CSRP/04 Loan 3425 SRI: Transport Project Preparatory Facility – CSRP/4 Consultancy Service for Design of Ticketing and Seat Reservation System for Sri Lanka Railways (044350-013)

Deliverable 1: System Requirement Specification

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Version History

Version	Date	Author	Comments
000	19/01/2018	MB	Outline document structure
001	30/01/2018	MB	Added background information
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Overview

The document is the System Requirements Specification for the Electronic Ticketing and Seat Reservation System.

The document describes the current situation and identifies the requirements for the new system.

Scope of Works

Burden Consulting Ltd has been engaged by Sri Lankan Railways, to undertake the following study which has been funded by the Asian Development Bank (ADB)

This study will develop a set of specifications for a new automatic fare collection and ticket reservation system that can be implemented by Sri Lankan Railways.

This document is the first deliverable of this project.

Abbreviations

Acronyms	Definition
POS	Point of Sale
SLR	Sri Lankan Railways

Glossary of Terms

Terms	Meaning
2D-barcode	A 2D (two-dimensional) barcode is a graphical image that stores information both horizontally and vertically.
Acquiring bank	An acquiring bank (or acquirer) is a bank or financial institution that processes credit or debit card payments on behalf of a merchant.
Authorization (transaction)	An authorization request is an approval on a cardholder account for a sale amount. It is issued by the credit/debit card to the issuing bank, through the acquirer bank.
Barcode	An optical machine-readable representation of data.
Booking module	The sub-system of the back-office ticketing system that manages seats/berths reservations.
Booking system	A system used to manage seat reservations.
Clearing (process)	The process of transmitting, reconciling and, in some cases, confirming financial transfer orders prior to settlement.
Customer	A person who intends to buy, is buying, or has bought a railway product for him/herself or for another person(s). May therefore be different from passenger (see passenger).
Distribution channel	The method (such as ticket office, on-board sales, mobile ticketing, public web site) by which tickets are distributed to the passenger by a railway undertaking.
e-ticket	Product purchased through the online product selling web site. It can be either kept in an email and shown to the inspector through a smartphone or printed.
Fare Medium	A physical medium used to host a Fare Product e.g. paper ticket, contactless smart card, magnetic ticket, etc.
Functional requirement	It defines a function of a system or its component. A function is described as a set of inputs, the behaviour and outputs.
Home-printed ticket	E-ticket printed by the customer.
Inspection	Operation made with a Fare Media for confirming the validity of a Fare Product. E.g. visual inspection made by a conductor, transaction made between a fare media and an inspection terminal.
Integrated Reservation Ticket	Tickets issued as international or national coupons and in which compulsory reservations are integrated.
International journey	A passenger journey by rail crossing the border of at least one country.
Issuing bank	The bank that holds the cardholder's account.
Local journey	A passenger journey by rail whereby a passenger does not cross a border of a country.
Commuter ticket	Entitlement for a commuter journey.
May	Denotes an implementation suggestion.
M-ticket	Short form of "mobile ticket". A fare product managed by a mobile phone application.
Non-functional requirements	This is an overall property of the system or of an aspect and not a specific function.
Non-integrated Reservation Ticket	Tickets that can be produced without any online transaction with an attributing system (e.g. reservation).
One-click payment	A service provided by payment service provider that allows customers to make online purchases with a single click, with the payment information needed to complete the purchase having been entered by the user previously.
Passenger	A person who intends to make, or is making, or has made a journey using the transport services and other services of one or more railway undertakings.
Payment Service Provider	Provides shops online services for accepting electronic payments by a variety of payment methods including credit card, bank-based payments. It is generally connected to an acquiring bank.

(Fare) Product	Entitlement to use a Public Transport service or entitlement to a reduction on the price of a Public Transport service.
Settlement	The completion of a transaction or of processing with the aim of discharging participants' obligations through the transfer of funds.
Shall	Denotes a mandatory requirement.
Should	Denotes an optional requirement.
Transport controlling organization	Any organisation which can control a passenger's ticket before, during or after a given journey (or part of it).

(Fare) Product

Current Situation in Sri Lanka

This chapter describes the current situation in Sri Lanka for buying and using a ticket on the rail network. It also highlights areas for improvement and discussions that have been held to understand the wider issues in Sri Lanka with regards to multi-modal integrated ticketing.

System Overview

During the initial stages of the project it was necessary to collect as much information about the current systems and processes as well as understand what SLR would like the future system to look like.

In this stage of the project the following tasks were undertaken:

1. Collect and review all available relevant studies, reports, materials, documents, and information including findings from the PPTA.
2. Collect all necessary information of existing, ongoing and future planned development works of Sri Lanka Railways and consult all relevant agencies/stakeholders. Take all findings into consideration in the study.
3. Consider the status and the future trends of the ICT industry in Sri Lanka to assess the possibility of obtaining support services.
4. The Ticketing Function is under the Commercial Sub Department of SLR. Therefore, consult Commercial Dept. officials and identify the process of ordering printed tickets by the Station Masters, deciding pricing structure and the way of maintaining accountability. The project outcome will finally be handed over to this department.
5. The revenue collection from the ticketing and seat reservation and the Ticket printing function will be the responsibility of the Accounting Department of SLR. Therefore, consulting the officers of the Accounting Sub Dept. and Commercial Sub Department must be done to identify the requirements, to identify division/boundary between the functions of Commercial and Accounting Departments, identify other requirements and future plans.
6. The consultant may propose re-engineering requirements to the existing manual processes. However, it is not intended to implement a wider re-engineering process at this stage.
7. Consult Railway Operating Department officials, Station Masters (users), in all three Operating Divisions to obtain their current and future system requirements, working environments, demographic requirements, features and facilities expected from the system etc. by them to make their operation efficient and easy.
8. Consult Railway Department higher officials including General Manager etc. to obtain their requirements and views.
9. Meet the officials of Sri Lanka Transport Board, National Transport Commission and Light Rail Transit Projects (two projects) and decide about how the current and future ticketing systems of those organisations to be integrated with the Railway Ticketing and Seat Reservation System to enable multimodal transfer by passengers with single ticket.
10. Prepare the System Requirement Specification (SRS) for approval of the stakeholders.

The remainder of this section contains the output from the above tasks.

Ticket Sales

Sri Lankan Railway (SLR) has 175 stations and 164 sub stations. In the current ticketing system, separate tickets are issued between each origin and destination resulting in hundreds of thousands of possible combinations of tickets for 1st, 2nd, and 3rd classes.

In practice, stations have tickets for nearby and for popular destinations. For other destinations, book tickets (hand written tickets in standard format) are issued.

This system requires that 50,000 - 60,000 combinations of tickets are printed.

Ordinary tickets are pre-printed at Railway Headquarters. The size of the existing ticket is about 2"x 1" and consists of following information printed on it.

- Serial Number
- Station of origin and destination in all three languages.
- The price
- The class
- The issue date which will be impressed on the hardboard ticket
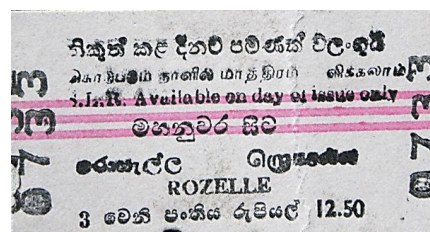
When ordinary tickets are issued, they are impressed with the date. They are perforated when checked at the entrance station and are finally collected at the destination station to prevent re-use. The tickets that are collected are sorted serially by staff of origin station and recorded in a "collected ticket register". The purpose is to identify out of sequence tickets which might indicate cheating at the origin station.

At present, SLR issues several different ticket types which include:

- Ordinary Single Class Tickets,
- Workmen Single Class (Third Class),
- Intercity Express Tickets,
- Special Third Class return tickets,
- Rail Car and unattended halt tickets,
- Reservation Ticket Double fair Suburban 3rd Class Return Tickets,

- Zone Tickets (3rd Class),
- Ordinary and Concessionary Season Tickets (2nd & 3rd),
- Platform Tickets
- Book Ticket
- Excess Fair Ticket(EFT)

Ticket Reservation System

A ticket reservation system is in place that allows passengers to reserve a ticket on long distance journeys. This can be done either by turning up in person at one of 50 major stations. Alternatively, a service is offered by Mobitel that enables passengers to reserve tickets over the phone or online. They then need to go to a station or a Mobitel shop to collect the ticket. This service has an allocation of 30%(common to Mobitel and SLR) of the total number of tickets available. The remaining 70% is available for sale by SLR.

In the Ticket office, such as at Colombo Fort in the pictures below, the passenger provides evidence that they have reserved a ticket and it is then printed out. The information system enables passengers to determine what seats are available. This information is only available at the station and public do not have access to the availability of the tickets.

| Schedule of available seats | Ticket office windows to collect reserved tickets | Cash payment | Reserved ticket |

Ticket Printing

The tickets issued by the Sri Lanka Railway (except the tickets issued through Mobitel Reservation System) are printed in a press run by the Sri Lanka Railways at the headquarters.

The printing machines used to print the tickets are very old. These machines are manually operated and most of the time these machines will breakdown. Since these machines are very old spare parts are not available and the Railway staff is using alternative methods to repair the machines.

Logistics and Storing of Tickets

Once the ticket is printed they are shipped to relevant railway stations using the trains which includes manual recording, loading and unloading.

The tickets are stored in a special cupboard.

Disadvantages of the Existing Ticketing and Reservation System

The existing systems have the following disadvantages:

- Frequent shortages of tickets at stations due to delays in importing blank tickets, delays in printing tickets, printing machine breakages. When no tickets are available they need to be written out by hand, which is a very slow process.
- Cost per ticket is high due to imported paper from the Netherlands being used for printing tickets and due to high inventory carrying cost. No local alternative source is available.
- The system is totally manual. This causes delays in issuing tickets at busy stations.
- Loss of revenue due to ticketless travel.
- The date imprinting machines are very old and do not print the date properly
- It is not possible to collect timely information about traffic patterns as all data is collected manually
- The seat reservation system has been partially automated by Mobitel. However, it is still a requirement to go to the station to collect a paper ticket
- Difficulty in tracking fraud
- Lack of flexibility e.g. it is not possible to introduce flexible ticketing fares
- Information on available ticket types and their purposes are not well communicated to the users
- Only two channels are available for passengers to buy tickets

Freight Services

There are three types operations carried out by the SLR at Colombo Fort Railway Station related to Freight Services.

1. Passenger Luggage Service
2. Locker service(Only available at Colombo Fort)
3. Parcel Service

First two operations are provided via cloak room in the main platform of the station.

Passenger Luggage Service

In this service SLR accepts baggage from passengers and charges for its transportation to the destination. Passengers can carry up to 35 kg free of charge if they hold a first-class ticket and if the baggage is over 35 kg they should pay. Other limits are shown in below.

There is a published list of charges for the service based on the weight of the luggage as shown in the picture. Based on this tariff the passenger has to pay the appropriate fee one the luggage has been weighed. Everything is done manually. A manual machine issues a receipt and all transactions are recorded in a series of logs.

There is no automated system available to track the luggage.

Locker Service

The locker service available for all passengers for a charge of Rs. 50/= + Rs. 8 as tax per day (roughly US$ 0.5 per day). The availability of lockers is not visible publicly and locker management is done using a manual process.

Parcel Service

The monthly income of the Colombo Fort Railway Station through Goods handling is around Rs. 6.5 million and all-island monthly income is 19 million

According to the officer in-charge all major currier services (DHL, FedEx, etc...) use Sri Lanka Railways to send goods as it is cost effective. Most of the lottery and movie distribution is done using Sri Lanka railway.

There is no automated tracking system. All management and handling are done manually.

All the data needs to be recorded manually so the staff spend a lot of time book keeping.

Areas for Improvement
Several areas have been identified as needing improvement, these include:

- Computerizing the receipt issuing process – High priority
- Introducing a barcode and tracking system for luggage and parcels
- SMS alert system for customers so they can track their parcels and luggage
- Registered customer portal to handle regular customers
- Parcel delivery to the customers front door
- Packing facility at major stations
- Security tapes
- Proper storage facilities
- Proper equipment to handle goods
- Dedicated Goods trains, as freight has increased significantly over the last couple of years

International Approaches to Automatic Fare Collection

Introduction

Public transport ticketing has come a long way over the last 30 years. The major technology back then was paper based but there has been a gradual change as new technologies, ranging from magnetic stripe tickets to smartcards, have been developed and successfully implemented in many major cities worldwide. Historically, transport operators have only considered smartcard systems to pay for transport, so called closed schemes. The resulting system was built, in most cases, to a proprietary specification by a single supplier. These schemes required a considerable capital investment for the infrastructure, as well as on-going operational costs.

Customer expectations have changed significantly in recent years, especially with the advent of the internet and online retail. There is a general expectation that all transactions can be undertaken in a fast customer friendly way. Standing in a queue for a ticket machine does not fit this model. The introduction of smartcards has meant that customers no longer need to queue at the ticket office window to renew their monthly or annual season ticket. This can be done online and the new ticket delivered the next time the card is passed over a reader. Auto-top-up is also available in many schemes to registered users who can get their pre-paid balance automatically topped up when it falls to a pre-defined threshold. All the payment is dealt with in the back office. This chapter looks at worldwide approaches to AFC in public transport.

