ASCI Journal of Management 39(1): 33–54

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Risk Management in Large Information Systems (IS) Projects: A Case Study of the Indian Railways Computerized Passenger Reservation System ♣

Introduction

Kumar is an auto-rickshaw driver in Bangalore. He moved to Bangalore from rural Mandya with his wife and two sons a few years ago in search of a better life for his family and good education for his sons. He travels with the family to Mandya for festivals by train and uses the Indian Railways passenger reservation system (PRS) to plan his journey and buy tickets. "This computer system is smart. I can reserve return tickets from Mandya here in Malleswaram. It also saves me much hassle and time. I want my sons to study and apply computers to [*sic*] the benefit of common people like me", he exudes. Venkatesh is an information technology (IT) professional from Chennai settled in Northern California's Silicon Valley. He visits Chennai for holidays with his family every year. During his short stay, he travels by rail to visit his in-laws in Bangalore, his wife's grandparents in Mysore, and to take a break in the Munnar resort in Kerala. He plans these trips and buys tickets using the Indian Railways PRS over the Internet from Silicon Valley. "I had heard people talking about [the] PRS. Till I started using it, I just wouldn't believe that a *desi* system could be so good", says Venkatesh. Mr.

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♣ This study would not have been possible without Mr. Amit Kaushik, who arranged for the field study in India. We are very grateful to the following officials of the Indian Railways who spared time for the interviews and provided impetus for the study: Mr. S. K. Nanda, Executive Director, Railway Board; Mr. Amitabh Pandey, Group General Manager (IT), IRCTC; Mr. U. K. Sood, Project Manager, PRS at CRIS; Mrs. Sarla Balagopal, Deputy Project Manager, PRS, and her team at CRIS; Mr. Vikram Chopra, Chief Commercial Manager, Northern Railways; Mrs. Seema Kumar, Deputy Chief Commercial Manager, Northern Railways, Mr. Jai Pal Singh of National Rail Museum, and the many employees of Northern Railways.

Kobayashi, an affluent tourist from Japan, is an indirect user of PRS. He is able to plan his holiday in Delhi and Rajasthan—travelling by *The Palace on Wheels*, one of India's oldest and most popular luxury trains—sitting in Tokyo through his travel agency. These are not isolated instances. Interviews with passengers at reservation centres around Bangalore and Delhi and a study of web blogs show that the PRS has created a level ticketing platform for millions of rail travellers from different socio-economic backgrounds—from auto-rickshaw and taxi drivers across India to affluent non-resident Indians and foreign tourists around the world.

The present paper is about the passenger reservation system, the unheralded achievement of the Indian Railways. PRS started as a pilot project in 1985 on two trains between Delhi and Chennai with a few reservation centres in Delhi. In 2003–04, it was operational at 1,200 centres, had 4,000 terminals, covered 3,000 trains and handled one million reservations per day. The article attempts to identify and analyze the organizational and technological challenges faced in the design and implementation of PRS and how the railways managed to contain the risks that are inherent in such large projects. When the Indian Railways initiated the PRS project in 1983–84 in the pre-PC era, computer systems (hardware, software and programming languages) were expensive, unfriendly and inflexible. Many information systems (IS) projects in the United States had failed due to overselling of the technology by vendors, and the failure of managers to realize their role and that of human social factors in implementing IS (Lucas, 1975; Bostram and Heinen, 1977). Labour unions in India, fearing job losses due to computerization, had opposed the introduction of computers and struck work in organizations. Furthermore, government departments in India were not known for innovation and were perceived to be inefficient by the public. Therefore, the main motivation for this study was to find answers to the questions: How did the Indian Railways, a government sector behemoth, implement a world-class passenger reservation system without major setbacks? How did the organization contain the risks inherent in such a large IS project?

The remaining sections of this paper are organized as follows: Section 2 examines the growth of the Indian Railways from its humble beginnings in 1851 to becoming the world's second largest railway network (after China) under a single management. This story by itself is so fascinating that TV channels National Geographic and Discovery have produced full-length documentaries on the Indian Railways. The methodology and conceptual framework adopted by this study are discussed in Section 3. Data collection

methods, sources of data and the data collected are described in Section 4. Section 5 analyzes the data collected and identifies some success factors. Section 6 discusses the project risk factors and maps the success factors to project risk factors. The conclusions are presented in Section 7.

Indian Railways: Historical Overview[1]

The beginnings of the Indian Railways may be traced to the vision of Rowland Macdonald Stephenson (1808–95)[2], whose family had been engaged in commerce for several generations and was interested in India. Stephenson studied civil engineering at Horrow and started work in British shipping and navigation companies that covered India. He was interested in rail transport, which had made a huge impact on transportation in England. He made his first proposal for a rail transport system in India to the East India Company in London in 184l, which was rejected as a wild project. In 1843, he sailed to Calcutta to argue his case with officials of the Government of India and published a report on 1 January 1844 in *The Englishman of Calcutta* proposing six major lines. In July 1844, he asked for government support; the response was encouraging. With government support ensured, he sailed to London where he formed the East Indian Railway Company (EIR) with himself as the Managing Director (Bhandari, 2008). The first train of EIR was launched on 15 August 1854 from Howrah to Hooghly, a distance of 37 km.

