus Operator

The bus operator no longer communicates location and schedule information via the two-way radio. The AVL system automatically provides that information to the dispatcher. The MDTs are utilized for virtually all routine communications.

The bus location, direction, and travel speed is provided automatically to the dispatcher, allowing the bus operator to focus on the emergency situation. If the situation involves criminal activity, the bus operator triggers the silent alarm, alerting the dispatcher to the situation. The bus driver then has the capability of discretely communicating situational information via the MDT. The bus driver knows the dispatcher has access to real-time video/images from inside the bus.

4.4.3.4 Fleet Maintenance

Fleet maintenance personnel are provided with vehicle monitoring information, including alerts of impending vehicle system failures. In the event of a bus breakdown, the fleet maintenance personnel know the nature of the breakdown prior to response. Further, the fleet maintenance personnel know the location and direction of the bus on the travel way. This allows them to assess the possibility of a field repair, and if necessary, arrange for towing and an alternate bus prior to leaving the garage.

In the case of a major repair, the alternate bus and tow vehicles arrive on scene promptly and the disabled bus is promptly removed from the travel way. This reduces the impacts to traffic flow and the bus' schedule. In the case of a minor repair, the fleet maintenance personnel determine the proper traffic control layout enroute to the scene. This expedites the field repair and the return of the travel way and the bus' schedule to normal operating conditions.

4.4.3.5 Emergency Personnel

Emergency personnel will be involved in health and safety emergencies, and may be involved during a bus breakdown for traffic control. Emergency personnel learn of the situation from the dispatcher, who has received the information from

the bus operator and the AVL system. The emergency personnel have precise location, travel direction, and travel speed information provided either by the AVL system through the dispatcher or directly from the AVL system. This expedites their response to the bus.

Because of the amount of real-time data, the emergency personnel can more directly assess the situation on the bus prior to arrival on scene. The bus operator may continue to provide communication via the MDT, and the dispatcher can relay information from the real-time video/images of the bus' interior. They can determine the location within the bus of the individual with a health emergency, or the location of the offender in the event of a criminal action. They may also be able to determine the offender's type of weapon, if any.

4.5 *User Classes and Other Involved Personnel*

This section describes the stakeholders of the proposed StarTran system. It includes not only those groups/individuals that directly interact with the system, but also those groups/individuals that provide support to ensure the system's operational status. Each group/individual will be described below.

4.5.1 *Organizational Structure*

The Transit Manager serves as the head of StarTran. He reports to the Director of Public Works & Utilities, who reports to the Mayor. The StarTran Advisory Board provides advice on the StarTran system to the Mayor, the Director of Public Works & Utilities, and the City Council. In the modified organizational structure, additional IT/Telecommunications support is provided for the StarTran AVL system. The following figure graphically represents this and the IT/Telecommunications support is shown as an integral unit, but not one that directly reports to the Transit Manager.