Ticketing Technologies

Based on a review of international experience, it can be concluded that no unified, standardized solutions have emerged for existing AFC systems in major cities covering the totality of the operation of the system. Instead, there is competition between alternative models that include national standards, (e.g. ITSO, Calypso, *OV-chipkaart* in the Netherlands) and proprietary systems. (e.g. Oyster in London, Octopus in Hong Kong). The travel media that passengers use in public transport can vary significantly, and some locations accept multiple technologies—in the case of London Transport for London (TfL) magnetic stripe, smartcard (Oyster), EMV bank cards and mobile EMV (for example Apple Pay).[1] Travel media are always devised and developed in accordance with the business and security demands and IT capabilities of the time. The different fare media do not need to be considered in isolation, as there is no one technology that can address all the needs of users of urban and inter-urban transport. The technologies

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[1] EMV chip technology is becoming the global standard for credit card and debit card payments. Named after its original developers (Europay, MasterCard® and Visa®), this technology features payment instruments (cards, mobile phones, etc.) with embedded microprocessor chips that store and protect cardholder data. This standard may also be referred to as chip and PIN or chip and signature. Payment data is more secure on a chip-enabled payment card than on a magnetic stripe card, as the former supports dynamic authentication, while the latter does not.

complement each other, and several examples exist of cities or regions successfully implementing multiple technologies across multiple modes of transport.

Figure 1: Evolution of Ticketing Technology

Table 1: Strengths and Weaknesses of Ticketing Technologies

Technology	Technology Description	Transaction Speed	Possibility of Counterfeiting	Feasibility for time based tickets	Interoperability	Allows for flexible fares strategy	Multiple Sales Channels	Investment and operational costs	Speed of implementation
Cash	Passenger would pay driver on entry to the bus / tram	○	○	○	◑	○	◑	◑	◕
Token	Metallic token only for use in transport. Passenger pays on entry	○	○	○	◑	○	○	◑	◕
Paper	Passenger issued a paper ticket for the journey	○	○	○	◕	○	○	◑	◕
Magnetic Stripe	Journey information is encoded on a magnetic strip on the back of the ticket, similar to a US credit card	◑	◑	◕	◕	◕	◑	◕	◕
Transport Smart Card	Memory chip embedded in a plastic card with a contactless interface that carries passengers tickets. By presenting the card to a reader the passenger can enter the transport system	◕	◕	◕	●	◑	◕	◑	●
2D Barcode	2D barcode is either printed by the passenger before the journey or carried on a mobile device, similar to airline tickets.	◕	◕	●	●	◑	◕	◑	●
Contactless Payment Card	Use of a bank issued card to pay for journey by the passenger tapping in and out of the transport system. Payment is calculated in the back office	●	●	●	●	●	◕	◑	◕
Mobile	A mobile device can be used to carry a ticket which is then presented visually, or via a 2D bar code	◕	◕	●	●	◑	◕	●	●
Identity Token	Passenger presents a trusted token, e.g. contactless bank card, PIV card, ID card, or similar and back office calculates the payment	●	●	●	●	●	◑	●	◕
Near Field Communication (NFC)	This functionality allows a mobile phone to communicate in the same way as a contactless transport card or a bank card	◕	◕	●	●	◑	◕	◑	●
Biometrics	In its infancy in the transport space but uses biometrics to indicate a right to travel. The back office calculates the fare	◕	●	●	●	◕	◑	◑	◑

Box 1: ITSO, EMV, Apple Pay

ITSO Ltd (ITSO) is a UK non-profit distribution
technical, standardization and interoperability membership organisation with objectives to: (a) maintain and develop the ITSO specification for transport smartcards; (b) operate and manage an interoperable smart media environment; and (c) facilitate and support development of interoperable smart ticketing schemes that comply with the ITSO specification.

ITSO was established as a result of discussions between various UK passenger transport authorities concerning the lack of standards for interoperable smartcard ticketing. These discussions grew to include other authorities, transport operators and government. ITSO membership covers the breadth of the transport sector including transport operators (bus, tram and train operating companies), suppliers to the industry, local authorities and public transport executives. Supported by the Department for Transport, ITSO has links with major transport industry organizations and established smartcard schemes in the UK and overseas.

ITSO started out as the Integrated Transport Smartcard Organisation but this has been dropped and is now just 'ITSO'. That is because the specification covers other forms of ticketing besides smartcards and transport. The Department for Transport introduced in 2008 the English National Concessionary Travel Scheme for all people of retirement age and eligible disabled persons (according to the Transport Acts 1985 and 2000) using buses, which uses ITSO smartcards. Transport Scotland and the Welsh Government have implemented ITSO in their concessionary travel schemes. Transport authorities and operators are now rolling out commercial uses for ITSO-based smartcards throughout the country.

The ITSO specification is a technical platform on which interoperable smart ticketing schemes can be built. It defines the key technical items and interfaces that are required to deliver interoperability between both, components of a ticketing system – smart media (smartcards), points of service and back offices – and separate ticketing systems. ITSO smartcard specifications covers card, point of service and back office systems.

EMV. Originally a joint working group set up in December 1993 by Europay International, MasterCard International and Visa International, to develop a common set of technical specifications for the use of IC cards by the payment industry. Responsibility for the specification has now passed to a management company, EMVCo LLC (www.emvco.com), so that EMV is now used to refer to the group of specifications produced by that company.

EMVCo members worked jointly over the last few years to develop specifications that define a set of requirements to ensure worldwide interoperability and acceptance of secure payment transactions using integrated circuit cards. It accomplishes this by managing and evolving the EMV® Specifications and related testing processes. Today there are EMV Specifications based on contact chip, contactless chip, common payment application (CPA), card personalization, and tokenization. There are also EMV documents and materials regarding mobile payments.

Apple Pay is a mobile payment and digital wallet service by Apple that lets users make payments using the iPhone 6, 6 Plus, and Apple Watch-compatible devices (iPhone 5 and later models), iPad Air 2, iPad Pro and iPad Mini 3 and later. Apple Pay does not require Apple Pay-specific contactless payment terminals, and can work with existing contactless terminals. Transport for London accepts Apple Pay.

Table 1 indicates the strengths and weaknesses of the available technologies. The criteria identified in the table are generic and can be applied to any ticketing scheme across the globe. What this shows is that technologies such as smartcards, mobile phones and identity tokens provide the best potential for interoperable smart ticketing systems. Indeed, these technologies have been successfully implemented in cities such as London, Amsterdam, Washington DC, and Boston. As can also be seen from the table, there are many technologies that are being used for automatic fare collection, which means that Public Transport Operators (PTOs) have difficult decisions to make as to which technologies to support in the medium to long term.

Future Developments

Many major cities have invested significant sums in bespoke smartcard based ticketing systems that have delivered major benefits to both operators and the travelling public. Some of these schemes, such as Oyster for Transport for London (TfL) in London, are beginning to look at the next generation of open payment systems to build on current successes and look at how new technologies can be used to support them in this transition. A significant trend is the move away from issuing tickets to the use of more advanced forms of payment, including contactless bank cards and Apple Pay, in London amongst others, and the use of identity tokens, such as government issued PIV cards in Washington DC, to show that a passenger has a right to travel.[2] This has meant that we are seeing a movement away from bespoke ticketing systems to the adoption of retail solutions to meet transport requirements (Figure 2).

Figure 2: Trends in Automatic Fare Collection
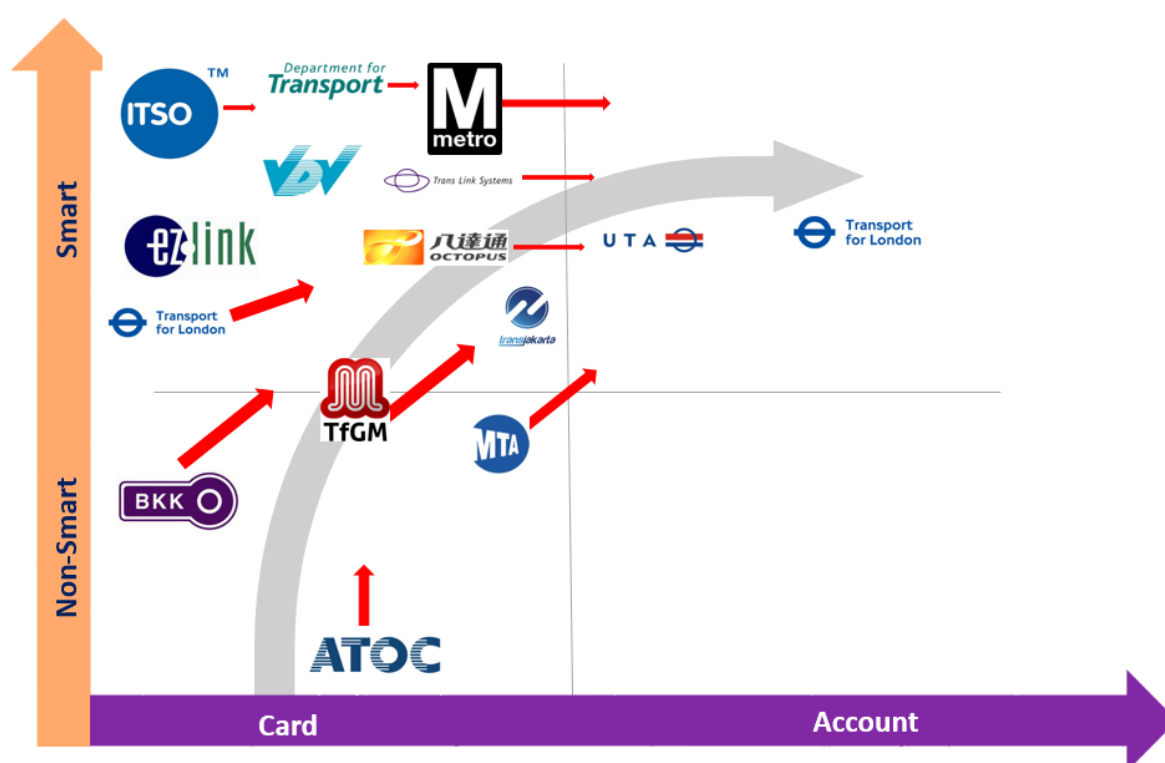
AFC should not be viewed as a simple replacement for traditional paper or magnetic ticketing. The introduction of AFC systems is also an opportunity to rethink the current fare policy and to offer additional or alternative fare possibilities to customers. This is because there is a clear link between fare collection technology and fare policy. The technology that has been in place for several years has been developed to implement the existing fare policies and products. As technology has developed it has allowed different fare policies to be implemented that were not previously possible due to the limitations

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[2] A **PIV card** is a United States federal smartcard that contains the necessary data for the cardholder to be granted access to federal facilities and information systems and assure appropriate levels of security for all applicable federal applications.

of the technology, for example daily fare capping in London on Oyster cards. Public transport is notoriously slow to instigate change. Consequently, there is a tendency to continue with existing fare policies and implement new technology, the result being a far more expensive way of providing fare collection than previously.

Business models. Smart ticketing is a global business and is, for the first time, being driven by standards. This allows off-the-shelf technology to be adopted with only limited local tailoring to reflect specific fare structures and cross-modal opportunities. By using open national standards for smart ticketing, payment systems, and communications infrastructure, public transport operators can access supply chains that are responsive, cheaper and address industry best practice. However, the use of new technology now allows for post-payment of travel, if passengers have a valid token, such as a contactless bank issued credit or debit card, and the journey is recreated from the taps in and out of the network. Payment is then calculated according to several variables including, time of day, zones crossed, applicable discounts, e.g. capping, and mode of transport.

Distribution channels. New fare collection systems must allow passengers to plan and book their travel through a wide range of sales and distribution channels and move away from a station centric approach. This goal requires a new system that can accommodate the speed, power and flexibility necessary to handle multiple distribution channels for ticket sales. There is a significant move away from traditional retailing at stations to more user centric approaches as shown in Figure 4.

Organizational and legal issues. There is a need for leadership in this area, which could come from national governments or operator supported groups, to provide confidence that when new AFC systems are introduced there will be a degree of interoperability to enable passengers to travel across several modes across a wide area. Legislation would be necessary to give any such proposals a strong foundation and ensure a level of compatibility between AFC systems.

Integration with travel information and traffic management. By creating a linkage between Travel Information, Journey Planning, Payment and Smart Ticketing, including a liaison with compatible mobile phone and contactless bankcard schemes, new AFC systems can ensure the passenger experience consistently meets the highest expectations. It can also break down barriers to usage of public transport systems and assist in obtaining a modal shift by making access to public transport easier.

Figure 3: Trends in Sales and Distribution

Development of smart ticketing standards. A common feature that has enabled the uptake of new technologies is the development of standards that can be directly applied to the transport sector, or require adaption for solutions to be implemented. The latter is particularly true for payment systems that have been adapted to meet the requirements of transport, which requires a high throughput of passengers at peak times, and cannot perform on-line authorization at the point of entry. Also, the underpinning mobile and communications technologies are all based on internationally standardized solutions.

Data privacy. Protection of customers' privacy is enshrined in the EU Data Protection Act, which AFC systems need to comply with. Additionally, where payment cards are used there are requirements to tokenize the card details, in compliance with Payment Card Industry Data Security Standards (PCI DSS) requirements to minimize the potential for fraud.[3] These issues are key to the successful implementation of a smart ticketing scheme, as any loss of trust in the system by users would damage passenger acceptance.

In Summary

As more and more cities adopt the use of these disruptive technologies, there will be a need to standardize the approach used, so that passengers have the same user experience across the country. There are two avenues, which are not mutually exclusive, for Sri Lanka—take part in the development of smartcard standards, either building on existing specifications, or through developing new standards and to focus on interoperability across modes and local administrations through development of new technologies, such as EMV cards or Apply Pay.

As technology evolves in this sector there will be a need to have a standard approach, or passengers will be less likely to use it if the experience is different in different locations. For example, cell phones work in the same way all over the world, so the user

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[3] PCI DSS are mandatory information security standards for organizations handling cardholder information in the payment card environment. Those organizations are required to demonstrate compliance on a periodic basis.

experience is the same. Apple Pay is the same in the UK and the US and China. Consequently, users know what they must do each time they want to use the service

The current trend is towards making payment of transport fares simpler, and allow the passenger to choose which payment product or device he wishes to use to identify himself to the network, to indicate that he is eligible to travel on that network. This simplifies the front-end systems significantly and moves a lot of the decision making as to which fare is best, from the passenger and into the back office.