Meanwhile, Stephenson advocated the acceptance of his 1844 proposal by the British Government in London for large-scale railway construction in India by that government (see Appendix 1 from the National Rail Museum Archives). The British government accepted this proposal, resulting in the setting up of companies to run the railways in India. One such company was the Great Indian Peninsular Railways (GIPR). On 22 December 1851, a small steam locomotive named *Thompson*, belonging to GIPR, started to haul some wagons containing earth in the state of Uttar Pradesh, then known as United Provinces. However, it did not last long and had a spectacular death with a boiler explosion, reportedly to the delight of construction workers who had viewed the locomotive more as a hindrance than help. Two years later, the first passenger train powered by a steam locomotive was introduced on 16

[1] Material on the history of the Indian Railways and the figures cited in this article are based on the archives of the National Rail Museum, New Delhi, and the websites listed in references. The IRFCA and Wikipedia websites provide extensive information and figures on the Indian Railways.

[2] Later Sir Ronald Macdonald Stephenson.

April 1853 between Mumbai and Thane by GIPR, covering a distance of 32 km. Around the same time, the East Indian Railway (EIR) ordered two locomotives from the UK, which acquired the names of *Express* and *Fairy Queen*. The latter is still chugging and is the oldest working locomotive in the world mentioned in the Guinness Book of World Records. In 1870, GIPR had carried two million passengers to and from Mumbai. By 1901, EIR carried 24 million passengers every year, the figure almost doubling to 42 million by 1916–17 and 72 million by 1927 (http://www.irfca.org; http://en.wikipedia.org).

In the colonial era, 42 railway companies operated in the country. After Independence, these companies were nationalized and run by the government as a central ministry. Thus, the Indian Railways became the second largest rail system in the world under a single management, the first being the Chinese rail system.

In its centenary year, 1951, the Indian Railways carried 1,247 million passengers on tracks designated as Class I lines, which exclude small branch connectors (National Rail Museum, 2003). By the 1970s, traffic on India's rails had increased manifold. Freight and passenger movement needed to be faster and with greater haulage capacities. Since diesel and electric traction are much more efficient in terms of fuel, maintenance, speed and haulage capacities, the union Railways Ministry decided to replace the steam locomotives with diesel and electric locomotives. The last steam service was closed in February 2000, except for the Darjeeling Himalayan Railway—the oldest mountain railway in India. It has the distinction of being the only train that still uses steam locomotives and was accorded 'World Heritage' status by UNESCO in December 1999.

The Indian Railways has about 1,08,706 km of total track (the length of rail track laid) and 63,327 km of route track (the track length between stations), 6,853 stations, and 37,840 passenger coaches. It employs about 1.55 million people directly and about 10 million indirectly; carries over 16 million passengers and 1.3 million metric tons of freight every day, and runs around 14,300 trains daily. During the last 20 years, suburban passenger traffic has increased by 116 per cent; non-suburban passengers by 120 per cent and passenger earnings have increased by 1,167 per cent (http://www.irfca.org; http://en.wikipedia.org). To facilitate effective management of this behemoth, the Indian Railways is organized into 17 zones. Each zone comprises several divisions with divisional headquarters. These divisions also operate numerous

schools and hospital for employees and encourage sports. Several Indian Railway employees have attained international levels in sports such as field hockey, table tennis and athletics.

Tickets of the trains run by the Indian Railways come in 10 categories, 40 kinds of quotas, 162 types of discounts, nine classes of reservations, and 100 types of passenger cars. Of the 16 million passengers who board one of Indian Railways' 14,300 trains each day, about one million have reserved accommodation (Pathak, 2006; http://www.irfca.org; http://en.wikipedia.org). The journeys can start in any part of India and end in any other part, with travel times as long as 48 hours and distances up to several thousand kilometres. These figures highlight the magnitude of passenger traffic on the railways and the complexity of the transactions that the reservation system has to handle on a daily basis. This increases the significance of PRS and how it has transformed passenger reservations in the Indian Railways.

Methodology and Conceptual Framework

Methodology

Computer-based information systems (IS), broadly defined as the application of computer and communications technologies to organizational processes, are about 50 years old. During this period, several methodologies and conceptual frameworks have been developed to study the successful implementation and effectiveness of IS. The methodologies have been adopted from the behavioural research stream and consist of positivist surveys, which attempt to identify the input and output factors and establish causal relationships between them, controlled experimental research, and positivist case studies (Benbasat, 1985). More recently, as information systems grew in scope and complexity, the interpretive case study methodology is increasingly being used (Orlikowski and Baroudi, 1991). The interpretive approach (Walsham, 1995: 75) assumes that our knowledge of the research problem is gained only through social constructions, such as interviews with the actors, documents, tools and other artefacts. It does not predefine independent and dependent variables but attempts to understand phenomena through the meanings that people assign to them. To paraphrase Greetz (1973: 9), the PRS study is our construction of other people's constructions of what they and their compatriots are up to; hence, an interpretive approach was considered appropriate.

