

10. POTENTIAL OF INFORMATION AND COMMUNICATION TECHNOLOGY TO ENHANCE TRANSPORT EFFICIENCY

The background of the page is a green-tinted image of a computer workstation. In the foreground, a black telephone is on a desk. Behind it, two computer monitors are visible. The left monitor displays a complex network diagram with many nodes and connecting lines. The right monitor shows a document or spreadsheet. The overall scene is dimly lit, with the primary light source being the screens, creating a professional and technological atmosphere.

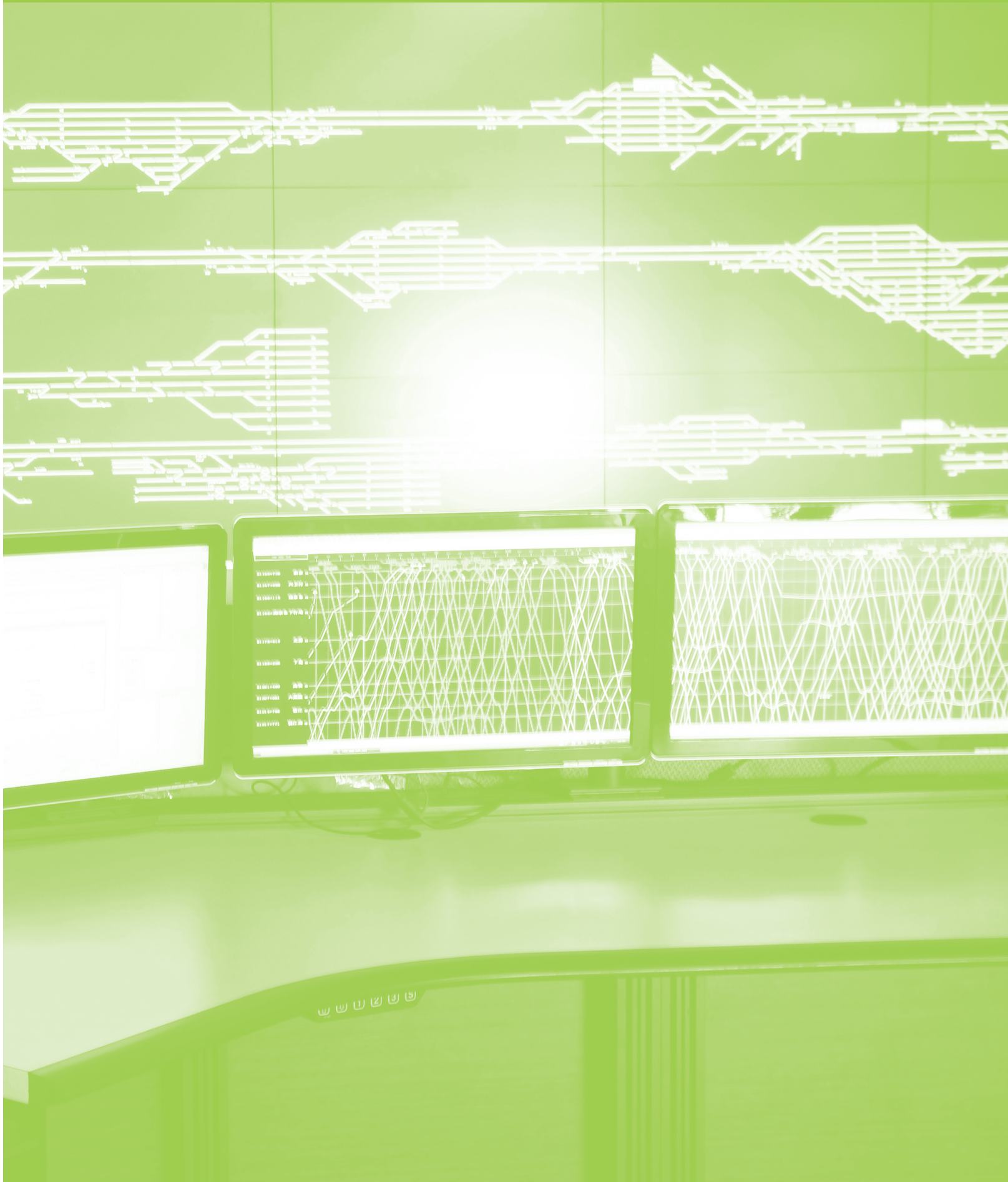


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10. POTENTIAL OF INFORMATION AND COMMUNICATION TECHNOLOGY TO ENHANCE TRANSPORT EFFICIENCY

Across the world, ICT technologies have proved to be crucial to greatly enhance the quality of transportation networks and satisfaction of their users. Singapore introduced congestion pricing to reduce the number of cars in the city and to encourage people to use public transportation.

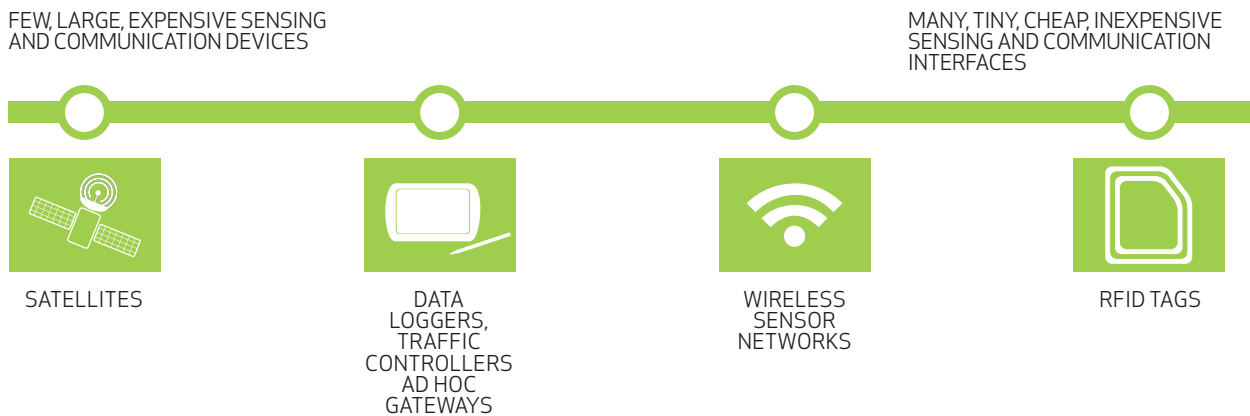
OVERVIEW OF THE POTENTIAL OF ICT IN THE TRANSPORTATION SYSTEM

Use of 'smart cards' in Hong Kong allows passengers to move seamlessly between different modes of public transport. Connected-Vehicle technology in the US is expected to greatly reduce the likelihood of road accidents. The port sector has also benefited from application of ICT. In order to improve the competitiveness of its ports and promote foreign trade, Philippines used large-scale application of ICT to implement a single window approach which has expedited the passage of goods and commodities through its customs administration. Similarly, in order to reduce congestion at the gates to the port,

Singapore has installed an ICT system called 'Flow-Through Gate' which identifies container trucks, completes the necessary formalities and provides unloading instructions in less than 25 seconds per truck, handling 8,000 trucks a day.

The value of ICT goes beyond just improving transport systems; ICT can also be used to integrate transport systems with other systems resulting in reduced energy use and greater customer satisfaction. For example, South Korea is building a smart city Songdo where all buildings, roads and other

Figure 10.3
A Spectrum of Sensing Devices



Source: Adapted from the Sensor Spectrum: Technology, Trends, and Requirements, Hellerstein, Hong & Madden
 Other sources:
http://www.aimil.com/product-Data_Logger-1570.aspx
http://www.spacetoday.org/images/Sats/MilSats/DSCS_SatInSpaceLockheedMartin.jpg
<http://blogs.dolcera.com/files/2009/08/wireless1.JPG>
<http://thesmartvan.com/wp-content/uploads/rfid-chip.jpeg> (accessed 20 March 2014).

infrastructure will be connected with wireless sensors, chips and other communication technologies. Through the use of big-data computing and analytics that match supply and demand of various services or utilities, it is expected that there will be more efficient use of energy, thus enhancing the sustainability of the infrastructure. Similar efforts are being made in Masdar city in Abu Dhabi. In China too, the concept of a smart city is taking root. Ningbo is using IT to improve its port logistics and smart transportation. Wuxin is using cloud computing infrastructure to deliver benefits to its citizens.

Indian firms have been world leaders in the development of ICT technologies for the benefit of some of the world's leading business firms and various government initiatives. Given the immense knowledge, power and technology capabilities that India's organisations have deployed for the benefit of solving other countries' transportation woes, it would be in India's benefit to make use of these valuable resources for solving its own problems in transportation.

TECHNOLOGY TRENDS IN THE TRANSPORTATION SECTOR

ICT components and technologies that could be used to improve the transportation system fall into three categories: (a) automation technology (sensors and controllers) which can help in location of vehicles and control of gates at access points; (b) communication technology (e.g., 3G) which can help in receiving and transmitting information to and from vehicles; and (c) information technology (hardware and software systems) which can be built on top of the underlying automation and communication systems to manage traffic, move victims during accidents to

nearby medical facilities, plan trips and coordinate transportation systems.

These three categories of technologies work together to improve transportation systems as shown in Figure 10.1. The transport infrastructure at the bottom forms the base for the system and provides a variety of information (data) such as: positions of vehicles, schedules of trains, identities of vehicles crossing check-posts. These data are 'captured' by sensors, 'transmitted' by communication networks, and 'analysed' by information systems (left side of Figure 10.1). Based on the analysis, the information systems then decide what action is necessary and that action is carried out either by a human being or directly through electronic signals to controllers which carry out the action, such as opening or closing a gate, or providing a warning message to motorists on electronic boards along highways etc. (feedback and control on the right side of Figure 10.1).

A simple example of how these three categories work to enhance customer experience is the 'Journey Planner' application provided by Transport for London shown in Figure 10.2.

This application provides 'integrated' solution options for journey planning using multiple modes. It also gives alerts in those options where there is an ongoing issue or planned maintenance activity. This solution is made possible in near real-time through the seamless usage of the three components of digital technology.

We now look at the components that are available and are likely to be available in each of these three categories of technologies.

Figure 10.4
Trends in Communication Technology Applicable to Transportation



Source: CETSI 2008 Intelligent Transport Systems, http://www.etsi.org/images/files/membership/ETSL_ITS_09_2012.jpg (accessed 20 March 2014).

SENSORS & CONTROLLERS

The spectrum of sensors ranges from large and expensive sensing and communication devices like satellites to tiny and inexpensive devices like RFID tags (Figure 10.3).

Satellites have been used for global positioning of vehicles. RFID tags are now commonly used in highway toll booths where the tags can be read by stationary RFID readers.

Wireless sensor networks (WSNs) have huge potential in transportation. WSNs are being used to generate safety warnings to drivers in specific black spots along the roads. These warnings are given based on data gathered in terms of vehicle volumes, speed and direction.

COMMUNICATION TECHNOLOGY

Some technologies that have been developed for transportation are: vehicle-to-vehicle, vehicle-to-infrastructure; and other central level systems to communicate traffic conditions, weather conditions and road conditions. These technologies often are extensions of existing communication technologies such as DSRC (Dedicated Short Range Communication), 4G/LTE (Long-Term Evolution), High-defi-

1. One petabyte = 10^{15} bytes.

nition radio etc., developed to make transportation efficient and safe.

As depicted in Figure 10.4, MAN (Metropolitan Area Network), mobile, satellite communications can be used to manage traffic through receiving information from vehicles (GPS technologies etc.) and providing real-time information to vehicles. Traffic signs can be suitably altered to manage traffic according to real-time requirements. Citizens can make use of communication technologies to appropriately plan their trips. Relevant safety systems (redirection of traffic, right-of-way to ambulances and appropriate display of road signage according to real-time traffic situation) can be activated using communication technologies.

INFORMATION TECHNOLOGY

There are several new developments in software systems that could help improve the transportation sector very significantly.

BIG-DATA ANALYTICS

Big data is a term used to describe voluminous (typically petabytes¹ and above), unstructured or semi-structured data flowing in real time which can be

analysed to identify patterns and take decisions as events are unfolding.

In the transportation industry, big-data analytics have tremendous potential. Various data streams from diverse sources—weather data; data on traffic flows; information on parking lots; departure and arrival schedules of trains or flights; and global positioning systems—can be aggregated across different dimensions and analysed to come up with solutions to transportation problems and needs. Alerting drivers in real time of weather-induced traffic delays and providing them with alternate routes; providing information on the availability of least expensive parking lots in the vicinity of their destination; and prediction of potential traffic volume growth to plan for the most optimal multi-modal transport option in a city are some examples.

CLOUD COMPUTING

Cloud computing relies on sharing computing resources rather than investing in resources for exclusive use. The sharing is done through the internet, with ‘the cloud’ being used as a metaphor for the internet. Cloud computing has traditionally offered significantly lower upfront capital costs; it also optimises operational costs through the addition of computing resources on-demand which helps in real-time scaling up as needed. Various software applications in the transportation sector, especially the ones that interface between multiple modes, are well suited to making use of cloud computing.

SOCIAL MEDIA/COLLABORATION/MOBILITY APPLICATION PLATFORMS

The advent of smart phones, social media and mobile internet has resulted in a host of new smart mobile applications. Some examples:

- **Waze.** An application that determines if one is stuck in traffic and alerts friends to take alternative routes.
- **Zimride.** An application that connects car poolers together for a one-time ride. It also integrates with the Facebook community to assess safety of travelling with an unknown person.
- **Google Transit.** Helps people plan trips using multiple modes of public transportation in more than 425 cities.

OPEN SOURCE FRAMEWORKS

There are quite a few applications that are beneficial to users of multiple modes of transport. Data exchange is a key requirement for achieving the benefits from these applications, and consequently, uniformity of data formats is also essential. Open

source² software greatly facilitates such uniformity through wider adoption. Google Transit Feed Specification (GTFS) is an example of an open source specification which defines a format for public transportation schedules and associated geographic information. Public agencies can publish their schedules in GTFS format so that the applications can use these data in an open and interoperable manner.

MITSIMLab is an open source application that has been developed at the MIT Intelligent Transportation Systems (ITS) Programme. It helps evaluate the impacts of alternative traffic management system designs at the operational level and assists in subsequent refinement of the design. Examples of systems that can be evaluated include Advanced Traffic Management Systems (ATMs) and route guidance systems.

The Transportation Analysis and Simulation System (TRANSIMS), is an integrated set of tools developed to conduct regional transportation system analyses. Los Alamos National Laboratory is leading the development of TRANSMIS. It is part of a programme sponsored by the US Department of Transportation and the Environmental Protection Agency (EPA).

These open source frameworks and applications help in making different systems interoperable and follow defined standards to avoid proprietary lock-in.

ICT ENABLED SYSTEMS

ICT-based systems and services fall into the following four broad categories:

- Inter and intra-vehicle systems, which as the name suggests, are systems within vehicles which help in improving safety and navigation
- Traffic management systems
- Transport co-ordination systems which help in multi-modal transport of passengers and freight
- Traveller or User Information Systems which provide users with real-time information about public transport or freight transport

Table 10.1 provides examples of systems or services under each of these broad categories.

The advent of smart phones and mobile internet has resulted in a host of useful applications, like Waze, which determines if one is stuck in traffic and alerts friends to take other routes; or Zimride, which connects car poolers together for a one-time ride.

2. Open source software refers to programmes for which the source code is available to the general public for use and modification from its original design. Open source code is typically created as a collaborative effort in which programmers improve upon the code and share the changes within the community.

Table 10.1
ICT Enabled Systems for Transportation

INTER & INTRA VEHICLE SYSTEMS	
Parking Assist System	Aids in parallel parking of cars through sensors
Collision Avoidance System	Helps avoid various collisions including rear-end collision, road-departure collision, intersection collision, etc., through inter-vehicular communication
Vehicle Diagnostics System	Alerts the driver on key parameters of the vehicle
TRAFFIC MANAGEMENT SYSTEMS	
Violation Warning System	Detects various traffic violations (signal, stop sign, etc.)
Reroute Information System	Provides alternate routes in case of congestion in a specific route
Electronic Payment System	A common system for electronic payment for tolls, parking, etc.
TRANSPORT COORDINATION SYSTEMS	
Commercial Vehicle Operations System	Identifies and tracks commercial vehicles for ease of interstate electronic clearance, automated roadside safety inspection, onboard safety monitoring, commercial fleet management among others
Multi-modal Schedule Integration System	Integrates and continuously updates the schedules of various modes of intra and inter-city transport
Freight movement coordination system	Classifies freight and appropriately routes it to its destination using the optimal mix of transportation modes
TRAVELLER/USER INFORMATION SYSTEMS	
Real-time information of public transportation system	Helps travellers/commuters reach their destinations taking into account their priorities (price, time, comfort, convenience, etc.)
Real-time information of freight transportation system	A single-window system for consignees to send their consignments and keep track of their shipments on real-time basis. The system helps shippers send their consignments based on certain parameters (price, time of travel, etc.)
Real-time information of multi-modal transportation system	A real-time single-window system (ticketing, pass-through, interface, etc.) to help travellers schedule their travel across various modes of travel

Source: Infosys Research.

FRAMEWORK FOR PRIORITISATION OF INITIATIVES

Clearly, all the ICT-based measures and initiatives described earlier cannot be implemented all at once. How then should they be prioritised? We have developed a framework for prioritisation, shown in Figure 10.5, that groups the various ICT solutions or initiatives into three categories: solutions that need to be implemented in the short term (0-5 years); the medium term (5-10 years); and the long term (10-15 years). The solutions were prioritised by scoring them on four parameters on a scale of 1 to 10:

1. Cost of implementation
2. Time requirement for implementation of the solution,
3. Potential benefit expected out of the solution,

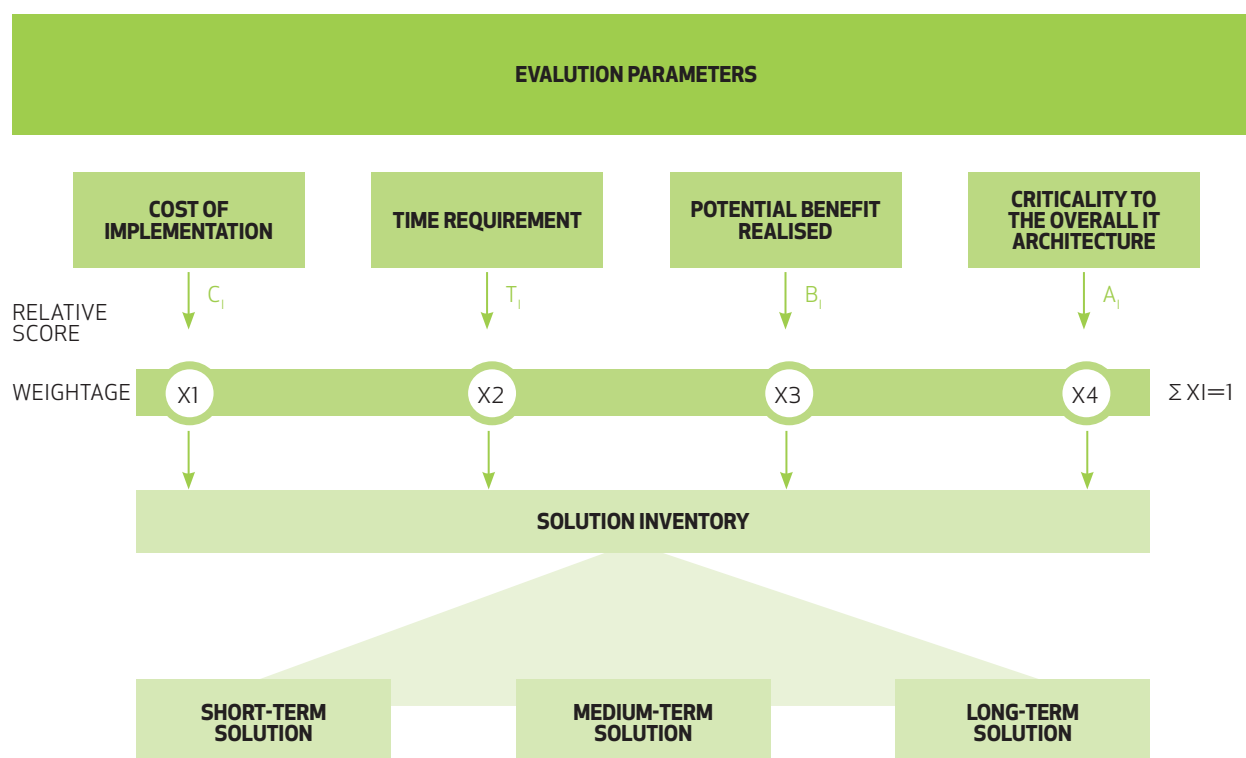
and

4. Criticality of the initiative or solution to the development of the overall architecture for a sector or for the whole transportation system

We assigned a weight to each of the parameters to arrive at an aggregate score for each solution. These aggregate scores were then used to place them in the short-term, medium-term and long-term categories. The results of this exercise and details about ICT solutions recommended in each of the three periods for the various sectors are given in the sector-specific chapters.

The solutions proposed for the short term have a heavy focus on building an efficient database for various functional areas across sub-sectors. The

Figure 10.5
Application Prioritisation Framework



Source: Infosys Research.
 ** all solutions are scored on a scale of 1-10 with 10 being highest and 1 being lowest.

other sets of solutions proposed for the short term are focused on scheduling and planning, which will help in addressing some of the key capacity and efficiency issues across the sector. Solutions proposed for the medium term are the ones which will bring significant changes in operations and infrastructure and also leverage the greater availability of data and the access mechanisms developed as a result of the measures taken in the short term. The long-term solutions have customer experience and advanced technology infrastructure as some of the key focus areas. These solutions are in the long-term category because basic infrastructure installed in the short and medium term is a prerequisite. Furthermore, scheduling and planning improvements carried out in the medium term will help in designing solutions to improve customer experience in the long term.

CAPACITY BUILDING FOR INFORMATION TECHNOLOGY IN TRANSPORTATION

In this chapter and in each of the sectoral chapters, we have identified initiatives as part of the study which will enhance efficiency, utilisation and safety of transport systems. All such initiatives will require a strong institutional foundation for development and implementation.

We propose a three-dimensional institution structure (Figure 10.6) to address the needs of the Indi-

an transport sector. The three dimensions are:

- i. Geographic area of focus, which determines whether the institution is a central, state-level or a city-level organisation
- ii. Functional area of focus (discussed later)
- iii. Sectoral area of focus

The various functional areas of focus are described below:

a. Standards and Process

These institutions will be involved in setting the standards for technology in transportation (for example, the technology to be used for toll payments on highways across the country). They will also be involved in setting up processes which facilitate implementation of technology in transportation (such as implementation of Golden Care implementation).

b. Policy Advisory

These institutions will constantly interact with the government, central, state and city-level ministries to help develop and implement technologies for their respective sub-sector needs. They will also advise governments on the policy framework for effective traffic management.

Figure 10.6
Proposed Structure for Transportation Institutions



Source: Infosys Research.

c. Consulting and Project Management

These institutions will also be involved in the conception of projects which will implement technologies for better transportation. They could also consult with private sector organisations and manage projects for deploying technologies in transportation.

d. Training and Research & Development

Over the years, there has been a substantial increase in the passenger and freight traffic across the transport sub-sectors. It has become imperative to build new R&D capabilities and training institutions to help in the development of technologies for solving problems in transportation. The institutions that we have proposed will develop and implement technologies for transportation and also train professionals in transportation.

We propose a multi-tier institution mechanism to oversee ICT for transportation in India (Figure 10.7):

Each of the institutions proposed can cover multiple functional areas of focus mentioned earlier. In this section, we explain the overall national level organisation, its roles and responsibilities. All the sector-specific organisation, and their responsibilities and

functional areas of focus, are discussed in respective chapters on the sectors.

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY IN TRANSPORTATION (IIITT)

We recommend that an autonomous central-level institution called the Indian Institute of Information Technology in Transportation (IIITT) be created. IIITT will be similar to RITA (Research and Innovative Technology Administration), which coordinates the US Department of Transportation research programmes and helps in the deployment of state-of-the-art technologies for improving US transportation.