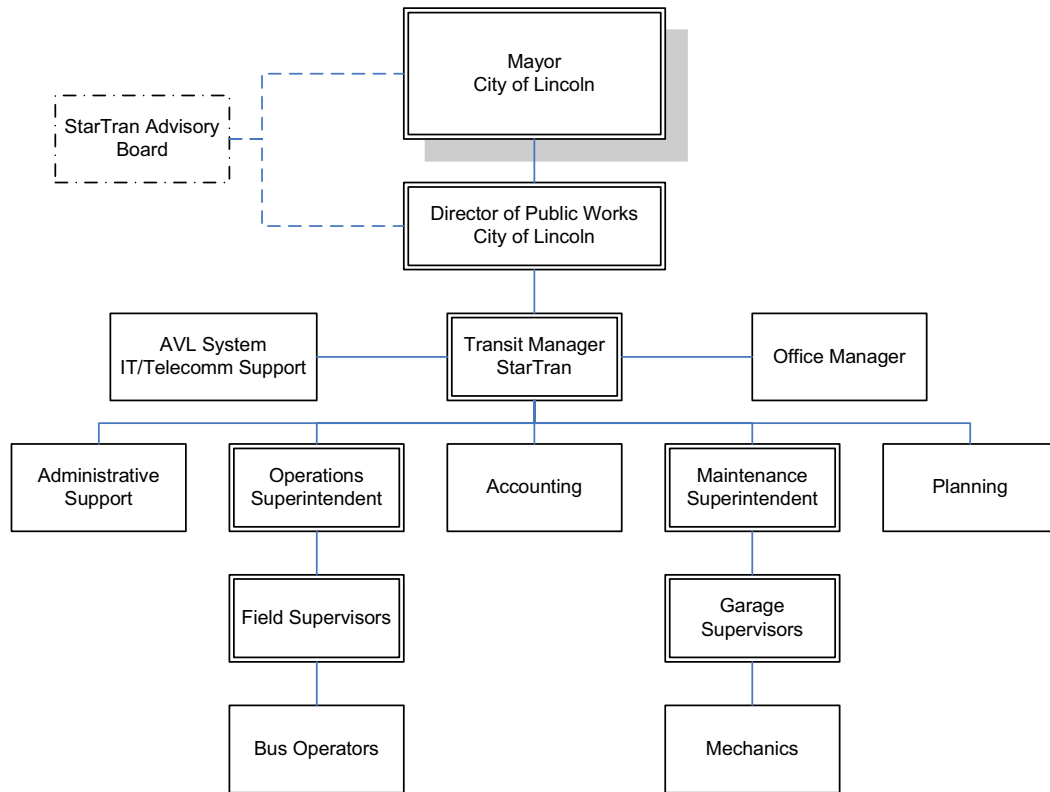


Figure 3 - StarTran Organizational Chart with AVL System

4.5.2 Profiles of User Classes

The following subsections describe each of the user classes for the proposed StarTran system. Each description also includes system responsibilities and interactions with the proposed system.

4.5.2.1 StarTran Management and Administrative

StarTran management and administrative staff are characterized as personnel who work primarily in the StarTran office. This includes program supervisors, office managers, customer service representatives, and accounts personnel. Their responsibilities include:

- Establishing budgets;
- Providing supervisory oversight;
- Responding to customer requests;
- Aggregating and reporting financial information; and
- Aggregating and reporting ridership information.

These responsibilities are executed with access to real-time data, and reporting functions involve assembling data largely provided by the AVL system. This user class directly interacts with the system, dispatchers/field supervisors, fleet maintenance, bus operators, and customers daily as well as IT, radio, telecommunication, and emergency management personnel as needed. This user also regularly interacts with the management of the various integrated systems,

ensuring data integrity and security as well as satisfaction with the results of the system integration.

4.5.2.2 Dispatchers/Field Supervisors

StarTran dispatchers are characterized as personnel who manage the StarTran bus operators. This includes the Operations Superintendent and Field Supervisors. Their responsibilities include:

- Ensuring fixed route service schedule adherence;
- Providing communication between bus operators and customer service representatives;
- Determining location of currently active buses;
- Scheduling demand-responsive or special transportation service requests; and
- Communicating assistance requests from the bus operator to the appropriate emergency personnel.

These responsibilities are executed with direct access to real-time data. Automated data is provided by the system, and additional data is available through either the MDT's or the two-way radio system. Emergency information is also provided by real-time images from the buses. This user class directly interacts with the system, customer service representatives, and bus operators daily, and interacts with IT, radio, telecommunications, and emergency personnel as needed.

4.5.2.3 Fleet/Bus Maintenance

StarTran fleet maintenance personnel are characterized as those individuals that directly maintain fleet equipment. This includes the Maintenance Superintendent, the Garage Supervisors, and the mechanic staff. Their responsibilities include:

- Preventative maintenance of StarTran buses;
- Emergency repair of StarTran buses;
- Scheduling preventative fleet maintenance; and
- Maintaining and managing fleet parts inventory.

These responsibilities are executed with access to real-time data, including vehicle component conditions. Preventive maintenance is scheduled with the assistance of real-time mileage/hours data from the system. Unplanned maintenance is performed based upon component condition alerts provided by the system. Field response to broken equipment is expedited by access to the bus's precise location data. This user class directly interacts with the system and bus operators daily, and interacts with IT, radio, telecommunications, and emergency personnel as needed.

4.5.2.4 Bus Operator

StarTran bus operators are characterized as those individuals that directly operate the buses and other vehicles that carry bus riders. This includes both StarTran bus operators, paratransit vehicle operators, and Transport Plus bus operators. Their responsibilities include:

- Safely operating their individual buses;
- Providing customer service to bus riders;
- Ensuring route and schedule adherence; and
- Providing bus/equipment repair notification.

These responsibilities are executed with direct access to real-time data. This data is provided by the system and its MDTs, as well as the two-way radio system. Information related to schedule delays is communicated automatically. Fare payments are partially automated. Emergency information may be communicated to dispatchers as alarms or via real-time images from the buses, coupled with real-time location data. This user class directly interacts with the system, dispatchers, and bus riders daily, and interacts with fleet maintenance and emergency personnel as necessary.

4.5.2.5 Bus Rider/Customer

StarTran bus riders are characterized as those individuals that utilize StarTran for public transportation within the City of Lincoln. This includes those individuals who use the fixed service, the demand-responsive service, and the special transportation services such as during UNL football games. Their responsibilities include:

- Safely using the StarTran service;
- Obtaining appropriate route and schedule information; and
- Providing the appropriate payment for service.