Data Collection and Analysis: Four-Stage Framework

Although the interpretive approach does not predefine the variables, it needs a conceptual framework to guide the collection and analysis of qualitative data. Several frameworks have been developed to study the success/failure of information systems over the past 30 years of information systems research. For purposes of this study, the organizational innovation framework, which views IS implementation as a stage-by-stage innovation process, was adopted with some modifications. The original innovation framework consisted of three stages: initiation, adoption and implementation. After a preliminary study of the PRS, it was decided to adopt the following four-stage framework.

Initiation stage: This stage consists of the feasibility study and decisions leading to the approval and funding of the PRS project. Key activities include: building the need for the PRS, identifying the project management team, and approving a budget and the schedule. The outcome of this stage may be a decision to proceed or not to proceed with the system.

Project stage: This stage comprises activities that get the system up and running. Key activities are selection of the vendor and hardware, systems design, software development, system integration, testing, data conversion, redesigning manual procedures, and roll-out.

Implementation stage: During this stage, the organization accepts and uses the PRS. Activities include: debugging the software and system, rework, system performance tuning, and training staff who are accustomed to the manual system of reservation. In the implementation stage, the limitations and errors of the system are discovered and corrected and PRS becomes indispensable to passenger reservation activities.

Growth stage: Once it has been demonstrated that the system is serving its original purpose, the organization makes plans for further investment in technology infrastructure and for extending the use of the system to other areas; or plans to develop other applications linked to the system.

Data Collection

Sources of Data

The primary sources of data for this article were interviews with passengers and reservation staff in Delhi and Bangalore, members of the Railway Board, managers and staff who were familiar with the manual system and associated with the PRS from its beginning, managers of the Centre for Railway

Information Systems (CRIS) that played a significant role in the project, managers of the Indian Railways Catering and Tourism Corporation (IRCTC), and staff of the National Rail Museum. The interviewees were based in Delhi and Bangalore, and the interviews were conducted in 2002 and 2003 during visits to the cities. The interviews were tape-recorded with the permission of the interviewees and subsequently summarized or transcribed. Follow-up telephone interviews were also conducted, and further clarifications taken via e-mail, to ensure accuracy of data and interpretations. Appendix 2 lists the people interviewed and the number of interviews conducted.

The official secondary sources of data were minutes of the meetings of the Railway Board and its subcommittees, internal memos, annual reports, the Indian Railways' budget documents, books and magazines, the Indian Railways website, and documents and artefacts in the National Rail Museum, New Delhi. Unofficial secondary sources included media reports available at the Rail Museum and articles on the Internet and in newspapers. Historical reconstruction was done from archival documents and recollections of the past by the interviewees for the period 1985–2002, focusing mainly on 1985–87 when the PRS was initiated, developed and put into service.

The main focus of data collection was to identify the success factors, i.e., what the Indian Railways did right, at each stage, to design and implement such a large and highly successful PRS. However, the interviewers consciously avoided the terms 'success factors' and 'project risks' and leading questions about these.

Data Collected

Initiation Stage: 1983–84

Limitations of the manual system: About 500,000 passengers were seeking reserved accommodation each day on the Indian Railways in 1983–84. Delhi alone accounted for 50,000 reservations per day during the peak season. The manual system had reached its peak capacity, resulting in long queues and waiting times, and inefficient services at the reservation counters. Complicated rate calculations, manual ledger books and paperwork led to errors. Obtaining confirmation for a return journey from the starting station was another problem. Hence, the requirement was for universalized services that can reduce waiting and service times, and support reservation by any train in any class on any date, ticketing, cancellation and changes, enquiries, and confirmed return journey reservation from a single counter. It was not a

situation of may be useful to computerize, but a situation where work could not be managed unless computerized.

The idea of computerization: The above challenges set Mr. Madhavrao Scindia, Railways Minister in Prime Minister Rajiv Gandhi's government, thinking about computerizing reservations. These leaders were technology-friendly and foresaw the need for adoption of new technology to facilitate rapid economic development. They had observed similar systems in developed countries and wanted to implement one in India. Furthermore, if airlines could have computerized passenger reservations, why not our railways?

Concerns and fears: Like any IS project, PRS had its own share of concerns about its success, both from the railways staff and the management. The reservation staff had never seen a computer; they doubted the ability of computers to handle the complexities of PRS and their own ability to learn and use the system. They were also concerned about job losses and changes in job specifications and work methods. These concerns were acknowledged and recognized by the management of the Indian Railways. They assured the labour unions that there would be no retrenchment due to the new reservation system and the staff would be trained to operate the computerized PRS. On the other hand, it was foreseen that many more jobs would be created. Management cited the case of use of robots in the Japanese auto industry. Between 1979 and 1984, about 10,000 robots were brought into use in the Japanese automobile industry, replacing 7,000 workers. At the same time, about 60,000 new jobs that required newer skills of a higher order were created in the industry. These assurances and explanations mitigated the concerns of staff and cleared the way to appoint a project team and proceed with the project.

