Mysore Intelligent Transport System

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Background

The city of Mysore is located about 140 km southwest of Bangalore. It has a population of about one million people. It is a historic city with a significant tourist industry. It is growing as a satellite city of Bangalore, with entities from various sectors relocating to Mysore. It is also developing as an IT hub. The city is adjudged to be well-planned and it does not suffer traffic congestion of the scale of larger cities such as Bangalore. It has a road network of about 1200 km.

Urban bus services in Mysore are provided by Mysore City Transport Division (MCTD), part of Karnataka State Road transport Corporation (KSRTC). MCTD has a fleet of about 500 buses, and operates from 4 bus depots.

The modal share of KSRTC buses in Mysore is 42.2%. Other private and mini buses constitute 10%. Two-wheelers (motorcycle) have a high modal share at 23.3%. Cars / jeep account for 16.2%.

Mysore Intelligent Transport System

A comprehensive ITS system has been implemented at the MCTD. This is a significant part of a broader strategy to increase public transport utilization. Some of the key goals were:

1) Effect a Modal Shift, viz., a switch from use of private vehicles to Public transport and thereby increase Ridership
2) Provide safe, convenient, environment and friendly service to the commuters and thereby progressively increase Commuter Satisfaction Index
3) Effective and efficient monitoring system with an appropriate operational Management Information System (MIS) for day to day operations that include planning, scheduling, utilization, monitoring /tracking in real time
4) Effective MIS system for management with information on trends, with provision for optimization through Decision Support System (DSS), and a Business Intelligence System
5) Contribute to the existing Knowledge base on effectiveness of ITS projects in resolving Traffic Congestion, bringing about Modal Shifts and reducing Green House Gases (GHG)

Picture 1: Passenger Information System – Display boards at bus shelters

In keeping with these objectives, six particular ITS features were identified for user requirements:

1) Services for customers at the bus stops and stations, including information and ticket sales
2) In-vehicle services for passengers, including announcements and other information
3) In-vehicle services for drivers, including communication with the control centre
4) Management services for Operational Managers, including access to service and violation information, incident management facilities and communications
5) Services for KSRTC Management, including reports and data for analysis

6) Services for other users, including access to incident and accident information

Prior to the ITS project, MCTD already utilized hand-held electronic ticket machines across its fleet, and had in-vehicle passenger information units on some of its buses.

A comprehensive ITS system was procured during 2011 with the expectation that initial deployment would be complete by end-2011 and the system would be in full use during 2012. In reality, the complete deployment took much longer than. There were challenges on a number of fronts, like:

- finalization of the requirements and functionality
- technical issues and stabilization of the in-vehicle hardware
- the supporting software
- set-up and configuration
- the installation processes
- achievement of a sufficient level of technical performance for full acceptance

A Conditional Operational Acceptance Certificate was issued in September 2014, which allowed a 'cure period' to resolve agreed outstanding issues and complete a program of modifications to the hardware. The full Operational Acceptance Certificate was issued from 1st October 2015.

The ITS system at MCTD was developed to provide the following applications:

- GPS-based Automatic Vehicle Location
- GSM-based data and voice communication
- Central Control Station
- Central Control Station applications
- Real-time passenger information in-vehicles, at bus stops and bus stations
- Real-time passenger information on IVRS and SMS
- Digital Signage System
- MIS reports