IIITT's charter will be to:

- (1) Develop the overall framework of ICT enablement in Indian transport sector
- (2) Facilitate various activities of national-level sector-specific organisations
- (3) Interface with various external stakeholders, both national and international, for R&D
- (4) Indigenise technology and solutions deployed by other countries for enhancing transportation in India
- (5) Advise on policies regarding transportation
- (6) Consult and help in the project management of implementation of technology in transportation

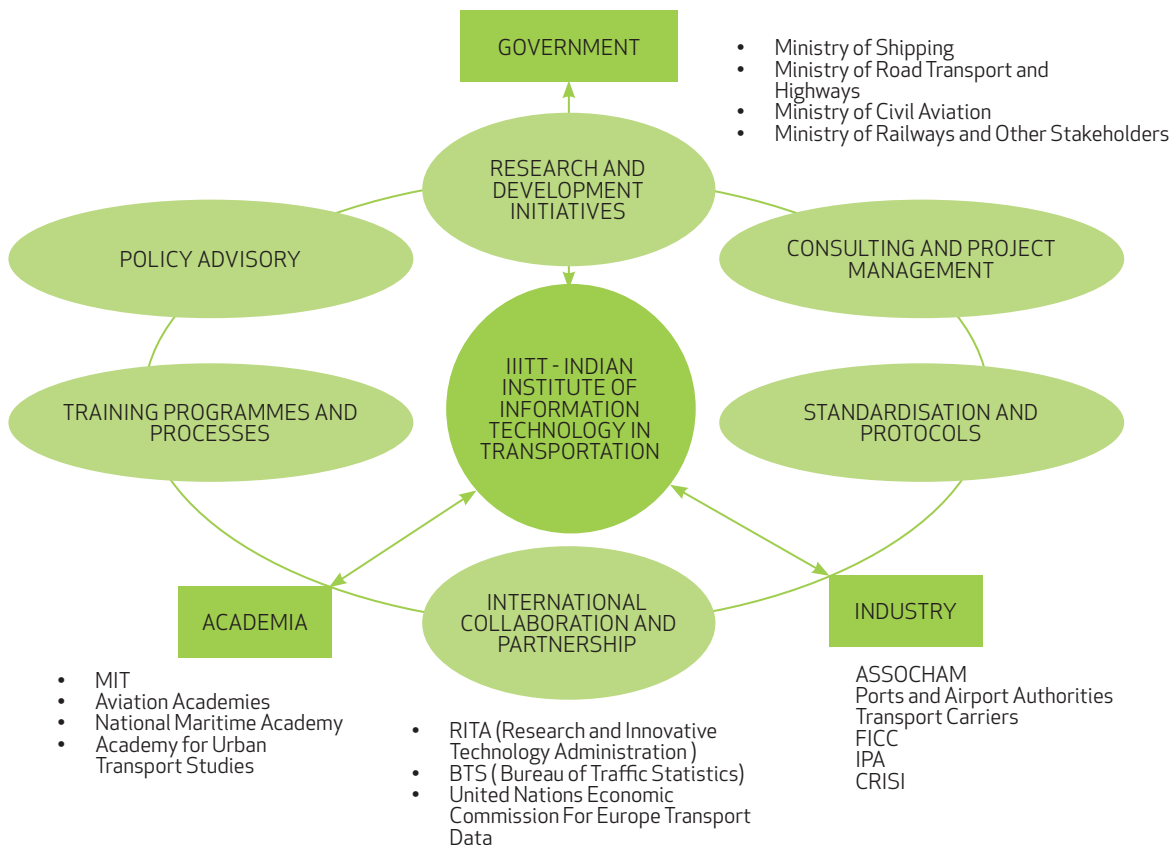
Figure 10.7
Four-Tier Institutional Framework for Transportation

	SUB-SECTORS	CENTRE	STATE	CITY*
TIER 1 - (OVERALL NATIONAL LEVEL INSTITUTION) - IIITT - INDIAN INSTITUTE OF INFORMATION TECHNOLOGY IN TRANSPORTATION	RAILWAYS	✓	←————→	
TIER 2 - (NATIONAL LEVEL INSTITUTION FOR SUB-SECTORS)	PORT	✓		
TIER 3 - (STATE LEVEL INSTITUTION FOR SUB-SECTORS)	AVIATION	✓		
	ROADS	✓	✓	✓
TIER 4 - (CITY LEVEL INSTITUTION FOR SUB-SECTORS)	URBAN ROADS	✓		✓

* Cities with population greater than 5-6 million will have their own roads and urban roads institution for facilitating ICT in transportation.
 ←→ Railways will have a centre level institution which will interface with all states.

Source: Infosys Research.

Figure 10.8
IIITT - Indian Institute of Information Technology in Transportation



Source: Infosys Research.

Figure 10.9
Sector-Specific Institutes of Transportation



Source: Infosys Research.

IIITT will assist the Indian government and departments related to transportation in the following functional areas (Figure 10.8):

- (1) Initiate and review R&D programmes
- (2) Develop and deploy new technologies relevant to transportation; consult and manage projects for implementing technologies in transportation
- (3) Collect and publish transportation relevant statistics; use analytics to improve transportation
- (5) Provide training for transportation professionals and serve as a knowledge and skill-dissemination repository

IIITT will coordinate with all other proposed central-level sub-sector institutions, state and city-based institutions. IIITT will also collaborate with international institutions to develop new technologies, indigenise successful technologies used in other countries for deployment in India and facilitate training for transportation professionals.

All the sector-specific national institutions (Figure 10.9) will co-ordinate with IIITT for all the areas where they need any specific assistance. The sector-specific national level institutions are as shown in Figure 10.8. Detailed roles and responsibilities of the individual sector institutions are covered in chapters on the different sectors.

ICT FOR RAILWAYS

KEY ISSUES

Indian Railways (IR) has been a pioneer in the introduction of computerisation in its major areas of activities. In the mid-1980s, it created the Centre for Railway Information Systems (CRIS) as an autonomous application development and implementation agency. Computerisation began with payroll, accounts and the apportionment of freight revenue and tonnage; then it expanded to cover almost every field of rail operations and business.

Since then, customer management, which includes booking of tickets, freight and parcels, have seen successful ICT applications. The Passenger Reservation System (PRS), Freight Operations Information System (FOIS), Unreserved Ticketing System (UTS), Parcel Tracking System (PTS) are important examples of successful implementations of ICT by IR. Similarly, operations of trains and management of crew have had full level of ICT deployments such as the Control Office Applications (COA) and Crew Management System (CMS). Production units, maintenance of rolling assets and fixed assets, workshops, human resources, accounting, safety and medical services have seen pilot IT deployments and full scale applications will be rolled out in suitable phases.

Strategic planning, which includes decisions on new routes, capacity enhancements on existing routes etc, has been assisted by the Long Range Decision Support System (LRDSS). This has enabled

Figure 10.10
Major Departmental Activities and Applications

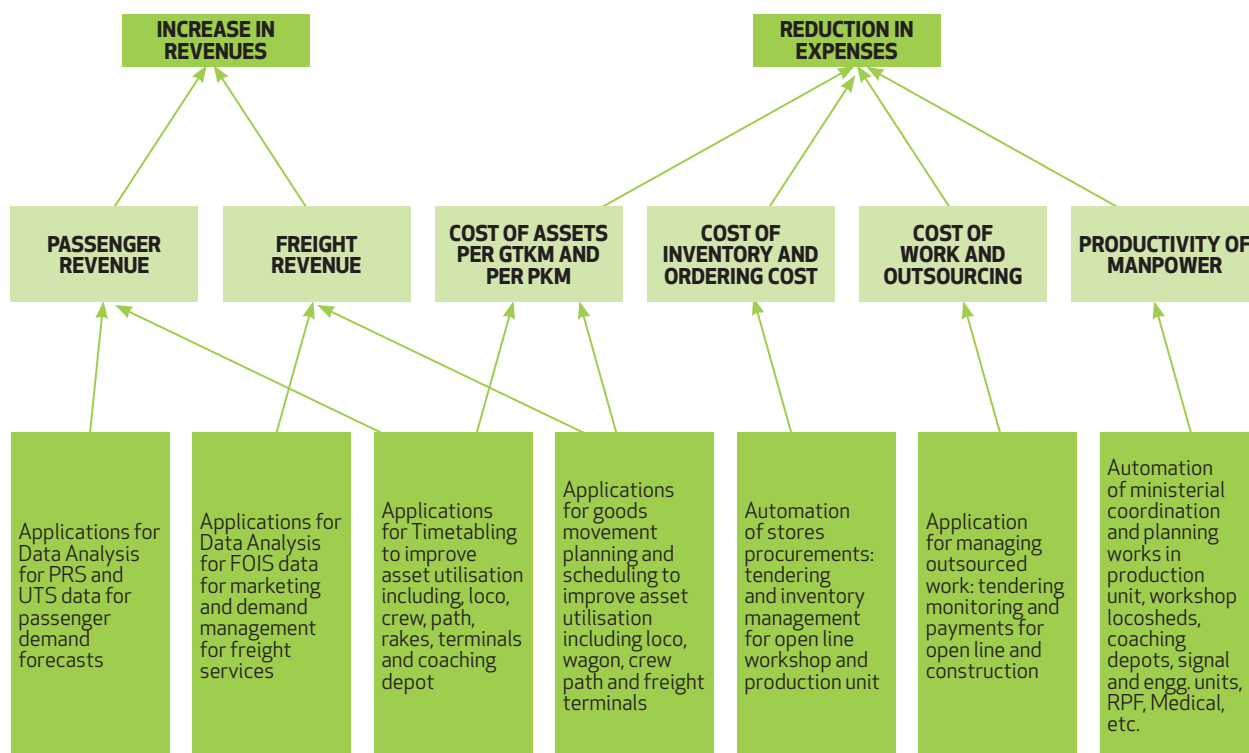
CUSTOMER MANAGEMENT	Passenger Reservation & Ticketing	Freight Management System	Customer Pricing	Multichannel Management	Customer Service
DEMAND FORECAST AND PLANNING	Corporate Strategy	Demand Forecasting	Operational Planning		
SALES AND MARKETING MANAGEMENT	Sales Planning	Execution Planning	Marketing Planning	Campaign Management	
OPERATIONAL MANAGEMENT	Train Operations	Crew Planning & Scheduling	Terminal Operations/ Freight Tracking	Signaling & Safety/Train Control	Decision Support System
ASSET MANAGEMENT	Asset/Equipment Tracking & Distribution	Asset Lifecycle Management	Capital Investments & Infrastructure	Materials Management	
PRODUCTION MANAGEMENT	Production Planning	Production Scheduling & Implementation	Quality Control		
MAINTENANCE MANAGEMENT	Maintenance of Way & Reporting	Maintenance Scheduling & Reporting	Facilities Maintenance	Work Order Management	
PROCUREMENT & 3RD PARTY MANAGEMENT	Direct Procurement	Indirect Procurement	Contracts Management	Capital Goods & Services	PPP Contract Framework
F&A, MIS	Revenue & Financial Accounting	Asset Accounting	Business Intelligence & Analytics	Corporate Governance	
WORKFORCE MANAGEMENT	Recruitment	Training & Certification	Payroll & Compensation & Benefits	HR Operations	

CURRENT IT ENABLEMENT ACROSS BUSINESS UNITS

	The IT enablement has been good and has yielded positive outcomes
	The IT enablement has been done but has not yielded the desired outcomes
	The IT enablement has either not been done or requires a great deal of process re-engineering

Source: Infosys Research.

Figure 10.11
Potential Role of ICT in Increasing Revenue/Decreasing Expenses



Source: Infosys Research.

sourcing of rich operational data and professional experience in its use in decision making. Unfortunately, this system has become dysfunctional due to software obsolescence.

Figure 10.10 shows the major departmental activities that need to be undertaken by IR, and the extent of use of ICT in each of these activities.

The time is now both ripe and opportune for IR to focus on developing decision support systems to enhance the efficiency of business, operations and assets management. The latter requires a changeover to a regime of need-based predictive maintenance of assets. Equally important is the development of compatible interfaces with the regional railway networks and major transport generating entities like ports, mines, etc. The issues of uniformity of data formats, development of ICT standards and protocols also need attention.

There are five main strategic and operational issues that need prioritisation.

INCREASING REVENUE AND DECREASING EXPENSES

IR is short of both passenger and freight capacity. However, revenue can be maximised by the introduction of ICT support systems. For example, the effort should be to deploy coaches in circuits to improve load factors and avoid the detention of wagons because of congestion and stabling.

Figure 10.11 illustrates how these factors affect revenues and expenses. It also shows how specific ICT applications can increase profits either through an

increase in internal revenue generation or a reduction in expenses. In the following sub-sections, we elaborate on the interactions of various factors on each of the components of revenue generation or expenses. (The factors are identified in the middle row of Figure 10.11.)

PASSENGER REVENUE

Passenger revenue can be increased by raising seat and berth utilisation in existing trains and by increasing the number of trains with the same set of coaching rakes and locomotives. This requires better passenger demand forecasting, timetabling, integrated coaching and rake scheduling, scheduling of terminal facilities, optimisation of coach-crew allocation, locomotive allocation optimisation, and TTE allocation optimisation. IT solutions will make these complex tasks more manageable. There is extensive data available with the Passenger Reservation System (PRS) and unreserved ticketing system (UTS). It should be analysed for better demand forecasting which will need Business Intelligence applications.

FREIGHT REVENUE

Freight revenue can be increased by loading and carrying more freight with the same set of wagons and goods locomotives and without increasing the freight rates. The key lies in reducing the empty running ratio. FOIS and control office applications have the data on which advance data analytics can be run to provide a forecast of the pipeline for congested terminals and forecasting goods train arrival at the destination. As there are multiple constraints on the running of goods trains, it would be advisable

to handle the complexity by using ICT systems for planned goods train movement. This will improve utilisation of locomotives, wagons, paths, crews and freight terminals.

COST OF PURCHASES AND INVENTORY

Procurement by the stores in the various departments is a big item of expense. A systematic management of stores and the tendering process can reduce it. Different zonal railways have different inventory management systems. This makes it difficult to integrate the management of inventory. Therefore, a best-in-class inventory management system should be deployed across the different zonal railways and production units. Having a single source of data on the level of inventory across store depots, rates paid for items, lists of obsolete items, etc., will help in better management of inventory. The resulting increase in inventory turnaround, reduction of cost of holding inventory, increased availability of materials and reduced obsolete inventory could save huge sums of money. A good inventory management system is also likely to reduce discrepancies in records of stock discrepancies and vigilance cases related to stores.

COST OF WORKS AND OUTSOURCING

An increasing amount of asset maintenance work is being outsourced. This involves tendering and contract management, which includes the maintenance of fixed assets and rolling stock. The tendering work and monitoring the work of contractors is time consuming and leaves less time for inspections and monitoring of departmental work. As a result, the overall quality of both types of work suffers. A timely measurement of works and recording the measurements in IT systems will bring transparency and accountability. Contractual works are also prone to vigilance cases and arbitration. An increase in process automation will reduce time taken in tendering related activities and work monitoring activities which will lead to better overall quality of works. Computerisation of this aspect of railway working will greatly increase quality, reduce long-term cost and improve transparency in contract management.

PRODUCTIVITY OF MANPOWER

IR employs close to 1.4 million people and human resource (HR) costs are the largest component of its operating costs. A study needs to be commissioned to understand functioning of other lean railways and to identify suitable ICT applications for adoption in IR. Workflow-based office automation³ needs to be deployed at a very large scale. This will include automation of office work in loco sheds, coaching depots, wagon depots, signaling workshops, engineering workshops, etc.

The Personnel Department of IR needs large scale computerisation to reduce manpower and to increase

transparency. Processes implemented through ICT will make the system of promotions, postings, seniority lists, service sheets, leave records, etc., efficient, transparent and employee-friendly.

The training of employees is carried out in zonal training schools and officer academies. Large scale IT deployment for training which can enable anytime-anywhere learning using mobile devices will go a long way in reducing overall training cost and increasing effectiveness of training programmes.

ENTERPRISE-WIDE INTEGRATION AND KNOWLEDGE MANAGEMENT

Most IT projects are driven by the respective departments. Different IT solutions developed by different departments or divisions function as islands of information and do not interact with one another because there is no common platform or set of standards for information exchange. This is, therefore, a fragmented process without a single, strategic and overarching roadmap driven by business objectives. Ideally, IR's business strategy should be the starting point for identifying the focus areas to be IT-enabled. This approach would ensure that there is built-in synchronisation and cohesions among different project teams which function with a clearly defined purpose.

Enterprise-wide integration will provide additional benefits because there will be greater uniformity in data formats which will permit greater interoperability and facilitate seamless exchange of information.

UNIFIED FOCUS AND OVERSIGHT FOR APPLICATION

Currently, the Computer and Information Systems (C&IS) Directorate in the Railway Board plays the role of a CIO within the Railways. The Directorate is supported by CRIS, which is responsible for developing, implementing and maintaining ICT applications under a dynamic operational environment.

At the zonal railway level, there is an exclusive organisational arrangement for implementing and maintaining ICT applications in operational and commercial areas. There is a need to strengthen the C&IS Directorate to prepare an enterprise-wide Master Plan for ICT application and needs to be suitably empowered.

IT in the railways is a fragmented process. Ideally, Indian Railways' business strategy should be the starting point for identifying the focus areas to be IT-enabled. This would ensure that there is built-in synchronisation and cohesion among project teams.

3. Simple office automation refers to archival of documents. Workflow-based office automation is used not just for document archival but also for tracking jobs from start to finish. This is particularly useful in workshops.

Table 10.2
Major Suggested ICT Applications

CATEGORY	ICT SOLUTIONS	APPLICATION AREA	MAJOR BENEFITS
Demand Forecasting	Passenger demand analysis and forecasting system (Augmentation of PRS and UTS)	Passenger services	Increase seat/berth utilisation, introduction of new services, better customer satisfaction, increase in passenger revenue
	Freight demand analysis, forecasting and pricing system (augmentation of FOIS)	Freight services	Pricing system, analysis of data from FOIS, demand management
Scheduling	Passenger timetabling systems	Train operations	Optimised rake links, crew link, loco link, terminal constraint scheduling, better rake utilisation
	Goods movement planning and scheduling system	Train operations	Better customer satisfaction, increase in freight revenue
Procurement & Contract Handling	Inventory management	Stores procurement, Store depots, inventory management in Railways and production units	Reduction in inventory holding cost, increase in inventory turns, cost saving
	Management of contractual works	Construction, track and signal maintenance, loco, wagon and coach maintenance	Transparency in managing contractual works, improvement in quality of work and reduction of cost
Office Automation	Workflow-based office automation systems for loco sheds, coaching depots, wagon depots, signaling, engineering and OHE workshops	All railway establishments	Reduction of unnecessary paper work and computerisation of necessary paper work, reduction of manpower, cost saving
	Human resources management system and accounting information system	All railway establishments	Computerisation of personnel and accounts departments

Source: Infosys Research.

Table 10.3
Issues Addressed and Expected Benefits of Demand Forecasts

ISSUES	SOLUTION FEATURES	IMPACT
Data on passenger demand is not analysed to suggest new services	Capability to analyse data available from PRS and UTS	Knowledge of demand in actionable format
Long wait list in some classes of travel while empty seats and berths in others in same train. Similarly uneven utilisation based on service type, day of week, etc.	Capability to analyse demand for specific class, day of week, time of day, season of the year.	More utilisation of berth or seating capacity
Data analysis and freight demand forecast are done manually and are not accurate which results in lack of advance planning for resource needs	Data analysis application for FOIS data	Better demand forecasts of goods service which will lead to better planning of resources to meet the demand

Source: Infosys Research.

Table 10.4
Benefits of Scheduling Applications for Passenger Trains

ISSUES	SOLUTION FEATURES	IMPACT
Trains wait for entry into major terminals	Simulation of terminal facilities	Smooth entry and exit at major terminals
Trains wait for precedence to higher priority trains	Simulation of timetable to check the options to reduce the impact	Better services for low precedence trains
Goods trains paths are reduced	Optimise goods train paths	More goods trains can be run
Traffic block time for maintenance is less	Optimise the designed traffic blocks	Better maintenance
Robustness of timetable in case of failures is not checked	Simulation of timetable to see impact of equipment failures	Reduced impact of equipment failures
Unexpected events such as asset failure and public agitation make scheduling difficult	Dynamic optimisation allows system to instantaneously offer optimal utilisation of available paths	Utilisation of network capacity is optimised

Source: Infosys Research.

PROPOSED ICT SOLUTIONS

A list of major ICT interventions that are required are shown in Table 10.2, and they fall into four broad categories:

- (1) Demand Forecasting
- (2) Scheduling
- (3) Procurement and Contract Handling
- (4) Office Automation

DEMAND FORECASTING: PASSENGER AND FREIGHT

IR has data on passenger demand between any two stations based on class of service, time of day, day of week and season of year. This data can be processed to get precise passenger demand forecasts. This will help in informed decision making with respect to pricing, introduction of new services, and increase in capacity of existing services.

Similarly, data on freight transport is also available for the last few years. A forecasting system can help make better forecasts of rake demand, which can lead to more efficient rake circuits. Therefore a thorough review of the working of FOIS needs to be carried out and additional applications need to be planned based on the review. This system should serve as the backbone for decision making in freight operation planning. Table 10.3 lists the issues that demand forecasts will address and the associated benefits.

SCHEDULING

PASSENGER TRAINS

Trains wait a long time for entry at the terminals. A holistic solution to address the causes that result in long waits is needed. Making a coaching timeta-

ble is a complex planning exercise. The objective of any time tabling exercise is to prepare a feasible and workable timetable by taking into account terminal facilities, path for running trains, maintenance of trains, etc. Timetable simulation software can help. Table 10.4 lists the issues that scheduling applications for passenger trains will address and the associated benefits.

FREIGHT TRAINS

Coaching trains run according to timetables but goods trains run as and when a path is available. To cope with the dynamic problems of freight operations, IR has implemented transaction processing systems. They include, FOIS, PRS, COA and CMS.

The next stage in IT implementation is a planning and scheduling system which can assist in making goods trains' schedule and control charts 24 or 48 hours in advance. This has the potential to change the basic character of railway operations from execution- to planning-intensive. In the absence of such a system, the operational planning complexity cannot be precisely managed in great detail and most of the decisions are taken at execution time. This reduces the utilisation of assets.

A scheduling and planning system has the potential to improve the operating ratio by 3-5 per cent by increasing the utilisation of assets. Table 10.5 lists the issues that scheduling applications for freight trains will address and the associated benefits.

PROCUREMENT AND CONTRACT HANDLING APPLICATION

The procurement of equipment and materials and handling of contracts for outsourced work need ICT applications to increase transparency and to make oversight easier. E-tendering has been implemented

Table 10.5
Benefits of Scheduling Applications for Freight Trains

ISSUES	SOLUTION FEATURES	IMPACT
Planning for goods train operations is ad-hoc. Train-running information beyond the jurisdiction of the divisional control office is non-existent and not taken into account for precision in freight train scheduling.	Planning and scheduling system for goods train	Better plan
Terminal detention of locomotives at yards is high	Locomotive planning be integral part of scheduling application	Increased loco utilisation
Rakes wait at terminal for loading and unloading	Simulation of terminal facilities	Increased wagon turnaround
Shortage of wagon rakes for freight customers	Scientific allocation of empty rakes	More revenue from same number of rakes
Sometimes crew is available but still not used and sometimes no crew is available	Crew requirements are simulated in advance to give precise forecast of requirements	Increased utilisation of crew
Some divisions have more locomotives than they can handle	Locomotive movements are planned in advance to avoid such situation	Increased utilisation of locomotives
Conflict in traffic block commitments and goods train movements	Incorporation of traffic block commitments is lacking in goods movement planning	Better traffic block planning
Out of path coaching trains adversely affects goods movements	Tactical decisions can be made keeping in view of current running of trains	Better utilisation of paths
Advance precise information about empty rake placement or loaded rake placement is difficult to give and adhere to	Precise information of rake placement	Reduction of labour wastage for freight customers and faster release of rakes

Source: Infosys Research.

Table 10.6
Benefits of ICT Applications for Procurement and Contract Handling

ISSUES	SOLUTION FEATURES	IMPACT
Cumbersome process of tendering and tender processing	Automation of business rules and IT assistance at each stage of decision making.	Simplified system assisted process
Costly process for third parties to participate in tenders	Simplified process based on single earnest money, contractor/supplier profile, e-tendering, e-payment, etc.	Easy for third parties to participate, thus increasing competition and reducing cost for third parties
Lack of transparency and scope for manipulation	Transparent process with audit trails and time stamps for activities	Increased transparency, easy monitoring by vigilance agencies
Need for removal of opportunistic suppliers and contractors	Central system for monitoring, approval, blacklisting and rating	Improvement in quality of suppliers and contractors in long run
Unavailability of pricing trends for similar supplies and services in other zones	Centralised data on all previous tenders for works and stores	More information leads to better negotiations
Difficult to monitor the progress of tenders and works contracts	Easy access to information from anywhere will make it easy to monitor by higher officials	Better monitoring leads to more
Delay in measurements and inspections	Inspection and measurement recording in the system	Transparency and easy to fix responsibility for delays
Delay in payment	Invoice and payment tracking	Timely payments

Source: Infosys Research.