New technologies have a cost (production and distribution) and a robust strategy for managing the cost and deployment is a critical issue within some existing systems. It is also important to bear in mind that there will be a substantial customer base for the smart-ticketing product, and their needs must be considered during the process otherwise take up rates and acceptance of the scheme may be low. After sales issues and data security are also important attributes to consider, as this ensures the customer will feel confident when using the smart ticketing.

In many cases, it is true to say that schemes continue to remain beholden to past decisions, where fare collection technology imposed significant limitations. This drove the need for zonal-based structures to support fares integration with multi-ride and periodical fare products, to operate in 'open' fare collection environments. These fare structure and fare product concepts are often subject to widespread public and political acceptance and support. New paradigms offered by Near Field Communication (NFC) and bank-issued smartcards opens new horizons.[4] Through the integration of fare collection systems and mobile. This means that there is a link between location, payment and information which can be combined to improve the travelers experience and provide the operator with more information about what type of service passengers want.

This poses challenges public transport authorities and policymakers to rethink how to best deliver customer service and offer different value propositions off the back of these new technologies. Based on the past, this would tend to suggest that an ongoing evolution rather than a revolution will occur from a policy perspective. A further implication may well be an extremely pragmatic approach to business case development associated with next generation fare collection systems.

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[4] Near Field Communication (NFC): An extension of the Proximity Card (ISO/IEC 14443) contactless technology, allowing both ends of the communication channel to be self-powered and providing enhanced functionality, primarily in mobile telephones. Colloquially also used to describe the incorporation of unpowered 14443 compliant chips into other devices (e.g. stickers applied to mobile phones that do not have inbuilt 14443 compliant functions, touch areas on posters that can be interrogated by NFC enabled mobile phones). Relevant standards are ISO/IEC 18092, 21481, ETSI TS 102190 as well as ISO/IEC 14443.

Vision for Rail Ticketing in Sri Lanka

Based on the issues raised by SLR staff and the fact that the ticket issuing equipment is the same equipment that was used on the formation of the railways in 1864 is necessary to update the ticketing system to meet the requirements of a modern railway and make use of technological innovations.

Because of this a vision for ticketing on the Sri Lankan Railways has been defined. The new system will:

- Be simple, quick and easy for passengers to use
- Provide multiple sales channels and ticket media including paper, mobile and smart card to reduce queuing
- Provide automated ticket sales to speed up data collection and analysis
- Offer multiple payment methods to reduce cash
- Integrate with other transport modes to provide one ticket for multi-modal travel
- Provide better operational information in a shorter timeframe

Overview of the System

The ticketing system proposed will rely upon six distribution channels to provide various ticketing services to SLR's passengers.

Firstly, SRL Station Ticket Offices (STO) will offer the full range of tickets for both commuter and long distance travel and will become the unique distribution channel to issue Pay-As-You-Go (PAYG) and Staff Warrant smart cards.

Secondly, customers will be able to purchase tickets for local and long distance journeys through a network of Ticket Vending Machines (TVM) which can be in office blocks, shopping centres as well as major railway stations.

In some instances where a station has no ticket selling capabilities it will still be possible to purchase tickets on-board the train from the conductor. This will be done using a light version of the equipment to be used in the STO and based on handheld terminals.

Through the online ticket selling web site, customers will be able to purchase long distance tickets. These e-tickets will be either printed by the customer (known as "home-printed ticket") or kept in an email (known as "email ticket") ready to be shown to the ticket-inspection staff.

The mobile application will provide an optimized interface to the online product selling server. Passengers will be able to purchase tickets from their smartphones. The ticket will then be downloaded to the mobile phone and visible as a 2-D barcode.

A network of third party agents and kiosks, as shown in the picture, will be implemented such that passengers can top-up their season tickets and /or PAYG stored value tickets.

The passengers will have access to traditional media such as paper ticket and to more modern media such as m- ticket (mobile ticket) and electronic ticket (e-ticket).
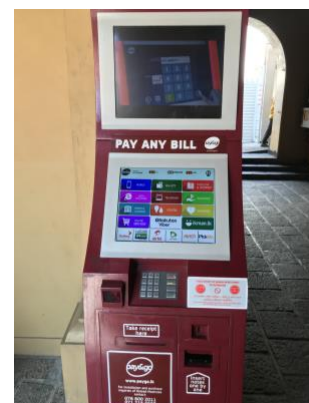
The diagram below describes the ticketing system.
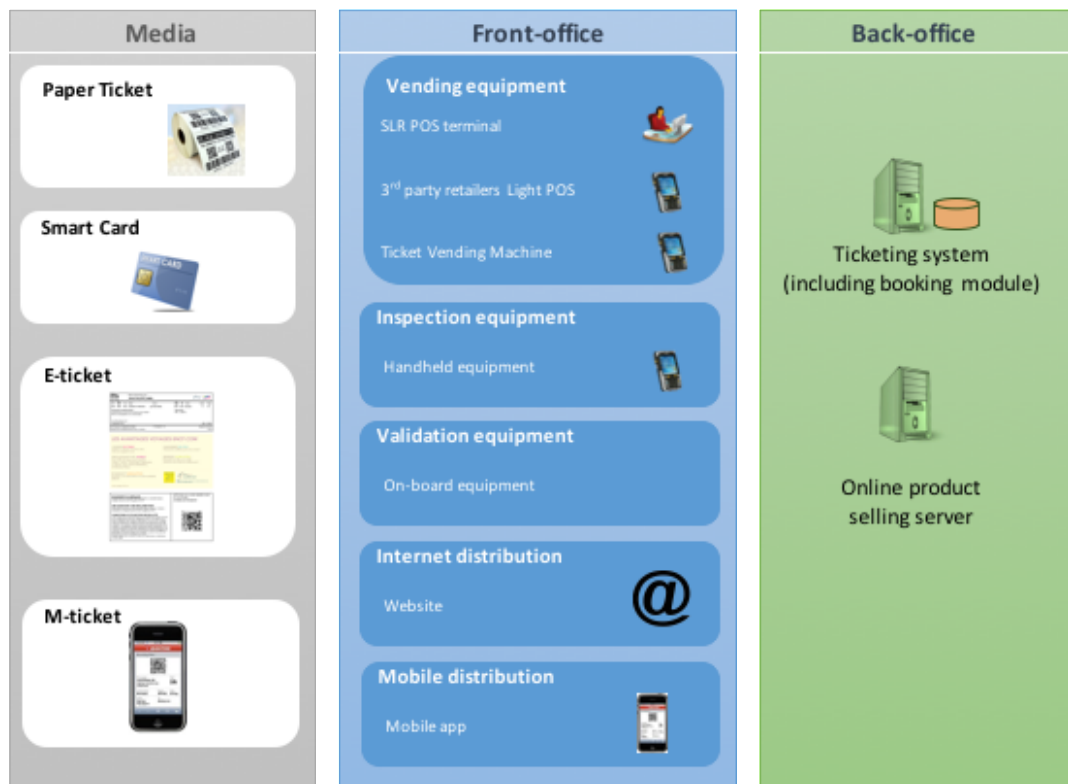
Overview of AFC system components

The first layer of this architecture shows all the media that will be available to SLR passengers. These are the paper ticket (either on secured paper such as RTCT2 or printed on thermal paper), smart cards, e-ticket (either in the form of home-printed ticket or kept in an email) and m-ticket (i.e. ticket hosted by a mobile phone application).

The second layer covers the different vending and inspection equipment.

The requirements for the last layer, the back-office system is described in the present specification.

The back-office, is composed of two main systems, namely:

- **The back-office ticketing system** manages the train inventory, the fare policies, the reservation and customer details. Additionally, it also generates reports, collects information from the front-office equipment, supervises the front-office equipment, connects to external ticketing systems and administers the whole ticketing system.

- **The online product selling server** allows sales of e-tickets and m-tickets from the SLR web site.

Interoperability with other Modes of Transport

Sri Lanka is undergoing a period of major infrastructure investment in transport sector. Significant resources are being focused on developing transport links across the country with the construction of new expressways, LRT and rail projects prominent.

Any smart ticketing scheme that is introduced by SLR will ultimately need to be interoperable with other public transport ticketing systems, such as LRT, and Bus as they are implemented.

The demand for public transport services which comprise bus and rail transportation jointly accounts for 50.9% of the total motorized transport in Sri Lanka. This share was around 67% 10 years ago. Of this 67%, bus accounts for 61%. The introduction of a common ticketing scheme will have significant benefits for a large part of the population.

There has already been significant work undertaken in this area as ICTA commissioned a report to investigate the potential for implementing a "Unified Transport Ticketing and Payment Platform" the key objectives of this study were identified as:

1. To have a unified card solution for the whole of Sri Lanka covering bus and coach payments, payments for train journeys and for Toll payments;
2. To implement a system to collect payments for all methods of transport and distribute the collections to the relevant Ministries, Departments or Authorities;
3. To check the feasibility of using Bank cards (debit/credit cards) for payments on all transport modes;
4. Analysis on Lessons learnt from world, regional, and local systems;
5. Analyse how to integrate platforms such as the NPP, NDI and DTI;
6. How the money collected is going to be reconciled with the amounts being deposited in the banks. For this the stakeholders need to come to a decision on who is going to be the authorised bank, Trustees and Custodian;
7. Analyse Open Standards and Technologies for implementation;
8. Analyse key security threats arising from external sources and identify the weaknesses within the current system;
9. Marketing options for the card. A catchy name for the card;
10. Analyse key cultural barriers to implementation;

The SLR scheme will need to consider the findings of this report when implementing a system.

An additional area for future research will be the potential to use any stored value scheme for the purchase of low value products in convenience stores, tea shops etc. this will need to be discussed with the Bank of Ceylon to ensure compliance with the emoney license. It will also be necessary to agree commercial terms with retailers.

Data

Recently, many cities and regions introduced a smart card system for their public transport systems. In addition to ticket handling, being an alternative for individual regional or urban tickets, these systems also provide valuable data. Without these systems, information of origins and destinations, number of passengers, trip lengths, etc. can only be made available by time and budget consuming surveys. These surveys often only provide limited data due to time and budget restrictions. Smart card systems have the potential of providing more and better insights of revealed passenger behavior. These insights are helpful when dealing with the main current challenges in the public transport industry.

Within the public transport industry, there are several challenges. Due to the increased focus on cost savings, there is more attention to measures that increase cost efficiency of public transport. In the meantime, passengers require higher quality of the services.

Although both developments seem to be a contradiction, measures do exist that serve both objectives. Improving operational speed and service reliability, for instance, will lead to higher quality and lower costs at the same time. However, to find and optimize cost-effective measures, data is required. Fortunately, the amount of data is increasing rapidly. Automated Vehicle Location (AVL) data, has already been available for a long time and recently much more passenger data (Automated Passenger Counting (APC) data) has become available as well). These data support public transport design and decision making, since they enable planners to illustrate the costs of certain problems and the benefits (and additional costs) of potential solutions, for instance the transformation of a regular bus line into a high quality Bus Rapid Transport (BRT) system or into a tram line or optimized synchronization between tram and train). These costs and benefits are relevant for decision making and may be incorporated in cost-benefit analyses.

Example from NL

Chip ID	Check In Location	Check Out Location	Check in Time	Check Out Time	Route Number	Vehicle	Ticket Type

TABLE 2: AFC TRANSACTION DATA, BASED ON OV-CHIPKAART DATA

Data provides
- Waiting times
- O-D data
- Ticket type usage
- Connected journeys & interchanges
- Peak travel periods
- Passenger numbers
- Route planning
- Scheduling info

This data, when analysed, will give SLR significant insight into the operational performance of the rail network. This will enable better use of resources and provide passengers with a more reliable service.

Freight Services Overview
This section will describe the requirements for the new parcel and luggage tracking service.

Parcel tracking
When a parcel is handed over to the SLR staff the following information will be recorded electronically:

- The weight and size of the parcel
- The destination SLR station
- The address of the recipient
- Name and address of the sender
- The value of the contents, for insurance purposes
- The required delivery time
- payment

With this information, the cost of sending the parcel can be calculated and the payment made using either cash or credit / debit card.

A unique identifier will be allocated to the parcel so that the sender can follow its progress through the parcel tracking website.

Luggage fees
For large items of luggage it is necessary to pay a fee for them to be carried on the SLR. The cost of this is dependent upon the weight and destination of the luggage.

An electronic system will be provided that records the relevant information about the luggage needed to calculate the appropriate charge.

All the data gathered from the above processes will be stored in the back office system and this will be used to track the progress of the parcel delivery and confirm that a parcel was sent and received by the correct recipient on the date requested.

Ticketing Back Office System Requirements

Background

The following activities were undertaken to develop the specifications for the Central System

1. Consult and examine the Data Center facilities available with Telecom. Service Providers and with Ministry of Defense in the SPI Building ("Suhurupaya") and decided the way of obtaining Data Center facilities required by the system.
2. Evaluate the pros and cons and the financial viability of running the system in SLR's own Data Center.
3. Study the capabilities of the existing Data Processing Unit of SLR and propose how and to what level, the unit needs to be developed (including skills of the staff to be recruited to   different level of the unit) to provide support services along with the system vendor.
4. Study the accounting procedure adopted with the manual system and propose the revenue accounting system that can be implemented along with implementation of the new ticketing system

System overview

The ticketing back-office system will be at the core of the ticketing system. The ticketing back-office is comprised of several functional modules including:

- Inventory module
- Fare policy management module
- Booking module
- Data collection and reporting module
- Front-office equipment supervision module
- Customer and profile management module
- Journey planning module
- Price engine module
- Clearing and settlement module
- Administration module
- Accounting module
- Manual ticket entry module
- Parcel / Luggage tracking

These modules are defined for clarification purposes and do not suggest that the final solution should be designed in this way. The ticketing system supplier may decide to merge some modules together (or split some into several modules), according to his design. The new system shall comply with the functional requirements described in the remainder of this section.