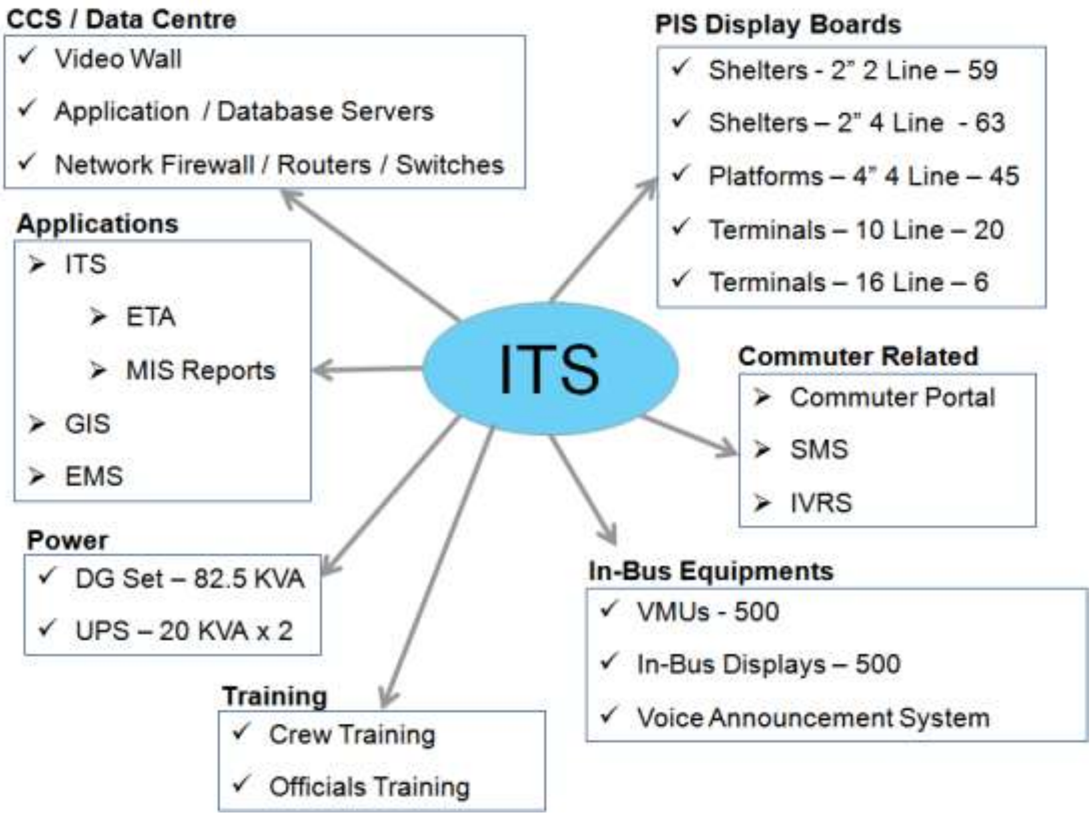


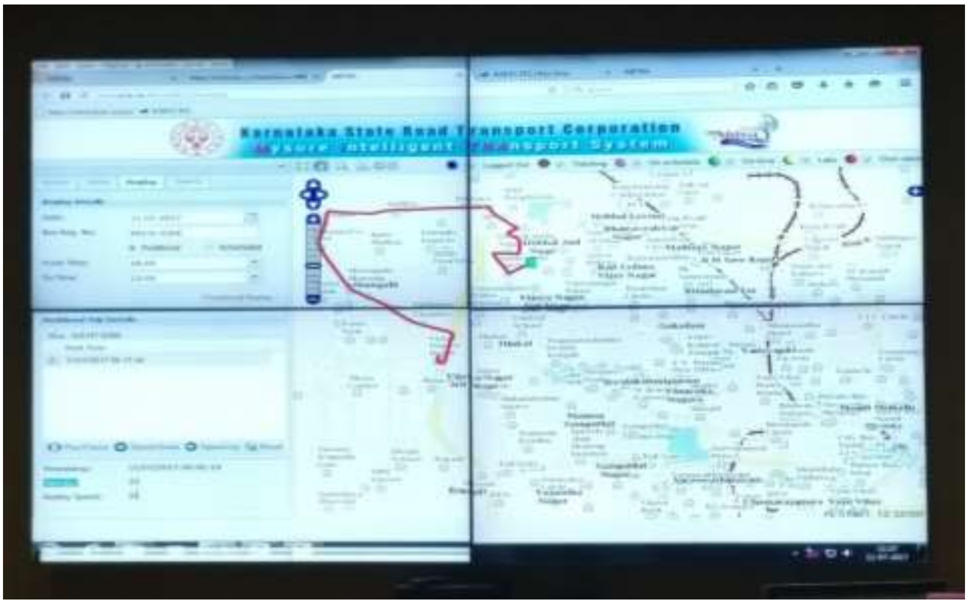
Figure 1: Overview of the ordered system