These responsibilities are executed with access to real-time data. Bus riders can obtain real-time route and schedule data, including estimated arrival times for active bus routes. Bus riders can plan their routes using interactive systems that provide starting location and time, ending location and time, and any required transfer information. Bus riders are provided with bus stop, arrival time, and other enroute travel information via an automated, ADA-compliant announcement system within each bus. This user class directly interacts with the bus operators daily, and interacts with emergency and customer service personnel as necessary.

4.5.2.6 Police/Fire/Emergency Management

Emergency personnel are characterized by those individuals who respond to emergency events within the City of Lincoln and Lancaster County. This includes the Lincoln Police Department, Lincoln Fire and Rescue, UNL Police Department, Lancaster County Sheriff, Lincoln-Lancaster County Emergency Management, NEMA, and NSP. Their responsibilities include:

- Ensuring public safety;
- Responding to health emergencies, including bus operators and riders;
- Responding to vehicle accidents, including those with StarTran buses; and
- Responding to crime scenes, including those on StarTran buses.

These responsibilities are executed with access to real-time data. Assistance requests are communicated to the StarTran dispatcher via automated systems, MDTs, or the two-way radio system; the StarTran dispatcher then contacts the appropriate emergency personnel via 911 or direct line. Upon contacting the appropriate emergency personnel, the StarTran dispatcher can provide the bus' exact location, direction of travel, and speed due to the AVL system. This user class directly interacts with the dispatchers, bus operators, and bus riders as necessary.

4.5.2.7 IT/Radio/Telecommunications

IT, radio, and telecommunications personnel are characterized as those individuals that install, maintain, and operate the various information systems used by StarTran. This includes computer personnel, network engineers, radio technicians, and telecommunications specialists. Their responsibilities include:

- Installing new computer networks, and radio and telecommunications systems;
- Maintaining and operating existing computer networks, and radio and telecommunications systems; and
- Supporting City of Lincoln and Lancaster County agencies in their use of computers and networks, radio systems, and telecommunications systems.

These responsibilities are executed with access to real-time data about the information systems, and generally real-time data about the activities the information systems support. System maintenance scheduling is based on planned preventive system maintenance, as well as reaction to unforeseen system failures. This user class directly interacts with the system and management/administrative personnel daily, and with dispatchers/field supervisors and fleet maintenance personnel as needed.

4.5.3 Interactions Among User Classes

Interaction among each of the user classes has been identified in the particular user class. However, the types of interactions among the user classes will be discussed here.

The routine system operation is generally automated, with interaction occurring between the system and the user classes identified above. The bus operators operate the buses and work to maintain route and schedule adherence. Much of the schedule data is automatically reported from the bus to the dispatcher by the system. Requests for health, safety, or equipment emergencies are provided by the bus operators to their dispatcher via MDTs or two-way radio, who then relays the request to emergency management or fleet maintenance personnel

respectively along with detailed location and direction data. Routine preventive maintenance is scheduled by fleet maintenance personnel with no interaction required by the bus operator; the system provides the information automatically.

Route or schedule variance is provided to bus riders whenever desired, and is provided in real-time. The information may be provided via Internet, text messaging, email, or other means. Long-term and temporary route or schedule adjustments are provided via the StarTran website.

IT, radio, and telecommunications personnel interact with each unit within StarTran. They receive requests for system upgrades and repairs, perform those activities, and provide feedback to the appropriate unit regarding system changes. They support the system's electronic infrastructure, providing the systems that allow the various user classes to communicate. The IT, radio, and telecommunications personnel also support the information systems that gather StarTran financial and statistical information, aggregate the systems for reporting, and generate the reports for the appropriate political oversight bodies. This information is also used to project necessary system improvements and upgrades.

Management and administrative interaction with dispatch and fleet maintenance supervisors is typically limited to oversight. They ensure the respective groups are managing budgets and performing acceptably, as well as providing feedback regarding future system needs. They also interact with the various City of Lincoln and Lancaster County groups, as well as managers of other integrated systems, sharing information about system performance, and planning future system management and improvement strategies.

4.5.4 Other Involved Personnel

4.5.4.1 Transport Plus

Transport Plus is a private transit company that supports StarTran. Through a contract with StarTran, they provide vehicles to supplement StarTran's HandiVan fleet for large special transportation service events or in the event an inordinate amount of StarTran's normal fleet is undergoing maintenance. In this capacity, Transport Plus may operate as bus operator and fleet maintenance among others. Therefore, they have an interest in any existing or proposed StarTran system.