Table 10.7

Benefits of ICT Applications for Work-Flow-based Office Automation

ISSUES	SOLUTION FEATURES	IMPACT
Need for better planning of traffic blocks, power blocks and non-interlock working	System to coordinate planning block to reduce impact on train movement	More blocks for maintenance, better utilisation of blocks, less impact on train movement
Planning for inspections, recording of defects	Handheld devices for collecting inspection reports	Saving of time for inspecting staff
Monitoring of output of scheduled maintenance activities	Update of data for schedule maintenance and visibility to senior officers	Better maintenance
Material management in field maintenance	Recording of consumption of material on time	Better material planning
Monitoring of outsourced work	Timely recording of work executed by third parties	Better quality work and work monitoring

Source: Infosys Research.

successfully for the purchase and works tenders, auctions of scrap material, and reverse auctions. The interactions between third parties and railways should be enabled by ICT applications. Previous rates should be available at a single location and ratings on quality of suppliers and contractors should be available centrally. Table 10.6 lists the issues that ICT applications for procurement and contract handling will address and the associated benefits.

WORKFLOW-BASED OFFICE AUTOMATION

The majority of IR's staff is employed in the maintenance of assets. These activities could benefit immensely by using workflow-based office automation products, particularly for recording data and scheduling of activities.

Locomotives, coaches and wagons are maintained in loco sheds, coaching depots and wagon depots and periodic overhaul (POH) workshops. The major activities at these places are inspections, preventive maintenance, breakdown maintenance, replacement of worn-out parts, lubrication, etc. These centres need unique applications, customised for their requirements. A thorough study of the activities at these places should be carried out to understand the workflow, associated paper work and record keeping, and the possibilities for improving work processes. Separate applications are likely to be needed for loco sheds, coaching departments, wagon repair shops and POH workshops.

Flexibility of operations is a key aspect of the work at these centres, and manual processes are very

flexible. Therefore, any software-based application must maintain the flexibility of operations.

Fixed assets, which include rail tracks, bridges, signals, and overhead electric equipment, are maintained on location, and the maintenance staff travels to the site. Inspection, periodic maintenance, condition-based maintenance and breakdown maintenance are the major activities in the maintenance of fixed assets. Further, the maintenance of these assets often require blocking of traffic and/or electric power and disabling of interlock features.

In order to keep the number and duration of these blocks to the minimum and to make maximum use of a block when it is implemented, coordination between various departments is essential. These maintenance activities need software applications specially designed for this purpose. Separate applications will be needed for track and bridge maintenance, overhead electrical equipment (OHE) maintenance, maintenance of signals, and blocking of traffic, power and interlock operation. Table 10.7 lists the issues that office automation will address and the associated benefits.

HUMAN RESOURCE MANAGEMENT

A comprehensive HR management system should be developed to better manage processes and costs as well as to allow proper tracking of skills and gain improved efficiencies by assigning the right people to the right jobs. Such a system should also maintain an updated record of leave and entitlements, making HR management efficient and effective.

There is a strong requirement in the railways for a comprehensive IT security framework to safeguard critical information and avoid unauthorised manipulation/ damage to the data. Numerous transactions with external users need very high levels of security.

INSTITUTION AND CAPACITY BUILDING

As can be seen from the previous sections, there are several areas where IR can benefit from the use of ICT. However, given the very large size of IR as an organisation, bringing about these changes will require strong institutions and a large number of professionals having domain knowledge and expertise in ICT.

The following four features are required for any institutional structure for implementing ICT in IR on a large scale:

- **Agency with Authority and Reach:** The Agency should have the benefit of domain knowledge of the various discipline verticals as also the authority to push the required changes across the entire system. Given the geographical spread and setup of the railway system, a body of professionals would also be required at the zonal railway level.
- **Specialised Entity for Developing, Implementing and Maintaining ICT Products:** This entity will be responsible for developing, implementing and maintaining ICT applications across the entire system. It will also develop ICT standards and protocols for the entire organisation.
- **Dedicated Organisation for Operationalising ICT Applications at Field Level:** This organisation will be responsible for operationalising and maintaining ICT applications at the field level under dynamic operational environment.
- **Human Resources:** Given the size of IR, application of ICTs in the various departments across the organisation will require large numbers of staff trained in the use of ICT for specific tasks. Taking into account the dynamic nature of ICT technology and the dynamic nature of work of railways, induction and periodic training has to be an essential component of human resource development.

We, therefore, recommend the following institutional changes which are both economical and least disruptive:

- (1) Computer and Information Systems (C&IS) Directorate at the Railway Board be greatly enhanced to encompass the entire gamut of

ICT applications on the network

- (2) Centre for Railway Information Systems (CRIS) be converted from a society to a non-profit company with much greater freedom
- (3) Organisation(s) for operationalising ICT applications at field level be converted into autonomous bodies
- (4) IR Institute of Transport Management (IRITM) be entrusted with the task of human resource development

C&IS DIRECTORATE

The C&IS Directorate has the responsibility of conceptualising and driving ICT enablement across the system and functions within the Railway Board. C&IS should continue being a directorate within the Board so that it can draw on the authority of the Board. However, it should be enlarged to reflect the requirements of major disciplines and the support units of IR. Furthermore, each zonal railway should have an ICT person in an executive position so that he or she can implement decisions taken by the enhanced C&IS. This Directorate will be the interface with the external stakeholders and also oversee the functioning of CRIS and the field organisations.

CENTRE FOR RAILWAY INFORMATION SYSTEMS (CRIS)

CRIS was established as a specialised organisation under the aegis of the Railway Board as a Society under the Societies Registration Act. It brings together domain experts and qualified technical personnel to create customised software products for the railways. Over the last 25 years, this innovative organisational design has enabled IR to successfully implement and sustain major IT Projects in several areas. It has helped to develop a range of applications as part of six virtual verticals—Business, Operations, Procurement, Asset Management, Planning, Financial and Human Resources, Security. CRIS can be made into a not-for-profit company with a lot more freedom and empowerment than at present so that it can attract talent. The enhanced CRIS can also assist in creating standards and protocols in areas of technology, maintenance, data management and security.

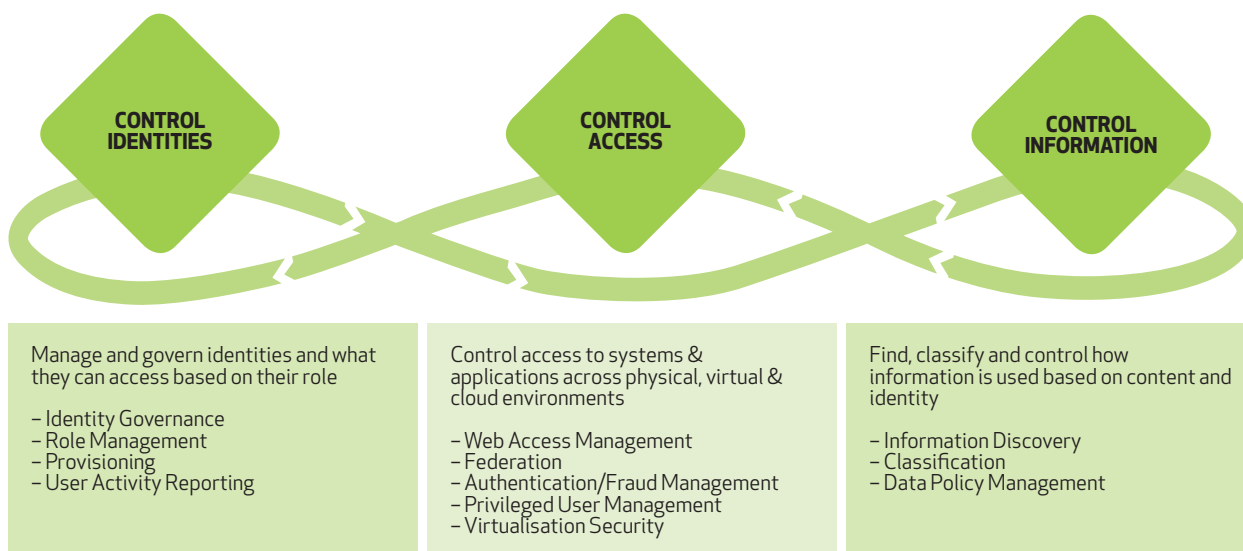
DEDICATED ORGANISATION(S) FOR OPERATIONALISING ICT APPLICATIONS

IR has created central and field level organisations for operationalising ICT applications in operations and commercial areas. These organisations are an important interface between CRIS and zonal railways. As the workload increases, there is a need for strengthening the organisational structure both in terms of autonomy and manpower continuity.

IR INSTITUTE OF TRANSPORT MANAGEMENT

IR Institute of Transport Management (IRITM) is the premier institution for training railway managers in operations and commercial disciplines. The Institute is well endowed with physical and technical resources. It can be strengthened with minimal expenditure for capacity building of the railway personnel from vari-

Table 10.12
IT Security Framework



Source: Infosys Research.

ous disciplines in application of ICT in their areas of working. It can also promote need-based research and scanning of new technologies.

LONG RANGE DECISION SUPPORT SYSTEM (LRDSS) PROJECT

The LRDSS is an investment planning software tool developed by an American company in the late 1990s with funding provided by the World Bank. The software was acquired by IR for the simulation of its network and identifying capacity bottlenecks on the system under operational conditions for the purposes of investment planning. With the passage of time, the software has become obsolete and the new version has not yet been developed. CRIS has the capability to develop the required software, dovetailing the same with the operational data available with them. This tool can then be gainfully used both for long range decision making as also for operational decision support on a day-to-day basis. As such, the LRDSS project should be housed with CRIS.

SECURITY

There is a strong need for a comprehensive IT security framework to safeguard critical information and avoid unauthorised manipulation/damage to the data as well as denial of service to authorised users. There are various external applications like passenger reservations, IR portal, and freight operations involving numerous financial transactions from external users which require high levels of security. Similarly, internal application like MIS, financial applications, workshop designs containing sensitive/confidential internal data stand a risk of unauthorised access, data leakage, etc., which are required to be secured. Employee transfers happen on a regular basis and in most cases, user access/accounts are not deleted/remains active post the

transfer/new assignment, thereby posing a grave security risk.

Considering the above challenges from external as well as internal users, there is indeed a great need for IR to have a comprehensively secure framework for IT network/applications/infrastructure that should at the minimum provide control for identities, access and information.

In this respect, the IT Security Framework must provide the following capabilities:

- Host-based access control for protecting critical servers
- An audit trail of untampered logs of every incident that has happened
- Identity management
- Web access management and single sign-on (SSO)
- Data loss prevention

It is suggested that a Joint Working Group comprising cyber experts, representatives of Indian Computer Emergency Response Team (CIRT-In), National Critical Information Infrastructure Protection Centre (CERT-In) and railway professionals is set up to address the critical issue of cyber security.

SUMMARY OF RECOMMENDATIONS

Given that there will be large benefits from introducing ICT solutions, we recommend that there be intensive implementation of ICT as soon as possible. While generally the implementation of ICT solutions can be done relatively quickly, adequate capacity in the implementation agencies is essential for effective implementation. In that context, some ICT solutions which are likely to be more centralised, such as demand forecasting and scheduling, could be

There is very little data available on public transport and freight movement by road. Sensors and controllers can help gather raw data; communication technology can transmit it to computer systems which analyse the data.

implemented with less strengthening of CRIS, compared to procurement, contract handling and workflow office automation which need to be introduced on an enterprise-wide level to ensure uniformity and inter-operability, and hence require integration and capacity building in the numerous field organisations

ICT in Railways should also result not only in the ability to track goods and passenger movements, but also generate 'on-time' performance in public domain to enhance transparency and accountability. We recommend that for the first three years, the focus should be on increasing both passenger and freight revenue and improving asset utilisation through ICT solutions described under demand forecasting and scheduling. Strengthening of C&IS and CRIS should also be initiated immediately, particularly to increase the number of qualified people. CRIS should be converted from a society to a non-profit company in this phase.

By the third year, we expect that CRIS would be sufficiently strengthened at both the centre and in the regional and field level so that for the it can implement ICT solutions for procurement, contract handling, office automation and human resource management. During the years three-five, we recommend that these ICT solutions be implemented and that strengthening of CRIS and C&IS continue.

ICT FOR ROAD TRANSPORT⁴

KEY ISSUES

There are three areas of the road sector where ICT could play a significant role in mitigating problems: (1) Good quality data to support evidence-based policy-making; (2) Increase in efficiency of the road transport system and satisfaction of its users; and (3) Management of safety and care of the injured.

GOOD QUALITY DATA

Effective policy making requires good quality data on aspects such as: composition and volume of current traffic; condition of roads and its association with the volume of traffic; and information about vehicles (number, kilometres travelled, level of pollution control). While a considerable amount of

these data are collected, they are not available in a readily useable form and hence are not used much for policy making.

Considerable data is available on the physical achievements in the roads sector, but not much on performance and outcome-focused indicators. Such performance-related data is needed for benchmarking within the roads sector and for comparison with other modes. In that context, it should be noted that almost no data is available on non-motorised transport (NMT) even though it serves an important need for short trips and provides access to public transport.

Data is also needed on the condition of roads so that maintenance can be more effective and efficient. More extensive data is required on accidents which include the circumstances of the accidents (location, how or why the accident happened, and number of injuries and fatalities, etc.) so that roads can be designed to be safer and measures taken to reduce the number of accidents. On the requirements for data on public transport, we find that while considerable data is collected on government-owned buses, there is very little data about privately-owned buses even though they provide about 90 per cent of public transport. Similarly, almost no data is available on the movement of freight by road.

ICT will play a pivotal role in filling these data gaps. Detailed studies will be required where sensors and controllers will help gather raw data about number of vehicles, passengers, etc.; communication technologies will be used to transmit the raw data to computer systems, and hardware and software systems will be used to set up the databases. Software programs and data analysis will facilitate drawing of conclusions. For example, systematic origin-destination studies are required for freight traffic. The chapter on the roads sector describes in detail the processes required to carry out such studies.

INCREASING EFFICIENCY AND USER SATISFACTION

A lack of integration between various transport agencies, both within and between states, leads to inefficiency, delays and poor customer service.

COORDINATION BETWEEN STATES

In order to ensure uniformity and interoperability throughout the country, the Government has decided to create a National Register and State Registers of Driving Licences (DL) of drivers and Registration Certificates (RC) of motor vehicles. This initiative would help not only in interoperability between states but will also improve enforcement and instant verification of Driving Licences and Registration Certificates (see the chapter on roads

4. Chapter 2, Volume III on the roads sector covers ICT applications extensively, particularly related to issues of data collection and use.

for more details). Sharing of data between RTOs and with traffic police and insurance companies will help in ensuring that defaulting drivers/vehicles are penalised, vehicles that are not traffic-worthy can be towed, the insurance premium of at-fault individual drivers can be increased, etc.

INTER-STATE MOVEMENT OF FREIGHT

Considerable time is lost by freight transporters at borders between states, because of long waits for border checks and payments often done manually. We give three examples of application of ICT that can expedite processes at borders.

NEW NATIONAL PERMIT SYSTEM (NNPS)

Under the NNPS that is already being used in some states, permit fees can be e-paid. The technology was developed by NIC. States should use this e-payment facility to plug revenue leakage and to reduce waiting time for the freight vehicles at the border check posts.

GREEN CHANNEL

Gujarat currently implements the 'Green Channel' concept, whereby commodities with a single destination are accorded 'Green Channel' status. The papers of such commodity movements are prepared in advance and are sent to the check post. Since freight with a single destination accounts for a large proportion of consignments and is likely to increase with containerisation, this concept helps reduce delay in freight movement. We believe high-value freight and sensitive commodities should also use the 'Green Channel'. Proper sealing and certification mechanism can be put in place for safe movement of freight.

AUTOMATION AND COMPUTERIZATION OF INTER-STATE CHECK POSTS (ICPS)

Presently, Gujarat and Andhra Pradesh have automated ICPs. This has resulted in 100 per cent checking of vehicles and a fourfold increase in revenue collection. The automation can lead to faster delivery time, fewer opportunities for leakage in revenue and stabilised revenue flows.

STANDARDISATION OF TOLL PAYMENT

Operators of the many toll roads have different methods of payment resulting in long queues at toll booths. In order to increase efficiency and productivity of the toll-based system of payment, the method of toll payments should be standardised.

The Nandan Nilekani Committee on Unified Electronic Toll Collection proposed an OBU that can be read across all tolls. Details of the Committee's recommendations appear in the chapter on roads.

INTEGRATION OF TAX PAYMENTS

Currently different data on manufacturing and transportation of products is being collected by the different taxation departments (Excise, CST and VAT). These data can be brought under a centralised

In ports, different IT solutions function as islands of information and do not communicate with one another because there is no common platform for information exchange. This defeats the whole purpose of automation resulting in no savings in time.

database system through which movement of different commodities can be tracked. The ensuing data collection can help in efficient movement (lower cost and time) of freight.

SAFETY MANAGEMENT AND CARE OF THE INJURED

Indian roads have high levels of accidents and injuries. The treatment of injured persons is extremely slow and ineffective leading to a high level of fatalities. A new safety initiative (post-accident initiative) called 'Golden Care' is recommended to reduce fatalities in the event of an accident on National Highways or State Highways. The 'golden hour' is a term used in emergency medicine and refers to the time immediately following a traumatic injury, when prompt medical attention is most likely to prevent death. Under the Golden Care Initiative, when an accident occurs, medical care should be provided to the victims within the golden hour. Administrators should ensure that whenever an emergency situation occurs on the highways, victims are rushed to a nearby medical centre within 10 minutes of the accident. The chapter on roads provides further details of this proposed safety initiative.

ICT FOR PORTS

KEY ISSUES

While the cargo traffic at Indian ports is expected to grow rapidly in the coming two decades, the ports are already stretched to capacity, with the capacity utilisation already close to 100 per cent or higher at many major ports. Low productivity, congestion and delays are the norm at most Indian ports. While increases in capacity at ports will help, ICT can help improve productivity and efficiency at ports.

A preliminary study of the ICT applications at various ports in India suggests that though the basic automation of terminal operations and other functional areas has been undertaken or is being implemented, it has not yielded the desired results due to lack of integration and a holistic approach towards automation. Different IT solutions function as islands of information and do not interact with one another because there is no common platform or set of standards for information exchange. Therefore, stakeholders still need to have documents verified at multiple points, even though each of these

Ports are dependent on a community of service providers such as shipping lines, freight forwarders, customs, clearing agents, etc. All the stakeholders need to be ICT-enabled and share real-time information and status updates with one another.

points or offices themselves might have been automated, as there is no communication link or compatibility between the existing systems. This defeats the entire purpose of automation resulting in no savings in time.

A discussion with the port operators highlights some of the problems they experienced in managing terminal operations:

- **Lack of standardisation:** Many of the Indian ports use proprietary formats for Electronic Data Interchange (EDI) with Customs, which are not compatible with international standards like UN/EDIFACT (Electronic Data Interchange for Administration, Commerce and Transport). There are no formal standards or formats used across stakeholders. For example, codes for identification of hazardous cargo are different between ports, customs and CONCOR. Some cargo is considered normal by the ports while CONCOR considers that cargo as hazardous.
- **Lack of real time information:** In the absence of a web portal which provides real-time information on vessel schedules, expected times of vessel arrival (ETAs) and details of berth allocation to the concerned stakeholders, often a vessel has to wait for a long time in the channel before berthing. These pre-berthing detentions add to vessel turnaround time and increase cost.
- **Lack of automation in yard planning:** Most of the ports and container freight stations (CFSSs) do not have automated yard plans. Yard reports are still paper-based and are not updated every time a container is moved from one location to another, making it very difficult for the Custom House Agents (CHAs) and others to track containers, especially those of foreign origin which need to be sent back within six months.
- **Manual process for documentation:** Several processes such as issue and collection of a Delivery Order (DO), Let Export Order (LEO) released by Customs are still handled manually, thereby introducing delays in the system. A CHA has to go to different shipping agents for getting Delivery Orders (DOs) for all the importers the CHA represents. Any change in the document requires several authentica-

tions and can be very cumbersome.

- **Integration of CFS with port systems:** Currently Customs is not integrated with the CFS operations at most of the ports. Therefore, the CHA is required to accompany the trucks with the necessary documents each time they move in or out of the CFS. This creates bottlenecks in speedy clearance.
- **Traffic management at port gates:** Manual verification of documents at the port gates and issuance of gate passes take up a lot of time leading to congestion and traffic jams.
- **Origins to destination tracking of EXIM goods:** Existing logistics systems available at ports and logistics service providers do not have the provision to track cargo once it has left the port's premises. It therefore becomes very difficult for importers to get a realistic estimate of the Expected Time of Arrival (ETA) of their consignment. They are dependent on the information provided by the transport operators which is not available in real time and is often unreliable

FRAMEWORK FOR IMPLEMENTATION OF ICT

As discussed earlier, introducing ICTs in individual processes is not likely to yield much benefit in the performance of Indian ports. Attention must be paid to systemic issues such as integration of various processes.

INTEGRATED IT POLICY AND PLANNING

Going forward, all major ports would need an extensive IT infrastructure to manage their day-to-day operations. In addition to their usual assets such as cranes, machinery, etc., they will need to set up data centres, have enough computers, servers, network connectivity, application software and trained manpower to manage all these ICT-related additions. In the absence of comprehensive guidelines for ICT enablement of port operations, each port has devised its own ICT strategy and implemented custom solutions which may or may not be compatible with the ICT systems at other ports. Therefore, in order to create an interconnected network of ports and ensure consistency in ICT policies, ICT infrastructure and the business processes being covered, it is required that the Ministry of Shipping lays down the ICT policy and roadmap for India's maritime sector. Towards the end of the section, we discuss additional institutions that could assist the Ministry in development of such a policy and set of standards.

INTEROPERABILITY AND ELECTRONIC DATA INTERCHANGE (EDI)

Once a uniform policy and roadmap are established for all the ports, attention needs to be focused on making the various systems interoperable both within and between ports. Ports do not work in isolation but are dependent on a community of service providers such as shipping lines, C&F agents, freight

forwarders, transport operators, customs, clearing agents, etc. Therefore, partial technology enablement will not help; instead, it will create problems related to data sharing, redundant data entry, handling of multiple paper documents, processing delays and human errors. It is therefore envisaged that in future, all the stakeholders in maritime trade will be ICT-enabled and would be able to share real-time information and status updates with one another. The shipping line will share the location of its vessel and communicate its expected time of arrival (ETA) to the port, in order to avoid pre-berthing detentions. The ports, in turn, will plan the loading and unloading schedule and evacuation strategy. Pre-submission of cargo details to customs through EDI will also save processing time. All these initiatives for stakeholder automation can significantly reduce cargo dwell time at ports and help in improving India's trade competitiveness.

The vision for the maritime sector in India is to create a well-knit community of ports and associated service providers which will help them share the latest information, analyse data, monitor progress and support quick decision making. This will require interoperability between IT systems owned by various entities and provisions for EDI. It is therefore imperative that we lay down standards and protocols for these information exchanges. All software applications and solutions developed for the maritime industry will need to conform to these standards. Since it will involve international shipping lines and other overseas service providers, it is proposed that the standards comply with international norms.

SINGLE WINDOW SYSTEM FOR TRADE FACILITATION

Maritime trade requires interaction with a number of government agencies and private service providers. A trader has to submit documents at various counters and separately follow up with them for licenses or permits and cargo clearances. The absence of a single point of contact and limited transparency across departments reduces the overall process efficiency. The Single Window concept attempts to look at various processes and documentation requirements from the trader's point of view and weed out the redundancies. Most of the leading maritime nations are moving towards creating a National Single Window (NSW) for improving transparency and reducing process lead times. Indian ports should also move to a Single Window regime to reduce turnaround and dwell times and improve India's competitiveness in international trade.

SMART CARGO

Smart cargo is the next step in automation of maritime operations. Recent developments in RFID and GPS technologies seek to make the cargo intelligent. The containers will have smart tags and

will be able to identify themselves to the RFID tag reader providing information on content, origin-destination, etc. They can also have sensors attached to them which will raise alarms in case of unauthorised seal tampering or other unusual conditions like a rise/fall in temperature beyond threshold limits. We can also track the door to door movement of these containers right from the container yard to the delivery point using sophisticated technologies. This will reduce handling time and eliminate risks associated with container security and missing consignments.

ICT TECHNOLOGIES

We now turn to some of the ICT interventions which can help in better management of port traffic and improve the overall efficiency of the system.