Operations and MIS reports provide reports on the service production, irregularities, performance metrics, etc. A set of following 12 reports are generated on a regular basis:

1) Driver duty performance
2) Route deviation Report
3) Improper Stoppage Report
4) Missed Trips Report
5) Harsh Acceleration / Braking Report
6) Trip Adherence Report
7) Bunching of Buses
8) Bus stops Skipped Report
9) Speed Violation Report
10) Bus Breakdown Report
11) Schedule Adherence Report
12) Depot Punctuality Report

Central Control Centre

The Central Control (CCS) is located at the Central Bus Station (CBS) and is adjacent to the departure platforms. It houses the operations management (dispatching) personnel, the operations analysis personnel, and the computer platform (servers).



Picture 2: Display wall at the Central Control Station

The CCS operates throughout MCTD service hours, in two shifts. The CCS is set up as four sets of workstations, each of which can access the real-time software utilities as well as the databases and historic data. Currently, one set is assigned to each of the four MCTD depots. In addition, there is a large-screen display on one wall. The workstations are currently configured for a mix of real-time and previous event analysis activities.

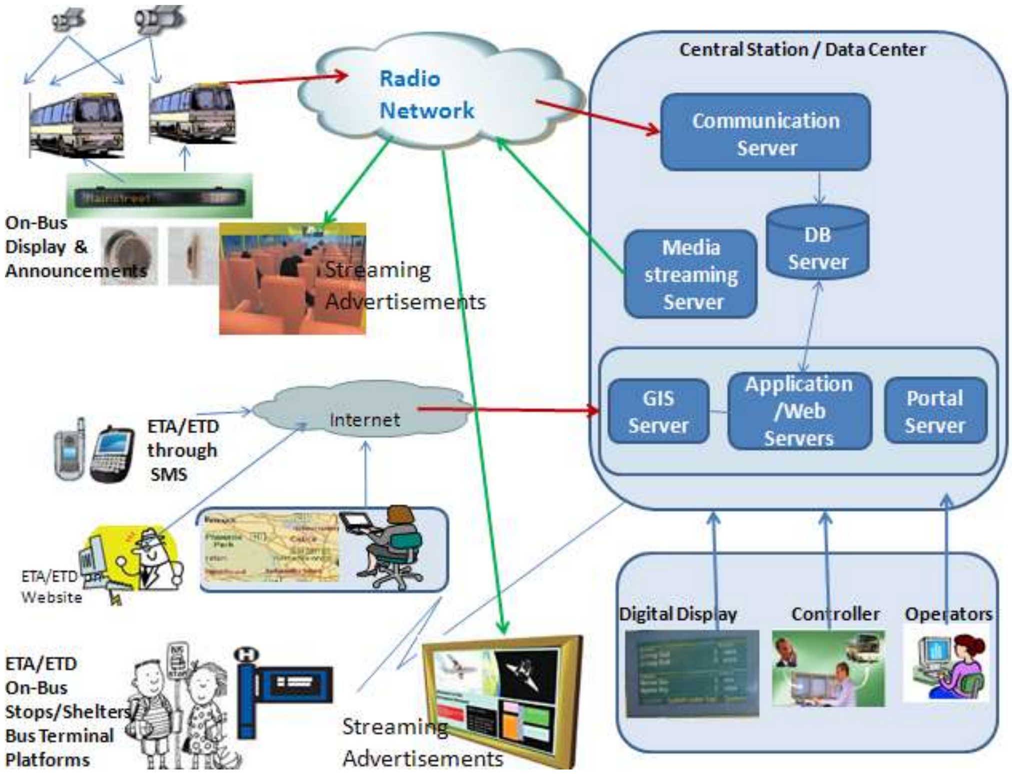


Figure 2: A general schematic of the system

Procurement process

The ITS system was acquired through a single procurement to cover all of the required ITS equipment and software, the supporting IT and communication platforms, training and a three-year maintenance period.

