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Transit ITS Implementation Guidance

Part 3: Technical Studies Associated with ITS Management

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Technical Studies Associated with ITS Management

1. Introduction

The World Bank has participated in the financing of several ITS systems in China. Given the complexity of these projects and their potential for dramatic transformation of transit operating agencies, it is worthwhile to provide some guidance to staff from transit systems contemplating ITS projects. The World Bank commissioned a series of three papers to assist in this effort. This first paper is a description of the key ITS applications for transit operations and where they are most beneficial. The second paper reviews a number of previous installations and reports on lessons learned, both positive and negative, in the hope of maximizing the effectiveness of technology in improving transit services. This third paper is a set of outline Terms of Reference (TOR's) for professional services associated with ITS project management to assist in project implementation.

The first of the TOR's is for an internal management study to review the technical capacity of the information technology function and to review the fundamental business processes of the agency. The second and third are for a contractor to assist the agency in making a number of strategic and tactical decisions based on data developed from automatic vehicle location (AVL) systems and advanced fare collection systems.

2. Internal Management Planning Study for Intelligent Transportation Systems

2.1 Introduction and Background

The introduction of new technology in transit agencies tends to focus primarily on project implementation with limited planning for post implementation operation. This is particularly true for transit systems making a transition from an operations driven environment to one which takes full advantage of information technology in their strategy and execution. Information technology projects frequently do not live up to their promise for a number of reasons. While some are technical, most are allied with organizational issues within transit systems. This brief paper describes a scope of work for an internal technology management study to accompany any large scale transit technology project – particularly those which cross traditional internal functional areas such as automatic vehicle location. This discussion is directed primarily toward transit systems with a limited information technology and wish to enhance their capability prior to implementing a large scale ITS project.

It will be necessary for a transit system with limited existing technology applications to develop an information technology function. In larger transit systems, this is best done through a department with a senior manager directly reporting to the chief executive officer. In smaller systems, this might consist of a single person. The activities in this functional area may be performed through a combination of internal staff and outside contractors.

The responsibilities of this information technology function include:

- In cooperation with executive management, establish priorities and resource allocation for IT projects.
- In cooperation with executive management, establish governance policies and clearly define the role of the IT function and its relationship with operating and staff function and transit service contractors.
- Establish enterprise standards and regulations including operating systems, desktop tool standardization, procedures on personal use of computers, password changes, offs-site access etc.
- Maintain technology infrastructure including:
    - System hardware
        - Replacement and renewal
        - System upgrades
        - Routine maintenance
        - Power supply management
        - Asset identification and management
    - System software (operating system and common enterprise software)
        - Install upgrades
        - Maintain licenses
        - Maintain passwords
    - Communications system
        - Troubleshooting
        - Maintenance contracts
        - Operation during non-business hours
    - Application software
        - Upgrade installation
        - Warranty management
        - User support from vendor
- Information technology operations
    - Backup and off-site storage and retrieval
    - Security
    - User support, help desk – work order system
- Staff training and development
    - New staff orientation
    - Software upgrade orientation
    - Staff development
    - Assure redundancy in staff capability
- Project development and management
    - Project feasibility studies
    - Project planning
    - Project specification and procurement
    - Project management

    - Project implementation
    - Acceptance testing
    - Post installation operation
- IT Technical support
    - Database queries
    - Vendor liaison
    - Queries using data from different functional areas

This list is not all-inclusive but represents the types of activities necessary to assure proper use of new technology in transit operating environments.

In addition to an information technology function, operating units will have some responsibility for technology management. Among these are:

- Establish quality standards for data entry
- Data error checking
- System operation
- Liaison with information technology function
- Data archiving
- Work process reengineering
- Data file creation for new projects
- Develop acceptance testing criteria for new systems and upgrades with IT staff
- Establish internal (within department) priorities for application development and upgrades
- Define reporting requirements
- Identify staff development opportunities
- Manage application specific work flows[1]
- Participation in developing application software functional requirements, vendor selection, etc.