The next section details the functional requirements of these modules.

Functional requirements

Inventory module

The ticketing system shall allow SLR administrators to manage an inventory of the transportation resources that are available. These resources comprise the routes (e.g.

stations, lines, etc.), trains (timetable, route, etc.), the carriages (type, number, etc.) and the seats (type, locations).

The inventory shall cover all resources related to commuter and long distance trains. Some of these resources may be subject to reservation. Consequently, the inventory shall be closely coupled with the booking module.

The inventory should contain, at least, the following:

- Routes and stations inventory

  - Stations (location, distance between the station, and identification of the stations).

  - Routes definitions (stations that are part of the routes, distance between the stations).

- Train inventory

  - Routes on which the train operates.

  - Departure and arrival station.

  - Timetable (departure and arrival time at each station).

  - The dates when the train operates.

  - Type of train: seat reservation required (Long Distance train) or no reservation required (Commuter trains).

  - Lay-out of train carriages (number, type, class).

  - The availability of the carriages within the route (e.g. a carriage may not be part of train during the entire route).

  - Train type (e.g. high speed).

- Carriage inventory

  - Type of carriage (e.g. seat, bar, vehicle).

  - Carriage characteristic (i.e. 1st, 2nd 3rd, class, smoking/non-smoking, compartment/non-compartment).

For train requiring seat reservation, each carriage shall comprise an inventory of the seats and vehicle capacity:

  - Inventory of seats

    - Location of the seats (i.e. row number, compartment location),

    - Seat type (i.e. window, corridor)

    - The applicable fare.

  - Inventory of vehicle capacity (for vehicle transportation carriage)

The structure of the inventory is given for information purposes and does not involve any requirements.

Fare policy management module

The fare management module will manage fares for SLR-operated transport (i.e. Commuter journeys and Long Distance journeys).

Management of fares involves creation, update, export and deletion of fares.

Fares for Commuter and Long Distance Routes
This module manages all the fares that are available on the SLR railway network. It is closely linked to the Inventory module. Distance-based and route-based fares shall be supported by the system.

A fare should be defined at least by the following:

- Fare description (in English, Tamil and Sinhalese).

- The period during which the fare is applicable.

- The origin and destination of the journey (for route-based fares).

- The price:

    o The price for 3rd class, 2nd class and 1st class per kilometre (for distance-based fares).

    o The route price (for route-based fares).

- Fare conditions

    o Carriage type to which the fare is applicable (e.g. 1st class, 2nd class or 3rd Class).

    o Period during which the fare is applicable (start date and end date).

    o Whether a particular status (e.g. age, SLR staff etc) is required.

- After-sales conditions:

    o Exchange conditions (e.g. exchange period, fee, number of exchange allowed).

    o Refund conditions

- The distribution channel where the fare is available

The fares are communicated to the front-offices equipment, the online product selling server.

The fare management shall include creation, update, export and deletion of fares and shall be implemented via a simple interface to allow for changes to be made quickly.

Booking module
The booking module shall be accessed from SLR's distribution channels and potentially third party providers authorized by SLR to retail tickets.

The reservation system shall support reservation of supplement such as luggage or parcels as defined by SLR.

The reservation of vehicle carriage shall also be supported by the booking module.
The booking module shall support pre-reservation to allow a user-friendly purchasing process from the online product selling web site and the SLR POS.

There are no mandatory requirements for the ticketing system to support over-booking.

The booking module shall allow the facility for an upper limit for the number of seat reservations that can be sold for each train's inventory. This limit can be changed manually at any time from the date of the beginning of ticket sales until departure date.

Data collection and reporting module

The data collection and reporting module centralizes all information collected by the front-office equipment and all the systems that are part of the back-office ticketing system. The new ticketing system should support as many measurements as possible.

Based on this data, it shall be possible to create custom reports easily. These reports shall be either displayed through the web interface or written into a report file.
The visualization of the extracted data shall be possible with the use of standard charts (e.g. histogram, bar chart, pie chart, line chart).

Report files shall be generated instantly or in a periodic way. The frequency of the generation shall be configurable. The report format shall, at least, include CSV, XML, XLS and PDF.

Front-office equipment supervision module

The front-office equipment supervision module shall be connected to each front-office equipment (hand-held terminals and POS) to provide information regarding its status.

The status can be one of the following "running", "out-of-service" or "fall-back mode". The status shall be displayed in such a way that the entire front-office equipment status can be visualized easily.

It shall also be possible to set alerts in relation to the status. In such way that a status change (e.g. from "running" to "out-of-service") triggers an alarm. The alarms shall be displayed and stored for audit purposes.

This module shall also manage remotely the main software application that are hosted on the hand-held terminals. For instance, the update of an application could be managed remotely and centrally by the back-office ticketing system. The application that shall be subject to remote-installation and configuration are those which require frequent updates.

OS updates may also be handled remotely by the front-office equipment supervision module.

Customer and profile management module

The ticketing back-office system shall implement a light-weight CRM system, to allow the management of customers. This involves creation, update and deletion of customer details.

The customer details include at least the following data:

- The customer basic details such as name, surname, address, email.
- The banking details if automatic debit has been set up.
- The profile of the customer that entitles him to specific prices.
- History of purchased tickets, purchased card distribution etc.
- History of payment transactions.
- A link to his/her customer data on the online product selling server (if any).

The access to the customer information shall be protected through user privilege, which are defined via the administration module.

Journey planning module

The journey planning module shall ensure the computation of Long Distance journey itineraries. The module shall respond to itinerary requests (by the ticketing system or online product selling server) and provide the most suitable journey.

Price engine module

The ticketing system shall be able to compute the price for a Long Distance journey based on the current fare data. For this, the ticketing system shall integrate a price engine module that will compute, for a given itinerary and based on the price information available in the fare table, the itinerary price.

Clearing and settlement module

In future, there may be instances when tickets are sold on SLR that can be used on other modes of transport. All tickets sold by SLR for non-SLR operated transport and tickets sold by other Transport Operators for SLR-operated transport, will require settlement.

The Central System will require the functionality to enable settlement to happen between multiple operators in a quick and convenient manor according to the business rules agreed by the relevant parties.

Administration module

The administration module manages all users that are provided with access to the ticketing system.

Each user shall be able to log into the ticketing system using individual credentials.
The back-office system should manage the following user groups:

- SLR staff operating the STO at each station.
- SLR maintenance team. They perform maintenance task on the front-office equipment (hand-held terminals and STO).
- SLR ticketing system administrators. They administrate the system (manage users, grant privileges to users, etc.).
- SLR ticketing system operator. They operate the system: generate report, create new fares, connect to the supervision interface, etc.
- SLR inspectors.
- SLR accountants

The system shall allow the creation of new groups easily.

Accounting module

The ticketing system is expected to provide an interface for SLR's accounting tools.
This interface shall provide the functionality to export the following minimum data from the ticketing system to the accounting system:

- Revenues from fares distribution by SLR.
- Revenues from parcels and luggage transported by SLR
- Fraud related data (payment follow-up of the fines issued by the conductors).

The actual design of this interface shall be defined with the future selected supplier of SLR's ticketing system based on inputs provided by SLR's revenue control teams.

Manual ticket entry module

If for any reason the distribution of tickets cannot be carried out from a POS or a handheld sales device, the STO staff or the inspector will issue tickets manually. In this case, the ticket's details will be written manually to a blank ticket and a copy of this ticket will be kept at the station or by the on-board inspectors.

The system shall allow such tickets to be manually entered into the system (for reporting and accounting purposes). A visual interface shall allow an operator to enter the ticket copy's details into the manual ticket entry module.

Parcel and Luggage Tracking

This module will allow for the registering of parcels and luggage that are to be transported on SLR.

When a parcel or item of luggage is accepted by the system the following information will be recorded as a minimum:

- Date and time
- Location of receipt of parcel / luggage
- Staff id receiving parcel / luggage
- Weight of luggage / parcel
- Destination
- Charge (1st class, 2nd Class etc)
- Parcel /luggage ID number
- Name of sender
- Name of person receiving parcel / luggage
- Required delivery time
- Supplement e.g. for faster delivery
- Train parcel / luggage will be transported on (route no, car location etc)
- Intermediate points on the journey, e.g. storage facilities, vehicle ID, etc)
- Location parcel / luggage delivered to
- Delivery time of parcel / luggage
- Details of person receiving parcel / luggage

Other data information may be necessary to be collected and stored to enable the process to operate efficiently. This will be agreed with the system provider during the detailed design stage.

The system shall allow the parcel / luggage to be tracked on-line via a web portal so the customer can check progress of the parcel / luggage.

Non-Functional requirements

Modularity

The back-office ticketing system shall be designed in a modular way. This means that the functionalities of the ticketing system shall be separated into independent and easily updatable modules, such that each module contains everything required to execute only one functionality. In this way, upgrading the booking module for instance shall have as minimum impact as possible on the other modules (e.g. inventory module or the customer management module).

Extensibility

The interface between the front-office equipment and the ticketing system back-office shall be based on standard protocols (e.g. SOAP, REST, XML or JSON) and be thoroughly documented by the ticketing supplier.

Scalability

The new ticketing system shall be capable of supporting future growth of passengers. To achieve this, the ticketing system shall be able to scale horizontally: increasing the capability of the ticketing system should be achieved by adding hardware.

From a software perspective, this requires that the modules of the ticketing back-office that are affected by traffic increase shall be capable of operating in cluster mode. The scalability requirements therefore only apply to the modules, for which a growth in passenger traffic leads to a significant growth of the module usage (e.g. the booking module).

Availability

The ticketing system shall have a suitable level of redundancy to meet a minimum of 99.8% availability.

Security

The security mechanisms required between the back-office systems and internal remote equipment (i.e. POS equipment, on-board equipment, mobile application and Internet web browsers) shall be sufficient to ensure the integrity of the data collected and protect the system from external attack. Further details are described in later sections of this document.

Additionally, the back-office systems shall ensure that sensitive data are encrypted within the data-base (e.g. customer credentials, bank account identifiers for direct debit, etc.).

Online Product Selling Website Requirements

System overview

The online ticket selling web site will allow customers to purchase passenger tickets for Long Distance journeys, top-up or renew PAYG and Commuter Season Tickets, issue staff travel cards and Warrants, consult train timetables, and reserve seats.

This section addresses the functional and non-functional requirements of the online product selling web site.

The figure below describes the online product selling web site in interaction with the customers, the SLR administrators, the ticketing back-office system and the PSP (Payment Service Provider) gateway.
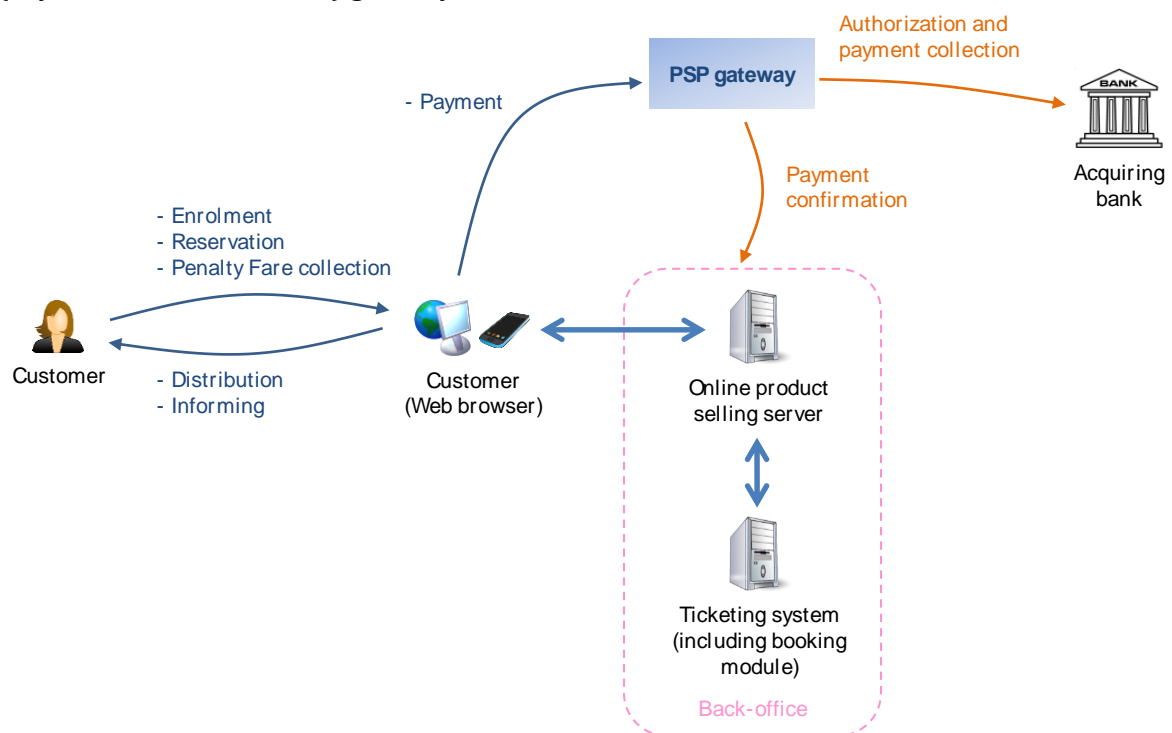
Online product selling web site system data flow

Functional requirements

Informing

The online ticket selling web site shall provide information regarding the train schedules as well as the fare offers and price conditions. Customers shall additionally be able to enquire about train and seat availability.