The Procurement, launched in June 2010, was handled through the offices of the Controller of Stores and Purchases of KSRTC. The ITS consisted of the following main elements:

- Real Time Passenger Information System
- In-Vehicle display System
- Automated Voice Announcement System
- Central Control Station
- Automatic Vehicle Location System
- Enterprise Management System
- MIS Reports
- Training

The main dimensions of the package were:

- 500 buses
- 105 bus shelters
- 6 bus terminals
- 45 platforms

Implementation process

Implementation was planned to be arranged in three phases. Following initial build phase, a two-week pilot of the equipment had to be carried out on 10 buses and one bus-stop. Any modifications were to be identified and rectified, prior to the full system roll out. However, this plan could not materialize. Ideally, the following three phases had to be followed:

Build

- Site survey
- Site survey sign-off
- System study and Review SRS
- Procurement of Hardware
- Installation and Commissioning of Hardware and Applications
- Customization of Applications

Pilot

- Installation of Vehicle Mounted Units (VMUs) and Displays
- Integration Testing of Application
- Run Pilot for one bus route
- Performance tuning
- Generate MIS reports
- Basic training – Pilot Phase

Rollout

- ITS Application configuration
- Data management

- Delivery and installation of remaining VMU and Display units
- Commissioning and testing
- Backup and restore
- System fine tuning
- Training
- User Acceptance Test

The implementation structure was as follows:

- *KSRTC* is the Project Implementation Unit (PIU)
- *MCTD* is the User of the ITS system
- *M/s eGestalt Technologies* was employed for RFP preparation
- *M/s CMC Ltd*. (now migrated to TCS) is the Supplier of the ITS system. CMC / TCS have been responsible for delivery of the system, installation of the equipment both on the buses and at the bus shelters/terminals. KSRTC supported the installation. The Supplier also provided training to the technical and maintenance staff of MCTD, who then carried out all of the wiring and installation.
- *M/s IBI Group* was the Project Management consultants. They were responsible for the planning and organization of the ITS delivery.
- *M/s ICT* was the Monitoring and Evaluation consultants
- *M/s Lumiplan* were the Comprehensive Service Operations Analysis consultants (this activity was not specifically linked to the ITS Project but has contributed to its success in indirect ways)

System Capital Cost

The Supplier tendered for the system at a price of about Rs.14.6 Crore, equivalent to about $3 million, or about $7,000 per bus. This includes all in-vehicle, display and control centre equipment and software, the IT and communications platform; training, and maintenance over a three year period. This does not include the KSRTC's costs of the project design, management and procurement; the in-house cost of installation in buses, shelters, terminals, etc.; the Project Management Consultancy; or the Monitoring and Evaluation consultancy. These additional costs have been equivalent to more than one quarter of the ITS system capital cost.

Due to substantial effort required to meet the requirements, to get the technical system to full working order, and to the additional work (e.g. additional bus stops), the Supplier estimates that it has cost them more than Rs.18 Crore. The Supplier indicates that items that drove the costs included:

- The Supplier had to put in a lot of effort to figure out exactly what the Client wanted
- There are different perspectives about "ITS" in India and elsewhere. This meant there was a big learning curve, with the costs falling on the Supplier
- It was necessary to have planning sessions for a full and common understanding of the requirements
- It was a difficult environment for the Supplier to enter
- The high variability of the bus stop locations

Thus, besides the above stated points, a first-time implementer of ITS should pay attention to the following points:

- Lack of a comprehensive and accurate list of bus stops. The actual number of bus stops turned out to be about four times more than the nominal list.