In order to improve the success probability for ITS projects, a pre-implementation management study is suggested. This work is intended to complement the technical activities associated with the project. The objectives are:

- Develop a proper climate for implementation of new systems
- Clearly define the roles of staff in project implementation and operation
- Improve the efficiency of business processes post implementation
- Assure that the new system is used to its full potential

[1] For example, when new timetables are developed, they must be communicated internally and externally through a variety of means (paper schedules, on-street information, call center, website, dispatching, driver assignment, etc.) This process crosses several functional areas each of which may have tasks lying on the critical path to implementation. Cross function co-ordination of tasks such as this is critical.

This study may be done by the system prime contractor (or subcontractor) or through an independent contractor. For smaller transit systems, a review of "best practices" might suffice for the development of procedures manuals. In any event, a management review should clearly define responsibilities for tasks during and after project implementation, **many of which will not be realized by the transit staff prior to implementation.**

2.2 Outline Terms of Reference

(These outline specifications can be supplemented with text from the previous sections of this document)

The *(agency name)* within the next year plans to issue a request for proposals for the installation of an automatic vehicle location system for its buses. While the primary objectives of this system is to improve the quality and performance of the transit system primarily in the area of customer information, we want to assure that *(agency name) is* sufficiently prepared for the changes required to manage its operation in a more technology-driven environment.

The *(agency name)* is committed to a reassessment of its management practices with the introduction of this new technology. This will require the assistance of a contractor who has both information technology experience as well as subject matter expertise in transit operations. It is envisioned that this contractor will

Project Objectives

- To guide the (agency name) in making a number of decisions to improve the organization environment for the introduction of planned intelligent transportation systems, and
- To develop procedures to assure efficient, reliable and secure technology infrastructure for the transit system.

The contractor will perform an internal review of the current organization environment and make recommendations for enhancing management functions to take full advantage of new technology systems. This will include identification of transit system staff requirements both during and after project implementation as well as the development of appropriate information technology business procedures.

Project Task

Task 1 - Review existing management systems and capabilities

- Interview existing staff
- Broad review of internal management practices
- Identify information flows in critical cross-function areas including:
    - Schedule (timetable) development, customer information systems, dispatching operations
    - Dispatch operations, operator timekeeping, payroll, financial management

Task 2 - Identify transit system information technology function requirements

- Identify the activities necessary to support the project both during and after implementation.
- Make recommendations on how to develop an information technology capability within the organization.
- Provide recommendations concerning the role of central information technology functions and those of operating and staff functions.
- Recommend how functions will be undertaken including using internal staff or outsourcing to specialty contractors

Task 3 - Develop operating procedures for information technology

- Develop internal operating procedures (manuals) for transit system information technology strategy and operations

Task 4 - Estimate resource requirements for continued operation of technology system

- Develop cost and personnel estimates for project implementation and continued operations.
    - Internal staffing costs
    - External vendor costs
- Make recommendations on staff development and recruitment if necessary
- Identify risks to implementation schedule due to expectations of staff availability for data development, acceptance testing, training, etc.

Project Deliverables

The contractor shall develop the following work products during the course of this assignment:

- An assessment of existing staff capabilities and management processes focusing primarily on organization skill deficiencies and required changes to certain staff functions to facilitate transition to a more technology driven enterprise. (Task 1)
- An information technology plan describing role and function of information technology in the transit agency. (Task 2)
- Information Technology Operations Procedures Manual (Task 3)
- A guidance paper on organizational resource requirements to implement and successfully maintain these ITS systems. (Task 4)

3. AVL Data Management Study

3.1 Introduction and Background

AVL systems have the capability of providing substantial management information to transit operators. Unfortunately, there is a sizable gap between the capability and actuality. A study to assist transit operators in using AVL data to improve tactical and strategic management decisions would greatly enhance the value of the installed AVL system. A proposed project to develop tools to sue this data as well as improve the capacity of transit operators is described below.