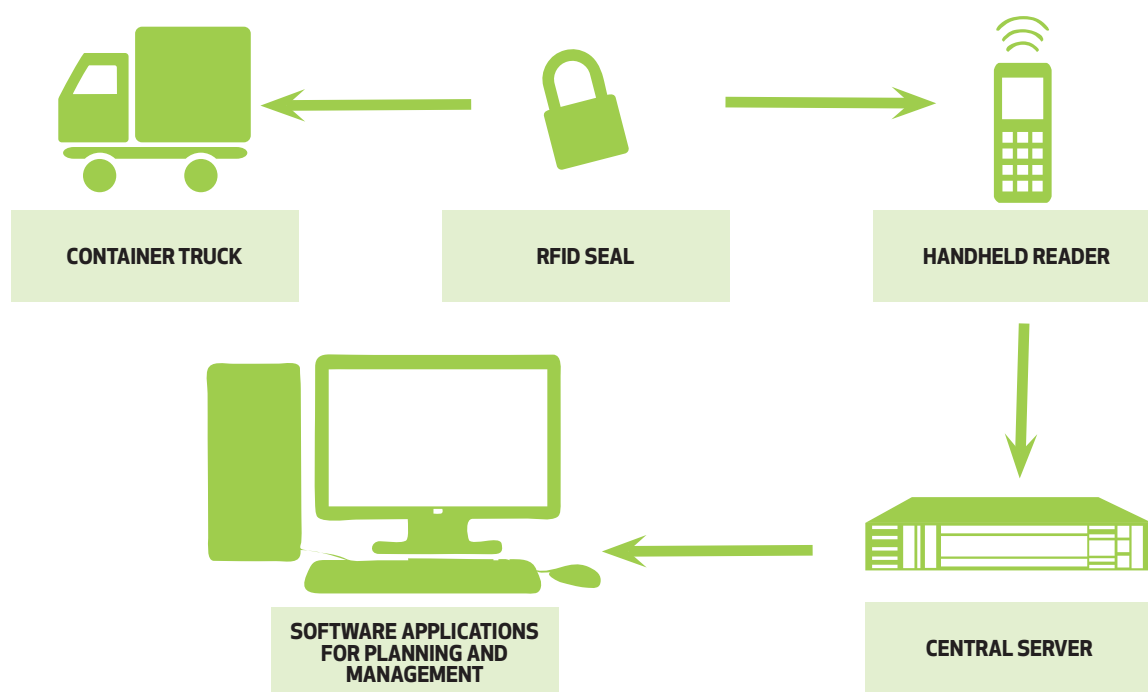
YARD PLANNING AND INVENTORY MANAGEMENT

Today over 60 per cent of the world's deep-sea general cargo is transported by containers and therefore an efficient and robust container terminal management system can play an important role in determining the overall attractiveness of a port. Efficient loading and unloading of containers and management of the storage yard is one of the most complex operations at a port and needs specialised skills. Average turnaround time for containers is a critical metric in this context, and it is here that the value of an effective and efficient yard planning and inventory management system becomes evident. In the case of consignments of perishable goods, such systems are critically important because delays can result in the loss of the entire shipment.

Currently, at most Indian ports, dry bulk cargo is stored in open yards where individual plots are not well demarcated and numbered. In most of the ports, data on the current occupancy of these plots and their availability schedule is not readily available. Exporters and importers don't get a clear view of the yard storage space to plan the movement of their cargo. This leads to sub-optimal utilisation of a port's storage yard and loss of revenue. Yet, certain sophisticated software modules are available today which employ complex algorithms to optimally utilise the available storage space in the Yard. **Geographic Information System (GIS) solutions** could be used to get a real-time view of the storage area. Data on plot allotment and expected evacuation date could be

Smart cargo is the next step in maritime operations automation. Containers will have smart tags and will be able to identify themselves to RFID tag readers and provide information on content, origin-destination, etc.

Figure 10.13
RFID-based Yard Planning and Inventory Management System



Source: Infosys Research.

maintained online. The software also has provisions to define various rules and controls for better yard operations and planning, thereby increasing yard throughput and enhancing customer satisfaction.

Another useful application is the **Radio Frequency Identification (RFID) technology** for monitoring container movements in the yard. RFID provides the ability to automatically collect real-time data about the physical location and properties of any container which has been RFID-tagged. An active RFID system consists of two key components: a tag which is called a transponder, and a reader device, which is referred to as an interrogator. The reader can initiate communication with the tags by sending out a wake-up signal and listening to their response. These responses could be used for the following purposes:

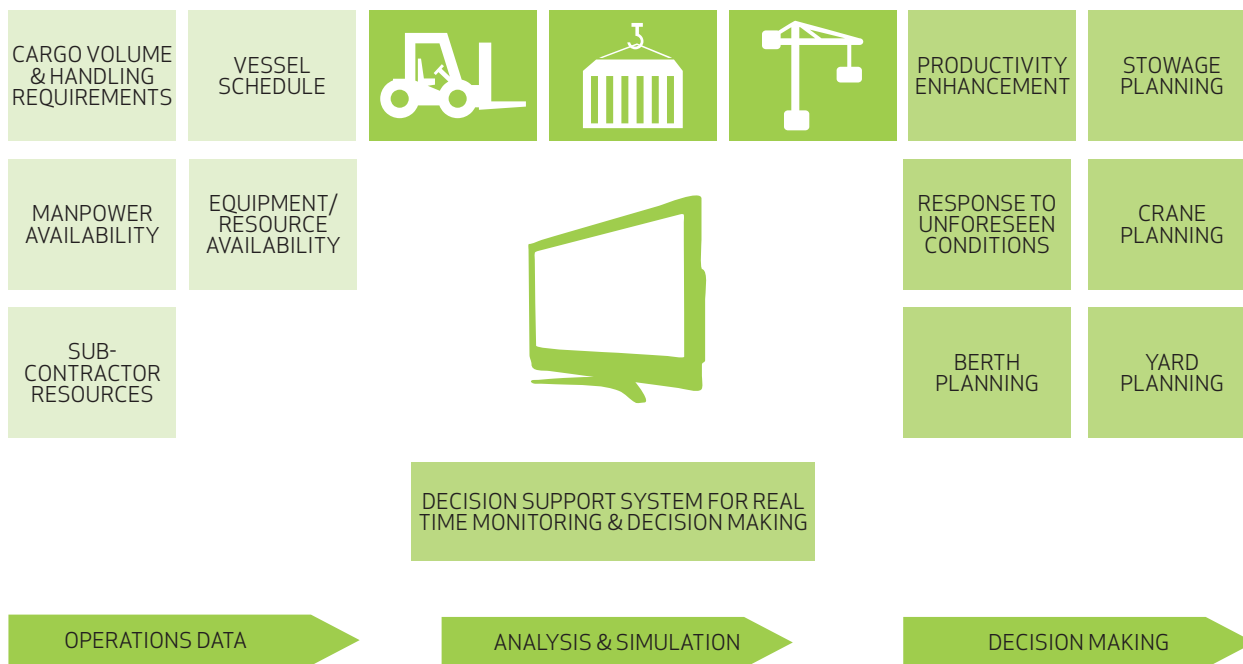
- **Identification and data capture:** Container identification number and other key information stored in the tags related to cargo origin-destination, etc., can be captured by the reader.
- **Location mapping:** RFID tags can be buried at regular intervals in the passageways to serve as location markers. These tags can be read by readers in the yard and provide information on the exact location of the container. Additionally, some tags can also have a GPS module which would transmit its location to the control room.
- **Electronic sealing (e-Seal) of containers:** Electronic container seals could be used to

identify cases of seal tampering. These seals are active RFID tags which can broadcast the fact that they have been opened or removed without authorisation. These tags cannot be counterfeited. Everyday millions of containers are handled at various ports around the world and it is not feasible to physically inspect all of them. This creates a huge security risk. RFID can help in reducing security concerns without adversely affecting port productivity through real-time scanning of containers. Those with e-Seals that have not been tampered with can be processed in a fast track mode, while the others could be segregated for a detailed examination.

RFID technology can make Inventory management as simple as 'walking the yard' as shown in Figure 10.12. The operator can take a handheld tag reader and carry out a yard survey; in the process he would be able to capture the required information from the RFID tags in the stored containers. It would have all details related to origin-destination, date of entry-exit, etc. This would also eliminate the issue of data accuracy which is due to the usual lag between manual data collection and its entry into the system.

Even the shipping companies can know at any point in time where their containers are located and can track their movements for further analysis and route optimisation.

Figure 10.14
Decision Support System (DSS)



Source: Infosys Research.

VEHICLE TRAFFIC MANAGEMENT AT PORT GATES

Traffic congestion at the port gates is another critical problem area for terminal operators. Mandatory security checks and document verification is required before a truck can enter the port premises. Currently, most of these operations are controlled manually with very little or no automation. In order to manage the expected exponential growth in traffic, technological solutions will be essential for expediting movement of vehicles in and out of port premises without compromising on security and statutory requirements.

The entry and exit of vehicles and drivers through the gates of a container terminal can be automated. An **Optical Character Recognition (OCR) system** installed at the terminal gates can be used for identifying the tags on a container and vehicle. This information can then be compared with the expected arrival or departure of the vehicle as stored in the port database for authentication. The driver's **biometric identity** and his authentication documents could be stored in a **'smart card'** which he can flash at the counter to gain entry. An automatic barrier and traffic lights system can undertake the required physical control of the gate towards the inner area of the terminal. The yard operations manager would decide on the best possible storage location for the incoming container and pass on the information to the gate operator. At the gate, the operator would be able to identify the allotted location through the GIS system and accordingly provide the truck driver

with a printed message showing the exact position or slot within the parking area.

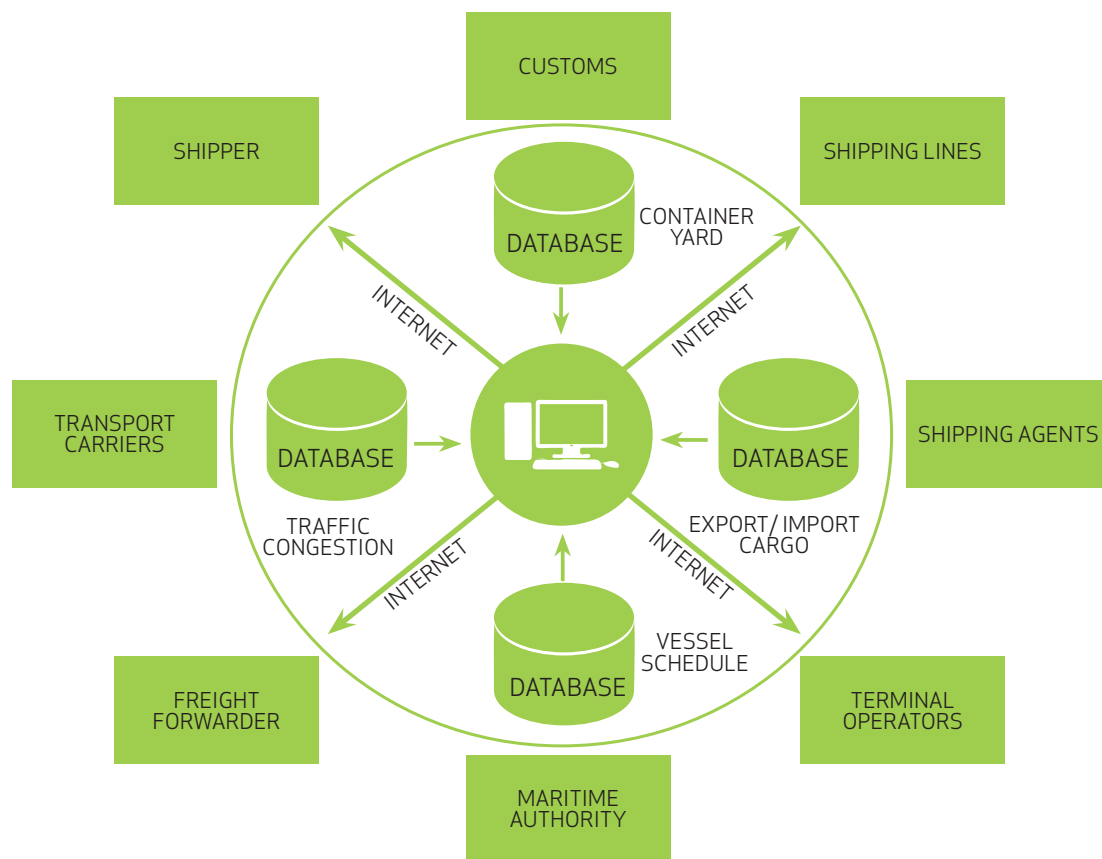
ENTERPRISE RESOURCE PLANNING (ERP) SOLUTIONS

In addition to managing port operations, the port operator also needs to carry out several administrative and human resource related functions such as payroll processing, financial management, procurement, estate management, hospital management, customer grievance redressal, etc. Many Indian ports have their own custom-made IT applications to meet each of these requirements. This lack of integration, even within a port, leads to creation of multiple data pockets which do not support seamless flow of information. Therefore, the management of a port does not get an integrated 'dashboard' view of operations, leading to inefficiencies and sub-optimal resource utilisation. The lack of uniformity across ports in reporting on these important managerial functions constrains benchmarking of performance. It would be useful for the ports to consider implementing Enterprise Resource Planning (ERP) solutions driven by an integrated suite of software modules that supports the basic internal business processes of any organisation.

PORT/TERMINAL INFORMATION SYSTEMS

These systems essentially provide a dashboard view of all the operations at the port along with related performance metrics. They are equipped to collate and integrate operational information from varied sources such as vessel berthing schedule; planned

Figure 10.15
Port Community System



Source: Infosys Research.

unloading and loading requirements; and the available equipment and manpower resources. With this information, they use complex algorithms to prepare an integrated resource management plan that includes a deployment plan and initiatives required to ensure short vessel turnaround time with maximum asset utilisation.

These modules can also be integrated with the HR management software at the port, to provide information on the availability of manpower, their skills, planned leave, etc. Detailed analysis of historical data on deployment of equipment can help in identifying underutilised or overutilised resources. Accordingly, the port management can decide to procure additional equipment which will help in increasing its throughput. It can also help in identifying critical skills which are in short supply and design training programmes for employees to acquire those skills.

SIMULATION-BASED DECISION SUPPORT SYSTEM

With the increase in size of shipping vessels and mounting pressure to reduce vessel turnaround time, most modern ports have become mechanised with

sophisticated equipment for loading and unloading of cargo. Berthing of multiple vessels with competing loading or unloading schedules creates pressure on equipment operators to provide resources in time. Many factors with associated uncertainties affect the allocation of equipment. Effective and efficient allocation decisions require extensive data analysis, along with simulation that allows port operators to evaluate alternative choices. A robust Decision Support System (DSS) provides these facilities for analysis and simulation and thus can greatly facilitate more efficient allocation decisions as shown in Figure 10.14. Choices for deployment of resources assisted by a DSS can be communicated to equipment operators in real time through a Wireless LAN (WLAN).

The simulation system associated with a DSS can also be used to create a virtual environment for training the workforce. For example, training on handling of explosive or inflammable liquids such as chemicals, oils and liquefied gases and operating automated cranes can be provided under near-real conditions, thereby honing employee skills and improving efficiency.

PORT COMMUNITY SYSTEMS

A port has several stakeholders—terminal operators, cargo owners, freight forwarders, carriers, etc. The success of a port depends largely on its ability to integrate all its stakeholders with sharing of information being a key requirement. For most Indian ports, currently this is being done offline through multiple channels thus creating problems related to availability of up-to-date data, its accuracy, and the delay in decision making.

To resolve these issues, we propose creating a single technology-based platform for bringing together all the stakeholders to form a Port Community System (PCS) (Figure 10.15). In a PCS, each port would have a web portal which would provide real-time information related to all administrative and operational activities involved in the supply chain. A combination of RFID and GPS-based solution with a web interface can enable customers to constantly monitor the movement of their containers along with other information related to vessel berthing and port operations. This would help them trace and track their assets, have a real-time estimate of their inventory, and accordingly take informed business decisions.

The website could also provide other value added services such as:

- Port gate traffic view: Displays of live feeds from multiple cameras positioned at the gates
- Vessel schedule: Online publication of vessel details and berthing schedules
- Online bulletin board: To make announcements, receive feedback and resolve queries
- Cargo availability: Loading and unloading information related to export/import cargo

Once the system matures, it can include trade regulatory bodies, banks and other government agencies in this community. For example, ports can directly send invoices to the traders' banks for services offered, banks would get the necessary authorisation from the traders and credit the port's account; all these transactions being done online. An 'e-customs' solution could also be developed later, whereby all the customs-related documentation and other formalities are carried out through this portal. Such a system would increase transparency, reduce corruption and significantly improve the port's efficiency. Reduction in paperwork and follow-ups with customs officials would also reduce the cost of operations.

Implementation of a nationwide Port Community System (PCS) has already been initiated under the supervision of Indian Ports Association (IPA). However, discussions with several port officials suggest that the current PCS rollout has not been very successful mainly due to issues around proprietary message interchange formats and lack of interoperability of the IT systems owned by varied stakeholders.

An e-customs solution should be developed, whereby all customs documentation and other formalities can be managed through this portal. This would increase transparency, reduce corruption and improve port efficiency.

We therefore emphasise the need for standards and protocols for information exchange in the Indian maritime sector, in line with international norms. Before we embark upon an ambitious plan like PCS, we should first focus on building the foundation and developing stakeholder capabilities.

AUTOMATION OF BULK CARGO OPERATIONS

A 'smart' port is characterised by seamless integration of automated equipment, existing terminal processes and terminal operating systems. 'Last mile' automation of port operations using ICT systems can go a long way in increasing even a smart port's throughput. This is especially true, in the case of ports handling bulk cargo. Personnel dealing with last mile operations can be given mobile PDAs (handheld devices) which can be used to enter real-time operational data like time of vessel berthing, crane deployment, time taken for cargo unloading or loading, etc. These data can then be compared with planned milestones to monitor progress and take corrective actions, if required. Such a system would also save time by avoiding redundant paperwork as formalities like safety checklists, cargo discharge records, etc., that can be completed online

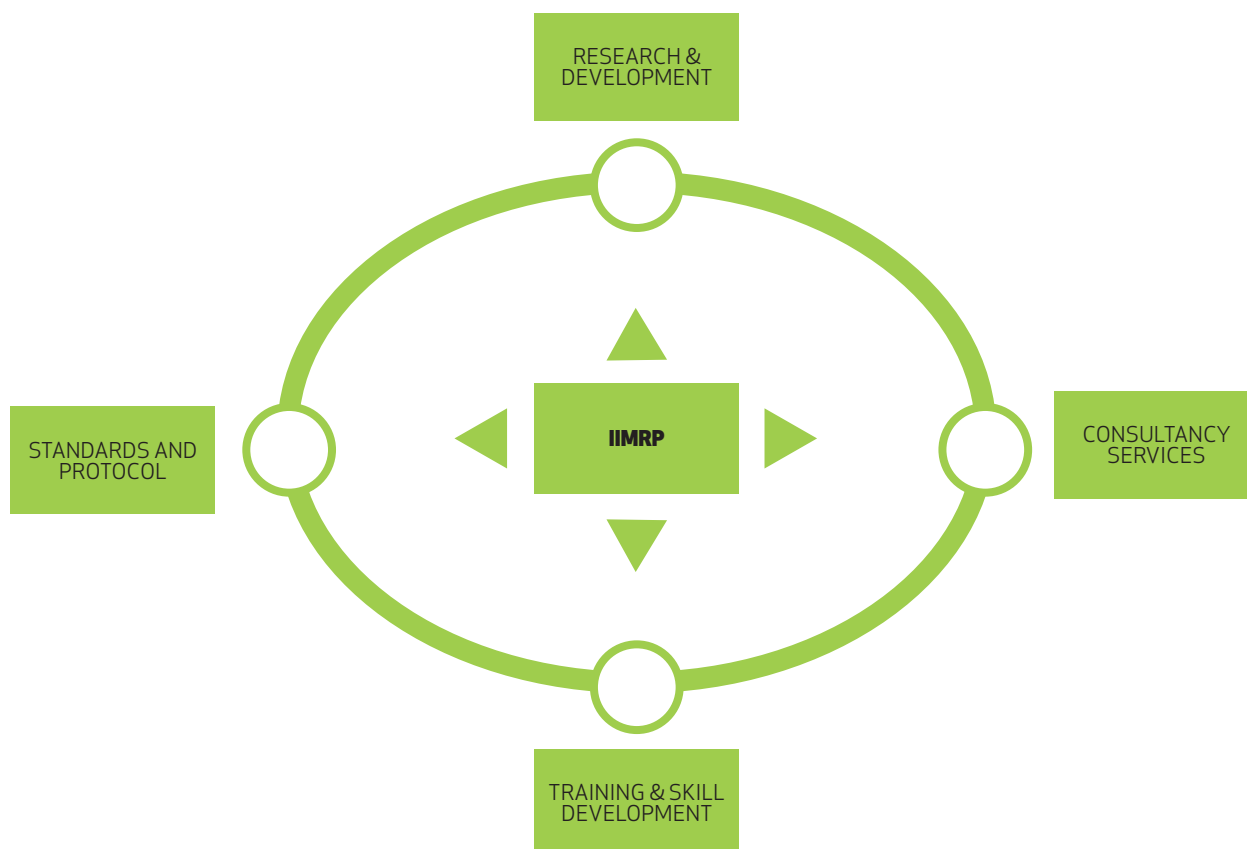
Another example of an ICT solution for last mile operations is when a ship is anchored at the port and cargo is being discharged. During unloading, the ship's position shifts due to change in distribution of material in the hold, tidal fluctuations, wind etc. All these have an adverse impact on the efficiency of the port's unloading and loading operations. Therefore, some ports use automatic grab ship unloaders which are equipped with hold and materials scanning system. They use sensors to detect the relative location between the hold and the loading machines as well as the actual distribution of materials inside the hold. These inputs are used by an inbuilt software module to prepare a discharge strategy for uniform loading and increasing the operating efficiency.

INSTITUTION AND CAPACITY BUILDING

A well-coordinated and integrated approach will require a strong institutional framework. In that context, the Committee recommends the establishment of an organisation, called the Indian Institute of Maritime Research & Planning (IIMRP). In addition to developing and implementing a well-coordinated introduction of ICT in the ports sector, IIMRP could be given a broader mandate to strengthen

Figure 10.16

Roles and Responsibilities of Indian Institute of Maritime Research & Planning (IIMRP)



Source: Infosys Research.

India's competitiveness in sea trade and commerce, and provide direction to the policymakers for that purpose. IIMRP would be expected to perform the following functions (Figure 10.16):

- Support the government in policy making, strategic planning and developing the road-map for the sector
- Carry out high-end research and development activities to improve operational efficiency and cut costs. This will include building large scale simulation models to analyse and predict traffic flow, as well suggest infrastructure development/augmentation
- Impart training in specialised areas for maritime professionals helping in development of a pool of qualified professional ready for managing impending growth
- Provide advisory and consultancy services to industry. It will analyse changes in international trade patterns and industry developments to chart the future of Indian maritime sector
- Develop standards and protocols for ICT solutions which would ensure interoperability between organisations and seamless flow of information.

IIMRP would be controlled by an advisory board which will have representatives from the industry, government and academia as shown in Figure 10.16. Such a body could be partly funded by the central government through annual grants and partially by the private sector. Besides, the IIMRP could also generate revenue by providing commercial research and consultancy services to the international maritime industry. Training and management development programmes for the industry could be another source of income.

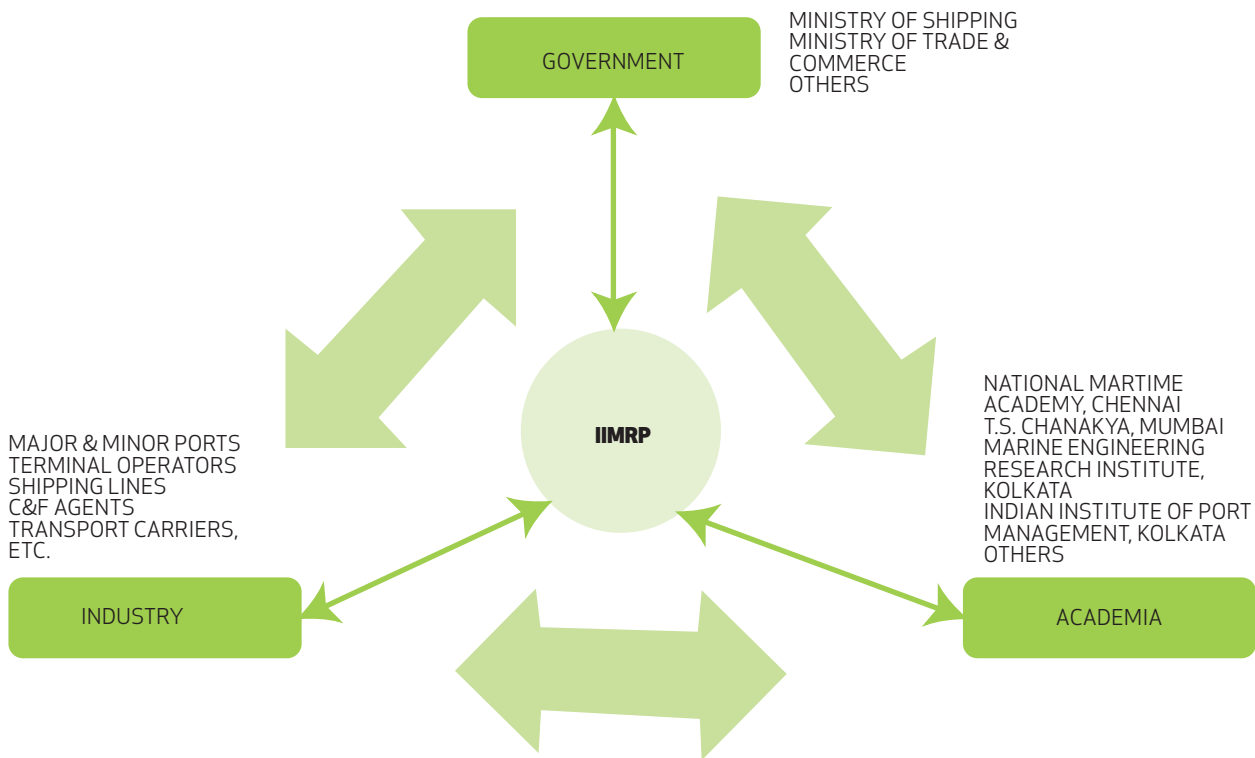
ICT IMPLEMENTATION ROADMAP

For the effective implementation of ICT applications in managing port operations, considerable groundwork is required. Therefore, we have divided this mission into three phases (Figure 10.17).