- Lack of accurate definition of the individual bus stop locations, thereby causing extensive errors in geo-fenced positions.
- Practice by drivers of stopping away from the official bus stop position, and thereby not being within the correct geo-fenced area.
- Errors in route lengths, up to 10%, thereby leading to large discrepancies between scheduled and actual kilometres operated (as per ITS). Errors had crept in over the years, the ITS distances proved to be correct.
- Driver practice of trip-cutting; other deviations that did not follow the correct route or serve all required stops.
- Driver practices of starting trips from location other than the correct start point, thereby causing trips to not open or close correctly within the ITS system
- In the initial phase when driver should manually open and close trips, failure by drivers to correctly do so, thereby leading to trips appearing to not operate
- Lack of discipline in timely updating of schedule or base data information, thereby leading to the ITS system having outdated or incorrect base data.
- Cumulative impact of these and other errors leading to buses being missing or inaccurately reporting their ETA at bus stops.
- The passenger information boards have generally proved to be very reliable, both at the CBS and at bus stops. The principal issues arising have related to the supply of electricity and to theft of items such as the UPS, rather than with the units themselves. ETA has generally proved satisfactory, especially when data integrity and operational discipline issues were overcome.
- The VMU (the in-bus units) has been the one area of ongoing technical difficulty. This is rather crucial to the overall system performance as it generates the vehicle location and transmits it to the central system in real-time. Missing or defective data has serious impacts on ETA, operations management, MIS reporting, and downstream use of the data for planning purposes. Further, the VMU hosts the data files for the in-vehicle displays and stop announcement system, and these have also been impacted from time to time.

Four particular points about the VMUs are worth noting, as they can offer useful cautions to future designers and implementers of ITS system:

1) The problems manifested themselves as failures, malfunctions, software errors, and data loss and corruption. These were initially attributed to the VMU itself. However, over time it became evident that the root cause lay in the power supply and power protection. Surges, spikes, transience and drops in the power supply caused a wide range of problems. These ranged from physical damage to the circuitry through to apparent software glitches, resets and data corruption. This highlights the importance of conducting root cause analysis and of having expertise available rather than just monitor failure types (symptoms).
2) The power supply issue stemmed from not having designed the VMUs from the outset to cope with the erratic power supply issues experienced on buses. This can include the need for assisted-start if the bus battery is low or flat.
3) The power supply unit (which is separate to the VMU) was redesigned to give greater protection. This involved a modification that was deployed fleetwide. While reasonably successful, the fuse was integrated in the power card, located within the power supply unit. This led to two problems. First, damage can still be done to the power supply unit, especially to the power card itself which on a number of cases has been burned out and rendered unusable. Second, replacement of the fuse requires removal of the power supply unit, dismantling it, and then either soldering on a new fuse or replacing the power card itself. This

is a time-consuming process, especially compared to merely switching an externally-located fuse.

4) The means of mounting and securing the power supply unit was complicated. It was time-consuming to install and to remove the unit in the bus, meaning that a unit could not be quickly switched, for example when a bus was passing through CBS. This meant that repairs could usually only be attended to when the bus returned to the depot. At their own initiative, MCTD devised and deployed an alternative mounting system that now allows rapid installation and removal.

There were such ongoing problems in the initial operational phase but the ITS system has stabilized since its initial deployment and it now provides a reliable and extensive source of data. MCTD has rapidly developed how it utilizes the ITS system for the planning, operational and post-event processes, and also to improve passenger information and customer support.

Benefits of using ITS

KSRTC have become quite a proficient user of the ITS within a fairly short space of time. The ITS is facilitating change in depot management, operational practices and operational discipline.