4.5.4.2 StarTran Advisory Board

The StarTran Advisory Board makes initial review of and acts upon matters related to the operation of the system, including transit related studies and plans, route studies and evaluations, performance indicators, rates, fares and schedules. They meet monthly with the StarTran staff, and as needed during committee meetings.

4.5.4.3 City of Lincoln/Mayor/City Council

The region's political bodies provide the vast majority of the financial support for the StarTran system. The City of Lincoln provides approximately two-thirds of StarTran's annual operating budget. This budget is authorized by the City's

political bodies on behalf of the area's constituents. These bodies have a direct interest in ensuring StarTran operates as efficiently and effectively as possible.

4.5.4.4 Lincoln Metropolitan Planning Organization (MPO)

The Lincoln MPO is the region's overall planning organization. This agency studies the region's growth patterns, specifically how they relate to the transportation system. Based on this information, and coupled with system needs provided by the Department of Public Works & Utilities, the Lincoln MPO prepares a five-year TIP, as well as a 20-year LRTP. The projects listed in these documents are intended to reflect the community values and visions for improving the overall transportation system, including StarTran projects.

4.5.4.5 Omaha MAT

Omaha MAT is the transit provider in the City of Omaha, Nebraska metropolitan area. Because of the close proximity between Lincoln and Omaha, interest naturally exists in the adjacent region's public transportation system. Administrative components of the City of Omaha MAT could provide redundancy for StarTran (or vice-versa) in the event of a homeland security or other large-scale emergency. Because of these situations, the City of Omaha MAT has an interest in StarTran's existing system and any potential modifications.

4.5.5 Nebraska Emergency Management Agency (NEMA)

NEMA is the statewide agency responsible for coordinating response actions to natural and homeland security emergencies. This agency directs the application of statewide resources to respond to emergencies within the state of Nebraska. Any incident management systems or activities will involve NEMA.

4.5.6 Nebraska Department of Roads (NDOR)

NDOR has responsibility for all state highways and roads. As such, NDOR has deployed several systems which could be leveraged with the StarTran AVL system, including road weather information systems (RWIS), commercial vehicle operations (CVO) systems, and freeway management systems (FMS). These systems can provide information that may support the StarTran system operation, and may, in turn, benefit from data provided by the StarTran AVL system.

4.6 Support Environment

The proposed system is primarily an automated system, utilizing AVL, MDTs, two-way radio, and POTS infrastructure to share information between various user classes. Although routine communication is automated, human communication exists; it is expedited by the various automated systems.

As mentioned previously, the IT, radio, and telecommunications user class supports the proposed StarTran AVL system as well as the associated communication and reporting systems according to accepted industry practices. This includes regularly scheduled maintenance along with accepted capital replacement cycles. The support activities for the information and

communication systems are performed within the existing StarTran, City of Lincoln, and Lancaster County facilities utilizing existing equipment.

The bus fleet is supported by the fleet maintenance user class. This includes regularly scheduled maintenance according to manufacturer recommendations, as well as daily vehicle washing. Capital replacement is performed on an as-needed basis, utilizing increasing support expenditures as an indicator for scheduling replacement vehicles. The support activities for fleet maintenance are performed within the existing StarTran facilities utilizing existing repair equipment.

Transit services are provided Monday through Friday from 5:15 a.m. – 7:10 p.m. (with special transportation services until 10:00 p.m.) and Saturday from 5:55 a.m. – 7:10 p.m. except holidays. StarTran's normal office hours are Monday through Friday from 8:00 a.m. – 4:30 p.m. However, an automated phone service satisfies customer information requests outside of the normal business hours. Automated trip scheduling capabilities are available 24 hours-a-day through the StarTran AVL trip-planning interface.

5 OPERATIONAL SCENARIOS

The following scenarios describe situations in which the StarTran AVL system could improve operations and safety. Each scenario is a step-by-step description of how the proposed system should operate and interact with its users and its external interfaces under a given set of circumstances. The scenarios will tie together the system, the users, and other entities by describing how they interact.

5.1 *Scenario 1: Bus Operator Automated Systems*

Marcel, a StarTran bus operator, usually begins his work shift with administrative activities. After receiving supervisory direction, he boards the bus and prepares the AVL system. He begins by logging into the system.

The system then prompts Marcel for the route to be followed. He enters the planned route number, and the AVL system retrieves the appropriate route and schedule information from the AVL system server. The bus' AVL system then asks Marcel to verify the appropriate route and schedule information were properly retrieved.

Once he provides verification, the bus' head sign is automatically updated to reflect the appropriate route information. The fare payment schedule is automatically adjusted to reflect the verified route, modified as necessary by the system clock to reflect any applicable time-differential rates.