FOUNDATION BUILDING

In the first phase, the focus needs to be on: (a) developing the ecosystem; (b) capacity building; and (c) creating the necessary institutions. This phase will include initiatives such as setting up of an independent body to carry out R&D in the maritime sector, define standards and protocols for process automation, and bring about consistency in technology implementation at ports.

Figure 10.17
Organisational Framework for IIMRP



Source: Infosys Research.

EXPANSION OF ICT IMPLEMENTATION

The second phase should then focus on setting up ICT systems at ports and to provide assistance with technology implementation to the various stakeholders. Different IT solutions like ERP, PCS, e-Customs, etc., will be implemented as per the ICT policy and standards defined in Phase I. This will help in creating an interconnected network of ports and other service providers like shipping lines, transport operators, freight forwarders, etc., which will be able to exchange real time information on cargo movements, carry out extensive data analysis and support decision making.

INTEGRATED TRAFFIC MANAGEMENT

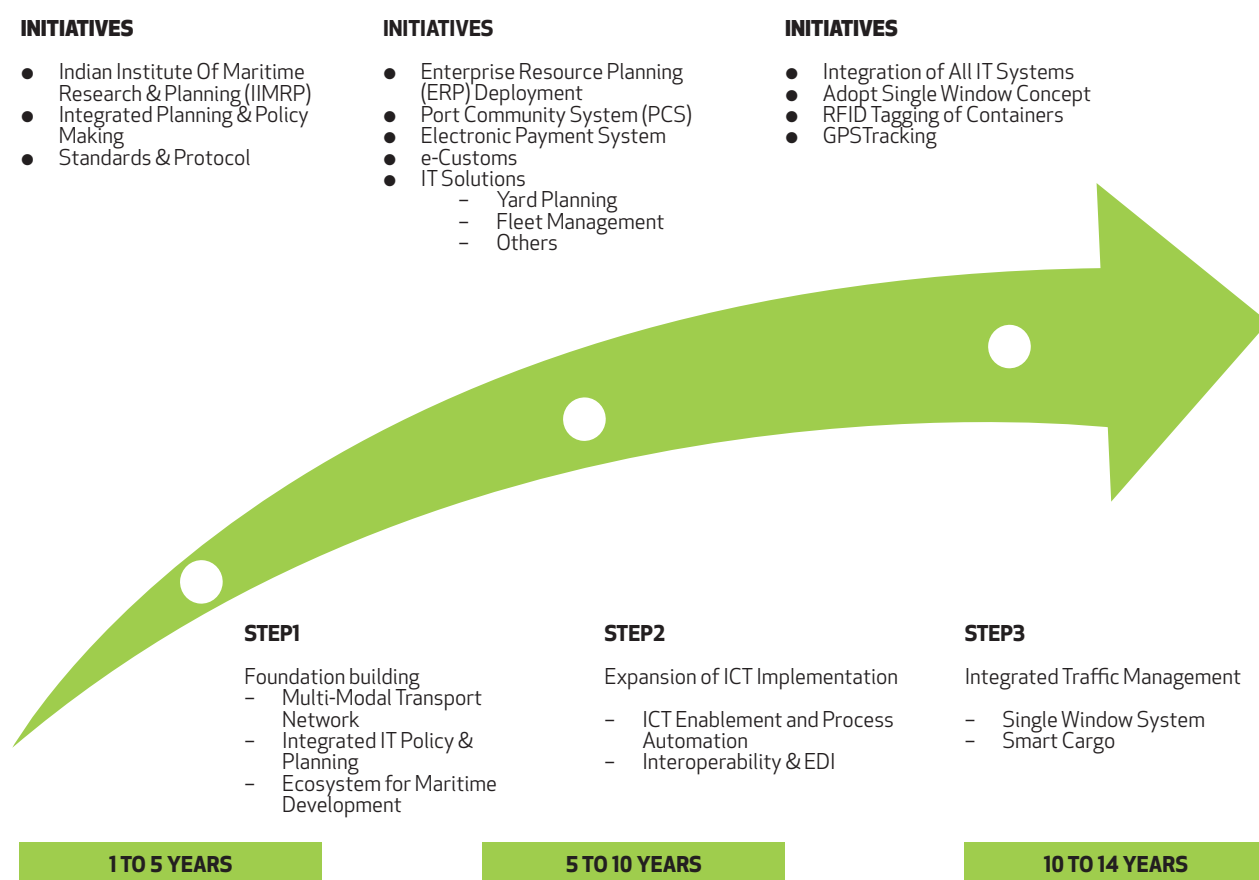
In the third phase, the focus should be on integrating business processes and IT systems of various stakeholders so as to eliminate redundancies. Some of the initiatives which could be taken in this phase include adoption of the Single Window concept, i.e., creating one interface for a trader to manage his operations so that he does not need to coordinate separately with each of the many agencies involved. Another example would be the use of technology such as RFID tagging, GPS, etc., to make cargo ‘smart’ so that it can signal its location and other details to concerned parties.

A review of various ports in India and interactions with some of the key stakeholders suggest that the use of ICT tools and their acceptance and maturity vary across the country. Therefore, a ‘one size fits all’ approach cannot be adopted. Separate studies will need to be taken up to assess the IT maturity of individual ports, benchmark their technology capabilities as compared to others and identify specific action items for each of them in line with the overall ICT enablement roadmap for the Indian maritime sector.

ICT FOR CIVIL AVIATION

The future of air transport in India will be governed by the willingness of the sector to adopt the latest technologies and by the capacity of government and regulators to create an enabling policy environment. With competitive forces at play in the airlines sector, regulators need to do little in the way of specifying exact technologies to deploy. Instead, the regulatory role is in specifying ICT protocols for (a) passenger and cargo management; (b) achievement of minimum service standards, including safety and security; and (c) for data collection. Once these ICT standards and protocols are defined, the various airlines

Figure 10.18
ICT Implementation Roadmap for the Ports Sector



Source: Infosys Research.

should be permitted ICT selection and implementation choices as per their preferences, with the regulatory role changing to ensuring compliance.

The airports present a different set of issues. The market structures are such that only one airport serves an urban catchment area, effectively rendering it a monopoly service provider. Further, rules applicable to the vast majority of airports under government administration must also apply to the handful of systemically critical airports that are managed under public-private partnerships. As locations for the processing of incoming and outgoing passengers and cargo, the government also retains a vested interest in protecting the security of the entire industry and of the country. Consequently, the appropriate regulatory principles with respect to ICT allow more room for government to be more exacting in its specifications. This is so as to prevent monopoly rents, to secure bulk purchase discounts for the airport system as a whole, and to train a common pool of staff.

The final element of the aviation sector where government has perhaps the greatest rights and responsibilities to choose and manage ICTs is in the sphere

of airspace control and air navigation services. India must fulfill these sovereign responsibilities as a matter of course, as well as under the Chicago Convention of 1944 to which it is a signatory. Being the sole provider of these services, the regulatory and operational roles essentially become one and the same.

ICTs has an important role to play in data collection and management. Extensive coverage and quality data make it possible for airlines to efficiently plan their networks and schedules to best meet extant and latent demand. Data on airlines' finances and operations assists regulators in efforts at maintaining a market that is viable, competitive and functions smoothly. Authorities that regulate airports, meanwhile, must have access to current and expected airport cost structures, and to current and expected usage. The development of new airports, capacity expansion at existing airports, and the identification of strategies for network management each requires the use of sophisticated economic models to analyse and forecast passenger and cargo traffic. This sophistication notwithstanding, the quality of the results on which these important decisions are based will only be as good as the data supplied.

By rights, the aviation sector should be particularly pre-disposed to the collection, management and dissemination of complete and robust data. Each of the major agencies that participate in the sector—airlines, airports, government authorities and regulators, MRO service providers, freight forwarders and logistics firms, and so on—are established and recognised, and are subject to the oversight of some combination of domestic and international governments, shareholders, customers and specialised institutions that set safety and other operational standards. These agencies must operate robust information and technology systems to perform their activities. The closed nature of these systems means that the agencies are in complete control of all the data generated by their activities. As a simple example, airline databases maintain origin-destination records of every passenger, and or every maintenance exercise undertaken on every aircraft in their fleet. Moreover, there are in-built checks and balances within the system. For international travel, government customs and immigration databases can be used to verify the origin-destination record for any given passenger. Both airlines as well as MRO service providers maintain logs of the maintenance on an aircraft. Airports and airlines must both account for passenger traffic numbers. In short, the aviation sector normatively lends itself to the collection of high quality data. That said, there is still much that can be done to ensure the data is deployed and made widely available to best use.

By 2020, India should look towards providing a ‘seamless experience’ across the entire air journey for both passengers and cargo. This section looks at some specific examples of technologies that could be deployed by the sector; matters related to the creation of an enabling policy environment are considered in the Chapter on Civil Aviation.

ICT-RELEVANT ISSUES

As outlined in the chapter on Civil Aviation, growing traffic places enormous pressure on aviation infrastructure. There are five main strategic and operational issues that need attention, and where ICTs may help in reducing problems.

CONGESTION AND DELAYS

The rise in demand for air travel has led to an expansion of fleets for scheduled, non-scheduled and general aviation, leading to rapid increases in aircraft movement. This growth has put extreme pressure on Air Traffic Controllers (ATCOs) resulting in a high attrition rate. The pressure on infrastructure and personnel is exacerbated by cancellations and delays because most aircraft are not equipped with CAT III systems to aid landing during bad weather. There are high cancellation rates at Mumbai airport in the monsoon season and at Delhi airport during

periods of dense winter fog. Furthermore, the majority of delays are ‘reactionary’ in that they are accumulated delays caused by prior unavailability of an aircraft or crew, by missed passenger connections and changed aircraft routing (see Figure 10.18).

INEFFICIENCIES IN HANDLING OF AIR FREIGHT

Air cargo represents about 10 per cent of industry revenues. Additional growth is hampered by factors such as: (a) inadequate parking bays; (b) lack of adequate warehousing space especially in Tier-2 and Tier-3 cities; (c) slow customs and other regulatory clearances; (d) 3-5 days of dwell time for import and export cargo at Indian airports vis-à-vis a global average of 6-12 hours; and (e) pilferage of goods in transit and storage.

SAFETY AND SECURITY

The Central Industrial Security Force (CISF) and state police forces hold delegated responsibilities for airport security (under the overall regulatory authority of the Bureau of Civil Aviation Security), though there is wide variation in the application of desired security and safety protocols. Technology interventions such as the use of biometrics and RFID are required to increase the effectiveness of the force deployed and to automate certain operations.

NEED TO IMPROVE CUSTOMER EXPERIENCE

Airlines and airports find themselves squeezed between rising expectations of customers regarding their experience of air travel, and rapidly increasing numbers of air passengers which stretches personnel and infrastructure, making meeting those expectations an ever greater challenge. Consequently, airlines see a market-driven imperative to: (a) reduce delay (b) decrease waiting time both during parking of vehicles, check-in and security clearance; (c) establish hassle free boarding procedures; and (d) provide safe and reliable facilities. Airlines should work in conjunction with airports to introduce technologies and develop procedures that will shorten waiting times and allow for faster aircraft turnarounds.

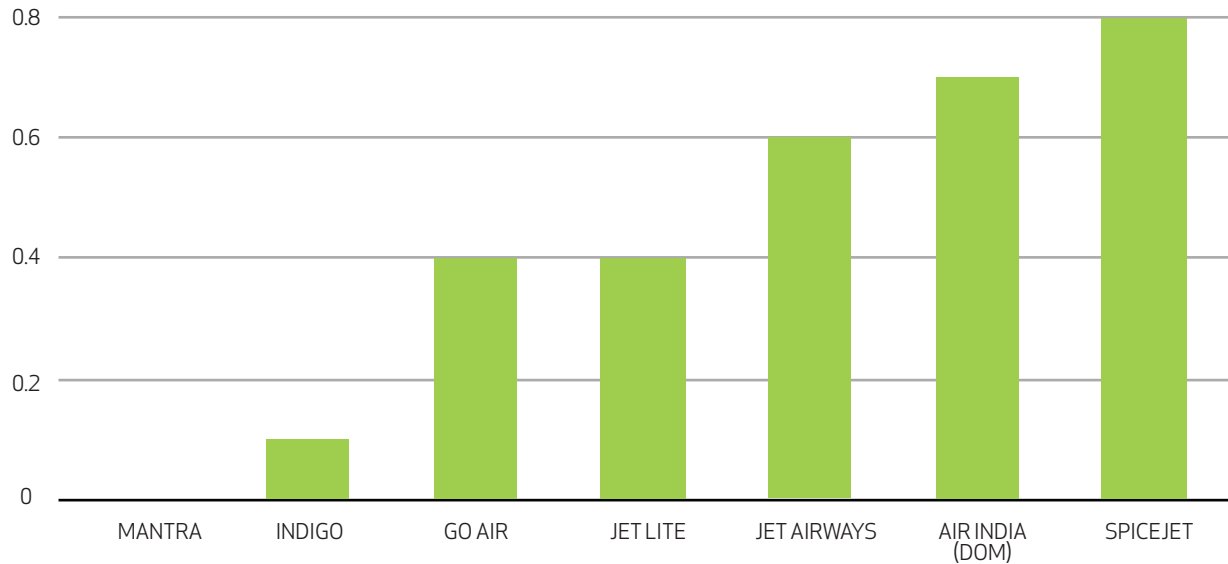
LACK OF TRAINED MANPOWER

With respect to ICT, the Chapter on Civil Aviation notes that there are shortages in the sector along the following dimensions: (a) for pilots overall; (b) for engineers trained to maintain, repair and overhaul sophisticated engines and airframes; (c) for avia-

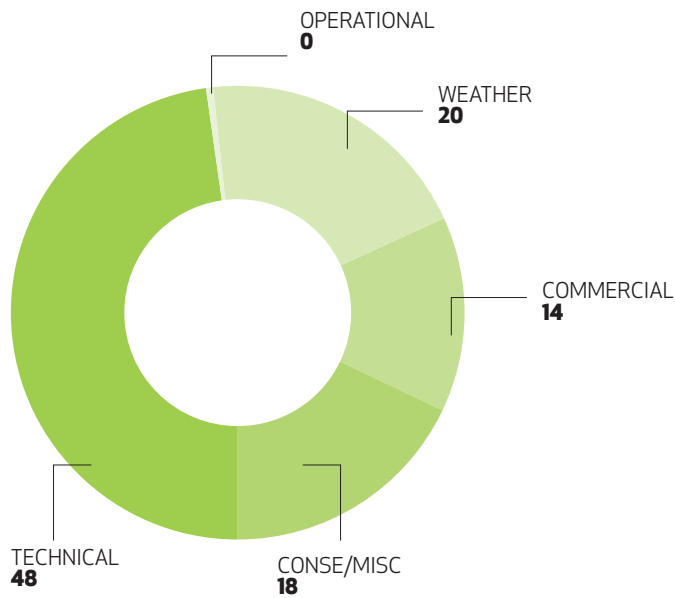
The aviation sector normatively lends itself to collection of high quality data, yet much needs to be done to ensure that the data is deployed to best use. By 2020, India should provide a ‘seamless experience’ across the full air journey for both passengers and cargo.

Figure 10.19
Flight Cancellation Statistics
 [per cent]

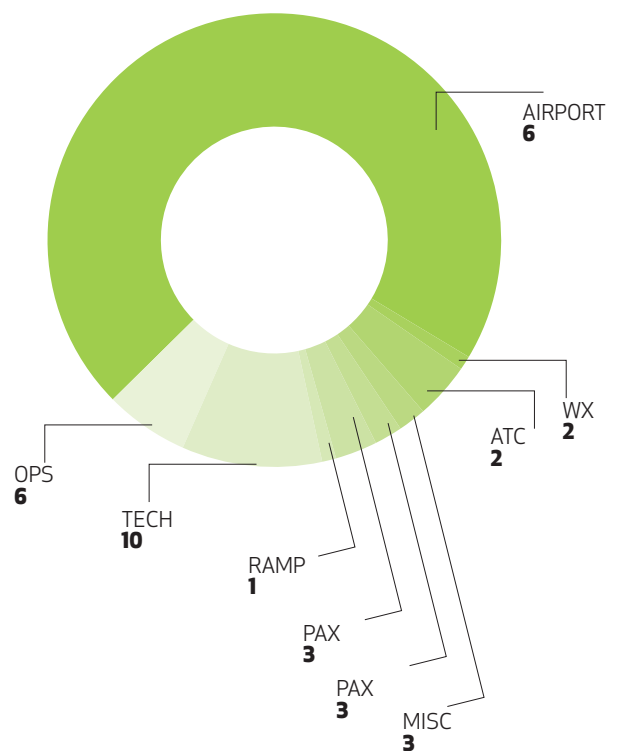
Cancellation Rate of Scheduled Domestic Flights (May 2013)



Reasons for Cancellations



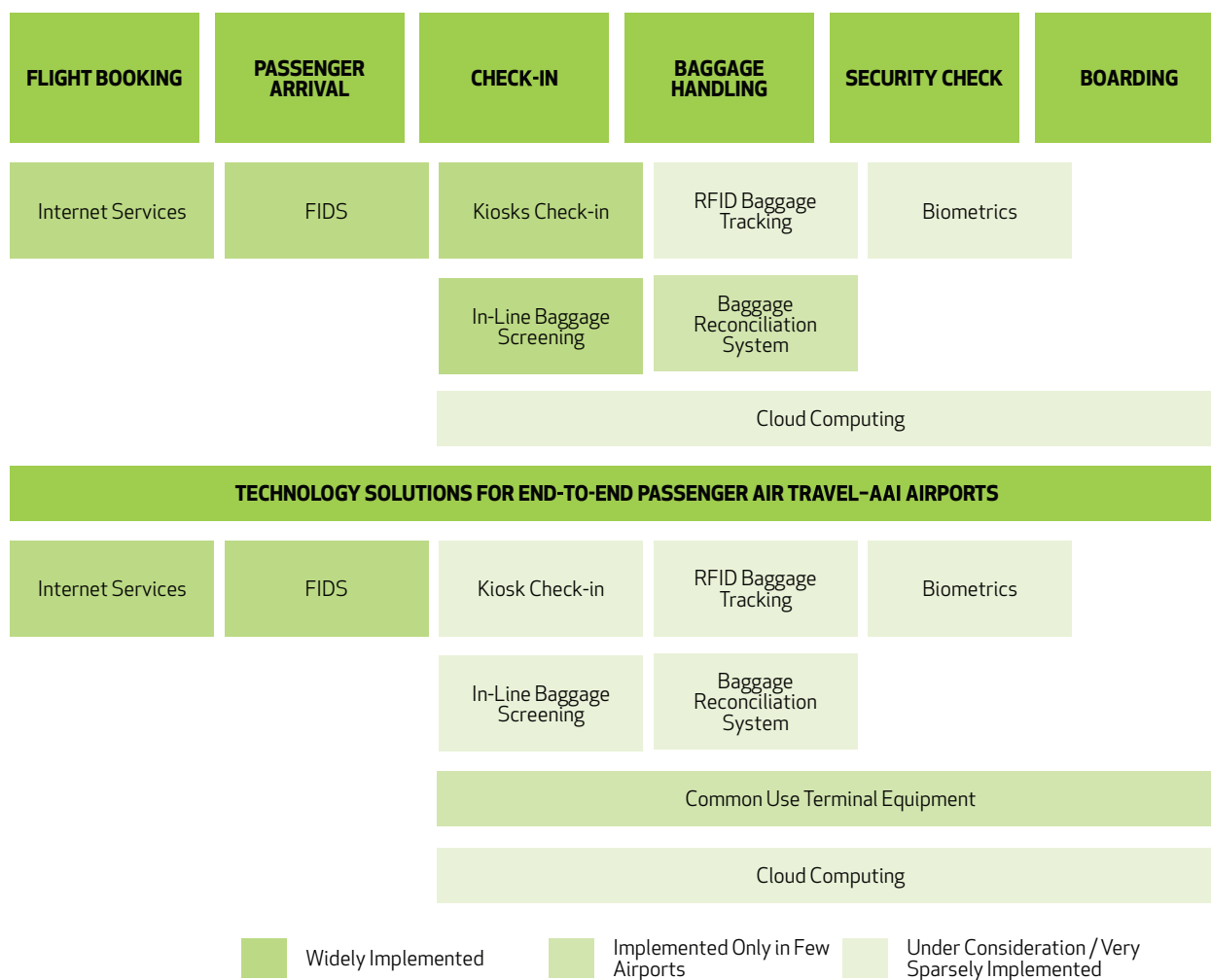
Reasons for Delays



Wx = Weather
 ATC = Air Traffic Control
 Misc = Miscellaneous
 PAX = Passengers
 Tech = Technical
 Ops = Operations

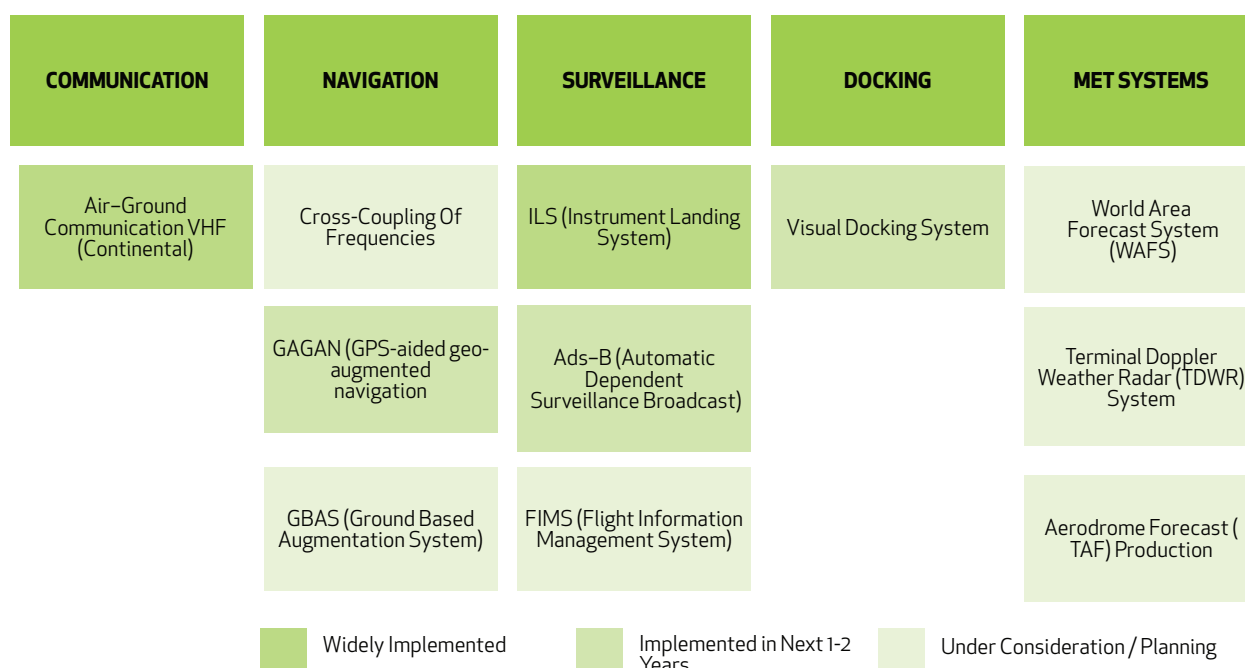
Source: Directorate-General of Civil Aviation (DGCA).