Management involvement and project team: The PRS project had the support of the Prime Minister, the Railways Minister, and the Chairman and members of the Railway Board; and was given the 'no objection' green signal by the staff and labour unions. This was the context in which a project team was set up in Northern Railway, one of the largest zones of the Indian Railways, under the leadership of Mr. R. D. Saklani, Executive Director, Operations and Information Systems, Railway Board. A memorandum of understanding was signed between the Indian Railways and Computer Maintenance Corporation (CMC), a government-supported systems-integrating company, for the project in June-July 1985. The railways project team decided to start

PRS as a pilot project in Delhi and implement it in other zones only if the pilot project was successful. The team held meetings with the Railways Minister every fortnight, during which complete information on the progress on the project was provided, especially during the early stages. This ensured the involvement of the minister and management at the highest levels in the initiation stage of the PRS project.

Project Stage: 1984–85

Appointment of vendor: CMC proposed to employ a VAX 11/750 computer for the pilot project because they had been using it at their research centre in Secunderabad. They were in the process of developing a prototype PRS based on their understanding of the manual reservation system. CMC assured the railways that if VAX 11/750 and the project were not successful, it would take back the hardware and treat all the expenditure incurred as its own R&D effort. This was rather unusual for an IS implementation project where the vendor was willing to take responsibility for the failure of a project and bear all the expenses. This offer led to CMC's appointment as the vendor of hardware and systems development services for the PRS in mid-1985.

PRS development: CMC set up its own project team and office in New Delhi to conduct a detailed systems study of the reservation system and prepare functional specifications. The CMC team held frequent structured meetings with the project team of Northern Railways under the leadership of Mr. R. D. Saklani over a period of one year. The railways' requirements, especially printing of reservation charts, were found to be very stringent, and CMC expressed the inability of its hardware and operating system to meet all of them. Consequently, the railways consciously agreed to defer some of the requirements (for example, printing of reservation charts) so that the project could proceed. The specifications were revised and fine-tuned several times to make them as detailed as possible; at the same time, there was a compromise on some of the requirements that the technology available at that time could not deliver.

Implementation Stage: 1985–89

Putting to service: The CMC project team rolled out the PRS prototype with onward reservation in October 1985. It was put into service in November1985 on two trains—the Tamil Nadu Express and the Grand Trunk Express, running between New Delhi and Chennai. There was a parallel run for 15 days during which the reservations made by the PRS system were compared with the

manual ones to ensure accuracy. Before accepting the functional and financial compliance of the system, rigorous manual checking was done in the background: the fare computation module, cancellation module, journey date change module, concession fare module—were all thoroughly checked. Thereafter, all reservation activities associated with the two trains were transferred to the PRS system and manual reservations ceased. Once the PRS was proved successful on these two trains, it was implemented for onward reservation on all trains originating from New Delhi. Gradually, the work of manual charting was also transferred to the PRS.

Limitations of the prototype system and enhancement: Limitations of the prototype system were discovered when more trains were added. New Delhi had three reservation offices—at New Delhi, Delhi (Main) and Nizamuddin. The railways wanted to implement PRS on all the trains originating from New Delhi, especially for upper class reservations, in each of the three reservation offices. However, the hardware capacity was inadequate to meet this additional load. When Vaishali Express was put on the system, it became extremely slow and service time greatly increased. This train had to be taken off the PRS computerized system and reverted to the manual system. It was then realized that the capacity of the pilot system had been exhausted and needed an upgrade.

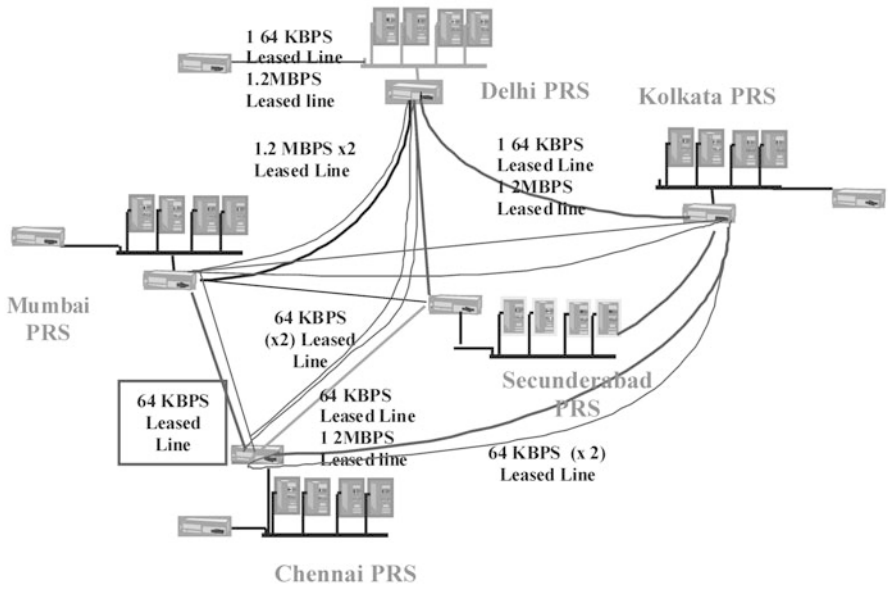
The software for the pilot project was written in FORTRAN and had a flat file data structure. Although the system delivered the required outputs, some of its integration features were clumsy. These were addressed in the enhanced version known as Integrated Multi-train Passenger Reservation System (IMPRESS), which took 30 man-years of programming resources to develop. It had 2,700 subroutines and four integrated modules: Inquiry, Reservation, Charting and Accounting. IMPRESS was implemented in Delhi in May 1987; it was extended to Mumbai in June 1987; to Kolkata in July 1987, and to Chennai in October 1987. Each of these locations was also provided its own VAX 11/750 computer hardware. Meanwhile, as a long-term strategy, the Railway Board had set up its own systems and software development organization, the Centre for Railway Information Systems (CRIS), in 1982. CRIS was a public sector undertaking set up to develop software for another major project of the Indian Railways—the Freight Operations Information System (FOIS). The railways entrusted the implementation of IMPRESS for the fifth location, Secunderabad, to CRIS. IMPRESS was implemented in Secunderabad in October 1989 with an indigenous hardware developed by