The system then loads the appropriate bus stop announcements for the chosen route. These prerecorded announcements are consistent regardless whether Marcel or another bus operator is driving the route, and have been verified as ADA compliant. These announcements are then broadcast at the appropriate bus stop throughout the route.

5.2 *Scenario 2: Security/Emergency Response*

While performing her duties, a bus operator, Susan, notices an individual enter the bus. This individual was profiled on the previous evening's news as a person wanted for questioning related to a recent violent crime. Susan knows she must convey this information to the proper authorities, and do so in a manner that does not expose the other customers or her to potential violence.

Susan continues with her route as if nothing has happened. After leaving this bus stop, she uses the MDT to notify StarTran dispatch of the situation. James, the StarTran dispatcher, confirms receipt of her message, and advises her that the Lincoln Police Department has been notified.

James, who is still on the line with the Lincoln Police Department, accesses the bus' AVL system data. He relays to the Lincoln Police Department the bus' current location, its direction of travel, and the speed at which it is traveling. He then engages and accesses the real-time camera located within the bus. Using the information provided by the bus operator, James identifies the suspect and relays his seat location to the Lincoln Police Department as well.

The Lincoln Police Department notifies the nearest on-duty police officer, who follows the bus to the next stop. James advises Susan to stay parked at the next

bus stop. At the next bus stop, the responding police officer enters the bus and apprehends the individual without incident.

While this process is documented for a security incident, the same interactions could occur for a health emergency.

5.3 Scenario 3: Trip Planning and Real Time Status Information

Mary Lewis is a retired schoolteacher. She regularly volunteers at the Lincoln City Libraries, and usually drives her car. However, her car is in need of body repair work, and will be in the shop for approximately a week. Mary's coworker suggests she use StarTran service while her vehicle is being repaired.

Mary accesses the StarTran website from the library's computer. She selects the trip planning function from the website, and enters her starting location (at home) and her ending location (the library), along with the time she needs to be at the library. The StarTran trip planning function provides the bus stop nearest her starting location and the time she must be there to catch the bus. It tells her she must make one transfer, and provides the transfer location and estimated wait time at the transfer station. The trip planner also provides the bus stop nearest her ending location and an estimated arrival time. Mary prints out the trip plan and takes it home with her.

The day arrives when Mary plans to take the bus to volunteer at the library. Unfortunately, inclement weather has entered the region and Mary does not wish to wait for the bus in the snow. Using the information she has saved on the printed page, Mary calls the StarTran route status line. After entering her bus stop and initial route information, the system advises Mary the bus is running 3-5 minutes behind schedule due to inclement weather. Mary uses the extra time to make sure she has her overshoes for the trip to the bus stop.

5.4 Scenario 4: Dispatcher Management of Routes and Schedules

StarTran has recently hired a new bus driver, Gregory. After passing the necessary examinations and completing his introductory training, Gregory has been assigned the #7 Belmont route.

Although he studied the route, Gregory has the normal apprehension associated with starting a new job and being concerned with performance. His dispatcher, Julie, advises him that she will use the AVL system to help ensure he is performing well.

Gregory starts his route at midday, and approximately 20 minutes in, experiences confusion over the planned route. He accesses the bus' AVL system, and using the inlaid route map loaded based on his login, he realizes he made a wrong turn. He quickly corrects his routing and continues with the remainder of the planned route.

Meanwhile, the AVL system has informed Julie that Gregory is off-route. By the time she accesses the system, he has returned to the proper route but is now behind schedule. The AVL system advises Julie he is behind schedule, and appears to be making up a little of the time. Julie contacts Gregory via the MDT and inquires about what happened. Gregory advises her he made a wrong turn,

but corrected it and made sure he did not miss a stop. He is now trying to make up time at each stop so as not to impact the remainder of the afternoon's schedule. Julie reminds him the schedule has some cushion built in at the 2:40 p.m. Autumn Wood stop, and if he's diligent between now and then, he'll be back on schedule at that point.

5.5 Scenario 5: Automated Fleet Management

Manny, a StarTran Garage Supervisor, is responsible for scheduling maintenance for a percentage of the StarTran fleet. As part of his goals, he plans for as much preventative maintenance as possible, limiting the amount and expense of unanticipated equipment failures. He also knows that unanticipated equipment failures impact operations by requiring equipment rotation and perhaps contracting of additional equipment from Transport Plus.

Manny recognizes that a key to meeting his goal is regularly scheduled preventive maintenance. Realizing that scheduling every oil change to be performed in one day is not a practical method of accomplishing this goal. Using the daily mileage/hours reports automatically provided by the AVL system, Manny is able to plan needed preventive maintenance over the upcoming workweek.