Figure 10.20
Present Status of ICT Applications in Aviation Industry



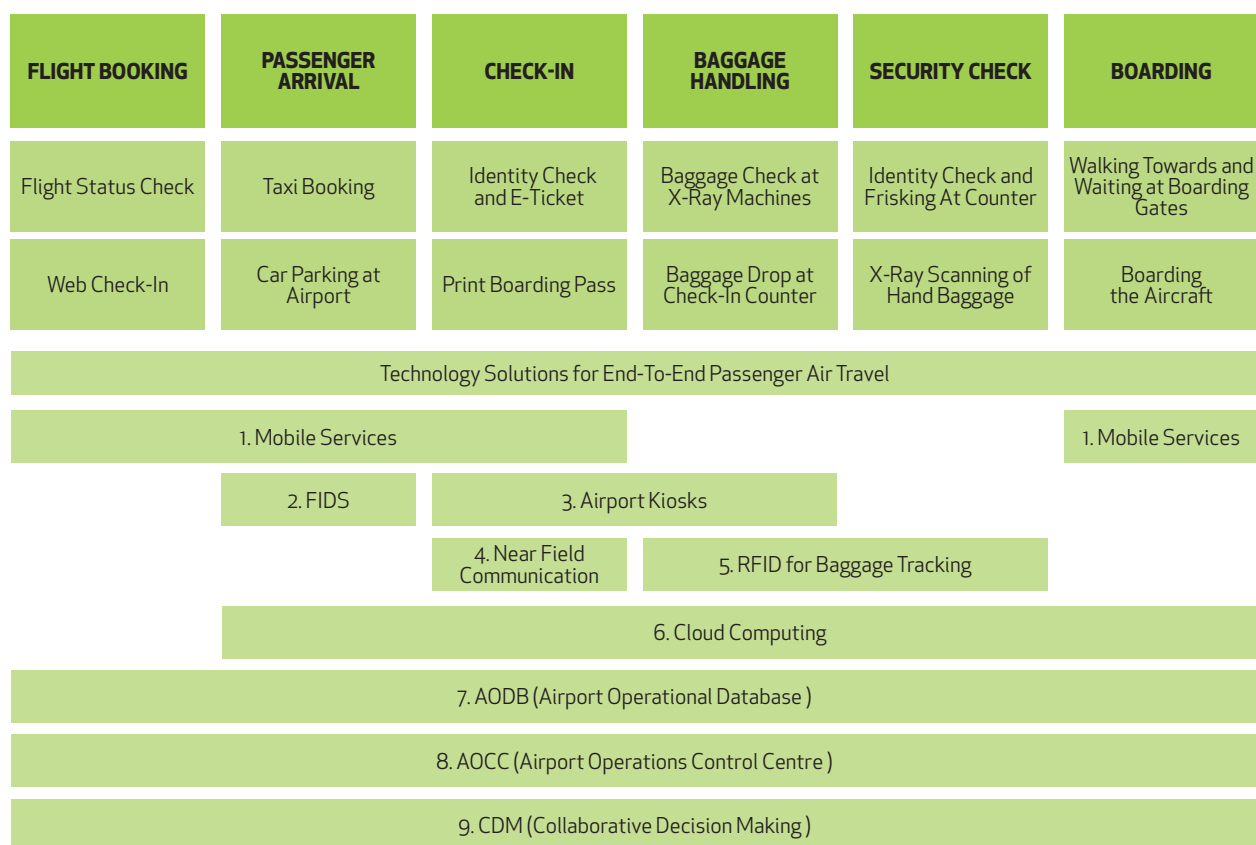
Source: Ministry of Civil Aviation (MoCA).

Figure 10.21
Current Status of ICT in Air Traffic



Source: Infosys Research.

Figure 10.22
Proposed ICT Application Map



Source: Infosys Research.

tion economists, statisticians, regulators and policy-makers. Besides the core skills and knowledge base that allow these professionals to undertake their jobs, each of them will also be required to acquire enough technical skill to keep pace with changing technologies.

PRESENT STATUS OF ICT APPLICATIONS

Airports operating under public private partnerships (PPPs) in India are keen to deploy numerous technology initiatives over the next five years. Airports under the Airport Authority of India (AAI) lag the benchmarks set by the JV airports on only a few fronts. Figure 10.21 shows the level of implementation of ICT for various aviation operations. ICTs are widely used for flight booking and flight information display systems (FIDS), for example, Common-Use Terminal Equipment (CUTE) has been implemented at 38 major airports run by AAI. But for other aspects of airport operations, ICTs are sparsely used.

ICT IN AIR TRAFFIC MANAGEMENT

Because of the increase in air traffic and international compliance requirements, there has been considerable technological development in Air Traffic Management (ATM) in India since 2010. Figure 10.22 shows the status of implementation of ICTs for

various sections of ATM. Some of the key initiatives recently completed or planned over the next four or five years are:

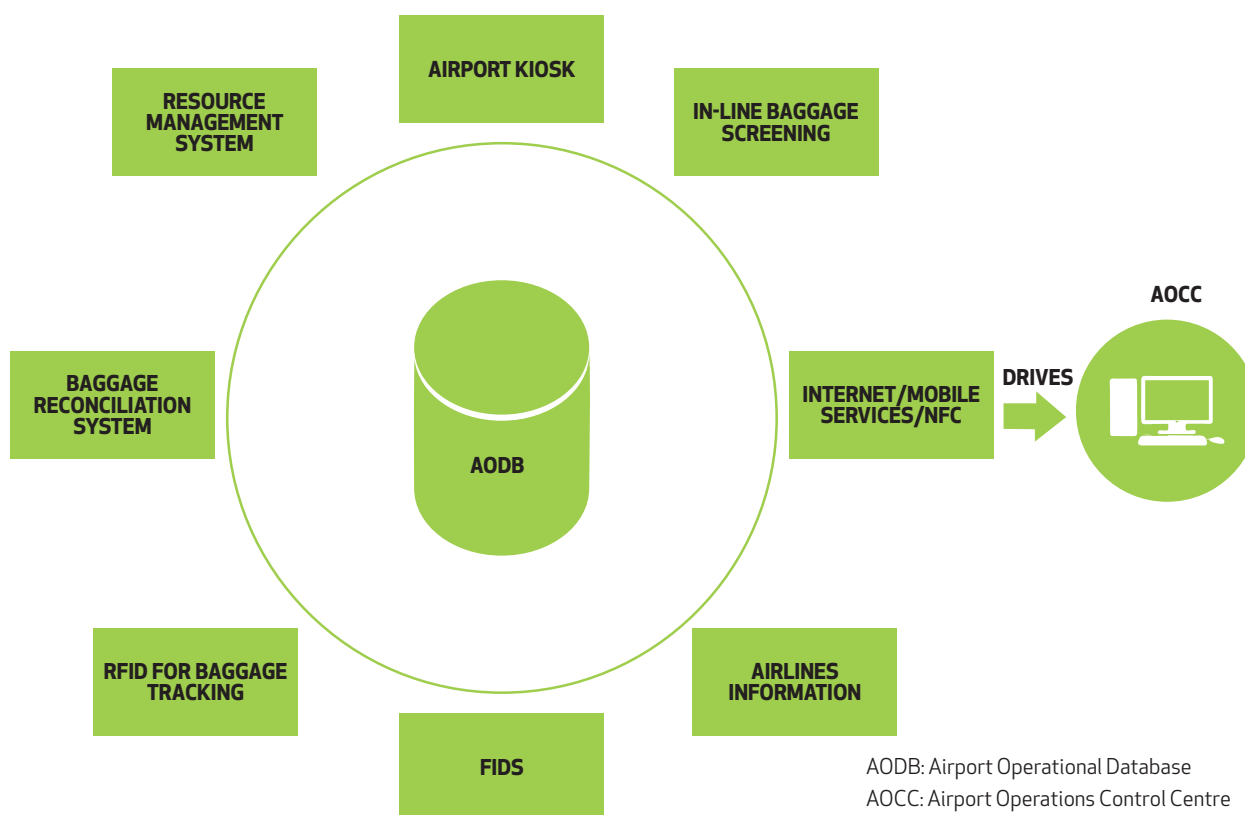
- Starting 2008, GPS-aided geo-augmented navigation (GAGAN) is currently under implementation. GAGAN implementation will make India the fourth country to have a satellite-based augmentation system (SBAS). GAGAN is currently undergoing certification by the regulator (DGCA).
- The first phase of the implementation of Automatic Dependent Surveillance-Broadcast (ADS-B) technology is underway, replacing radar as the key method for aircraft control and navigation. ADS-B has been deployed at 21 major airports.

PROPOSED ICT INTERVENTIONS

We have identified four main areas where ICT can play a role in addressing the key issues discussed earlier:

- Optimisation of airport operations
- Effective management of airspace and airside operations
- Safety and security enhancement
- Efficient air cargo operations

Figure 10.23
The Airport Operational Database



Source: Directorate General of Civil Aviation (DGCA).

AODB: Airport Operational Database
 AOCC: Airport Operations Control Centre
 FIDS: Flight Information Display System
 NFC: Near-Field Communication
 RFID: Radio Frequency Identification

OPTIMISATION OF AIRPORT OPERATIONS

Figure 10.22 shows the various technological solutions that can be used to improve all components of airport operations starting from flight booking all the way to actual boarding of the flight by a customer. Regulatory approval and procedures should be in place to permit non-physical (i.e., via the internet or via mobile phones) check-in of passengers at all airports. This frees up requirements for physical counter space, decreases the time that passengers must spend at airports, and increases passenger processing rates. These aspects are discussed in more detail below.

MOBILE SERVICES

Smart phones have enormous potential to increase both personal and business productivity. Approximately 82 per cent of passengers carried a smart phone in 2013, up from 54 per cent in 2011, 28 per cent in 2010 and 16 per cent in 2008. Mobile phones can be used for ‘on-the-go check-in’ while driving to the airport. Applications are being developed by Societe Internationale de Telecommunications Aeronautiques (SITA) wherein the mobile app will guide the user through various processes based on his/her itinerary. At the airport, a mobile 2D bar coded boarding pass (BCBP) allows passengers using online check-in to carry their boarding pass

in digital form on their mobile phones and then use it to navigate their way through the airport touch points—bag drop, security and boarding gate—and on to the aircraft with minimal human intervention. While the technology for realising these services is available, the regulatory framework is missing.

FLIGHT INFORMATION DISPLAY SYSTEM (FIDS)

FIDS is a computer system used to display flight information (arrivals and departures) in real-time to passengers. The FIDS receives airport and flight-related information from the Airport Operational Database (AODB). AODB is a central database to store, manage and distribute information about airport operations.

AIRPORT KIOSKS

An airport kiosk is essentially an interactive computer terminal which is fully network integrated and connected with the airlines’ databases. Kiosks can be used for ticket purchase, baggage check-in and flight status monitoring.

NEAR FIELD COMMUNICATION (NFC)

NFC is a wireless communication mechanism that uses electromagnetic radio fields to transmit data between digital devices such as smart phones. Depending on their configuration, NFC devices

Figure 10.24
Proposed ICT Application Map for Air Traffic Management



Source: Infosys Research.

can read from and/or transmit information to other enabled devices. Enabled smart phones can be put to multiple uses such as paying for airplane tickets over the POS, identity verification and security processing.

RFID FOR BAGGAGE TRACKING

Currently, bar codes are being used for tracking baggage. RFID technologies are superior to bar codes and provide the ability to automatically collect real-time data about the physical location and properties of any piece of baggage which has been tagged. RFID has three main advantages:

- More reliable, and easier to use: information is transferred via radio waves and a line-of-sight between the tag and reader is not required
- An RFID tag can store much more information and hence can identify an item uniquely
- RFID tags are very secure; it is extremely difficult to copy them and they could be made to trigger security alarms in case of theft

A RFID reader communicates with the tag to infer the identity of the object to which the tag is attached. The tags themselves consist of an electronic circuit, which stores data, and an antenna which communicates the data via radio waves. When the reader broadcasts radio waves, all the tags within range will communicate.

CLOUD COMPUTING

Cloud computing is typically subscription-based pay-as-you-go service which eliminates investment in hardware, personnel training, purchase of software licenses, and daily administration of servers. A solution provider from whom this service is purchased carries out these tasks. Thus, it results in significant cost savings in terms of infrastructure, easier software upgrades, as well as staff recruitment and training. Meanwhile, a safe and secure network to store, process and transfer confidential data is ensured. However, cloud computing may not be suitable for all applications and depends critically on the integrity and ongoing viability of the service provider, and upon the regulatory ambit of the jurisdictions in which the servers are actually housed.

With security in aviation being of paramount importance, it may be preferable to consider a 'cloud' that is sponsored either by all parties in the aviation sector, or by the government itself, once sufficient technical capacities are acquired.

APPLICATIONS INTEGRATION

All individual systems and technologies such as FIDS, CUTE and BRS implemented at the airports should be integrated using the AODB (Figure 10.23). This AODB will be used to drive the AOCC (airport operations control centre), a control room with large screens to view all the information in form of dashboards, charts and reports. This control room will house stakeholders from various departments like the baggage, passenger, cargo and airlines who together will take informed decisions for the benefit of the airports and its passengers. Such real-time on-demand availability of common information will allow for better decisions by all participants in the industry, and by regulatory authorities. AODB has been deployed at Delhi, Mumbai, Hyderabad and Bengaluru airports. In addition, AODB is under installation at 10 major airports of AAI. While Delhi, Mumbai, Hyderabad and Bengaluru have an AODB at each airport, AAI is implementing a unique Centralised AODB, which will be accessed by all the 10 airports through VPN. The Centralised AODB is scalable and in future, more airports can be added at minimal cost. This is expected to go online by March, 2014.

EFFECTIVE MANAGEMENT OF AIRSPACE AND AIRSIDE OPERATIONS

Presently, ATM (Air Traffic Management) systems in India work well and are aligned with international benchmarks, but eventually they will need to adopt next generation standards. India's ATM system utilises ground-based navigation system such as use of radars due to which flight paths are fixed and pre-determined, leading to wastage of fuel and time. Hence, efforts are in the pipeline to transition to 'flexible use of airspace'. Using advanced technologies such as GAGAN, aircraft routes will be calculated in real time, factoring inputs such as weather and the current traffic situation, etc. This will help reduce delays due to airspace congestion as well as cut down on aircraft wait times in landing at airports. There are several areas, such as communication, navigation, etc., where ICT can play an effective role as shown in Figure 10.24.

VHF COVERAGE AND NETWORKING

Presently, VHF communication is available only in continental airspace above 20,000 feet. In order to provide overlapping coverage, VHF coverage up to 10,000 feet and above in Area Control Centres (ACCs) also needs to be implemented. Also, VHF networking should be worked out to support consolidation of sectors during lean traffic and deconsolidation during peak traffic periods. VHF networking has

GAGAN is the planned implementation of a regional satellite-based augmentation system to support en route navigation of aircraft. Currently, planes fly along predefined air routes. Planes with GAGAN receivers, however, will be able to get guidance and take shorter routes, saving both time and fuel. This will improve efficiency and save costs.

been implemented in the Upper Area Control in Southern FIR (Flight Information Region) in India. Consequently pilots in the en route phase transiting through this FIR have to make minimal contacts on VHF with the ATCOs thus reducing fatigue. This is to be replicated in other FIRs.

HF RADIO TRANSMISSION

Presently, HF radio transmission is available at Delhi, Mumbai, Kolkata and Chennai to use for air-ground voice communication over oceanic space. Additionally, HF R/T signals also work in mountainous and remote regions where VHF range cannot be achieved, provision of flight information service over the continental airspace for the uncontrolled and VFR flights and for dissemination of MET information.

SATELLITE PHONES

This is an alternative low-cost, high-quality solution to high frequency radio transmission. The use of such phones will have to be carefully managed, however, as they are presently considered sensitive by Indian security agencies.

INSTRUMENT LANDING SYSTEM (ILS)

Currently, there are 66 ILS installations at 55 airports. ILS assists a pilot to fly along a precise path, defined in three dimensions, during approach to land on a specific runway using radio guidance signals transmitted by ground equipment. ILS is used in cases of low visibility when the pilot cannot see the ground through the naked eye.

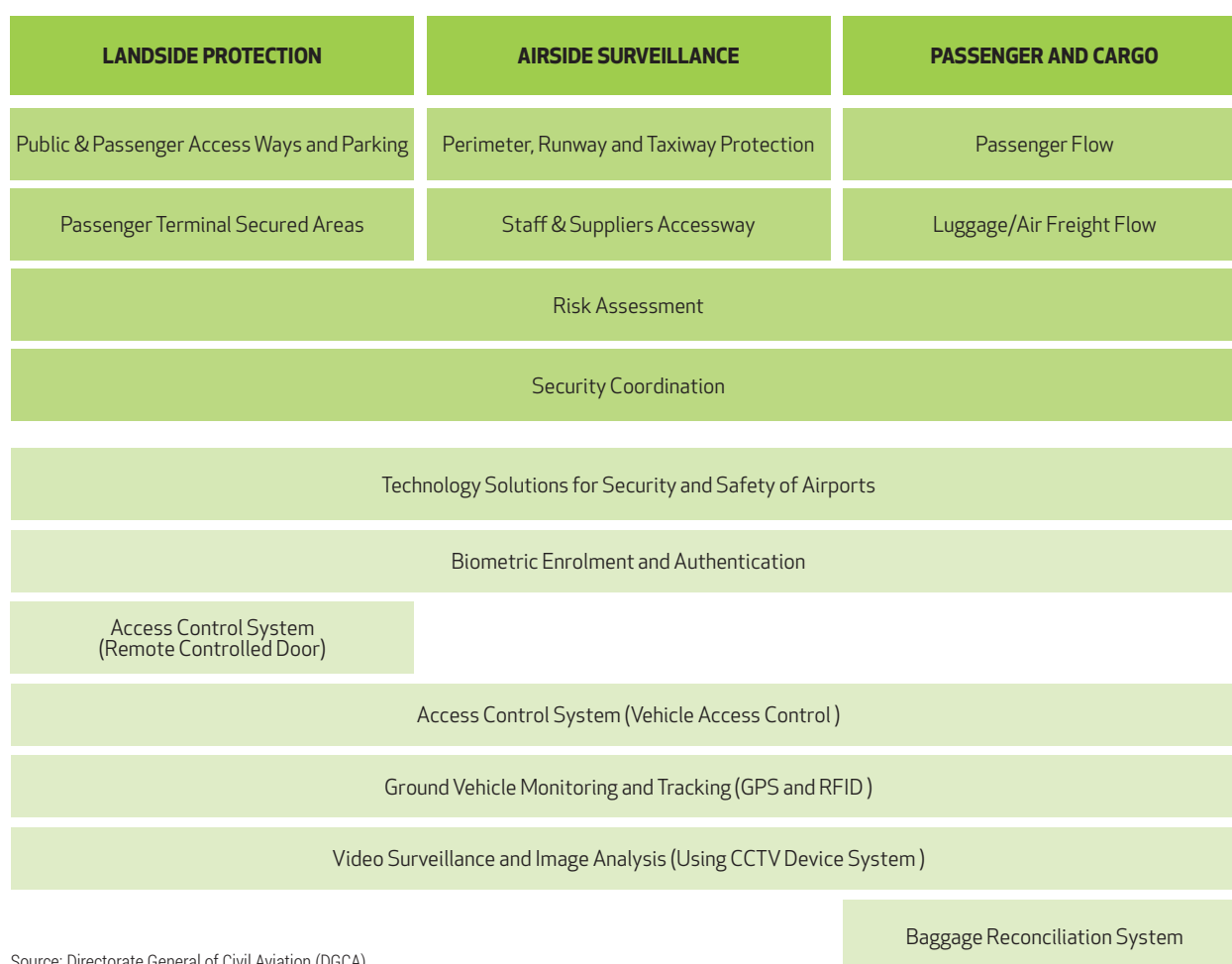
GROUND BASED AUGMENTATION SYSTEM (GBAS)

GBAS is a high-safety application which augments the GPS Standard Positioning Service (SPS) thus enhancing service levels. Compared to ILS, it is a superior technology that supports entire lifecycle of airside operations including approach, landing, departure, and surface operations within its coverage area. GBAS comprises of ground equipment which is complemented by GBAS avionics that is installed on the aircraft.

GPS-AIDED GEO-AUGMENTED NAVIGATION (GAGAN)

GAGAN is being designed to support en route navigation of the aircrafts. It is a planned implementa-

Figure 10.25
Proposed ICT Solutions for Safety & Security



Source: Directorate General of Civil Aviation (DGCA).

tion of a regional satellite-based augmentation system (SBAS). Currently, aircrafts fly from one place to another along predefined air routes. Planes with SBAS receivers will, on the other hand, be able to take shorter routes, saving both time and fuel. Hence, GAGAN would improve efficiency and save costs by:

- Reduction of ground aids
- Reduced workload of flight crew and ATCOs
- Improved capacity through reduced aircraft separation
- Higher accuracy and global coverage
- Improved safety

This project will be able to help pilots navigate in the Indian airspace by an accuracy of 3 m compared to the current accuracy of between 8-20m by using radars. The reference stations pick up signals from the orbiting GPS satellites. These measurements are immediately passed on to the mission control centres that then work out the necessary corrections that must be made. Messages carrying those corrections are sent via the uplink stations to the satellites which then broadcast the messages. SBAS receivers on the aircrafts are able to use those messages and apply the requisite corrections to the GPS signals

that they receive, thereby establishing their position with considerable accuracy.

AUTOMATIC DEPENDENT SURVEILLANCE - BROADCAST SYSTEM (ADS-B)

ADS-B allows pilots and air traffic controllers to 'see' and control aircraft with more precision, and over a far larger percentage of the earth's surface, than using radars. Unlike radar, ADS-B system's accuracy does not seriously degrade with range and atmospheric conditions. It uses conventional Global Navigation Satellite System (GNSS) technology and a relatively simple broadcast communications link. There are 21 ADS-B installations in India at present providing enhanced surveillance picture to the ATCOs.

DEPLOYMENT OF AIR GROUND DATALINK COMMUNICATION

As part of ICAO-mandated Global Air Navigation Plan, data link communication is being deployed globally for air-ground communication with the following benefits expected:

- Overcoming channel congestion
- Increased speed of data delivery

- Freedom from interpretational errors
- Reduction of fatigue for pilots/ATCOs

In India, data links were first deployed over Oceanic Areas for communication with aircraft over long ranges in the form of CPDLC (Controller Pilot Data Link Communication) in the late 1990s for aircraft equipped with FANS1/A avionics. Subsequently data links have been deployed at 46 airports for dissemination of ATIS (Automatic Terminal Information Service) bulletins comprising latest weather information and latest runway conditions, etc., at the airport to aircraft in flight. Data links have also been deployed for issuing pre-departure clearances to aircrafts at six major airports.

VISUAL DOCKING GUIDANCE SYSTEMS (VDGS)

VDGS is a system which gives information to a pilot attempting to park an aircraft at an airport stand after it has landed at the airport, usually via visual methods. VDGS gives automatic and precise guidance of aircraft along the guidance line to their final parking positions at the gate.

TERMINAL DOPPLER WEATHER RADAR (TDWR) SYSTEM

TDWR system should be implemented in the terminal area of the airport to detect wind shear and microburst associated with convective storms to improve safety and efficiency of aircraft operations. The primary advantage of TDWR over previous radars is that it has a finer range resolution—meaning it can see smaller areas of the atmosphere. Currently, these radars are being used in the US and a few other countries such as China.

INTERACTIVE WEB-BASED GRAPHICS

Web-based graphics such as weather charts can be used to see, monitor and overlay specific areas in the airspace that contains clouds, fog, precipitation, visibility values, etc. This information can be used as input parameters while calculating the ideal navigation route using GAGAN system.

SAFETY AND SECURITY ENHANCEMENT

Currently, all Indian airports together handle close to 160 million passengers and this number is estimated to triple by 2020. Given this high level of traffic in the presence of elevated security threats, it is critical to install effective and efficient security measures and procedures at Indian airports that can handle the greatly increased traffic without causing congestion and yet ensure the safety of passengers and airports. Figure 10.24 shows the range of technological solutions available to enhance airport safety and security.

BIOMETRIC ENROLMENT AND AUTHENTICATION

Biometrics refers to an automated system that can identify an individual by measuring his or her physical and behavioural uniqueness or patterns, and comparing it to those on record. Biometric systems

function under a three-step process under which individuals' biometric data is first recorded and then stored. Electronic sensors such as fingerprint readers or iris scanners or facial feature recognition systems then verify details periodically against the stored information as and when security clearances are required. There are severe ethical implications for the storage of biometric data, and especially for the general passenger population (as opposed to for employees of airports or airlines). Ensuring the integrity and security of the data is a critical issue, strict regulatory oversight will be necessary to prevent data misuse.

ACCESS CONTROL SYSTEMS (REMOTE CONTROLLED DOORS, SMART ACCESS CONTROL)

Solutions for access control include credentials management systems, contactless smart badges, vehicle identification systems, etc.

GROUND VEHICLE MONITORING AND TRACKING

The monitoring and tracking of passenger/commercial vehicles, can be achieved either using RFID or through GPS tracking.