Electronics Corporation of India Ltd. (ECIL), which was found to be inadequate for the task. It was replaced by the VAX 11/750 processor, similar to those in New Delhi, Mumbai, Kolkata and Chennai.

Growth Stage: 1989–2002

National PRS Network-CONCERT: During this stage, PRS was enhanced and extended to more locations, including remote areas, to provide nation-wide service. PRS in the five above-mentioned nodes were stand-alone systems with their own VAX 11/750, PRS software and database; and they provided onward reservations. The first step in providing return reservations was to link these nodes by using railway telegraph lines and a human intermediary at the returning station. As the next step of adding more stations, which clamoured for PRS, and attaining the goal of "from anywhere to anywhere reservations", the Indian Railways decided to develop the National PRS Network and serve any new PRS location from the nodes nearest to them. The task of developing the national network was entrusted to CRIS. After a detailed study of the technology used by IMPRESS, CRIS took the following steps to develop the national network: *(i)* upgraded the processors at the regional centres; *(ii)* networked the five regional centres via leased lines; (*iii*) installed micro-Vax processors at the new zonal locations; *(iv)* used satellite communications technology to improve the reliability of communications and provide service to remote areas, for example to Ladakh about 14,000 feet above sea level in the Himalayas, where alternative connectivity options were not possible; and *(v)* adopted modular architecture, which permitted the expansion of processing capacity in incremental steps. The national network was called the Countrywide Network of Computerized Enhanced Reservation and Ticketing (CONCERT). It was implemented in Secunderabad in September 1994 and in Delhi in September 1996; Delhi and Secunderabad were networked using CONCERT in October1997. Thereafter, CONCERT was extended (see Figure 1) to Mumbai (January 1999), Kolkata (June 1998), Chennai (April 1999) and countrywide in April 1999. With the implementation of CONCERT, the PRS national network on the Indian Railways can be used to make reservations for any train, date or class between any pair of stations for the travelling public from about 4,000 terminals in 1,200 locations across the country. After 15 years of dedicated management support and development efforts by CRIS, the railways achieved the goal of providing "from anywhere to anywhere" reservations envisioned in 1985.

Figure 1: **Network Architecture of CONCERT**



Source: Pathak (2006).

PRS on the Internet: Historically, consumer transactions in India have been cash dominant. With the availability of broadband networks and the use of technology in the financial services industry by 2000, consumers in middle-income groups could use credit/debit cards to pay for purchases. In October 2001, the Indian Railways Catering and Tourism Corporation (IRCTC), a public sector organization under the Ministry of Railways, made a presentation to the Railway Board for developing a web-based front end for the Railways PRS to provide customers with the choice of purchasing tickets via the Internet using their credit/debit cards. IRCTC considered ticketing via the Internet a separate business activity, which included purchase of the ticket, delivery of the ticket, follow-up and customer relationship management. IRCTC proposed developing a front-end software that would communicate with the back-end PRS; ticketing via the Internet would be a new way of using the PRS. IRCTC received fast-track approval on 31 October 2001. After a screening process in which IRCTC was assisted by consultants, the e-commerce platform Broad Vision was selected to develop the Internet interface for PRS.

The Minister for Railways inaugurated PRS on the Internet on 2 August 2002. For that particular month, revenues from Internet reservations were Rs. 5 million. During the course of the year, revenues increased ten-fold. In

July 2003, Internet PRS recorded revenues of Rs. 52 million. Four years later, in August 2007, PRS on the Internet handled 1.3 million reservations and generated revenues of Rs. 1,100 million (Vinod Astana, Director of Customer Service, IRCTC).