Payment

The online ticket selling web site shall rely on a Payment Service Provider (PSP), which shall be the National Payment Gateway, to acquire payment transactions through the web site. For this, the following mechanism shall be implemented:

- The customer chooses the tickets he wants to purchase and confirms the selection.

- The customer is directed to the payment gateway website to carry out the payment process.

- Upon confirmation of the payment by the payment service provider, he is directed back to the online ticket selling web site.

- The payment gateway server informs the online ticket selling server about the payment process.

The online product selling server shall not save or forward credit/debit card data (this would require compliancy to the PCI standards).

A transaction receipt shall be shown to the customer and sent by eMail. The transaction details shall be included (e.g. ticket price, the date of the transaction, etc.).

Distribution

The web site shall generate and distribute tickets that can be printed at home / office by the customer.

Enrolment

The web site may optionally offer the possibility for the customer to set up an account with SLR. This would allow him/her to:

- Assign log-in/password to a customer.

- Store personal information (e.g. current active concession cards).

- Store history of purchased products.

- Improve the user-experience (e.g. personal preference configuration, one-click payment if supported by PSP).

Reservation

The web site shall allow seats to be reserved. When booking a seat for Long Distance journeys the web site shall display the available seats in a graphical way; the passenger should then be able to select his seat based a graphical display of the carriages.

The reservation should be performed, at least, based on the following parameters.

- Departure station;

- Destination station;

- Single ride or return trip;

- Journey date(s) and time(s);

- Train preference(s): 1st or 2nd class, seat preferences (e.g. near window, near corridor, observation car etc.);

The web site shall allow the pre-reservation of tickets to allow concurrent reservations by different customers from the selection of the journey until the payment is confirmed. The related seats shall be pre-reserved to lock out other customers from reserving the same seats. A time-out mechanism shall be implemented so that a pre-reserved seat or berth, is released if the payment has not been confirmed after a certain period.

Cancelling the purchasing process by the customer shall also release the pre-reserved tickets.

Additionally, the web site shall allow reservation of vehicle carriage and multiple ticket for groups (known as group booking).

Penalty fare collection

The web site shall allow a passenger to pay a fine that he/she may have had imposed during an unauthorized journey. For this, the following synoptic shall be implemented:

- The passenger enters the identifier printed on the penalty notice (e.g. list of digits).
- The web site retrieves the penalty details from the ticketing back-office system.
- The passenger carries out the payment process has described in section 0.

Non-Functional requirements

Modularity
The online product selling web site shall be as independent as possible from the ticketing back-office system. In such way, that these two systems may be upgraded separately.

Scalability
The online product selling web site will be heavily exposed to web traffic; a growth in passenger traffic will lead to a significant growth of the web site usage.

As for the ticketing system, the online product selling web site shall be designed to operate in a cluster mode, so that it can scale horizontally. In such way, that increasing the web site capacity should be achieved by adding hardware.

Availability
The ticketing system shall have a suitable level of redundancy, to meet a minimum of 99.8% availability.

Security
The tickets that are distributed by the web site shall include a digital signature to certify the authenticity of the issuer and the integrity of the data. For this, the server will need to host a key pair to generate this signature.

Details regarding ticket security are provided in the security section of this document.

Future Proofing
The web site application shall be designed according to the n-tier architecture approach, whereby the business logic layer is separated from the presentation layer. In such way that the application could be updated easily to support future browser types (e.g. mobile, tablet) and Internet client-side application.

The web site shall also rely on standardized protocol to allow a better interoperability with future browsers. For instance, HTML-based technology should be preferred to Adobe Flash-based technology.

Supported Languages
The web site shall be available in English, Tamil and Singhalese.

Portability
The web site shall be accessible on PC browser, tablet and smartphone. A dedicated and optimized version shall exist for smartphone browser. This version shall ensure a convenient user-experience for users accessing the web site from a mobile browser.

Mobile Phone Application System Requirements

System overview

The mobile application will provide an optimized interface to the online product website. It will allow the distribution of the same products and cover the same features, with the following differences:

- The mobile application will use a different and optimized format for the tickets and vouchers, as described later in this document

- Penalty fare collection will not be supported.

This section provides specifications of the mobile phone application system. These specifications are supplemented by the description of the distribution channels provided in later in this document. The diagram below shows the interaction of the mobile phone application with the customers, the SLR administrators, the back-office ticketing system and the PSP gateway.
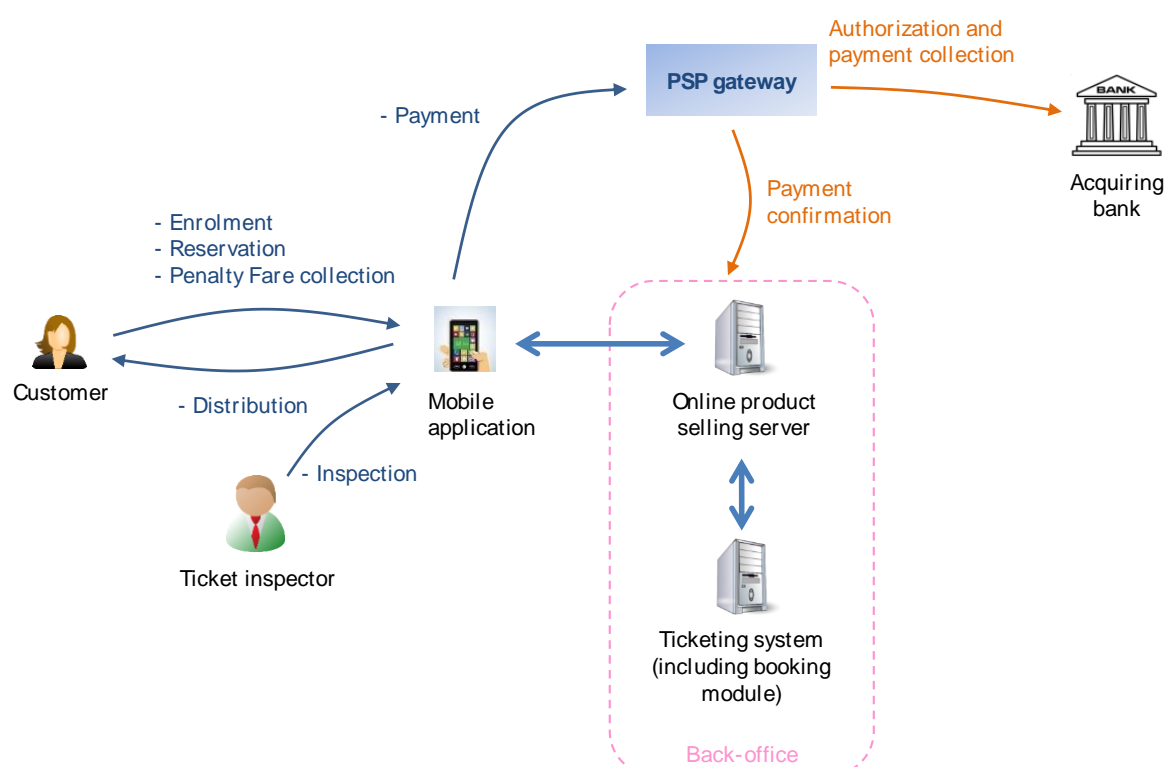
Mobile phone application system data flow

User Scenarios

The mobile application shall support two main scenarios: enrolment and ticket selection. Firstly, the customer downloads the application from the appropriate application repository. Upon the first execution of the application, the user may be requested to enrol to the service. During this process, the user creates credentials and the user account is generated.

As for the online product selling web site, the customer will be allowed to browse through the available tickets. Subsequently to selecting a ticket, the user will be taken through the payment process and the purchased ticket will be added to the ticket wallet. The ticketing supplier may decide to implement "1-click" payment to ease the payment process.

The ticket will be distributed in the form of an m-ticket (i.e. mobile ticket) comprising of bar-codes and alphanumeric text. Mobile tickets will be inspected on-board by the SLR inspection staff.

Functional requirements
This section details the functional requirements that shall/may be implemented.

Application download
The application shall be available from the appropriate public application repositories (e.g. Apple "Appstore" or Google "Playstore").

Enrollment
As for online product selling website, the mobile application may optionally offer the possibility for the customer to enroll to the service, as described previously

Ticket selection
The user shall have access to the list of the Commuter and Long Distance tickets available for purchase. The user shall also have access to the specific fares that he/she is entitled, depending on his/her profile.

Reservation
As for the online ticket selling web site, the mobile application shall allow seats to be reserved.

Payment
The mobile phone application shall support payment acquisition through a PSP, in this case it will be the National Payment Gateway. As for the online ticket selling server the PSP will be implemented in such way that the payment details are not stored or forwarded by the SLR ticketing system.

To offer a better user-experience the PSP may support "one-click" payment, so that the users will only enter the credit/debit card details once. During the first purchase, the credit/debit card details will be stored by the PSP. All the subsequent payments will simply require the credit/debit card to be selected from the application.

After any successful payment, a transaction receipt shall be sent to the customer by email showing the transaction details (ticket price, the date of the transaction, etc.).

Inspection
The passenger will show the mobile ticket - in the form of bar-code – to the inspector.

Non-Functional requirements.

Security
The tickets that are distributed by the mobile application shall include a digital signature to certify the authenticity of the issuer and the integrity of the data. For this, the server will need to host a key pair to generate this signature.

Additionally, the mobile applications and the online product selling server will exchange credential data, which are sensitive data. For this, HTTPS shall be used to secure the communication. This requires a key pair to be generated and a certificate to be ordered from a public certification authority (e.g. Thawte, Symantec, etc).

Future Proofing

New mobile phone OS shall be introduced easily.

For instance, the communication between the mobile applications and the online ticket selling server shall rely on standardized protocol to allow a better interoperability with future mobile phone OS.

Supported languages

The mobile application shall be available in English, Tamil and Singhalese.

Buying a Ticket

Introduction

This section describes the distribution channels of the new ticketing system and covers the main requirements applicable to the front-office equipment to describe how a passenger will buy a ticket in the new system.

This section focuses on describing the different distribution channels, and the ticket types that will be sold through these channels, the services that will be offered to the customers based on the number and types of front-office equipment required SLR.

The following tasks were addressed in completing this section:

1. Decide features of Ticket Issuance consoles and the Operating requirements and agree with users on templates of user interfaces.
2. Decide the requirement and the design of the ticketing counters at Railway Stations. It need to be noted that, reduction of Ticketing Counters and Station Staff are not the intentions of implementing the system.
3. Survey and study the speed of manual ticket issuance and decide the demanded speed and the system required for meeting such demand.
4. Consider parcel and goods transportation by train and the Ticketing Solution shall facilitate this operation.
5. At present, SLR is utilizing only one delivery channel for daily and season tickets and that is the manually issued paper ticket from the Station Ticketing Counter. However, possibility of making all other delivery channels, such as Ticket Vending Machines, Smart Card, Kiosk, Online, Mobile Ticketing etc., shall be considered.
6. Study the existing Seat Reservation system and identify whether there are differences   between user requirements and system features. Identify whether it is effective for SLR to continue with the system. Propose a methodology to continue such operators with the new system.
7. Consider the improved level of availability by introducing delivery channels such as Ticketing Counter, Kiosk, Online, Call Center etc.
8. Meet the current service provider for seat reservation and study the system of them. Identify the advantages and disadvantages of the system.
9. Carry out small scale Preference Survey (if necessary) to identify the passenger preferences about delivery channels etc.
10. [New] Cancellations and Refunds of tickets, typically from reservation system for long distance journeys
11. [New] Approach to discounting of tickets
12. Study and propose the way of using transport Smart Card for railway travel. Study other smart cards that have been implemented and that are planning to be implemented when proposing the card technology for Railway system.
13. Cards for single, multiple trips and cards for periodical (Season Tickets) use shall be made available with the new system.
14. The consultant shall study the existing manual Warrant Processing System and consider the   ways and means of automating that function and incorporating that into the new system.
15. The consultant shall study and propose about how the Smart Card can be used for all daily and season ticket types and for different classes

Description of Ticket Types

Fare Policy Supported.

Passenger fares were revised upward with effect from 01 June 2008, caused by fuel price increases. Passenger fares were then adjusted downward in line with the fuel price decreases with effect from 1st December 2008. In this fare revision, the number of zones were increased from four to five zones.

No revision of fares was made during the year under review (2016). Under this scheme of fare revision, fares of ordinary tickets are made available between any two stations and charged as shown below.

From any station / to any station	Charge per Kilometre (Rs)		
	1 class	2 class	3 class
1 Zone : 00 Km – 10 Km 2 Zone : 11 Km – 50 Km 3 Zone : 51 Km – 100 Km 4 Zone : 101Km - 200 Km 5 Zone : 201 and above	3.60 3.30 2.80 2.10 1.60	2.00 1.60 1.50 1.20 0.90	1.10 1.00 0.85 0.65 0.50

Any fraction of rupee is rounded up to nearest rupee.

The General Manager of Railway is empowered in deciding the passenger fares for Inter-City and value added train services under the following conditions.
The fares decided on should not be below existing normal passenger fares,
Fares so decided should be competitive with the existing passenger fares of the passenger transport market and could be able to draw the maximum revenue to the railway.

Ticket without reservation (Single or Return)

A Ticket without reservation is not related to a specific seat. Two types of non-reservation ticket shall be available: open ticket and non-exchangeable ticket.

Open ticket

This ticket is valid for a specific route with a given validity period. The passenger may use any train on the given route and within the validity period. This is most likely to be a Commuter journey.

An open ticket can be issued on thermal paper or as a mobile ticket.