VIDEO SURVEILLANCE AND IMAGE ANALYSIS

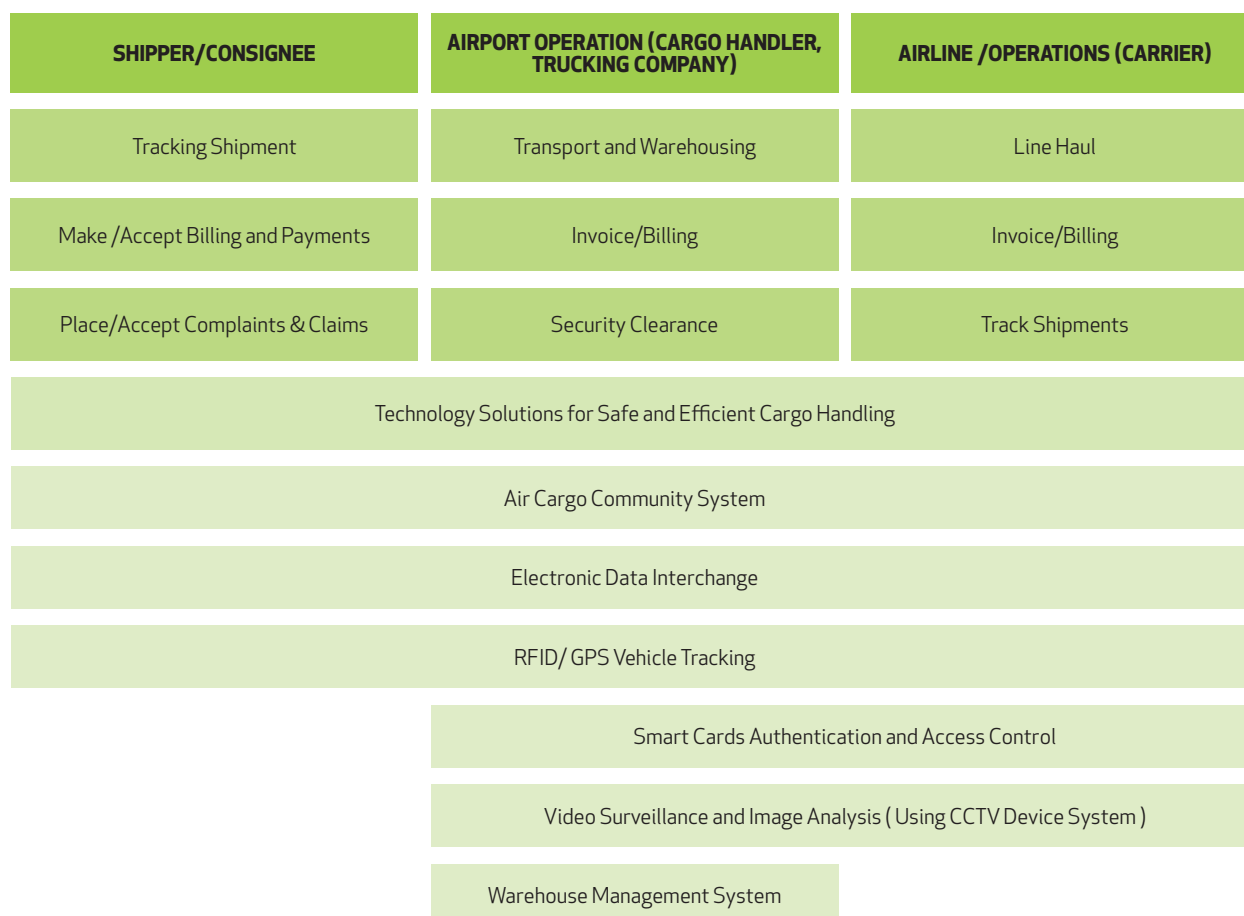
To enhance security of the air cargo and passenger terminals, terminals must install CCTV surveillance systems. Many systems also use some form of video recorders. These stored images are high resolution images with adequate zooming capability and hence can be used to obtain minute details about any suspicious activity or person. AAI has installed CCTV systems using advanced video analytics at 50 airports. Such systems have also been installed at six joint venture and greenfield airports.

BAGGAGE RECONCILIATION SYSTEMS (BRS)

BRS is used at airports to ensure that the passenger count matches the bag count for any given flight. As passengers check in, the airline Departure Control System (DCS) generates bag tags, boarding passes and messages called Baggage Source Messages (BSMs). A BSM will contain information such as passenger name, flight number identifier, destination, class etc. A BSM is unique for each passenger. The system can also be used for reconciling departing passengers and the bags that are being loaded onto their departing flight. BRS is currently installed at Delhi, Mumbai, Hyderabad and Bengaluru airports. AAI has contracted with SITA for providing their

Doppler weather radar systems should be installed in terminals to detect wind shear and microbursts associated with convective storms to improve safety and efficiency of aircraft operations. Currently, these radars are being used in the US and China.

Figure 10.26
Proposed ICT Solutions for Air Freight Management



Source: Directorate General of Civil Aviation (DGCA).

BRS solution at 38 major airports. Installations have commenced.

EFFICIENT AIR CARGO OPERATIONS

There is significant untapped potential for air cargo in India. The total air cargo handled in 2011 by all Indian airports together was 2.3 million tonnes (mt) which is far less than that handled by individual airports such as Hong Kong, Memphis, Shanghai and Paris. This is due to lack of operational efficiency in air cargo operations at Indian airports. Now, sufficient cargo handling capacity has been created through implementation of Automated Storage and Retrieval System (ASRS), Elevated Transfer Vehicle (ETV) and introduction of multi custodians for warehouse management. This is expected to meet requirements till 2020. Figure 10. 25 shows some technological solutions to enhance the operational efficiency in air freight management. The top of the figure shows the activities that are of interest to three groups of stakeholders: (a) shippers and consignees; (b) cargo handlers or trucking companies; and (c) air carriers. The bottom half shows the various technologies available and the activities and

stakeholders that would benefit from the implementation of those technologies.

AIR CARGO COMMUNITY SYSTEM

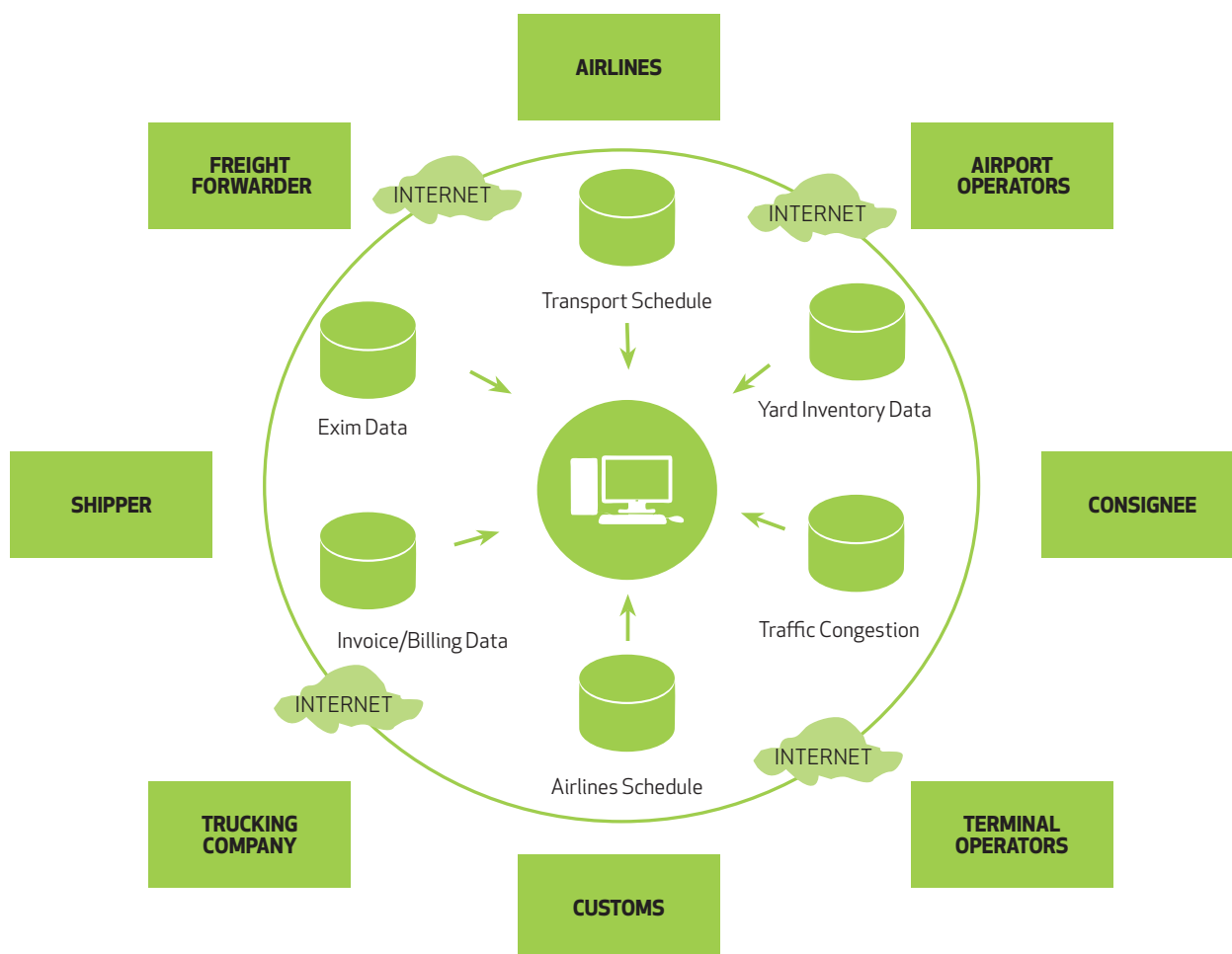
The air freight handling value chain has several stakeholders such as shippers, cargo terminal operators, trucking company, airlines, etc. Each of these entities has its own objectives and operates independently, with most of the information exchange happening manually. This leads to lost time and data inaccuracy, redundancy, increased costs and delayed decision making.

To resolve these issues, we propose a centralised information management system to integrate all these stakeholders so that there is more transparency in the entire value chain, leading to increased operational and economic efficiency. Each of the stakeholders will have a web portal wherein they can view all relevant information about other links in the supply chain (Figure 10.27).

ELECTRONIC DATA INTERCHANGE (EDI)

Generation and exchange of documents between air cargo handling authorities, customs and other agen-

Figure 10.27
Air Cargo Community System



Source: Directorate General of Civil Aviation (DGCA).

cies is a cumbersome and time-consuming process. The manual process leads to duplication of work making the entire process slow and more prone to errors along with the possibility of breach of security of confidential documents.

The air cargo community system discussed above can be further enhanced through EDI. Of course, EDI cannot be used for non-routine business documents like complicated contracts or information meant for humans to read and analyse. EDI is in operation at JV airports like Delhi, Mumbai, Bengaluru, Hyderabad and Kochi. At AAI-run airports, it is available at Chennai, Kolkata, Coimbatore, Amritsar, Trichy and Mangalore .

WAREHOUSE MANAGEMENT SYSTEM (WMS)

The primary purpose of a WMS is to control the movement and storage of materials within a warehouse and process the associated transactions, including shipping, receiving, storage and retrieval. The system also directs and optimises storage of stock based on real-time information

about the status of bins. The key benefits of WMS are space savings, increased productivity, reduced labour, increased accuracy and reduced inventory levels. The international concept of movement of loaded unit load devices (ULDs) from the airport terminal to the bonded warehouses is already taking place at Chennai airport.

OVERVIEW OF IMPACTS OF SUGGESTED TECHNOLOGIES

Figure 10.27 shows the expected impact of the proposed ICT solutions on the key issues in civil aviation.

SUMMARY OF RECOMMENDATIONS

Because various airports are at different levels in terms of their current use of ICT, it is not possible to give a roadmap for general application to all airports, as has been done for the other sectors. The use of ICT to improve aviation is recommended for the

Figure 10.28
Solution Impact Analysis for Proposed Solutions

ICT SOLUTION	CAPACITY AND EFFICIENCY ISSUES	SAFETY AND SECURITY ISSUES	CUSTOMER EXPERIENCE
Biometrics			
Electronic Data Interchange (EDI)			
GPS-Based Geo Augmented Nav. System (GAGAN)			
Warehouse Management System (WMS)			
Satellite Phone			
Instrument Landing System (ILS)			
Video Surveillance			
RFID For Baggage And Cargo Tracking			
Kiosks			
Air Cargo Community System			
Mobile Service			
Visual Docking Guidance System (VDGS)			
Access Control System (Remote, Smart Cards)			
Baggage Reconciliation System (BRS)			
Cloud Computing			
Airport Operational Database (AODB)			
Airport Operations Control Centre (AOCC)			
Collaborative Decision Making (CDM)			
Very High Frequency (VHF) Coverage			
Ground Based Augmentation System (GBAS)			
ADS-B System			
RFID/GPS for Vehicle Tracking			
Flight Information Display System (FIDS)			

following activities along with the proposed technologies as follows:

- **Optimisation of airport operations:** Deploy technology solutions such as: (1) Mobile services; (2) Flight Information Display Systems; (3) Airport kiosks; (4) Near Field Communication; (5) RFID for baggage tracking (6) Airport CDM, to increase operational efficiency and reduce costs.
- **Effective management of airspace and aircraft navigation:** Proposed technology solutions are: (1) VHF coverage and networking; (2) High-frequency radio transmission for air-ground communications; (3) Satellite phones; (4) Instrument Landing System (5) ADS-B (6) SBAS and GBAS.
- **Safety and security enhancement:** (1) Biometric enrolment and authentication; (2) Access Control Systems (Remote Controlled Doors, Smart access control); (3) Ground vehicle monitoring and tracking; (4) Video surveillance and image analysis, etc.
- **Efficient air-cargo operations:** (1) Air Cargo Community System; (2) Electronic Data Interchange; (3) Warehouse Management System.
- **Capacity Building:** It is recommended that an organisation, which we tentatively call Institute of Aviation Research and Planning (IARP), be set up for conducting research, innovation and training in aviation technologies.

ICT FOR URBAN TRANSPORT

KEY ISSUES

A number of key issues that need to be addressed to improve urban transport have been discussed in detail in the chapter on urban transport of this report. That chapter documents that it is important to use ICT technologies for improving public transport and non-motorised transport (NMT). This section aims to bring out some important ways in which ICT can be deployed, particularly in these two segments.

CURRENT STATUS

Until recently, not much attention was paid to leveraging technology to meet urban transport challenges. However that is changing, but not uniformly. Some cities are far ahead in managing their transport operations with the use of technology while others are a bit behind. On the issue of ICT implementation for urban transport, cities in India can be divided into three categories:

1. **Cities using ICT for Urban Transport** such as Bengaluru, Delhi and Mumbai, where

transport planning and some ICT implementation work has already been undertaken.

2. **Cities starting to use ICT for Urban Transport** such as Pune, Ahmedabad and Hyderabad, where some ICT solutions are already working, however, more work is required to develop them fully.
3. **Cities yet to start to use ICT for Urban Transport** such as Ranchi, Lucknow, Kanpur, Meerut, Mathura, where ICT implementation is at a very nascent stage, or no ICT projects have been implemented. Some of these growing cities are still in the planning stage and have yet to use technology for managing urban transport.

In order to get a feel for what can be done with ICT, we look at what has been, and is being done in Bengaluru. The city has state-of-the-art IT implementation processes in place. There has been a 7-10 per cent annual growth in the number of vehicles in Bengaluru, with personal vehicles comprising about 90 per cent of the total registered vehicles on roads, out of which 70 per cent are two wheelers and 20 per cent from light motor vehicles.

Since 2010, the city has started implementing Bengaluru Traffic Improvement Project (nicknamed B-TRAC), to address traffic congestion and safety issues by utilising the latest traffic management technologies. The focus has been to install intelligent transportation systems using digital surveillance, improve junction and street furniture, install enforcement cameras and increase awareness and capacity building. Under B-TRAC, the traffic signals were made vehicle-actuated, networked, controlled and monitored by the Traffic Management Centre. The timing of traffic lights is changed remotely and smart phones (BlackBerry) are used for enforcement. The automation centre receives the online field information from traffic signals, surveillance and enforcement cameras. Better compliance of traffic laws and rules has resulted in a reduction in the number of road accidents, less traffic congestion in central areas and reduced journey time (due to ICT-based implementation of signal synchronisation). The city has proposed a traffic training and road safety institute for capacity and institution building.

In Bengaluru, traffic signals are vehicle-activated and networked. The timing of traffic lights is controlled remotely. The automation centre receives online field information from traffic signals and surveillance cameras.

Indian urban transport needs to use modelling and simulation models to solve some of its traffic woes. There is a need to develop simulation tools that can accurately forecast the behaviour of large, complex, multi-modal transportation systems and their interaction with people and society.

ICT INTERVENTIONS

We now describe ICTs that can be used to address, to some extent, these problems in urban transportation.

MODELLING AND SIMULATION (M&S) FOR PLANNING PUBLIC TRANSPORT

Modelling and simulation are essential in the development, assessment, operation and designing of future transportation systems. Simulations can be used for long-range planning, to evaluate the impact of changes made to the transportation system, and they also aid in operation and management. The techniques can be used to get meaningful insights from real-time information, including dynamic traffic flow and supply and demand interactions. It helps in creating powerful visuals which can help in providing insights to travellers in making choices about time, route and mode of transport. Indian urban transport needs to use modelling and simulation models to solve some of its traffic woes. There is a need to 'develop simulation tools that can accurately forecast the behaviour of large, complex, multi-modal transportation systems and their interaction with people and society'.

A promising advanced simulation model is Urban-Sim which is still undergoing trials, but may be used in pilot studies now and if found appropriate can be used more widely. It is a simulation system for 'supporting planning and analysis of urban development, incorporating the interactions between land use, transportation, the economy, and the environment'. It can be used to forecast the effects of the different transport investments and land use policies on the community. The technology can provide 3D visualisation and scenario creation. The open-source simulation system also enables civic engagement on issues of transport infrastructure and land use.

NON-MOTORISED TRANSPORT (NMT)

Indian mega-cities are increasingly investing in motorised-vehicle-friendly infrastructure, even though non-motorised transport has several benefits: reduction in congestion, fuel saving, lower cost, improved air quality and health benefits for passengers. However today, non-motorised transport is seen as unsafe, uncomfortable and a 'poor man's ride'.

Promotion of NMT is made difficult because of the absence of any facilities that would make it a more attractive choice such as public bicycle systems; integration of cycles with other modes of public transport; park and ride facilities near railway stations and bus stops; priority for cyclists and pedestrians at intersections; dedicated and accessible footpaths. NMT can bring significant benefits for both passengers and society. There is need to change the mindset and policies so that these benefits are realised.

There are two potential initiatives for NMT that could benefit from the use of ICT.

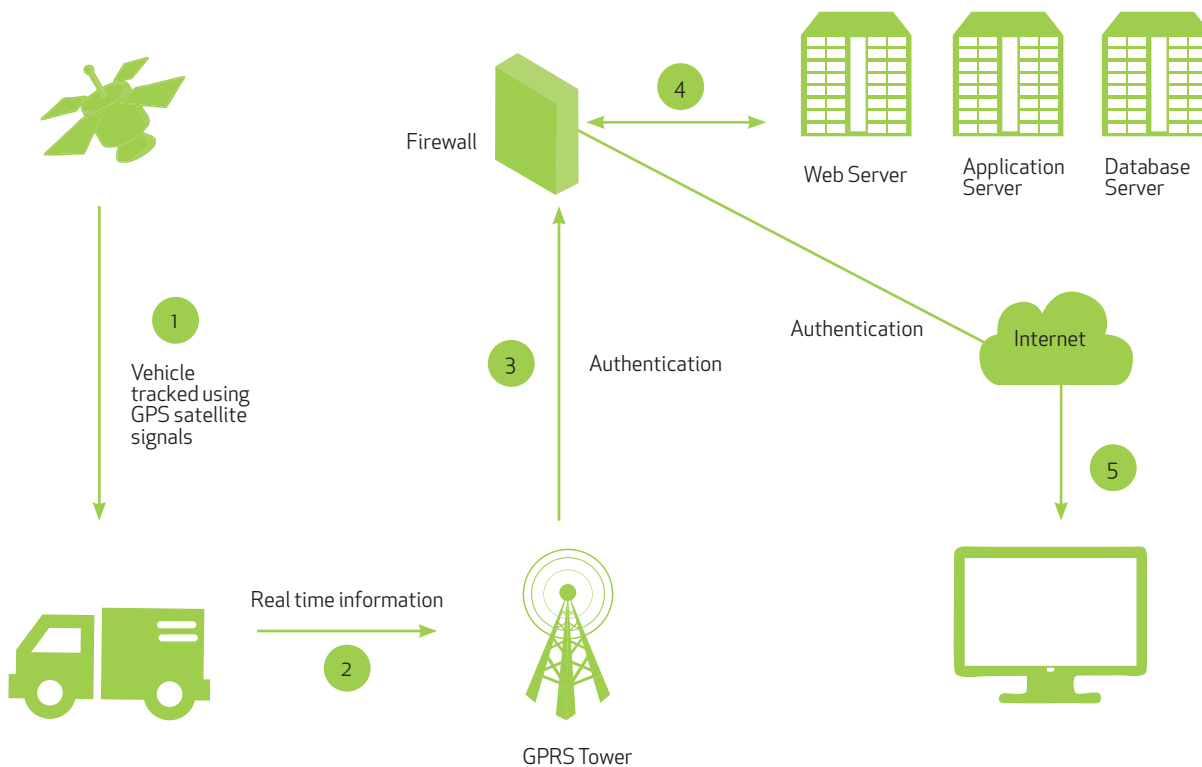
- **Public 'Smart Bikes' sharing system for upcoming urban conglomerates:** Bike sharing is a plan in which an individual rents a bike from an unattended urban location. Multi-modal smart cards and mobile phones can make paying for the service easy, and can provide real-time information on the availability of bikes through the internet. Bicycles in the scheme can have RFID tags or Global Positioning System (GPS) systems to facilitate tracking. Public bicycle sharing can serve as a link between intercity travel and the public mass transit system. The idea can be extended to the sharing of public electric vehicles or electric bikes for short distances, thus cutting down on fuel use and associated air emissions.
- **Intelligent traffic signals and crosswalks:** For accelerating the use of NMT, there is a need to give priority to cyclists and pedestrians at intersections. Intelligent traffic signals, crosswalks and 'cyclist priority' lights are some ICT solutions which can help in creating safe and secure intersections. In North America, certain cities have traffic signals in which pressing a button to cross the signal triggers the 'instant walk signal'.

London has installed 'cyclist priority' signals in which cyclists get a headstart before motorists get a green light by a few seconds. In this system, while there is a red light for the motorised traffic lane, cyclists have green lights allowing them to move 12m ahead to a second stop line. This allows the cyclists to clear the turning before the traffic coming behind them.

ERP FOR IMPROVING PUBLIC TRANSPORT SERVICES

Public transport agencies can utilise ERP to improve asset management and operational efficiency. ERP can have the basic functional applications integrated with special applications required for fleet management. Today, reliability is a key issue in public transport. ERP can be leveraged for preventing costly breakdowns (due to neglected fleet vehicles) and disruption of services. With ERP, the system can keep a

Figure 10.29
Vehicle Tracking Solution



Source: Infosys Research (Adapted from VISIONTEK, Linkwell Telesystems Pvt).

record of vehicle information including insurance, fuel economy, tire purchase and repair management, driving history, etc. The system can be implemented to integrate with management information systems.

ESTIMATION OF CONGESTION THROUGH PRESENCE OF MOBILE PHONES

According to the Telecom Regulatory Authority of India, more than 65 per cent of the people in urban areas have a mobile connection. This presence of mobile phones can be used to estimate congestion on the roads. It is reasonable to assume that in urban areas, an individual in a private vehicle has a mobile phone. Therefore, the density of mobile phones in a section of road is an indicator of the level of traffic on that section. Telecom towers are continuously in touch with all the numbers in their region, and therefore, it is relatively easy to know the number of phones in the region covered by the tower. Knowing the location of the towers, one therefore can know the number of phones (and hence traffic) in each of the regions covered by the towers. Thus, the transport department can have a map showing the level of traffic at any time in the city. The department can then provide information on congestion levels, emergency blockages, accidents and bad road conditions to drivers so that they can take alternative routes. Furthermore, the Traffic Management Centres can also use the information to take remedial measures to reduce congestion. Bengaluru, one of the major

ICT hubs of India, already uses such a system to identify congested areas.

VEHICLE TRACKING SYSTEMS AND FLEET MANAGEMENT

Vehicle Tracking Systems enable keeping track of the location of a vehicle in real time. The information is collected and shared with managers for management of the fleet.