Developing PRS on the Internet posed both technical and social challenges. Security of credit/debit cards and integration of the PRS system running on the proprietary open VMS platform, with the front end running on Intel servers, was a technical challenge. The most pressing social concerns were: the Indian population was not net-savvy, anxiety about the security of Internet transactions that involve bank account/card numbers, and consumers might not be willing to transact over the Internet. Despite these concerns, IRCTC developed the front-end software, which incorporated a very large proportion of rail reservations and rail reservation users' requirements. Initially, the railways would print and deliver the tickets to customers for a nominal delivery charge. By 2007, customers familiar with Internet browsing and with access to PCs, broadband and printers were able to print tickets at their offices, homes or even Internet cafes. Now, they can also reserve tickets through their Java-enabled mobile phones. Furthermore, like the airlines, IRCTC has made PRS available to travel agencies to reserve rail tickets for passengers. Thus, in a short span of five years, IRCTC had developed and implemented a world-class business-to-consumer (B2C) e-commerce site for rail passenger reservations.

The Cost-Benefit Trade-Off

Benefits

The benefits of information systems are usually categorized as tangible and intangible. Some examples of tangible benefits are cost savings, staff reduction and increase in revenue. Intangible benefits include improved customer service, higher quality of information, improved work environment, streamlined operations, and higher employee self-esteem and morale (Zwass, 1998). The PRS has resulted in several benefits to the rail travelling public and railways staff. Observations at PRS stations show that a passenger joining a queue of 40 persons (sitting in chairs while waiting) in a reservation office with four/five service windows gets through in about 30 minutes, of which 28 minutes is the waiting time and 2 minutes is the service time at the window. Delays, if any, are due to errors in filling the reservation requisition forms. With satellite reservation offices located at many places in metropolitan and

other important cities, the reservation facility is within the easy reach of customers. Significant savings have accrued to passengers by way of shorter commuter trips to reservation offices closest to them, instead of commuting to the main stations. Saklani (1987) estimates that the Delhi area shows a recurring annual saving of Rs. 100 million to the economy on account of reduced bus trips to reservation offices alone. The significantly reduced waiting time in queues and the elimination of the grey market for tickets have proved to be the biggest boon of the Indian Railways' PRS for passengers.

Several benefits have accrued to the railways reservation staff and management. For the staff, manual calculations, registers, ticket tubes and accounts books have all disappeared and their work environment has improved. They just key in the train numbers from the requisition forms and collect payments. From the management perspective, productivity of staff has almost doubled. Each counter clerk used to handle about 75 requisition forms per day in the manual system; post-PRS, he/she handles about 140 requisitions. Estimates indicate that for Delhi alone, about 15 million man-hours are saved annually as a result of the provision of computerized reservation and satellite reservation offices. A very significant intangible benefit is national pride. The Indian Railways management and staff are justifiably proud that they have successfully implemented a world-class, state-of-the-art system in a developing country. Some (Rajaraman, 2000) even suggest that the success of the railway PRS provided the launch pad for India's software industry exports which, according to a report (*Economic Times*, 2007), is expected to cross US$ 60 billion by 2010.

Cost

The Indian Railways is one of the oldest large organizations in India. Historically, its social obligations extended beyond providing transportation to the populace—to even opening hospitals and schools. Traditionally, whenever a new service was required of the railways, it set up its own organization to perform that service. Cost-benefit analysis was not an issue. The PRS project seems to have adopted the same approach, and the cost of the project has not been systematically tracked. Some railway officials estimate that about Rs. 250 crore was spent on the PRS up to the CONCERT stage, which works out to approximately US$ 60 million.

Risk Management and Success Factors

Risks are inherent in any project, and IS projects are no exception. Research has identified three factors that affect risk in IS projects: project size, project structure and familiarity with technology (Davis and Olson, 1985). In addition to these, organizational politics is also a potential project risk (Markus, 1993). Project size depends on the organizational reach of the project, the number of people involved, and project duration in terms of development man-hours required. Projects that are large by these measures are likely to be more risky. Project structure depends on the nature of the tasks to be performed by the system and the clarity with which these can be specified for programming. The structure of a project can be improved by providing clear definitions of the tasks to be performed and detailed system specifications. An elaborate structure lowers project risks. Familiarity with technology refers to the proficiency of the developing teams in the technology used for the project. Use of the latest technology with which system developers may be unfamiliar increases the probability of failure. Organizational politics in the context of IS usually refers to the use of IS by individuals or groups of people to promote their cause or to prevent others from doing so. Top management support, clear communication, user involvement and project leadership contain the negative effect of politics on project success. In most project situations, these factors can be recognized in the project initiation stage and project risks can be managed. The following sections identify the key factors that contributed to the success of the Indian Railways PRS and relate them to the project risk factors.

Initiation Stage

Top management support: Implementation success occurs when there is a commitment to change, a commitment to the implementation efforts, and when extensive project definition and planning takes place. Top management has to be convinced that IT systems are not just functions to be managed but enablers for achieving organizational goals. In the case of PRS, this was not necessary. The project was initiated by the Railways Minister and had the full support of the Prime Minister, both of whom were technology-friendly, and members of the Railway Board. Sufficient funds and resources were allocated for the project. Throughout the four stages, progress of the PRS system was monitored and supported at the highest level, despite changes in the ministry.