The Ticket data shall comprise: origin, destination, class, date for end validity of the ticket

Non-exchangeable ticket

This ticket is valid for a specific train number and a specific date. This is most likely to be a Long Distance journey

A Non-exchangeable ticket can be issued on thermal paper or as a mobile ticket

The ticket data shall comprise the following information: origin, destination, class, train number, train departure date and time.

Ticket with reservation (Single or Return)

This ticket is valid for a specific train number, a specific seat and on a specific date. This is most likely to be a Long Distance journey.

A Ticket with reservation can be issued on thermal paper or as a mobile ticket

The Ticket data shall comprise: origin, destination, class, train number, date of use, seat number, coach number, etc.

Season ticket

Multiple form of the season ticket exist:

- Weekly pass

- Monthly pass:

- Annual Pass

All of which provide unlimited travel between two named stations for the specific time.

These tickets have no reservation and can be purchased on Long Distance and Commuter journeys.

A season ticket can be issued on a smart card or as a mobile ticket.

The Ticket data shall comprise: origin, destination, class, train number, date of use, seat number, coach number, etc.

Staff Pass / Warrant

A staff pass is provided for all SLR staff to use the rail network free of charge. A travel Warrant is issued for government staff when they need to travel on official business.

The Staff pass is like a season ticket in that it has a period of validity but is available for all stations.

A Travel Warrant is for a specific trip, which could be a Long Distance or a Commuter journey. It also may be associated with a reservation.

Both the Staff Pass and a Travel Warrant will be issued on a smart card. This can also be reused by being reloaded with new tickets.

The Ticket data shall comprise: origin, destination, class, train number, date of use, seat number, coach number, etc.

Pay-As-You-Go (PAYG)

The pay as you go ticket is one which stored value is loaded onto a smart card. The value for the journey is usually deducted at the end of the journey, as in the Netherlands on the NS rail network.

This is issued on a smart card only and needs to be frequently toped-up with stored value over time.

The data about the journey shall be retained on the card, but also transmitted to the Central System. This data will include, origin, destination, class, date of use, value of journey etc.

Refunds and Amendments

A customer may request to have his/her journey refunded or amended, provided that this is permitted by the fare conditions.

The refund process is the following:

- The customers hand over the ticket(s).

- The STO staff provide the customer with the amount of money due. The same payments method should be used for the initial purchase and the reimbursement. (i.e. card/cash etc)

- If the ticket(s) is/are associated with reservation(s), the related reservation(s) is/are released.

- If an amendment is required, e.g. a change in travel date, the ticket will be exchanged for a new ticket and any additional payment requested

Description of the distribution channels

The SLR Station Ticket Offices (STO) and the reservation call centre are the two distribution channels available in the existing ticketing system. Complementing them will be four new distribution channels to be implemented in the new ticketing system.

- Ticket vending machines (TVM)
- Internet sales,
- Mobile application and
- From a light STO at a 3rd party location.

Through these 6 distribution channels, passengers will be offered convenient ways to purchase fare products. The following table provides the different fare products that will be distributed for each distribution channel and the related fare media.

Ticket Type	Station Ticket Office (STO)		Ticket Vending Machine (TVM)		Mobile		Web		Call Centre		3rd Party Agents/Kiosk	
Journey Type	C	LD	C	LD	C	LD	C	LD	C	LD	C	LD
Single	✓	✓	✓	✓	✓	✓		✓		✓		
Return	✓	✓	✓	✓	✓	✓		✓		✓		
Season (week, month)	✓	✓	Top up	Top up	Top up	Top up	✓	✓	✓	✓	Top up	Top up
Staff / Warrant	✓	✓					✓	✓				
Pay-As-You-Go	✓	✓	Top up	Top up	Top up	Top up	Top up	Top up			Top up	Top up
Payment Method	Cash Card	Cash Card	Card	Card	Card	Card	Card	Card	Cash Card	Cash Card	Cash Card	Cash Card

Station Ticket Office (STO)

Description

The SLR STOs are located at all SLR stations. The STO will likely remain one of the most important channel for ticket sales and will be a point of interaction where SLR customers can benefit from the largest range of services for ticket reservation and purchase.

The STO will ensure sales of Commuter and Long Distance tickets and will remain the only distribution channel for smart cards and Staff / Warrant cards.

Both cash and credit/debit card payments will be allowed at the STO. Each STO will be connected to the payment gateway for payment authorization requests and to upload collected transactions.

The STO equipment will be composed of, at least, a workstation with a stand-alone application connected to the back-office ticketing system, a printer, a cash register and a payment terminal. Further details are given later in this document when describing the STO equipment.

The STO, as distribution channel, will be able to provide numerous services: ticket selling, ticket distribution, ticket reimbursement, ticket exchange and compensation.

All tickets will be available for sales through the SLR STO equipment. These tickets are the following:

- Open and non-exchangeable Tickets without reservation (single, return)
- Open and non-exchangeable Tickets with reservation (single, return,)
- Season ticket
- PAYG
- Staff Pass / Warrant

Tickets with and without reservation will be printed on POS thermal paper ticket.
Season tickets and Staff tickets will be provided on smart cards. These will be re-usable.

Open ticket
The purchasing summary for an open ticket is the following:

- The customer informs the STO staff about the journey's details. This may include the departure station, destination station, journey date and time, etc. Additionally, he may inform the STO staff about his personal status that entitles him to discount prices (e.g. age).
- The customer is informed about the ticket price and the applicable conditions.
- The customer carries out the payment process. For this, he may either use his/her debit/credit card or cash.
- The journey details are printed onto a POS thermal paper ticket. The ticket is then distributed to the customer. A payment receipt is also given to the customer.

Non-exchangeable ticket
The process to purchase a non-exchangeable ticket is very similar to the open ticket.

- The customer informs the STO staff about the journey details. This may include the departure station, destination station, journey date and time, etc. Additionally, he may inform the STO staff about his personal status that entitles him/her to discount prices (e.g. age).
- The customer is informed about the ticket price, the applicable conditions and the train's details (e.g. time, train number).
- The customer carries out the payment process. For this, he may either use his debit/credit card or cash.

- The journey details are printed onto a POS thermal paper ticket. The ticket is then distributed to the customer. A payment receipt is also given to the customer.

Ticket with reservation

Purchasing a ticket with a seat reservation requires the following steps:

- The customer informs the STO staff about the journey details. This includes the departure station, destination station, journey date and time, single and return trips, etc. Additionally, he may inform the POS agent about his personal status that entitles him to discount prices (e.g. age).

- The customer is informed about the ticket price.

- The available train(s) and seat(s)/(s) (1st or 2nd class, etc.) are proposed to the customer.

- Upon selection of a journey by the customer, the seat(s) is/are pre-reserved, waiting for the purchasing process to complete.

- The customer carries out the payment process. For this, he may either use his debit/credit card or cash.

- If the payment process is completed successfully, the ticket(s) is/are printed onto a POS thermal paper ticket.

Sale of PAYG

The SLR STO will distribute PAYG cards. PAYG cards will be provided on a zonal basis. The requirement will be that PAYG cards will be used for travel across the whole SLR network. However, different cards will be provided for different zones in the country and will require a different minimum balance to be kept on the card based on the distance travelled.

- The customer request to purchase a PAYG card. If he is entitled to a discount, he shows to the STO staff the official document proving his entitlement (e.g. age, student. etc.).

- The customer identifies the locations he will travel to/from regularly so the appropriate card can be issued together with the class of travel required

- Based on this information the card will be loaded with a minimum amount of value as determined by the fare structure

- A deposit will also be charged for the card

- The cards is re-usable and can be re-loaded with another season ticket in the future

- Using his debit/credit card or cash, the customer purchases the card.

- The smart card is issued with the appropriate PAYG value installed.

Prior to the distribution, it may be decided by SLR to enrol the passenger so that the passenger's details are stored in the ticketing back-office. However, this should not be compulsory. If a passenger has his details registered he will be able to recover any value if the card is lost or stolen. For an unregistered card there will be no possibility for the passenger to recover any stored value.

Sale of season tickets

Currently season tickets are available in weekly, monthly and annual versions. The process for issuing a season ticket is similar to that for a PAYG card as season tickets will also be issued on smart cards.

- The customer requests a season ticket. If he is entitled to a discount, he shows to the STO staff the official document proving his entitlement (e.g. age, student. etc.).

- The customer identifies the locations he will travel to/from and the class of travel required.

- Based on this information the card will be loaded with a season ticket valid for either a week, a month or 12 months validity

- It shall be possible to generate additional validity periods easily within the Central System

- A deposit will also be charged for the card

- The cards is re-usable and can be re-loaded with another season ticket in the future

- Using his debit/credit card or cash, the customer purchases the card.

- The smart card is issued with the appropriate season ticket installed.

Prior to issuing the card the passengers details will be recorded in the Central System. This will speed up future renewals and enable a replacement season ticket to be issued in the case of lost or stolen cards.

Staff Passes /Warrant Cards

The staff pass and travel warrant will also be issued on a smart card.

The process will be the same as is currently in place and requests will be made internally from SLR for a Staff Pass.

This will be issued as a 1st class season ticket with 12-month validity across the whole network. This can be renewed annually, or cancelled if the member of staff no-longer works for SLR.

Warrant cards can be issued as return journeys in the same way as return tickets, but fulfilled on a smart card.

Ticket Vending Machines (TVM)

Not all tickets will be available for sales through the TVM equipment. The tickets available will be the following:

- Tickets without reservation (single, return)

- Tickets with reservation (single, return)

- Season ticket – top-up or renew only

- PAYG – top-up only

Tickets will be printed on POS thermal paper ticket.

TVMs will be installed at busy commuter stations and local offices and public areas to provide additional outlets for ticket sales. This will reduce the pressure on the STO and

make ticket buying easier for passengers. The full range of long distance and commuter tickets will be available. However, it will not be possible to reserve seats using a TVM.

Another way to reduce the need to queue at ticket office windows is to provide the functionality for passengers to renew season tickets at TVMs and top-up PAYG cards. The TVM will accept card only payments.

The process for purchasing a ticket will be as follows:

- The passenger will use the TVM interface to select the following:
  - Destination
  - Type of ticket – adult / child
  - Single or return
  - Class of ticket - 1st, 2nd or 3rd
  - Tickets issued will only be for valid the day of purchase
- Once complete the passenger will enter his debit/credit card and pay for the ticket
- Tickets will be printed on thermal paper
- Receipt issued

For renewing a season ticket the process will be:

- The passenger selects season ticket renewal from the menu
- Places smart card on the card reader
- Ticket on card is read
- TVM asks if this is to be renewed
- Duration of ticket is entered
- Request for payment
- Debit / credit card entered
- Receipt issued

Similarly, for a PAYG top-up the process will be:

- The passenger selects PAYG top-up from the menu
- Places smart card on the card reader
- Stored value on the card is read
- TVM asks if this is to be topped-up
- Amount to be added is entered
- Request for payment
- Debit / credit card entered
- Receipt issued

Online ticket purchase via the internet

Description
The online product selling web site will allow the distribution of home-printed tickets for Long Distance travel. It will also allow for the renewal of season tickets and for Staff Passes/ Travel Warrants.

The web site shall be available on PC browser as well as on mobile browser. The web site shall be optimized for mobile browsers.

Payments will only be allowed by card

Sale of tickets
Home-printed ticket will be printed by the customers using A4 sheets of paper. For domestic use only, home-printed ticket will be accepted in an electronic format (i.e. kept in an eMail ready to be shown to the customer).

Home-printed tickets are issued as personal tickets and are not transferable. They will be distributed with and without reservation.

Open ticket
Home-printed ticket will be available for open tickets and will be only available for trains departing on the same day as the ticket purchase.

The purchase of home-printed ticket for open tickets will be straightforward:

- The customer accesses the web site through a PC or a mobile phone Web browser.

- The customer inputs the journey's details: this includes the departure station, destination station, journey date(s) and time(s), single and return trips, number of passengers, personal status that entitles him/he to a discount (e.g. age) that he may have, etc.

- The customer is informed about the ticket price.

- The customer carries out the purchasing process. For this, he enters his debit/credit details through the PSP web site.

- The online product selling web site is informed about the transaction result. If the transaction is correctly processed than the ticket is displayed and sent by eMail to the customer.

Non-exchangeable ticket
Home-printed ticket will also be available for non-exchangeable tickets.

The ticket purchase process will be very similar to the purchase of open ticket. The difference will be that the customer will be informed about the train's details (i.e. the departure date and train number).

With reservation
Local tickets will be available from the online product selling server, with reservation. The purchasing process will require extra steps to allow the reservation of seats(s):

- The customer accesses the web site through a PC or a mobile phone Web browser.

- The customer inputs the journey's details: this includes the departure station, destination station, journey date(s) and time(s), single and return trips, number of passengers, personal status that entitles him to a discount (e.g. age), that he may have, etc.

- The customer is informed about the ticket price along with the available train(s) and seat(s). (1st or 2nd class, corridor seat, etc.).

- Upon selection of a journey by the customer, the seat(s) is/are pre-reserved, waiting for the purchasing process to complete.

- The customer carries out the purchasing process. For this, he enters his debit/credit details through the PSP web site.

- The online product selling web site is informed about the transaction result. If the transaction is correctly processed than the ticket is displayed and sent by eMail to the customer. If the transactions fails, the pre-reserved journey(s) is/are released.

- The customer may decide to print the ticket.

Online ticket purchase via a mobile application

Description
The mobile application will provide an optimized interface to the online product selling server. The mobile application will use a different and optimized format for the tickets.

Using a Ticket

Overview

1. The Railway Stations in SLR are not fully closed, enabling passengers entering station platforms from different directions. The proposed solution shall address this situation. However, the system shall have provisions for interfacing Electronically Controlled Gates with it.

Once a ticket has been issued it will be used by a passenger. This section describes the requirements for using a ticket.

The ticket validation equipment shall include the following.