Manny also utilizes the AVL system's real time equipment status alerts to receive notification of equipment functions that are reaching critical thresholds. During his shift, the AVL system sends Manny a pager notification regarding the #19 Salt Valley line bus. The bus' transmission temperature is reaching cautionary levels, indicative of possible impending failure. Manny contacts Louise, the responsible dispatcher, who has also received the same notification from the AVL system.

Manny and Louise determine the risk is low, as the bus is on the day's final run. However, Manny makes arrangements to pull this bus out of service at the day's end, and Louise makes plans to utilize alternate equipment while fleet maintenance personnel evaluate the bus and make any necessary repairs. The AVL system's notification has help avoid a potential transmission failure.

Regardless of the level of planning, unforeseen equipment failures will still occur. Such was the case when Manny received an AVL system pager notification about the #2 Bethany line bus' brake system failure. He quickly determines the failure will not permit a field repair. Almost simultaneously, Manny receives a call from Louise who has received the same notification. Louise advises Manny she has already made arrangements for a replacement bus to pick up the existing passengers and complete the route. While talking, Manny has accessed the bus' AVL system and has determined the bus' exact location and orientation on the roadway. He makes arrangements to have the bus retrieved and returned to the garage for repair. Because of the close coordination and the availability of real time information, the recovery team arrives just as the replacement bus has loaded the passengers. This minimizes the time the bus is disabled in traffic, thus reducing the secondary traffic flow impacts.

6 SUMMARY OF IMPACTS

This section describes the proposed system's operational impacts on the users, the developers, and the support and maintenance organizations. It also describes the temporary impacts on users, buyers, developers, and the support and maintenance organizations when the new system is being developed, installed, or trained on.

6.1 *Operational Impacts*

The operational impacts of the StarTran AVL system are numerous, and virtually all beneficial to StarTran and its customers. Throughout Section 4, Concepts for the Proposed System, and Section 5, Operational Scenarios, several impacts have been identified. This section will summarize the most important operational impacts by category. These operational impacts, taken as a whole, reduce operational risks while helping to extend existing budgets as well as increase customer safety, security, and satisfaction.

Real time AVL information will change StarTran's operational strategies. StarTran dispatchers will have easy, real-time access to location, travel direction, and travel speed data for the entire fleet. At a glance, the dispatchers will be able to identify at-risk buses/routes, and focus supervisory attention on them. By removing no/low risk bus operators and routes from the supervisory decision-making process, problem assessment and resolution will be quicker and more successful. This improves the system's overall efficiency.

Real-time and trip planning information will greatly benefit customers, increasing customer satisfaction and ultimately resulting in increased ridership. A fully mature AVL system can provide the customer with real-time status about bus location and schedule, minimizing customer frustration. Such a system can also provide the ability to plan a trip, providing the customer with time, transfer, and fare information. The system can also integrate automated trip scheduling abilities. Further, by providing this capability, existing administrative staff will not be required to respond to as many customer inquiries about bus schedule status, but instead will be able to focus on other strategic goals.

Security services provided by the StarTran AVL system will change how bus operators and dispatchers address emergency situations. Real-time location, direction, and speed information can dramatically reduce response times from fleet maintenance or emergency service providers. The ability to communicate via an MDT, coupled with possible real-time video/image capability, can improve the safety of both the bus operators and the bus riders. Further, should an individual perpetrate criminal activity on a bus, the likelihood of apprehending the suspect increases greatly due to the availability of real-time AVL system data.

Equipment management capabilities of the StarTran AVL system offer the opportunity to reduce equipment repair costs and decrease equipment downtime. By more accurately scheduling preventive maintenance and accessing real-time equipment condition data, StarTran fleet maintenance can better utilize existing staff and facilities, as well as respond to field repair situations.

Integration with other AVL systems, notably the Omaha MAT system, is another option available with the AVL system. If implemented, this integration will allow the concurrent use of IT and telecommunications facilities, and redundancy within the vehicle monitoring capabilities. This offers the ability to leverage additional capabilities at a minimal cost, and can help to provide service continuation in the event of a regional emergency.

Information management is one area where the workload may increase, although operational benefits may offset the increased workload. By adding a technology-based system to StarTran's operations, IT support requirements may increase over current levels. However, much of the archived information regarding bus routes, route scheduling, on-time performance, ridership, and other performance measures may be able to be consolidated into the AVL system from other disparate systems. Not only does this simplify support, it also reduces the administrative overhead otherwise required to aggregate the existing data.

6.2 *Organizational Impacts*

The organizational impacts of the StarTran AVL system are relatively benign initially, but may offer significant change opportunities over time. These changes revolve mainly around the reallocation of duties as a result of the fully mature AVL system's capabilities. An organization chart view of the changes can be seen in Figure 2 in Section 4.5.1.