3.2 Outline Terms of Reference

The *(agency name)* is about to issue a request for proposals for the installation of an automatic vehicle location system for its buses. While the primary objectives of this system is to improve the quality and performance of the transit system primarily in the area of customer information, we have found that frequently these systems do not provide the types of information necessary to make a number of strategic and tactical decisions. This is not so much a criticism of the technology vendors but rather a recognition that AVL technology can be transformational within an agency and operators are not suitably prepared for the challenges of transitioning from a data-poor environment to a data-rich environment.

The *(agency name)* is committed to a reassessment of its operations and planning practices with the introduction of this new technology. This will require the assistance of a contractor who has both information technology experience as well as subject matter expertise in transit operations. It is envisioned that this contractor will not only determine the information requirements to perform certain analyses but will actually support the staff of *(agency name)* in making changes to the transit system (such as running times, layover times etc.) on the basis of data rather than accumulated experiences and random observations. It is expected that this project will leverage considerable additional benefits from the AVL system. It is expected that the system being sought in this solicitation will post-process archived data rather than provide real-time information.

AVL System Project Description

To be supplied from DPR. This should include size of fleet, number of operating depots, fundamental design of the AVL system. It should also state if the AVL vendor is required to provide arrival time data at the stop level or only at the timepoint level. An expected schedule of events for installation of the AVL system should be provided.

Description of Data Uses

There are a number of areas where improved information can enhance transit quality and productivity. A few are cited here. Offerors are encouraged to enhance this list in their proposal.

On Time Performance

The most basic use of archived AVL data is the assessment of on-time performance. This is rather straightforward. Data for each timepoint should be assembled and a rating associated with each level of deviation from on time appended to each record. For example, departures between one minute early and five minutes late might be considered "on time", with other levels for late, early and very late. Certain deviations from on-time might be outliers which should also be identified.

Schedule (Running) Time

The primary analytical use of AVL among these is in the development of proper schedule times for transit services. Due to traffic congestion and vehicle boarding delays, there is inherent variability in the actual time that a bus travels between successive timepoints. However, customers rightfully expect a timetable denoting expected arrival times at timepoints. This conflict between an essentially probabilistic system (vehicle arrival times at stops) and a static system (published timetable data) is difficult to portray to the customer. There is a small body of literature on the task of producing schedule times which maximize the probability that a bus will arrive within an acceptable time window. This acceptable time window is usually between 1 minute early and 5 minutes late. In order to perform this assessment, a knowledge of the frequency distribution (number of occurrences) of the actual running times is necessary. Visualization on a graph is probably the best way of portraying this information.

By introducing some limited statistical analyses, a "best" time for each pair of timepoints can be developed for various time periods throughout the day. One attribute of a "best" time is one where there is little probability that buses will arrive at a stop early and be required to remain at the stop until the scheduled departure time. A best time is also not so short that a high proportion of buses depart late from the stop. By developing tools to review running time records, this best time can be determined easily.[2]

Sources of Delay

Having extensive data on the location of vehicles throughout the day enables transit managers to determine the sources of delay. These could be long waiting times at stops, intersection delays or street congestion. Combined with bus volume data on street segments, such data enable to estimation of increased transit operating costs caused by such bottlenecks. Also of importance is the excess customer travel time due to congestion.

End of Trip Layover Analysis

Allied with the task of developing appropriate times between successive timepoints is the task of allowing an appropriate amount of time at the end of a trip for schedule recovery and a driver break. Too much recovery time results in inefficient operation while too little time may result in drivers not being able to depart for their next trip in a timely

[2] This is not to say that under all conditions, a **satisfactory** running time can be established. More precisely, it means that given the operating environment, one set of running times is better than all others. This set however may result in unacceptable on-time performance if there is extreme variability in actual times. Other measures such as exclusive lanes and traffic engineering improvements may be required to produce acceptable on-time performance.

fashion. With a given distribution of actual terminal to terminal running times, a transit analyst can develop layover times which allow for schedule recovery and a reasonable break for drivers. One method might be to allow sufficient recovery time so that on average drivers have about 10% recovery and sufficient time that the probability that the driver can meet the scheduled departure time of the subsequent trip is a high number such as 0.95. With good data, the trade-off between reliability and efficiency can be made explicitly.