- Gates
- Validators
- Hand Held Devices (HHD)

Gates

Gates shall be installed at the major stations, and potentially neighboring stations, to enforce the requirement that all passengers must have a ticket to enter the network.

The gates shall be equipped with smart card readers and bar code readers so they are able to read 2-D bar codes on mobile and printed on POS thermal paper.

Passengers will present their tickets to the reader on entry and exit from the system.

The location and number of gates needs to be determined with the vendor to enable flows through the stations to be maintained and not to cause congestion at peak times.

Validators

Validators will be installed at stations with smaller numbers of passengers where it is not cost effective to use gates.

The validators will be able to read smart cards and 2-D bar codes on mobiles and printed on POS thermal paper.

The location and number of validators needs to be determined in discussion with the vendor.

Hand Held Devices (HHD)

These devices will be provided to ticket inspectors who can use them to validate tickets on-board the train and to sell tickets if required.

The HHD will have smart card reader and a bar code reader in-built.

Telecommunications

Overview

This chapter describes the current telecommunication facilities in Sri Lanka and its expansion plan. The usage of internet and mobile phone in Sri Lanka will be discussed here.

1. Identify the Data Telecommunication requirements of the Ticketing and Seat Reservation Network and explore the possibilities of fulfilling them in the current scenario, but with a view of having the telecommunication facilities available in SLR in the future. It should be noted that the Railway Telecommunication System is being designed, at present, by a consultant recruited for that purpose. Therefore, it may be necessary that a short-term solution be proposed for the Ticketing Telecommunication network until the railway telecommunication system be implemented.
2. The telecommunication requirements (bandwidths) at different levels (i.e. station level, server level, etc.) of the Ticketing and Seat Reservation Network shall be estimated and shall be given separately.
3. Examine all existing Radio and Optical Fiber Telecommunication System infrastructure, Operational facilities (at Railway Stations), available bandwidths etc.
4. Examine and evaluate that Data Telecommunication requirement can be obtained from Telecommunication Service providers, consider the current and future market trends, carry out financial evaluation to decide the best practical and economically viable network.
5. Consult Telecommunication Regulatory Commission of Sri Lanka (TRCSL) (if necessary).

Current Telecommunication System

The current telecommunication system in the Sri Lanka Railway is consists of cable-based systems and analog VHF/UHF radio systems. The summary of the existing system is given in the table below.

This system is varying from railway line to line. It is not adequate to cater the requirement of the current day to day operations in Sri Lanka Railways.

The existing telecommunication system does not provide an interconnected network between stations or central control system. This cannot be used in a e-ticketing system which needs to communicate with a central server and/or clustered servers.

	Line	From	To	Telecommunication		General
				Train Dispatching	Maintenance	
1	Coastal	Maradana	Matara	OFC based ATM system (Wenzel)		Public Telephones
2	Main	Maradana	Rambukkana	Copper cable-based system Station call type	Copper cable-based system Generator ringing code type	
		Rambukkana	Badulla	UHF/VHF Radio Communication		
3	Puttalam	Ragama	Negambo	Copper cable-based system Station call type	Copper cable-based system Generator ringing code type	
		Negambo	Puttalam	UHF/VHF Radio Communication		
4	Kelani valley	Colombo	Avissawella	Public Telephones		
5	Matale	Peradeniya	Matale	UHF/VHF Radio Communication		
6	Northern	Polgahawela	Maho			
		Maho	Anuradhapura			
		Anuradhapura	Kankesanturai	OFC base System + Radio Communication		
7	Talai Mannar	Medawachchiya	Talai Mannar			
8	Batticoloa	Maho	Batticoloa	Radio Communication + Public Telephones		
9	Trincomalee	Galois Junction	Trincomalee			

Source: Colombo Suburban Railway Project, Radio Telecommunication System Consultation – Final Report 2018

Proposed Railway Telecommunication System

The proposed Railway Telecommunication System is a LTE based solution which will cover the all railway stations in Sri Lanka. It can be a SLR own Communication Network (LTE Network) or outsourced to the Public Operators to provide the telecommunication network to the SLR.

A 4G or 5G based LTE communication network will provide the required telecommunication facilities to an e-ticketing system.

The proposed system may take some time to roll out all over the country. The current 2G, 3G and 4G communication networks of the public operators can be used until the SLR new communication system covers the entire country.

## Current Telecommunications Infrastructure

The current telecommunication infrastructure in the Sri Lanka Railway is not adequate to cater the requirement of the e-ticketing system. Until the proposed Railway Telecommunication System implemented, the Sri Lanka Railway should use the existing public operator telecommunication network to cater the requirements of the proposed e-ticketing system.

The next few sections will look in the current telecommunication infrastructure in Sri Lanka.

All most all the major public telecommunication operators in Sri Lanka has a good mobile broadband coverage around the country.

Current 2G, 3G and 4G coverage

The coverages of two major public operators (Mobitel and Dialog) were considered here. The coverage maps were provided by the operators.
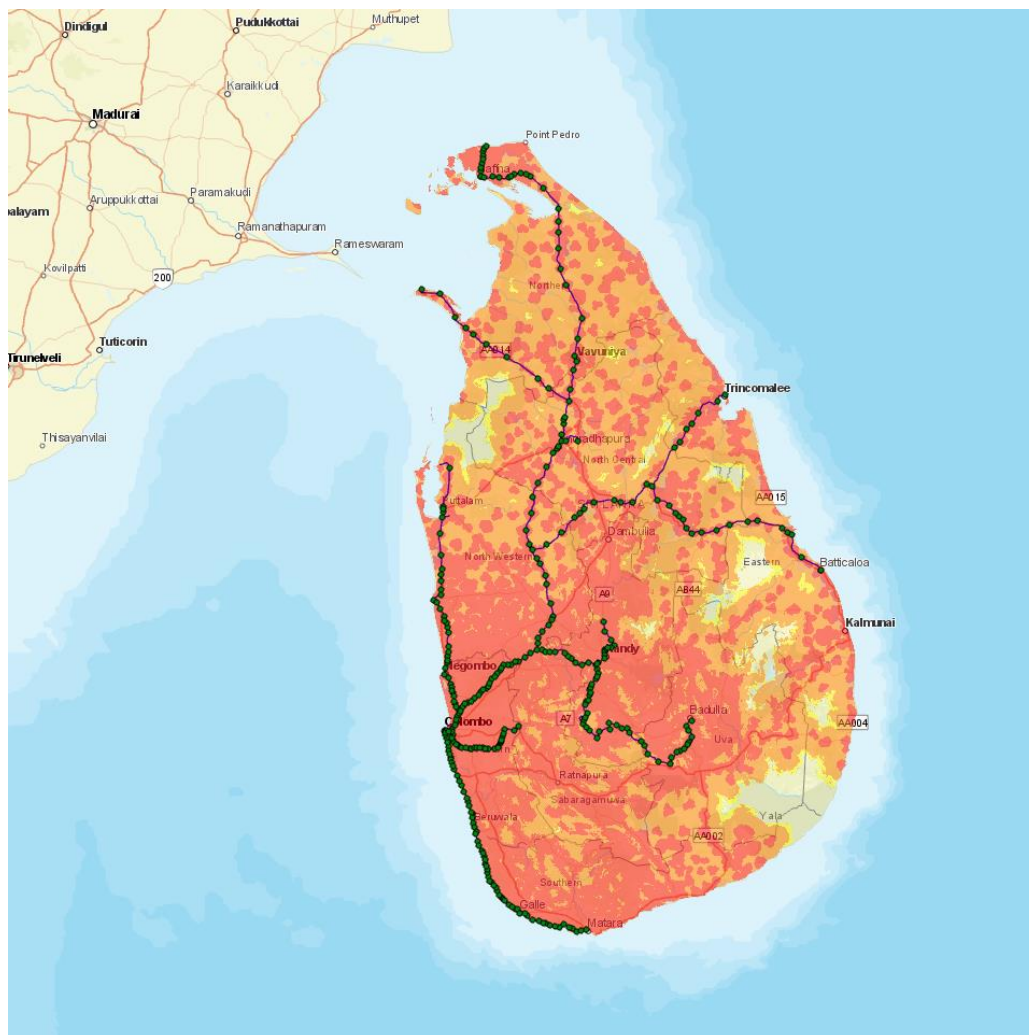
2G Coverage in Sri Lanka and Railway Stations

Based on the above coverage map more than 90% of the railway stations have the 2G coverage. When you consider the 3 G coverage it drops down to 80% as shown in the image in the next page.
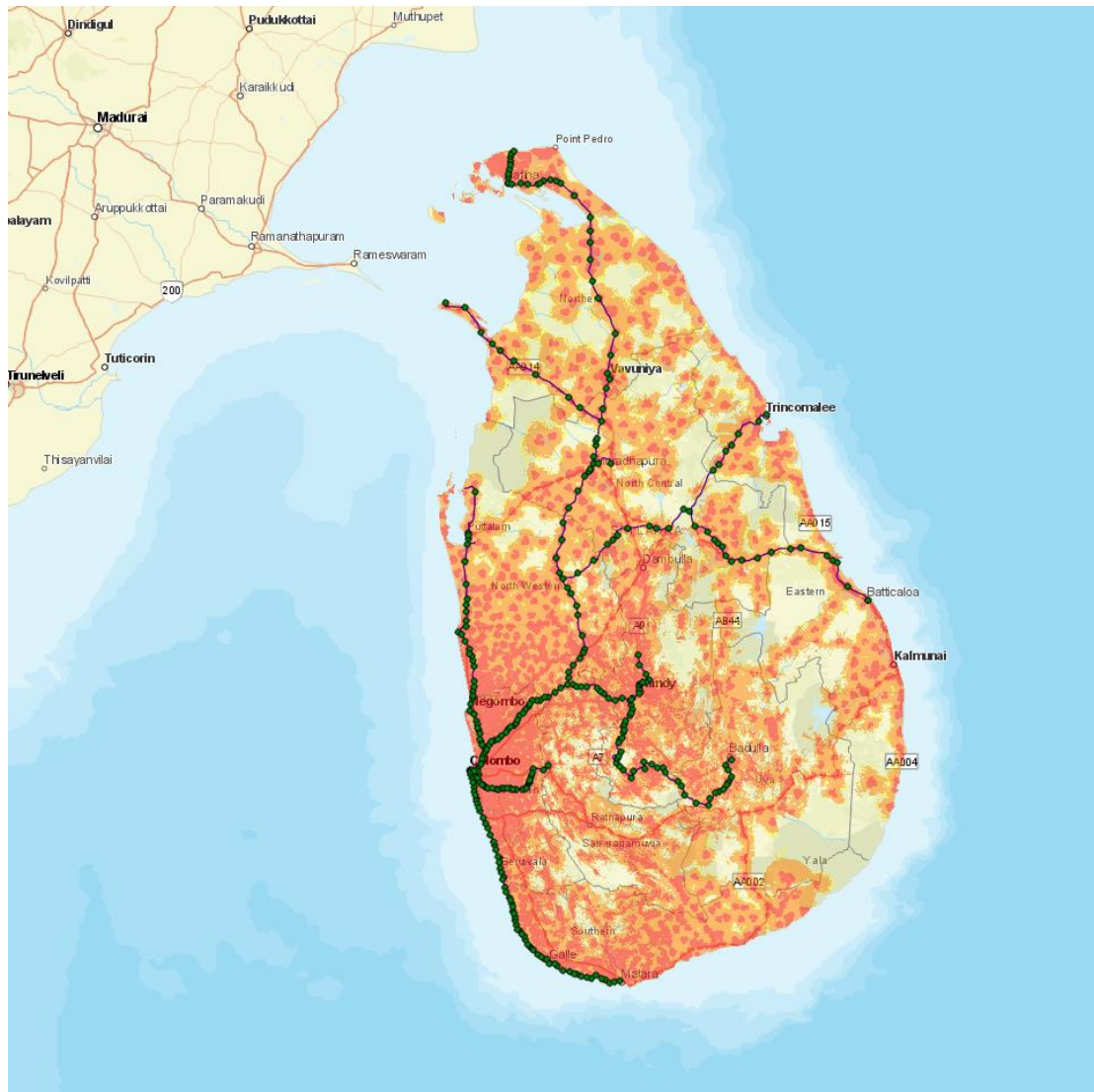
3G Coverage in Sri Lanka and Railway Stations

When it comes to the 4G coverage about 50% of the railway stations have 4G coverage. The 4G coverage map and the stations were shown in the image in the next page.

Based on the ticket sales report of 2017 of the Sri Lanka Railway there are 34 railway stations with over one million ticket sales per year. That is there only 34 stations in Sri Lanka that sells 2730 tickets or more in a single day on average. All these high-volume railway stations have 4G coverage which is depicted in the image in the next page.

There are 103 stations with sales over 200,000 tickets per year. Most these 103 railways stations have 4G coverage and all of them have the 3G coverage.

More than 90% of other stations have the 2G coverage and the transaction volumes are very less and the number of daily transactions would be very less.