Schedules and Productivity

KSRTC have revised all schedules based on the ITS data. They first started working on routes in 2014. They found that there was a substantial difference between the actual journey times in both directions throughout the day compared to the standard values they had been using. The '*Comprehensive Operations and Service Analysis*' (CSOA) prepared by M/s. Lumiplan provided valuable guidance on where and how resources could be more effectively deployed.

By using the travel times from the ITS system they could save buses, schedules or both; or they could reassign saved kilometres to where they would be better utilised. They also found that removing excess running time reduced buses idling at Central Bus Stand and helped to decongest it. By giving additional time where it was needed, they improved reliability, reduced lost trips, and reduced the reliance on overtime.

Through 2015, KSRTC have revised all schedules at least once. As a result, productivity has increased. MCTD now delivers more output with less input resources, and resources are better targeted. The changes are modest in scale, typically not more than 3%, but they are still worthwhile and indicate very good payback for the capital and management investment.

Allocation of Responsibilities for ITS at KSRTC and at MCTD

KSRTC have identified for every relevant section of KSRTC and of MCTD what its responsibilities are in relation to the ITS system and in using the resultant data. This has been formally signed-off and now constitutes part of KSRTC's and MCTD's internal procedures.

MIS Reports and ITS Responsibilities within MCTD

The reports provide two types of information. First, the reports have been divided into 12 MIS Reports, each designed for a specific audience. Primary and Secondary Users have been identified for each report. Second, the reports have been restructured around how the user should take action. For example, a report would list the ten worst performers on a specific metric, and the responsible person (Depot Manager, Maintenance Manager) would action those during the day.

One example is MIS 12, the Control Chart. Among other things, it automatically identifies schedules operating early or late. It is currently set to report cases of departures more than 10 minutes early.

The Depot Manager follows up all such cases. This is a configurable parameter, and can be set to a lower value.

Departure reliability has improved considerably. In 2012, the number of departures within five minutes of the scheduled time (early or late) was just 27%. By 2015, this had risen to 46%. By March 2016, it is about 90%.

Action at Depot Management Level

The Depot Managers have become actively involved in the use of the ITS system. The Depot Managers now use the MIS Reports as a primary management tool. Although the reports are comprehensive, they do not place a heavy burden on the Depot Managers. The MIS Reports help Depot Managers identify who they should follow up with, and give them strong evidence to work with. By focusing on deviation reports, the Depot Managers can identify non-completion of journeys, and cases of poor driving (sharp acceleration, harsh braking, overspeeding, etc.).

The Depot Managers claim that there has been a wide range of improvements:

- Buses pull out from the depot on time;
- Trips are completed
- Early and late departures have reduced
- Unnecessary trips have been removed
- There is no additional overtime, the time for trips is now sufficient
- Unions no longer come in demanding additional running time
- Revenue has increased although the number of buses and schedules has been reduced slightly, while delivering more kilometres.
- The number of complaints has reduced significantly.
- Accident rates are down
- Fake accident claims have been challenged and are now reduced
- Breakdown rates are reduced

The Depot Managers consider that discipline has improved considerably, and that this has a positive impact both on managing the service and managing the staff. The staff know that they are being monitored by the system, and are not inclined to deviate as a result.

Driver retraining and associated benefits

The MIS Reports identify unsatisfactory driving behaviour by drivers, such as harsh acceleration/ braking and over-speeding. The reports are structured to identify the ten worst. The Depot Manager follows up on these by interviewing them, arranging for driving instructors to monitor them, and arranging for retraining. Over time, all drivers with unsatisfactory behaviour would be identified and dealt with. The objective is to get them to improve their driving rather than to punish them.

Following benefits seem to have accrued:

- The most significant has been the reduction in fuel consumption, which has reduced from 4,800 litres to 4,450 litres per day for the depot. This is a saving of almost 8%. This reduction is a combined outcome of improvement in fuel dispensing system and the ITS.
- Accident rates are stated to have reduced, although there is not quantified data.
- Breakdown rates have come down, which may be due to less strain being placed on the vehicle by the driving style.