Identification of Bottlenecks

Buses operating on short headways have a tendency to "bunch" together. This is because a slight delay of a bus, for whatever reason, increases the time interval from the previous bus in the schedule. A longer interval results in more customer boardings each of which increases running time. The bus which follows starts to catch up with the previous bus since the time interval is shorter and there are fewer boardings than if the buses had evenly spaced arrivals.

By observing the time and location of all buses in a schedule, the sources of such bottlenecks can be identified and remedies introduced. This might include a holding strategy mid-route in which intervals between buses are controlled by delaying buses at that stop.

Reliability Analysis

A desirable attribute of transit service is consistency in arrival of the same trip across several days. Some method of measuring this consistency would improve the quality of transit service by reducing customer waiting time.

Project Objectives

The fundamental objectives of this project are to develop appropriate tools to analyze transit operations and with the assistance of a skilled transit analyst use the data from the AVL system to make appropriate changes to the transit system. It is envisioned that a contractor, independent of the AVL system vendor, be engaged to develop the tools and demonstrate their use in transit operations management. A successful project would include

- Development of appropriate tools to assist in making the decisions described in the previous section. These tools would include a graphic description of the operating environment.
- Adapting these tools to common desktop software programs such as Microsoft Access and Microsoft Excel for use by transit analysts.
- A reassessment of existing data capture and analysis methods to identify redundancies in data entry or processing
- Providing sufficient technical assistance to train users not only in the functional operation of the software but also how it might be applied to specific transit operations analyses.

Project Tasks

While offerors may organize their work in a method that suits them, in their proposal they should address their approach to the following tasks.

***Task 1* - Understanding of the business environment**

Through on-site interviews and discussions with key staff, the contractor shall review the business processes associated with data management. Particular attention shall be paid to the use of paper forms used by field supervisors who have responsibility for operations supervision.

Task 2 - Understanding of the AVL system vendor's environment and product offering

The contractor will become familiar with the technology vendor's product offering. At a minimum, the technology vendor is required to provide an ODBC connection to the AVL system database. The minimum set of fields to be supplied are as follows:

For each bus entering or leaving a timing point:

- Date
- Timing point number
- Scheduled arrival time
- Actual arrival time
- Scheduled departure time
- Actual departure time
- Block (or run or assignment number)[3]
- Trip number

For each bus passing a bus stop

- Date
- Bus stop number
- Arrival time
- Departure time
- Block (or run or assignment number)
- Trip number

The contractor should also be familiar with the schedule database supplied by the AVL vendor as well as the tables describing the stops on each route.

[3] This is a unique assignment number for the vehicle or bus operator

Task 3 - Development of functional specifications for software

In consultation with the staff of (agency name) the contractor will provide a draft functional specification for the proposed software which addresses the description of data uses section of this solicitation. This will include a description of data queries, user interfaces and any statistical procedures to be used in the software. A description of how readily accessible desktop software such as Excel and Access can be used to perform user-developed analysis shall be provided.

Task 4 - Development and testing of software

The contractor will develop the software using industry-standard procedure. The contractor will furnish a proposed testing plan prior to software installation. The testing will be performed by the (agency name) in consultation with the contractor. Any noted deficiencies will be corrected prior to final installation.

Task 5 - technology Software installation

Software will be installed by the contractor. It is envisioned that this will be accessible by up to three simultaneous users. The contractor shall prepare appropriate documentation including data table relationships, and instructions for performing basic tasks. The contractor will supply training appropriate to the installation.