Negotiations in good faith with labour unions: The railways management assured labour unions that there would not be any job losses due to computerization and that the staff would be trained to work on computers and handle the computerized PRS. During the course of the PRS project, the management adhered to their assurances. This pre-empted hostile actions by the unions.

Project Stage

Appointing a railways project team: Instances of treating IS implementation as a technical project that is left to the experts abound in IS literature. Outcomes of such projects have been generally unsatisfactory. In contrast, the Indian Railways viewed PRS as a management exercise and appointed its own project team before signing a memorandum of understanding with CMC. This was a key success factor. The railways management was in control of the project from the beginning.

CMC's assurance and familiarity with technology: The assurance by CMC that they would treat the project as an R&D expense in case it did not satisfy the Indian Railways was unusual. With such an assurance, the CMC project team had to work closely with the railways and ensure success of the prototype. The team identified with the staff, and their concerns became the concerns of the team. The CMC project team was familiar with the VAX computer technology.

Hurrying slowly: Many of the activities that surround IS implementation efforts involve information exchanges among designers and users—exchanges involving issues such as purpose, objectives, design, use, impact and evaluation. At each step, the project teams looked at the design of the system from the point of view of the counter clerk who had to use the system ultimately. Nearly 20 man-years were spent in developing the functional specifications of PRS, and care was taken to design user-friendly interfaces. While this approach might have slowed progress in the initial stages of the project, it enabled the project team to deliver the prototype system on time and without much rework.

Pragmatic approach to development: Project teams of the Indian Railways and CMC adopted a pragmatic approach to developing the PRS. The functional specifications for the system were worked out with considerable care. The system design was simple, with a few user-friendly screens, and was developed and implemented in stages: First, a prototype system on two

trains between Delhi and Chennai was implemented. After this proved to be successful and was accepted, the system was extended to other centres and enhanced—first to IMPRESS, and later to CONCERT.

Why is this pragmatic, step-by-step, bottom-up approach, with its simple design, so significant? Studies of information systems successes and failures have shown that often managers and information systems developers take the grandiose approach. Two instances—one of the French Railways Socrate reservation system and the other CONFIRM, the project of the US airlines, hotel and car rental services industries—suffice to illustrate this. Socrate, the first attempt to computerize the French Railways reservation system, was a disaster and had to be reworked. One of the reasons for its failure was that the system design was too complex, making the system difficult to use for both the counter staff and customers. French Railways had bought SABRE—the American airlines computerized reservation system developed for the deregulated airline industry in the US—and tried to adapt it in the context of the rail industry in a regulated economy. The Socrate case illustrates the consequences of wrong strategic and technical choices, as well as how actors interpret and appropriate technical tools (Mitev, 1996). The CONFIRM project, for integrating airline, rental car and hotel reservations, failed because it was very ambitious and technically complex (Oz, 1994). Members of the project management team did not come forward with detailed specifications, and the project faced technical problems in coordinating various transaction processing activities. These are in stark contrast to the Indian Railways PRS, which was developed indigenously and implemented stage by stage.

Implementation Stage

Expertise of CRIS database team: The Indian Railways considers the CRIS database staff as one of the most valuable assets of the PRS project. The database staff very thoroughly understood the requirements of the system, the forms for data entry, and the implications and interpretation of each field of input in the database. In some ways, they developed their own data dictionary. This was very important for the system to function accurately.

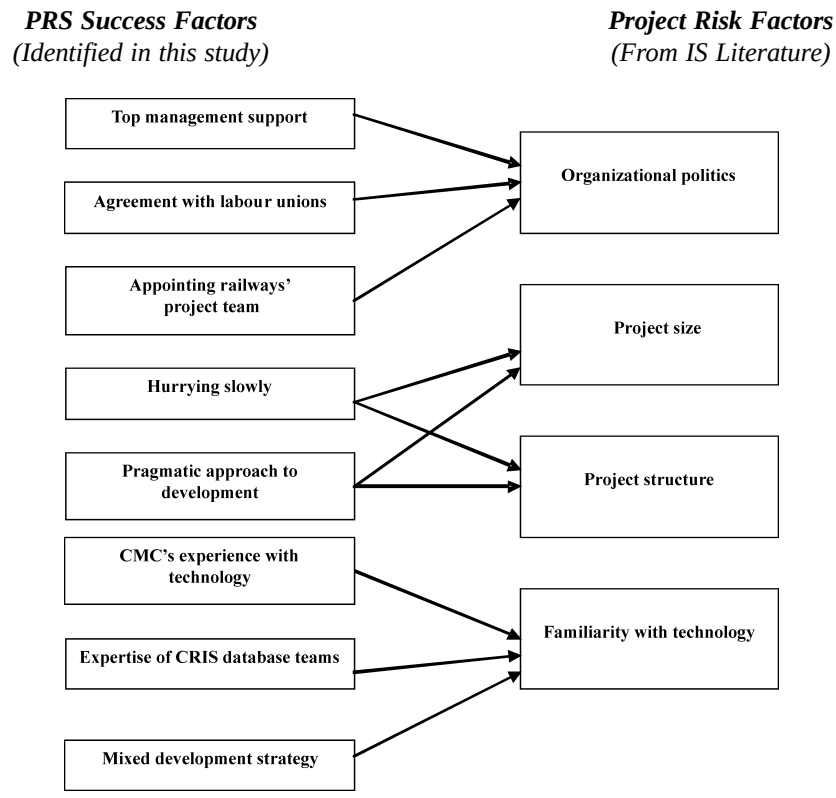
Centralized control: Changes to existing routes and trains have always been controlled centrally in Delhi. A log of the changes and the dates on which the changes were made was maintained. This ensured consistency of data at all the five regional nodes besides improving the security of the system.