No jobs are expected to be eliminated and responsibilities will likely remain the same for the short term. As the AVL system is integrated into daily StarTran operations, some administrative positions may be capable of having duties reallocated to better support the organization's mission. This could include other administrative duties or may even include dispatch-type responsibilities depending on the growth in ridership.

Dispatchers, with the ability to focus on at-risk routes and bus operators, may be able to manage additional routes. This would allow the StarTran network to grow without the need for additional dispatch personnel.

Were the AVL system's automated fleet maintenance capabilities to be fully exploited, the opportunity exists to reduce overtime, and respond to moderate ridership growth without additional equipment or personnel. Significant increase in ridership will obviously require both.

Naturally, as a technology-based system, IT support requirements may increase. Conceivably, this increase could result in the need for additional employees, although the need for additional IT support would be more than offset by gains within the other job classifications.

As with any new system, particularly a technology-based one, training will be critical. Each existing employee will require training in the AVL system, including its capabilities, limitations, and operating instructions. Further, training for new bus drivers must include AVL system operation, including standard procedures for emergency situations.

6.3 Impacts During Development

System developmental impacts on existing employees in most cases will be minimal. The exception to this is the project manager, his key technical advisors, and management-level decision makers. For them, the impact includes a time and knowledge commitment to guide the design and development process.

During the design process, multiple meetings will be conducted. It will be at these meetings that critical system capability decisions will be made. Therefore, the project manager, along with key technical and management personnel, will be required to attend these meetings. They will also be required to review project-related documents such as this ConOps, the System Architecture Analysis, the System Requirements Memorandum, the Estimate of Probable Cost, the Technical Specifications Document, the Bid Package and Vendor Responses, Test Plans and Scripts, and Test Results.

In addition to these demands on key personnel, a sample user group may be created to evaluate the system requirements, as well as participate in system reviews and demonstrations. It can also be expected that this user group may evaluate the system's initial capabilities and offer suggestions for future versions.

Because this system will be developed offline, there will be no impact to existing system users until the testing period. At that time, users may be called upon to utilize the system with the express purpose of trying to find flaws in the system. It is only this way that any proposed system design can be tested.

As this system represents a significant change from current operations, normal procedure would be to run the new system concurrently with the existing system/protocols to verify system capabilities. If necessary, this will be identified during the design process.

7 ANALYSIS OF THE PROPOSED SYSTEM

This section provides an analysis of the benefits, limitations, advantages, disadvantages, and alternatives and trade-offs considered for the proposed system. In the context of a ConOps document, alternatives are operational alternatives and not design alternatives, except to the extent that design alternatives may be limited by the operational capabilities desired in the new system. Design alternatives are explored in the System Architectural Analysis during the design phases of the project.

7.1 *Summary of Improvements*

StarTran's AVL system, when fully implemented, offers the following benefits:

Real-Time System Management - With the availability of real-time location, direction, and speed information, dispatchers can more accurately assess bus operator performance and more efficiently operate the transit system.

Real-Time Schedule Information - By providing real-time schedule information directly to customers, customer service representatives' time demands can be reduced while customer satisfaction is increased. The ability to automate the schedule and route information can eliminate the off-hours answering service while maintaining or increasing customer satisfaction.

Automated Reservations - By providing demand-responsive customers with the capability to request trip automatically, customers can make reservations outside of normal business hours, thus increasing customer satisfaction.

Safety and Security - By providing dispatchers with real-time location data and real-time video/image transmission, dispatchers can better ascertain potential emergency situation on the buses. Further, by providing the bus drivers the ability to communicate via the MDT, valuable information can be relayed between the bus operator and the dispatcher without unnecessarily alarming bus riders. This can help increase the safety and security of everybody on the bus.

Fleet Maintenance - By providing fleet maintenance personnel with real-time equipment condition data, as well as accurate odometer readings, both emergency equipment repair and preventive maintenance can be more easily scheduled. This can result in reduced downtime and increased equipment life.

Reporting - By providing a system with accurate, archived data from real-time data generators, information such as ridership and revenue miles driven should require less effort to assemble. This should allow administrative staff to direct their efforts to more strategic functions, while providing political bodies such as the Mayor of Lincoln, the Lincoln City Council, and the FTA with the information they require.

Emergency Operations - By integrating with surrounding AVL systems, system redundancy can be developed cost effectively. This provides the ability to operate during what otherwise may be a catastrophic system failure. It can also leverage existing investments in systems and infrastructure to extend system capabilities.