Task 6 - Capacity building within the transit agency

The contractor will be responsible for fully training the (agency name) staff in the uses of the software to address certain operating issues facing the agency. This goes fare beyond the application training in task 5. Rather it will include coaching staff in using the system to review actual schedule and operating problems. It is envisioned that this include two on-site weeks of training (these might be scheduled 3 months after project acceptance and 6 months after project acceptance) coupled with e-mail and telephone support. This might require the development of additional data queries for use by the staff. In addition to the on-site support, the contractor should expect about 200 hours over a year in off-site support.

Project Deliverable Items

The contractor shall be required to produce the following items during the term of this project:

- Development of functional specifications for analysis software (Task 3)
- Installation of tested software (Task 5)
- Development and execution of a capacity building plan to transfer contractor knowledge to the transit system (Task 6)

Instructions for Offerors

This should include any special conditions or format requirements of the proposal. A description of the evaluation criteria for offerors should also be prepared.

4. Advanced Fare Collection Data Management Study

4.1 Introduction and Background

Advanced fare collection systems have the capability of providing substantial management information to transit operators. Unfortunately, there is a sizable gap between the capability and actuality. A study to assist transit operators in using fare collection data to improve tactical and strategic management decisions would greatly enhance the value of the installed system. A proposed project to develop tools to use this data as well as improve the capacity of transit operators is described below.

In this project a number of performance monitoring tools would be developed to enable monitoring of ridership levels at the system, route, time period and stop level.

4.2 Outline Terms of Reference

(Note: These Terms of Reference can be modified for an Automatic Passenger Counting Project)

The *(agency name)* is about to issue a request for proposals for the installation of an automatic fare collection system for its buses. While the primary objectives of this system is to improve accountability and enhance customer convenience, we have found that frequently these systems do not provide the types of information necessary to make a number of strategic and tactical decisions. This is not so much a criticism of the technology vendors but rather a recognition that AFC technology can be transformational within an agency and operators are not suitably prepared for the challenges of transitioning from a data-poor environment to a data-rich environment.

The *(agency name)* is committed to a reassessment of its operations and planning practices with the introduction of this new technology. This will require the assistance of a contractor who has both information technology experience as well as subject matter expertise in transit operations. It is envisioned that this contractor will not only determine the information requirements to perform certain analyses but will actually support the staff of *(agency name)* in making changes to the transit system (such as service frequency and route alignment.) on the basis of data rather than accumulated experiences and random observations. It is anticipated that this project will leverage considerable additional benefits from the AFC system. It is expected that the system being sought in this solicitation will post-process archived data rather than provide real-time information.

AFC System Project Description

To be supplied from DPR. This should include size of fleet, number of operating depots, fundamental design of the AFC system. It should also state the fundamental database tables which will be available to the proposed contractor for this assignment. If there will be a combination of on-board and off-board. An expected schedule of events for installation of the AFC system should be provided.

Project Objectives

The objectives of this project are to assist the transit system in using data from the AFC system to improve the quality and efficiency of its services. This would be accomplished by the development of analytical tools and consulting services to enhance the technical capacity of the transit system staff.

Description of Data Uses

The introduction of an advanced fare management system can provide considerable planning data. It is comparable to having automatic passenger counters (APC's) on each bus with two major enhancements:

- While APC equipment can identify total boardings and alightings by stop, it cannot determine the boarding location and departure location for individual trips.
- The ability to associate a specific customer trip on a single bus with a smart card Id number enables considerable analysis of linked trips[4]

There are a number of areas where improved information can enhance transit quality and productivity. A few are cited here. Offerors are encouraged to enhance this list in their proposal. We will require, at a minimum, the introduction of a system of reports, graphs and tabulations to perform the following activities.

Operations Analysis

This would include the development of load profiles (the number of riders on board following a stop departure). Such information is useful in identifying both the appropriate service frequency to meet a specified loading standard and opportunities to alter the path of specific trips by covering only high demand segments of the route.

Another possible use of such data would be in analyses of stop locations and spacing. Fewer stops result in reducing average travel time and travel time variability.