4G Coverage in Sri Lanka and Railway Stations

The major public telecommunication operators also have high speed fiber optic network and it covers the most of the major stations with high volume ticket sales.
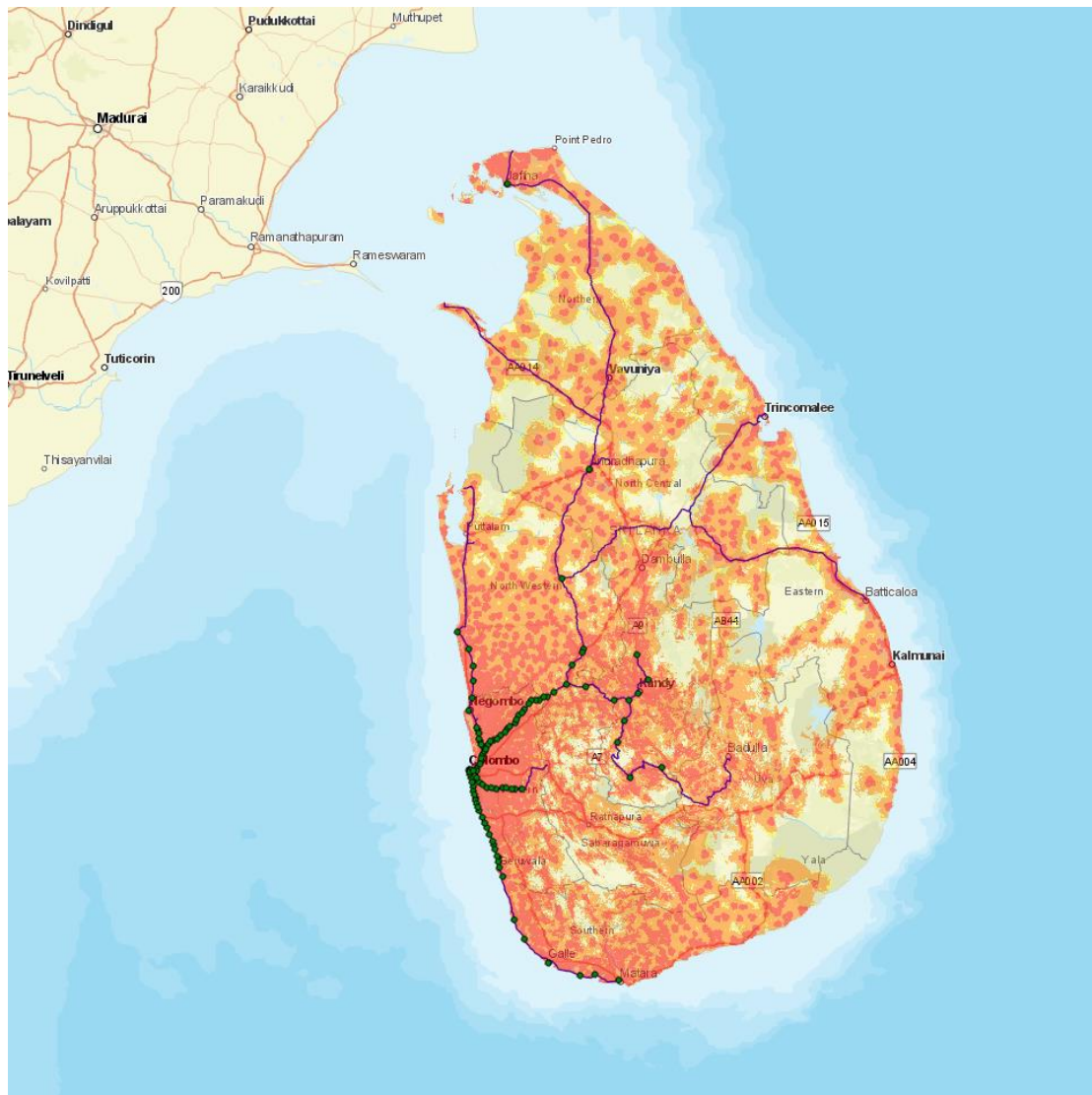
4G and 3G coverage in Railway Stations with High Volume Ticket Sales(Over 200,000 tickets per year)

Data Centers in Sri Lanka

The other major requirement comes under the telecommunication facilities is the data centers to cater the requirements of the Sri Lanka Railways e-ticketing system.

There are two TIER III Certified data centers in Sri Lanka, which provides 99.982 % availability. These two TIER III Certified data centers were operated by the Sri Lanka Telecom(SLT) and Dialog Axiata Group. They are in Pitipana, Homagama(SLT) and Malabe(Dialog).

Usage of Internet and Mobiles in Sri Lanka

For a e-ticketing solution it is vital to understand the telecommunication usage in the country. This section will look in to it, especially most of the railway commuters, who belongs to the employed population of the country.

Based on the 2017 December Statistics of the Telecommunication Regulary Commission of Sri Lanka, the mobile phone subscribers in Sri Lanka is now almost 28

million, that is nearly 130% of the population. This shows the trend in mobile phone usage in Sri Lanka.

The Fixed Broadband, Narrowband and Mobile Broadband Subscriptions in Sri Lanka is 1.21 million and 4.7 million are mobile broadband subscribers.

According the latest Computer Literacy Statistics (Computer Literracy Statistics - 2017(First Six Months) - Department of Census and Statistics) by the Department of Census and Statistics, Sri Lanka, the computer literacy in Sri Lanka is 28.3% and digital literacy is 38.7%. Although these figures are low, when it comes to the employed population in Sri Lanka, the computer literacy is 62.1%. Most of the railway commuters are employed population is Sri Lanka. The following table shows the computer literacy among the employed population of Sri Lanka.

Occupation group	Computer literacy (%)
Sri Lanka	**62.1**
Managers, Senior Officials and Legislators	73.1
Professionals	87.5
Technicians and Associate Professionals	86.8
Clerks and Clerical support workers	90.0
Services and Sales workers	57.4
Skilled Agricultura1, Forestry and Fishery workers	22.8
Craft and Related Trades workers	40.4
Plant and Machine operators and Assemblers	46.3
Elementary occupations	25.9
Armed Forces Occupations & unidentified occupations	75.4

Source: Department of Census and Statistics, 2017

In the same report, it gives the statistics on device use to connect to internet/ email in households, which shows the smarts phones are popular among them.

Gender, Sector	Desktop/ Laptop	Smartphone	Tablet computer	Mobile phone
Sri Lanka	38.1	56.9	2.1	2.9
By Sex				
Male	36.8	58.4	1.6	3.2
Female	39.8	55.0	2.7	2.5
Sector				
Urban	40.1	55.4	2.7	1.8
Rural	37.2	57.7	1.8	3.3
Estate	31.7	52.8	1.0	14.6

Source: Department of Census and Statistics, 2017

This shows most of the railway commuters are computer literal and most of them access the internet using their mobiles.

Revenue Protection and Security

> 1.0 Consider the physical and system security levels required by the system at different stages/locations.

Revenue Protection

In 2016, according to the Sri Lankan Railways Administration report, the SLR carried 136, 048,880 passengers of which 3,599,916 were found to be travelling without a ticket an additional 1,257,458 were found to be travelling in 1st Class without a 1st Class ticket.

Based on these figures it is estimated that ticketless travel is approx. 5%.

There is no information available as to the major causes of ticketless travel on SLR, but based on experiences from other countries one of the major reasons is difficulty in purchasing a ticket.

With the introduction of new sales channels this problem will be addressed as no-one should turn up to the station without a ticket.

By introducing gates it shall be possible to ensure that only passengers with a valid ticket for travel are entering the system.

Ticket inspectors shall be provided with Hand Held Devices (HHD) to check passengers tickets on-board and confirm that these tickets are valid.

Through introducing these measures, it should be possible to reduce the number of passengers travelling without a ticket in a short period of time

Security

Security mechanisms will be required for both the sale and the inspection process. Additionally, authentication and confidentiality mechanisms will be required to, respectively, authenticate the terminals to the back-office and to securely transfer the data to the back-office.

Inspection and ticket sale

During inspection, the terminal shall verify a signature included in the bar-code data. A key, present in the terminal will verify this signature. This verification shall prove:

1. that the ticket/voucher has been generated by the ticketing system (either by the online selling product server, by the mobile application server or by a handheld terminal) and
2. the integrity of the data.

When issuing a ticket, a similar signature mechanism shall be used to sign the ticket data. A key, located in the terminal, will be used to generate a signature using some ticket data. During inspection, this terminal and the other terminals will use a key to verify the signature.

The signature can be generated and verified using either public key and symmetrical key cryptography. Depending upon the system issuing the ticket different operation may be considered. The following table gives the cryptographic scheme that should/shall be used as well as the keys that need to be installed into each terminal.

The following table gives the cryptographic schemes that should be used according to ticket type.

Cryptographic scheme according to ticket type

Ticket type	cryptographic scheme
Home-printed ticket & Mobile ticket	Public-key scheme (because private key can be securely stored in the back-office)
Hand-held terminal thermal paper ticket	Public-key or Symmetrical scheme (as per the ticketing system supplier's choice)

Authentication and confidentiality

The terminal will require authenticating to the back-office server. Additionally, a confidentiality mechanism shall secure the traffic between these two systems. For this, different mechanism may be implemented. Namely, HTTPS with log-in/password, HTTPS in mutual authentication mode (this would require keys to be installed in the terminal) or applicative security protocols.

Physical Security

There is also a requirement for appropriate security to be in place when cash is being collected from the STO and other locations.

Access to the STOs shall be restricted only to staff who have a need to be in the STO.

Operations

> 1.0 Identify the service level demanded by the system and consider the ways of system maintenance to ensure the service levels.
> 2.0 Design a Service Level Agreement that can be included in the Bid Document.

KPIs and Performance Requirements

Role of KPIs and development of performance culture

Once an organisation has analysed its mission, identified all its stakeholders and defined its goals, it needs a way to measure progress towards organisational goals. Modern and sound management practice requires development of a set of indicators to assess the performance of the company and to enable benchmarking against similar businesses or lines of business. Key Performance Indicators (KPI) are quantifiable measurements, developed in advance, that reflect the critical success factors of an organisation.

Key Performance Indicators (KPI) will provide SLR with a way to measure progress against the organisational goals defined in their business plans. In consequence, KPI will need to reflect the business objectives and provide an opportunity to measure performance against the identified goals.

For simplicity, it will be critical to limit the KPI to the factors that are essential to the new AFC system.

KPIs as drivers of behaviour

Beyond driving the corporate performance, KPIs are also used as performance management tool at the operational level as they provide the staff with a clear message of what is important so that staff's attention could be focused on how to meet or exceed the KPI. The benefits of an appropriate performance management system in place for all the stakeholders in SLR, are multiple and include:

- Facilitated implementation of corporate vision and strategy;
- Establishment of accountabilities for the whole organisation;
- Provision of a common communications vehicle;
- Provision of a measurable, fair criteria for assessing performance;
- Provision of consistency in action between organisation units;
- Reinforcement of a continuous improvement culture.

KPIs as an AFC monitoring tool

The introduction of an AFC system on an outsourcing model will also require the introduction of Key Performance Indicators (KPI's) to allow SLR to monitor the effectiveness of the implementation and operation of the AFC system by the contractor(s) employed.

The responsibility for producing KPI's will lie with the contractor who will report on them monthly. The KPIs should be checked by the client-user to ensure they are correct.

Failure to reach KPIs will lead to financial penalties with persistent failure leading to stronger sanctions or ultimately termination of the contract.

Categories of KPI

The KPI's can be split into three key categories:

- Operational: provide information on the day to day operation of the system;
- Quality of service: provide information on how well the system performs;
- Financial: describe the reliability and quality of the financial information provided.

Given the size of the system the KPI's monitored need to be relevant focused and easily to verified by the client. In considering KPI's the outputs for each part of the AFC system need to be considered so that the KPI's can flow from them. Table below considers the specific outputs along the relevant KPI's.

Table 1 - KPIs for an AFC system

Metrics	Output	KPI
Operational	- Passenger numbers by route/mode/operator - Route miles covered - Passenger numbers tapping in / out - Complaints per operator - Availability of system statistics - Tracking of assets	- Reports on above by 8am following day - Availability against targets - Actual time to fix versus targets - Monthly Service Report available by day 5 of new month - Monthly reporting on Assets location and condition by day
Quality of service	- Availability of devices against targets - Ticket Medium Failure Rates - Availability/utilisation of Back Office System - Fraud Monitoring - Monthly Service Report on the System - Tracking of assets - Health and Safety Reports	- Daily outages and Failure Reporting - Time to fix reporting on whether targets are met - Monthly reports on availability of assets and back office systems - Reports on fraudulent activity and action taken - Monthly reports on assets and their location
Financial	- Daily/weekly/monthly/annual revenue reports - Revenue by route/mode/operator - Split of revenues by operator and settlement of amounts due - Revenue reports from agents and settlement of amounts due	- Daily reports by 8am following morning - Weekly reports by 8am Monday following - Monthly/Annual by day 5 of new period - Monthly settlement report with Operators/Agents by day 5 of new period

On the basis of this data, it shall be possible to create custom reports easily. These reports shall be either displayed through the web interface or written into a report file.

The visualization of the extracted data shall be possible with the use of standard charts (e.g. histogram, bar chart, pie chart, line chart).

Report files shall be generated instantly or in a periodic way. The frequency of the generation shall be configurable. The report format shall, at least, include CSV, XML, XLS and PDF.

Disaster Recovery

1.0 Consider and decide the location and features of the Disaster Recovery Center.

Failure management
It is proposed to utilise one of the three Tier 3 Data Centres in Sri Lanka provided by Sri Lanka Telecom (SLT), Dialog and Mobitel, to store the data generated by the ticketing system. This has the advantage that data will not be taken offshore and is easily accessible to SLR staff.

Part of the agreement with SLT will include a service level agreement to ensure that there is no loss of data in the event of a natural disaster or system failure. This could include a requirement to store data in a separate physical location

System migration
The existing system is fully manual. It will be discussed with the vendor as to the cost and benefits of importing all the historical data into the new system.

Costs

> 1.0 Prepare simple economic analysis including cost-benefit analysis by considering capital cost and operating costs. The consultant shall analyse whether it is economically beneficial for SLR to install and operate an electronic ticketing system and may propose the ways of   recovering the operating cost.

Currently there is limited information available regarding system costs.

It is proposed to develop the costs associated with the implementation of an AFC system over the course of the study as the final solution becomes better understood.

The final cost estimates will be included in an annex as an update to this report later in the study.