- The impression is that brake liner usage has come down. Again, this has not been quantified. The Depot Manager notices that the number of requests for requisition of brake liners is less than it was last year.

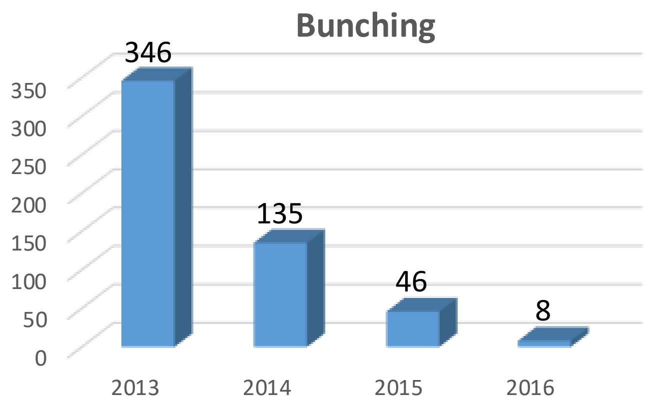
Improved operational discipline

KSRTC, through various changes in organisational and operational procedures has improved operational discipline. One notable change is that crew is now required to present themselves at CCS at the end of their shift, before they commence the last trip heading back towards the depot. Their Log Sheet is checked for trip adherence, to see whether they have performed the full schedule or whether any trips have been missed. If trips are missed, they are asked for the reason and this is cross-checked. Where relevant, there is communication with the depot and confirmation of whether overtime should be paid.

This ensures that the last trip departs on time, and also removes the incentive for crews to depart early on the second to last trip (or not complete it). Crew need to be present and presentable at the end of their shift, as they will be seen at CCS. A further benefit is that crew becomes familiar with the CCS and what work is done there.

Bus Bunching

Bus bunching has been an ongoing problem at MCTD. The MIS reports identify locations where most bunching occurs. The CCS team examines the schedules of the routes at the worst locations and sees how to adjust them. This has actually been quite successful in reducing bus bunching.



Graph 1: Total bunching in the month of April

Passenger Information Application

The ITS system has provided passenger information in three formats for direct off-site access by the user – website, SMS and IVRS. All three formats currently have very low usage. The fourth format for passenger information is the PIS boards. Although used by very many people, it requires the user to be onsite, and provides only ETA.

An application for smartphones was also launched following a 'hackathon' wherein IT students were encouraged to design the mobile application. There are some glitches in the app so the MCTD has now given the responsibility to TCS to redevelop an app.

Key Challenges

Some of the key challenges have been summarized in the following Table 1:

Table 1: Challenges faced

	Area	Challenges
1	ITS Domain-related	• Unavailability of historical project data (lack of lessons learnt from previous ITS implementations, in Indian conditions, of this scale) • Unavailability of best practices and guidelines, leading to a steep learning curve for all parties

2	Business Processes	• Time to map/adopt technologies vs. existing business processes
		• Additional rework required to meet the ITS solution requirements. Key issues included
		    ○ Lack of mature hardware and software with the Supplier was a major challenge
		    ○ Current bus operations of PIU was reactive, which results in regular changes to schedules which created issues with ITS system.
		    ○ Stand-alone Depot Management Systems of PIU meant that KSRTC staff had to enter schedule changes in two locations, which created challenges.
		    ○ Asset management (location of bus stops) at the start of the ITS project was limited.
		• The need to stabilize the technical solution while continuously optimizing business processes
		• Deploying rework changes during solution implementation
		• Synchronizing massive daily operational changes to system requirements:
		    ○ e.g., On Ashaad Friday majority buses redirected to Chamundi Hill
		    ○ Adhering to daily schedule changes and reflecting them in the system