[4] Linked trips are those which require a transfer between buses to complete the journey.

Service Planning

The data from the fare management system can be used to identify the relative performance of links (route segments) in the transportation network. The specific performance of a portion of a route during a specific time period (AM peak, midday, PM peak, night) is very useful in allocating resources to services. We would like to be able to observe passenger miles or load factors in each segment and productivity measures such as passenger boardings per bus service hour.

Integration of these tools with geographic information systems should shed considerable light on the performance of the network. Specific tools might include plotting circles at bus stop locations with the circle area being proportional to the number of boardings (or alightings). Other GIS analyses would be the load factor on each segment of the network with each link's width being proportional to either the number of buses (supply) or number of customers (demand). This would provide insight into the value of making certain traffic engineering improvements in reducing bus operating cost or customer travel time.

Service Restructuring

Having linked trip information (trips which require transfers between buses) enables the analysis of ultimate customer trip origins and destinations. This is invaluable in determining the network configuration since customer traffic flows between parts of the service area can be identified. This would enable the feasibility determination of new routes which may not go through the downtown and the development of through-routes - routes which travel through the downtown but do not terminate there.

Project Tasks

While offerors may organize their work in a method that suits them, in their proposal they should address their approach to the following tasks.

Task 1 - Understanding of the business environment

Through on-site interviews and discussions with key staff, the contractor shall review the business processes associated with data management. Particular attention shall be paid to the use of paper forms used by field supervisors or traffic observers who have responsibility for operations supervision.

Task 2 - Understanding of the AFC system vendor's environment and product offering

The contractor will become familiar with the technology vendor's product offering. At a minimum, the technology vendor is required to provide an ODBC connection to the AFC system database. The minimum set of fields to be supplied are as follows:

For each fare transaction:

- Date, Time
- Card identification number

- Route
- Direction
- Origin stop
- Destination stop
- Trip ID number

The contractor should also be familiar with the schedule database supplied by the AFC vendor as well as the tables describing the stops on each route.

Task 3 - Development of functional specifications for software

In consultation with the staff of (agency name) the contractor will provide a draft functional specification for the proposed software which addresses the description of data uses section of this solicitation. This will include a description of data queries, user interfaces and any statistical procedures to be used in the software. A description of how readily accessible desktop software such as Excel and Access can be used to perform user-developed analysis shall be provided.

Task 4 - Development and testing of software

The contractor will develop the software using industry-standard procedure. The contractor will furnish a proposed testing plan prior to software installation. The testing will be performed by the (agency name) in consultation with the contractor. Any noted deficiencies will be corrected prior to final installation.

Task 5 - Software installation

Software will be installed by the contractor. It is envisioned that this will be accessible by up to three simultaneous users. The contractor shall prepare appropriate documentation including data table relationships, and instructions for performing basic tasks. The contractor will supply training appropriate to the installation.

Task 6 - Capacity building within the transit agency

The contractor will be responsible for fully training the (agency name) staff in the uses of the software to address certain operating issues facing the agency. This goes fare beyond the application training in task 5. Rather it will include coaching staff in using the system to review actual schedule and operating problems. It is envisioned that this include two on-site weeks of training (these might be scheduled 3 months after project acceptance and 6 months after project acceptance) coupled with e-mail and telephone support. This might require the development of additional data queries for use by the staff. In addition to the on-site support, the contractor should expect about 200 hours over a year in off-site support.

While offerors may propose alternatives, one approach would be to develop a number of case studies showing how the data might be used in practical analytical problems faced by the transit agency.

Project Deliverable Items

The contractor shall be required to produce the following items during the term of this project:

- Development of functional specifications for analysis software (Task 3)
- Installation of tested software (Task 5)
- Development and execution of a capacity building plan to transfer contractor knowledge to the transit system (Task 6)

Instructions for Offerors

This should include any special conditions or format requirements of the proposal. A description of the evaluation criteria for offerors should also be prepared.