Growth Stage

Mixed system development strategy: Two strategies, in-house development and outsourcing, are available for organizations to develop IS. It is interesting to note that the Indian Railways outsourced the development of PRS and IMPRESS to CMC although the railways' in-house IT department, CRIS, was set up in 1982. This decision was rightly guided by the expertise on reservations that CMC had developed on its own and its "no-system, no-payment offer". At the same time, as a long-term strategy, the railways entrusted the development and operation of the national network CONCERT to CRIS. This was not the end of outsourcing, however. When IRCTC wanted to put PRS on the Internet, it viewed it as an e-commerce application and entrusted the project to a firm with deep experience and expertise in the e-commerce domain.

Figure 2 shows the association between the PRS success factors discovered in this study and project risk factors identified in the IS literature. In every association, the success factors had a moderating influence on project risks.

Figure 2: **Association between PRS Success Factors and Project Risk Factors**



Conclusion

The outstanding success of the Indian Railways PRS, a large government sector IS project, raises the question: Can it be replicated in other similar projects? Generally, the findings of case studies, especially some decisions, are context-specific and should be applied to other situations with due care. The project risk factors indicated in Figure 2 are derived from studies of a large number of projects. While the risk factors are widely applicable, the success factors that mitigate the risks depend on the organizational and external environment of each case. Nevertheless, it would be useful to explore the relevance of these factors to other similar projects.

Computerization of the PRS has been proclaimed as the most successful project undertaken by the Indian Railways. A system that was designed from scratch and implemented in 1985 as a pilot project on two trains has been progressively upgraded, daily processing over a million transactions across 1,200 locations in India and servicing thousands of customers over the Internet. The success of the project has demonstrated that information technology itself can have a huge impact on an organization and a population. PRS computerization has played a major role in communicating the positive effects of technology to the suspicious labour unions and workers in India. Furthermore, the success of PRS proved that Indian software engineers and project managers have the expertise and ability to carry out projects on a large scale. National pride engendered by this success and the satisfied expressions on the faces of customers at reservation centres across the country are the major intangible contributions of the Indian Railways PRS.

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Appendix 1

Extract from the 1844 Note of Rowland Macdonald Stephenson (East Indian Railway Company) advocating acceptance of his proposal by the British Government in London for large-scale railway construction in India.

> Age after age did the greatest of India's monarchs strive to perpetuate the memory of their name and rule by lavishing on 'paynim' mosques, idol temples and proud mausoleums those treasures of 'barbaric pearl and gold' that were cruelly wrung from the tears, the cries and the miseries of a suffering people. Let it now be the glory of Imperial Britain to confer on the same people a boon of inestimable value in the form of a work of the greater extent and utility which the world had yet seen; a work, which, by its facilities of intercommunion and rapid conveyance of the super bounding products of an exhaustless soil to the great emporia of commerce shall help to arouse the dormant energies of millions–quicken their intellectual and moral powers–dissolve the spell of a thousand habits and customs consecrated by the superstitious reverence of the ages, stimulate the creative industry that shall transmute the pestilential marsh into a healthful garden teeming with fertility and verdure and by its incessant encroachments literally cause the very desert 'to rejoice and blossom as the rose'; a work which by its multifarious influences thus called into action and the varied salutary tendencies thus endearingly impressed shall, as an auxiliary to all other reformative agencies, lend its effective aid in contributing to raise long prostrate India from the dust, and exalt her to her rightful position as one of the most magnificent empires under the sun.

Appendix 2

People Interviewed

Interviewee	*Number of Interviews*
Mrs. Sarla Balagopal, Deputy Chief Project Manager, CRIS	1
Mr. U. K. Sood, Manager, PRS, CRIS	2
Mr. Vikram Chopra, Chief Commercial Officer, Northern Railway	1
Mr. S. K. Nanda, Executive Director, Statistics; Railway Board	1
Mrs. Seema Kumar, Deputy Chief Commercial Manager, Northern Railway	2
Ms. Priya Srivastava, Deputy Chief Systems Manager, PRS, CRIS	1
Mr. Amit Pandey, Group General Manager (IT), IRCTC	2
Mr. Jai Pal Singh, Assistant Librarian & Information Officer, National Rail Museum	1
Employees, Northern Railway	3
About 20 PRS passenger users, randomly selected from the waiting lines of about 160 people in PRS centres in Bangalore and Delhi on four different Sundays when the waiting lines are long.	20