3	Project Management	• Delayed stakeholder engagement (PMC, M&E)
		    ○ Delayed scope finalization & additional rework
		• Complex communication channels
		• Complex Project financial management (multi-funding relationship, formats, norms, flow)
		• Long period gap between Project conceptualization to awarding Contract
		    ○ Changes in business requirements and technology
		• Recurring requirement changes

4	Project phases and activities	• The Vendor had a three-stage perspective
		    ○ Build
		    ○ Pilot
		    ○ Rollout
		• The PMC had a four-stage perspective
		    ○ Planning
		    ○ Design/build
		    ○ Procurement
		    ○ Implementation
		• These were different perspectives, with different philosophies, activities, testing and assurance.

		• The initial plan had 30 tasks, whereas the revised plan had 185. It required continual adaptation of the activities, sequencing and timelines – and reaching agreement

5	Solution Deployment	• Excessive rework was required during geo-fencing
		  o Multiple trips to capture, validate, and test physically
		• Buses were available only at night for installation work
		• Non-standard "in-bus" environment – not only different bus types/ designs, but non-standard even in the same models
		  o Impractical to standardize procedures
		  o Non-standard cabling needs
		  o Issues of batteries, VMU and relay placement
		• Design change requirements arose during implementation
		• Longer installation time than planned (old buses)
		• Availability of same voice-over (recording) for implementing changes
		• Longer time to freeze PIS (passenger information system) format requirements
		• Display multi-language formats per specifications
		• Non-availability of a single font (for Kannada + English)
		• Unable to perform Over The Air (OTA) activity for operational changes
		• Non established ITS equipment like VMUs, PIS display boards, etc., some of which was still in development
		• Ongoing VMU issues

6	Host Environment	• Non-availability of power supply at bus-shelters • Non-standard bus shelters • Security of ITS equipment in public places • Unplanned effort & cost o e.g., additional concrete shelter reinforcement • Integrating existing in-bus equipment (protocol mismatch) • Excessive vibrations in rural routes - affecting in-bus equipment performance • Different types of buses • Availability of 100% GPRS signal • Availability and applicability of local insurance policies for ITS projects

7	Contract	• Inadequate scope and structure for change control
		• Lack of flexibility (in the contract) to deal with field realities and changes
		• Aligning existing procedures with World Bank expectations
		  o Goods & services, consultancy services
		• Residual ambiguity in RFP
		  o Technical vs. functional requirement conflicts - e.g., LED boards, UPS need
		  o Missing / inadequate clarity on GIS scope, back-up power requirements

8	Business data	• Geo-fencing shelterless bus stops • Aligning documented route and stop data with field reality

		• Missing requirements in the beginning (dead KM)
9	Skill building	• Lack of ITS domain knowledge • Building competency within available time constraints • Timely availability of skilled workers
10	Commuters and other stakeholders	• Ensuring effective promotions & communications (ITS and its benefits) • Setting clear expectations from ITS solution • Other stakeholders ○ Getting timely approvals and support for deploying the PIS display boards from various local authorities like hospitals, tourist spots, railways,

11	Crew	• Initial resistance to change – fear of scrutiny
		• Adherence to geo-fence routes
		• Adherence to schedules and trips
		• Ensuring multi-lingual trainings
		• Finalizing training needs & material
		  ○ Initial In-effective training
		  ○ Revision of training material + process based on the feedback
		  ○ Re-training conducted for a large group after the changes

Going Forward

KSRTC has identified the following issues for the next stages:

- Effective alignment of current business processes (including crew discipline) with ITS to gain from its advantages
- Ensuring security & maintenance of in-bus equipment and PIS boards
- Effective usage of ITS (SOS alerts, MIS reports, instant geo-search) by Traffic Controllers, Operations Staff, Depot Management
- Integrating ITS system within KSRTC existing IT solutions
- Sustaining benefits of ITS – selection & identification of ITS data (what, when, where) and prioritize them according to business needs
- Implement ITS in other cities and also for inter-city buses after relevant modifications