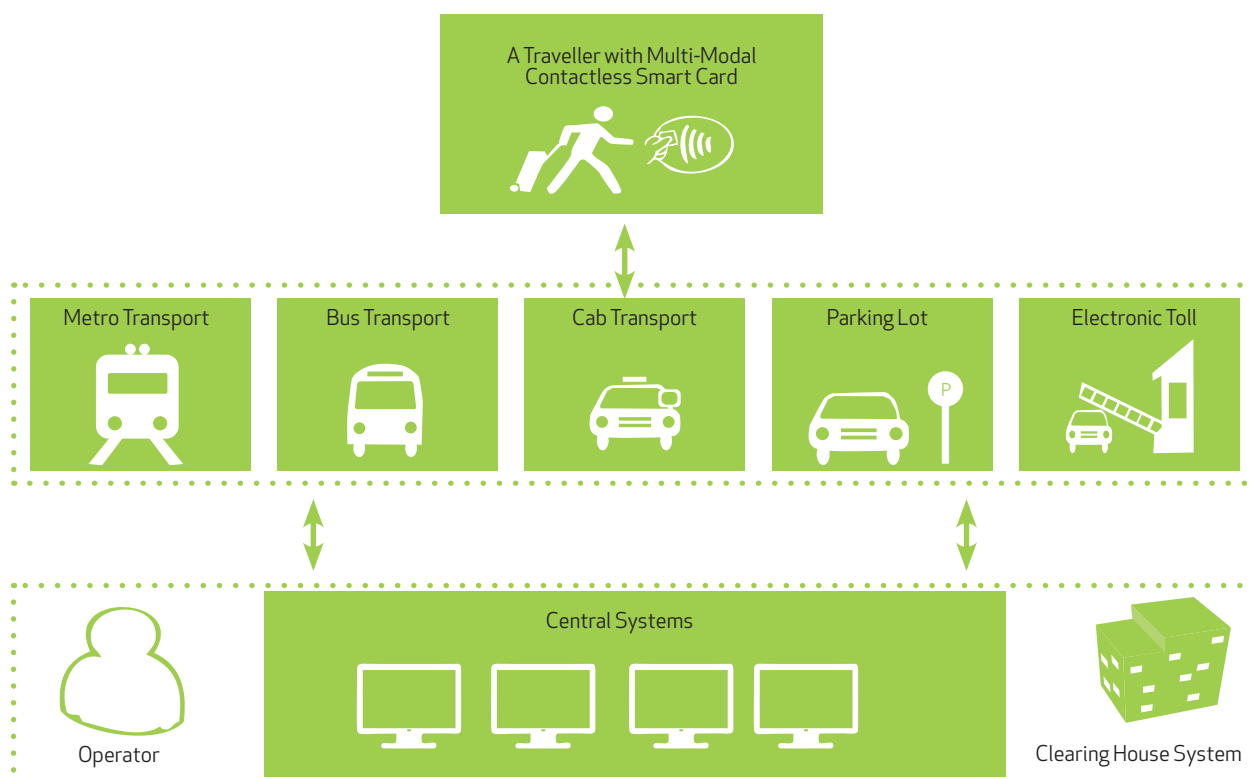
Vehicles can be tracked using mobile phone technology or GPS technology.

- Traffic scan with mobile phones can be used to track commercial vehicles. When a SIM card is installed in a freight vehicle with the required infrastructure, it can be used to track the precise location of the vehicle and determine the speed of traffic from its movement and hence is an efficient tool for fleet management. It helps in tracking actual travel time and the route used by the vehicle.
- Vehicles can also be tracked with GPS technology (Figure 10.29). An electronic device, installed in the vehicle emits signals. The signals are monitored by tracking agencies and helps stakeholders in remote management of the fleet.

INTELLIGENT TRAFFIC MANAGEMENT SYSTEMS

Intelligent Traffic Management Systems can remotely control and manage the network of traffic lights

Figure 10.30
Multi Modal Contactless Smart Cards Solution Architecture



Source: Infosys Research (adapted from e-ticketing solutions).

at different locations. Embedded Web Servers (EWS) are located at each intersection. The software at Central Traffic Management Unit monitors the operation of traffic lights and helps in remotely managing them from the Traffic Department. The system enables effective traffic management because the control is based on an integrated view of traffic in a particular urban area.

INTEGRATED FARE AND TICKETING SYSTEMS

Integrated fare and ticketing systems play a vital role in attracting passengers to public transport. Passengers benefit from an overall decrease in duration of the journey and the cost of travel. In addition, payments become easier, and the journey appears 'seamless'. The government too benefits because these systems can be blended with other e-governance activities. With enhanced data mining, analytics and decision support tools, the ridership data can be converted into customer insights and could be used by the managing authorities to create strategic plans for optimal routes, fares and scheduling, making public transport more appealing for the citizens. Further, multi-modal ticketing saves cost in maintenance of ticketing facilities, improves staff utilisation, and reduces the level of fraud.

Such integrated systems use multi-modal contactless smart cards with RFID technology which can

be used to pay for all modes of urban public transport (Figure 10.30). The contactless smart card is a rechargeable pre-paid card with stored value and an RFID chip embedded in it. A passenger can swipe the card across an electric reader when entering the transport system to deduct funds. The smart card can be easily reloaded through mobile wallet⁵, credit-debit cards, ATMs and other authorised service providers.

The system can evolve to provide discounts for children, the elderly and students. A card holder can travel at reduced cost with earned reward points. The system can also be expanded so that one card can be used anywhere in the country for public transit. A further improvement could be the development with a personalised smart card which can be integrated with other personal details so that the card can be used not just for public transport, but also to pay parking fees and tolls.

Smart cards are successfully implemented in many Asian and European cities. Hong Kong and London are world leaders in the implementation of smart cards. Hong Kong pioneered the implementation of smart card payments systems with its Octopus card. It's one of early innovators in worldwide adoption of contactless payments in the transit market. The card can be used to make payments on public transport,

5. Mobile Wallet helps in instant money transfer and is an easier alternative to cash/card payment options.

retailers and facilities, and it has the highest acceptance of a commercial card system.

In India, Delhi has launched the common mobility card 'More Delhi' which can be used on Delhi Metro and its feeder buses. The plan is also to extend the usage of this card to DTC buses and taxis in next few months.

PASSENGER INFORMATION SYSTEM (PIS)

The success of integrated fare and ticketing systems hinge on good passenger information systems so that passengers have valuable real-time information about the various transport modes and can make their travel plans accordingly. These information systems can significantly enhance the attractiveness of public transport.

Karnataka State Road Transport Corporation (KSRTC) has deployed ICTs in its bus fleets in Mysore. The system consists of GPS and real-time PIS in buses. KSRTC also plans to have video cameras for surveillance and installation of electronic ticketing machine in buses. There is also a plan to integrate fuel consumption data into the system, helping the KSRTC ensure higher mileage. This system will help in capturing data on distance travelled, fuel consumed and driver's behaviour.

INTERACTIVE CITY DASHBOARD

An interactive city dashboard would provide real-time information about city transport to travellers. A traveller will be able to get a digital map of a city with reports of accidents, highway and arterial congestion, road construction, special events, and weather and average travel times on the routes. The traveller will also be able to get information about public transport schedules, routing details and location of stops by simply entering his or her starting point and final destination. Based on such information, a person will be able to take the most optimum mode of travel. The dashboard will be accessible by smart phones and tablets and will be searchable and user-friendly.

Google has launched real-time traffic information maps in six Indian cities: Bengaluru, New Delhi, Mumbai, Chennai, Hyderabad and Pune. A user can activate the traffic and weather layers and get a colour-coded view of the traffic and temperature in a particular area.

CONGESTION PRICING FOR PRIVATE MOTORIZED VEHICLES

Congestion pricing is a charge levied on a road user at times of congestion. This is usually implemented during peak traffic hours on roads that see a lot of congestion. It encourages use of public and non-motorised transport, and thus assists in reducing congestion and emission lev-

els. While congestion pricing has been successful in many countries, before implementation it is advisable to ensure that public transport is available on congested roads so that people have an alternative transport option to avoid the congestion charge. Due consideration should also be given to cost and the required political will for implementing congestion pricing. In India, it should be first studied with pilot programmes and implemented only if results are promising.

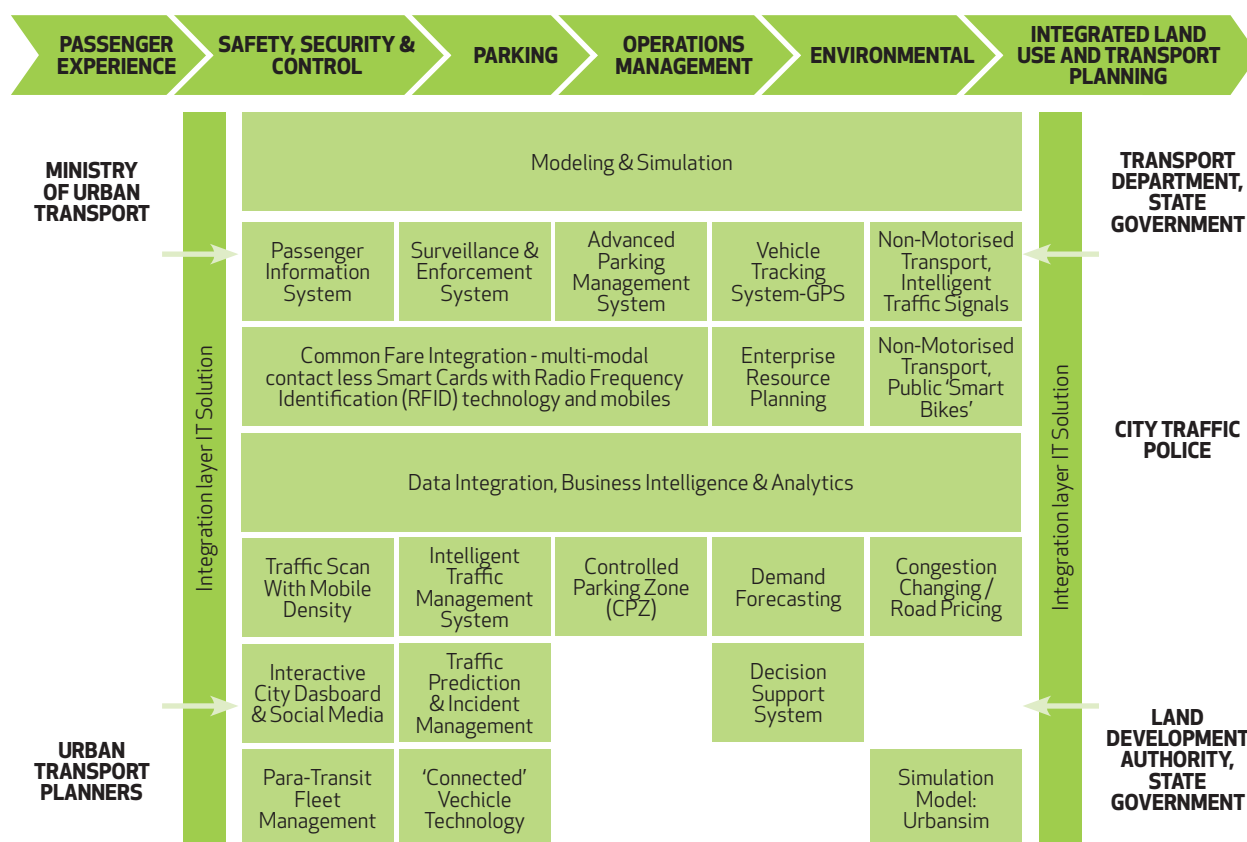
There are several technologies available for implementing congestion pricing. One option uses Dedicated Short Range Communication (DSRC) charging through transponders and gantries, where the vehicle has an on-board unit which has a smart card. When the vehicle passes the charging point, the roadside equipment, typically mounted on the gantry, communicates with the smart card and the charge is deducted from the card. At the second gantry, the vehicle's number plate is photographed for enforcement purposes. Another technology is a video-based system which relies on taking an accurate image of the number plate with the use of Automatic Number Plate Recognition (ANPR). This is the system used in London. The camera takes the picture of the number plate, converts it into appropriate alphanumeric characters and matches it with the electronic list of user accounts. In India, solutions such as KLiPR have been developed for ANPR. KLiPR can detect and read heterogeneous number plates and has a module for capturing an image of the driver to provide another layer of security for enforcement purposes. Another form of technology is GPS-based distance road pricing which is still being developed.

Congestion pricing has been successfully implemented in several cities around the world. In London, congestion pricing has been effective not only in increasing the use of buses by 6 per cent during the charging hours but also in raising revenue (£148m in financial year 2009/10). In 2008, Milan introduced an ECOPASS system in which vehicles are charged when they enter specified areas and the fee structure is based on the vehicles' potential air emissions. It uses the ANPR technology. In three years, the system resulted in reduction of highly polluting vehicles by 68 per cent and daily average emission of pollutants in the ECOPASS area of total PM10 by 15 per cent. In Stockholm, congestion pricing has reduced traffic by 18 per cent, increased green (tax exempt) vehicles by 9 per cent, and has reduced travel time on inner city and approach roads.

ENHANCING SAFETY THROUGH SURVEILLANCE AND ENFORCEMENT SYSTEMS

Intelligent surveillance and enforcement systems help in managing and enforcing traffic rules and regulations. These systems help in monitoring violations such as driving through a red light, jumping of

Figure 10.31
Future IT Infrastructure for Urban Transport in India



Source: Infosys Research.

lanes, over-speeding and parking violations. For such offences, enforcement cameras capture the image of the errant vehicle, locate the owner and send him or her a notice for fines. In the case of monitoring by traffic police, the use of smart phones has assisted in registering many more cases and in making the system more transparent.

ADVANCED SYSTEMS IN THE FUTURE

There are more advanced systems that are still in nascent stages. These solutions are still undergoing trials and will need detailed feasibility study under Indian conditions before they can be implemented. We discuss two such systems here.

PARA-TRANSIT FLEET MANAGEMENT

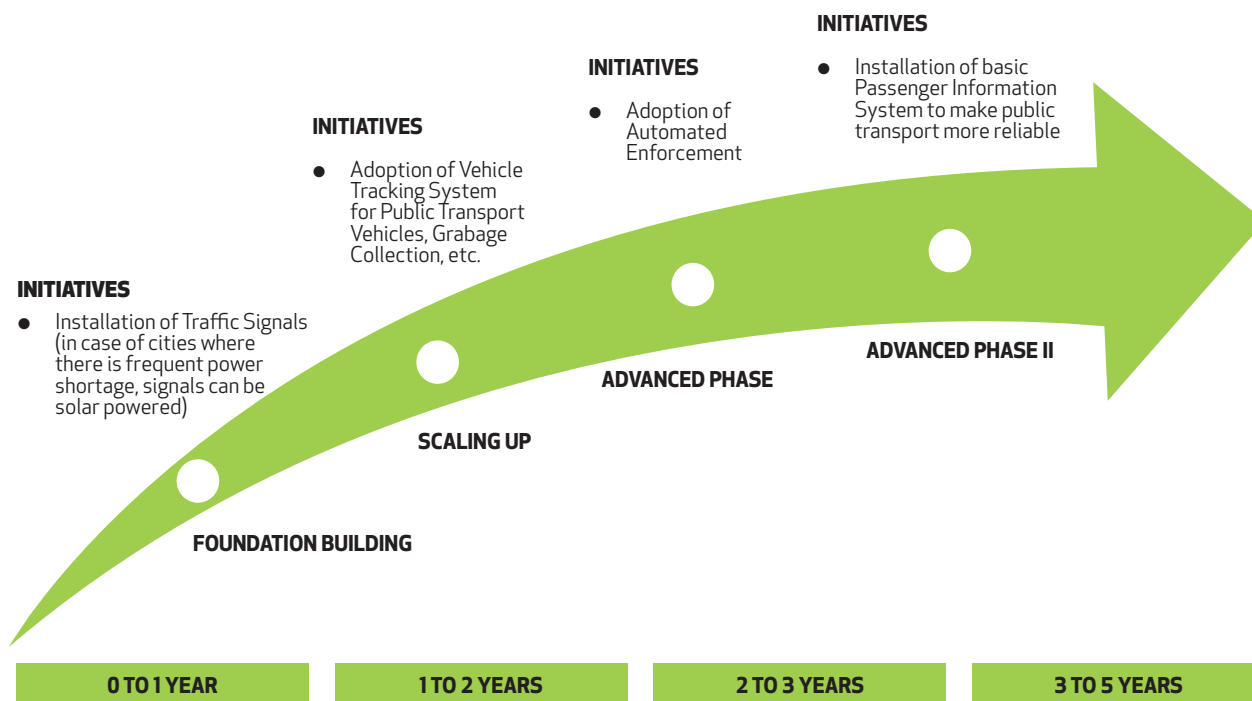
In para-transit fleet management, an operator who owns private buses or taxis would manage the scheduling or routing of the fleet in the city. The service would be offered through a web browser, where a traveller would prepare his own itinerary with the following options: (a) advance booking of a vehicle (bus or taxi); (b) whether shared acceptable (yes or no); (c) origin and destination of the traveller; and (d) how much waiting time would be acceptable. The payment can be made through smart cards, mobile phones, cash or internet banking.

Based on the bookings, the operator will be able to optimise the use of his fleet on two factors: (a) maximum passengers per vehicle and (b) lowest kilometre per vehicle per day. This system would enable better utilisation and improved operational efficiency of the available private fleet. The traveller will get greater flexibility, a better travelling experience and better safety.

CONNECTED VEHICLE TECHNOLOGY

With this technology which is still under development, vehicles would be connected to each other through Wi-Fi. A vehicle would have information about the speed and location of other approaching vehicles, roadway conditions and hazards which a driver may not be able to see. The technology increases the driver's knowledge about his driving environment and reduces the probability of crashes, either vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I). The vehicle's system would give warnings about potential collisions and other hazards. The technology is also expected to assist in collection and consolidation of real-time data from equipment located on vehicles and within the infrastructure. These data can be further used to manage the multi-modal transportation system for better performance.

Figure 10.32
Pre-Implementation Plan (Cities currently without ICT in UT)



Source: Infosys Research.

This technology is expected to prevent accidents and injuries on roads, and increase efficiency. The technology is undergoing initial tests under the Connected Vehicle Safety Pilot Program, run by the US Department of Transportation (DOT), Research and Innovative Technologies Administration (RITA) and University of Michigan Transportation Research Institute (UMTRI).

SUMMARY

Figure 10. 31 summarises this discussion on ICT technologies that would be useful for urban transport.

INSTITUTION AND CAPACITY BUILDING

As discussed in the earlier sub-sections, efforts are being made to introduce ICT in urban transport. However, these efforts are being carried out by multiple agencies without much coordination. But the development of an effective inter-modal transport network requires coordination between transport modes and between agencies. A strong institutional structure is required for such coordination, which should be based on the basis of developing a network of IT professionals in all the different agencies involved in urban transport.

ROADMAP FOR ICT IMPLEMENTATION

Urban transportation in India requires an implementation plan which will address the issues of traffic

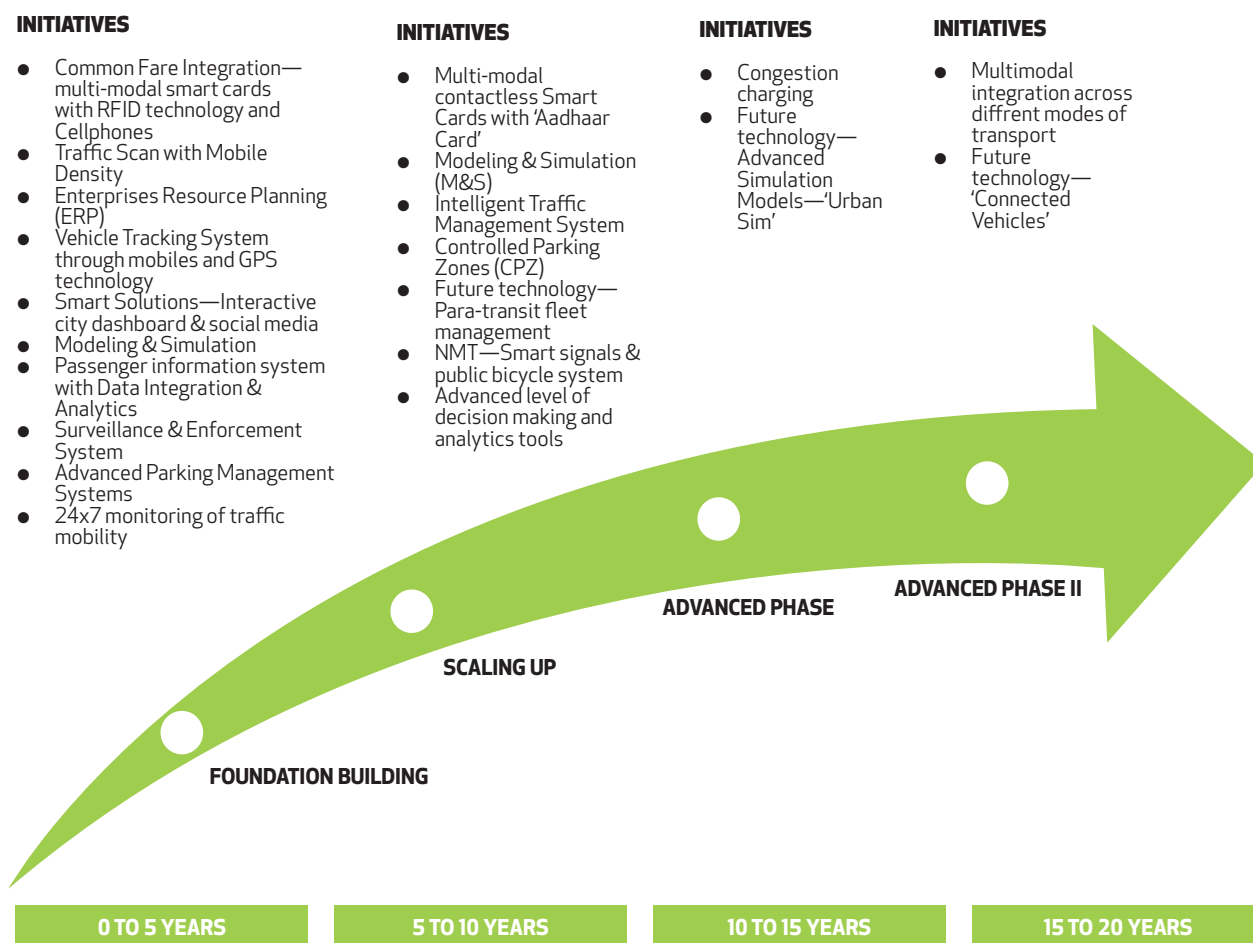
congestion, pollution, parking, safety by utilising the latest traffic technologies feasible in Indian circumstances. The plan should be flexible to accommodate the growing population and the technology solutions should be scalable in nature. Technological solutions can be implemented in a phased manner taking into account trends in urbanisation, the existing status of technology being used and funding available for urban transport. Category 1 and 2 cities have been introducing ICT in urban transport; however cities in Category 3 have not. Therefore, the roadmap for implementing is different for Category 3 cities.

PRE-IMPLEMENTATION PLAN FOR CITIES THAT ARE YET TO START USING IT FOR UT

Cities in Category 3 need to implement a 'Pre-Implementation Plan' lasting about five years and then implement the steps that are described in the following sub-section on the Implementation Plan for Category 1 and 2 cities (Figure 10.32):

- **Foundation Building:** Installation of traffic signals. In case of cities where there are frequent power cuts, traffic signals can be powered by solar energy.
- **Scaling Up:** Adoption of a vehicle tracking system for public transport vehicles, garbage collection vehicles, etc.
- **Advanced Phase:** Adoption of automated enforcement.

Figure 10.33
Implementation Plan for Category 1 & 2 Cities



Source: Infosys Research.

- **Advanced Phase II:** Installation of a basic passenger information system to make public transport more reliable.

Implementation Plan for more ICT-enabled urban transport system cities (Figure 10.33):

1. Foundation Building: Category 1 cities have used technological solutions for addressing their growing urban transport issues and have already started implementing some of these solutions. Some of proposed solutions that can be implemented at this stage are:

- Fare Integration through multi-modal smart cards with RFID technology and mobile phones
- Intelligent transportation systems and interventions involving digital video surveillance, 24x7 monitoring of traffic mobility, automated enforcement through smart phones and enforcement cameras and traffic modeling
- Data collection and monitoring by using mobile density as a proxy for traffic and

- GPS-based monitoring of the buses
- Setting up an interactive city dashboard and updating information of public interest on social networking websites including Facebook, Twitter
- Information dissemination systems involving variable messaging system, use of SMS and FM channels
- Operational efficiency through Enterprise Resource Planning (ERP) in transport agencies

2. Scaling Up: Some more advanced technologies can be added to urban transport in the next five to 10 years

- Intelligent transportation systems and interventions involving intelligent traffic signals and advanced level of decision making and analytics tools, simulation models.
- Parking management solutions—controlled parking zones (CPZ)
- Taxi & para-transit fleet management (future technology)

- NMT—Smart signals & public bicycle system
3. **Advanced Phase:** After a decade, urban transportation will have to be taken to a new level for a growing urban population. After feasibility studies, more advanced technologies can be considered for implementation at this phase. Some of the proposed solutions that can be implemented are:
- Congestion charging
 - Advanced simulation models like UrbanSim which help in integrated land planning and transport
 - Bus platoon systems
4. **Integrated Urban Transport:** At this stage, more technologies can be implemented which can support multimodal integration across different modes of transport. In the next 15 years, feasibility and pilot studies on future technologies would have been performed and would be ready to be Implemented.

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