7.2 *Disadvantages and Limitations*

No system or technology is perfect for every circumstance. Depending on the technologies utilized, system data may not be available from vehicles that are under structures or outside of communication system range. Some capabilities can also be short-circuited by bus operators not desiring their location data to be available. Therefore, it becomes critical that StarTran managers and supervisors explain the benefits of the system, and that dispatchers develop trust in their employee oversight policies.

A primary limitation of the AVL system, or any technology-based system, is the management and operations policies implemented along with the system. Technology-based systems are simply applications of technology to solve problems or improve operational characteristics. It takes humans to effectively implement technology, and oftentimes management and operations policies are not modified to take advantage of a technology-based system's capabilities.

An additional limitation is the cost of the fully mature system. Generally, it is cost prohibitive to build every desirable function into an initial system deployment. This means that some system functionality, including those mentioned in this document, may not be implemented in the initial deployment. This may cause frustration from those system users who must wait for their desired functionality.

Another potential disadvantage revolves around customer expectation. As with many ITS systems, once implemented, the customer becomes accustomed to a higher level of service. In the case of StarTran's AVL system, it is likely the customer will come to expect and rely on real-time schedule information. If for some reason the system fails (and does not have any redundancy), customers will invariably let their frustration be known to both StarTran and the region's decision makers. If handled appropriately, these situations generally offer opportunities to educate both the public and the decision makers about the capabilities and limitations of the existing system, including potential system improvements that can minimize future disruptions.

7.3 *Alternatives and Trade-offs Considered*

The primary alternatives considered for the StarTran AVL were the build and no-build options. The no-build option, while not detrimental to existing operations, fails to address the needs identified by StarTran management. These include the need to increase availability of transit information and dissemination, to improve overall dispatching and operating efficiency, and increase bus operator and bus rider safety and security. Therefore, the no-build option was discarded as it does not address the fundamental needs for StarTran operations.

When evaluating potential system implementations, consideration was given to a phased deployment of the system's functionality and a system with fully implemented functionality. A system with full functionality may prove to be cost prohibitive, and the full evaluation will become part of the design process. In addition, the more functionality designed into the initial deployment, the more complex that initial deployment becomes and the longer the project development

cycle. For technology-based systems, it is often easier to manage a phased implementation of features, allowing the fully mature system to be broken down into smaller, more easily managed projects.

Another consideration for an initial deployment being a fully mature system is the management and operational considerations previously mentioned. Often, the most difficult component of implementing a technology-based system is the process changes the human operators must adopt. In the case of a fully mature technology system deployment, the sheer number of system capabilities may make it difficult for personnel to understand the system. This can result in functionality that is not used at all, or not used to full advantage.

A more traditional proprietary system was also considered as an option. Some advantages of such a system are a slightly lower initial cost and components that have already been deployed and tested. The disadvantages, however, outweigh these potential advantages. For a traditional proprietary system, the life cycle costs are generally higher than a system based upon open standards. This results from an open standards system drawing on solutions from more potential vendors, as well as the ability to integrate different vendor solutions into one system. While more traditional systems may have had previous deployment and testing, a more open system will typically utilize commercially available solutions components that also have this advantage, and integrate these solutions into the open standards system.

Initial integration with other regional AVL systems was also considered, specifically the Omaha MAT. This offers the potential to leverage existing infrastructure to create redundancy for both the Omaha MAT and StarTran systems. The viability of this option will be further evaluated during the system design process. If still advantageous, agreements between the City of Omaha MAT and StarTran/City of Lincoln will be required.

APPENDIX A - DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

The following table provides the definitions of all terms, acronyms, and abbreviations required to properly interpret this Concept of Operations.

Term	Definition
ADA	Americans with Disabilities Act
AVL	Automated Vehicle Location
CAD	Computer-Aided Dispatch
CFR	Code of Federal Regulations
ConOps	Concept of Operations
CVO	Commercial Vehicle Operations
FHWA	Federal Highway Administration
FMS	Freeway Management System
FTA	Federal Transit Administration
FY	Fiscal Year
GIF	Graphic Interchange Format
GPS	Global Positioning System
IT	Information Technology
ITS	Intelligent Transportation System
LRTP	Long Range Transportation Plan
MAT	Metro Area Transit – Transit provider in Omaha, Nebraska
MDT	Mobile Data Terminal
MPO	Metropolitan Planning Organization
NDOR	Nebraska Department of Roads
NEMA	Nebraska Emergency Management Agency
NSP	Nebraska State Patrol
PDF	Portable Document Format
POTS	Plain Old Telephone System
RWIS	Road Weather Information Systems
StarTran	The public transit provider in Lincoln, Nebraska
TIP	Transportation Improvement Plan
UNL	University of Nebraska – Lincoln