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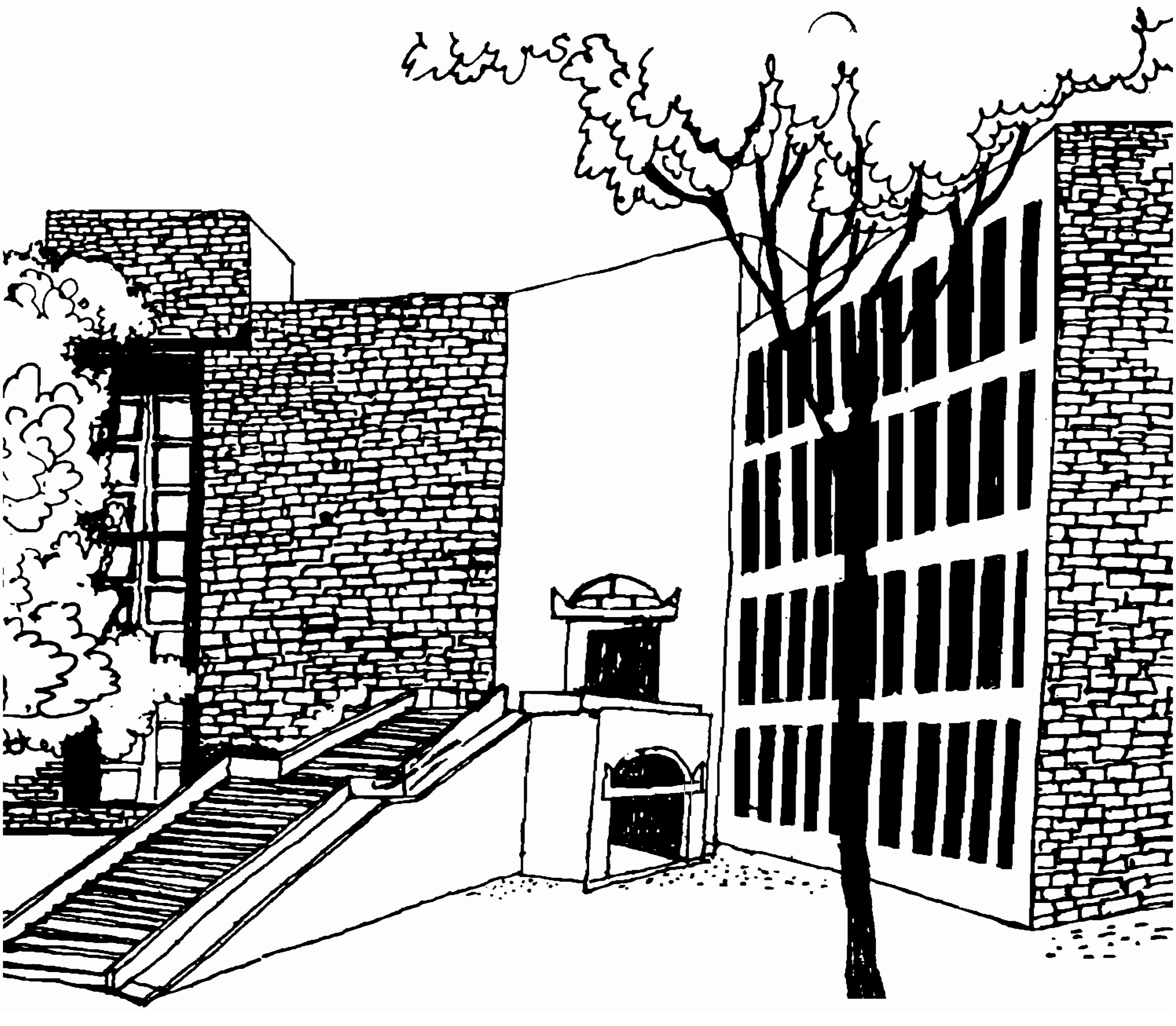

MANAGEMENT OF LARGE IT PROJECTS: THE PASSENGER RESERVATION SYSTEM OF INDIAN RAILWAYS

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Abstract

The Passenger Reservation System of Indian Railways is a major computer application in a visible, consumer sensitive area. This involves a distributed database, spread over five host computers located in five metropolitan cities in India, and terminals located in 34 cities. The objective was to improve the service level to the customer and the exercise may be viewed as an example of a successful application in a developing country. This paper examines this application and draws lessons for management of large Information Technology projects.

Introduction

Large public systems information technology (IT) projects in developing countries have the potential to impact on vast number of people, besides improving the functioning in areas of major governmental expenditure. Examples of such public systems are railways, road transport undertakings, banks, hospitals, educational institutions, etc. Implementing such projects poses many challenges, arising out of the technological complexity, socio-political environment, and organizational issues. Some studies [Gupta, 1983; Jain and Raghuram, 1992 (a); Madon, 1992] have identified various dimensions that determine the success or failure of implementation of large IT projects in public systems. While, by and large, the implementation of such applications has not been very successful, one exception has been the computerized Passenger Reservation System (PRS) of the Indian Railways (IR).

PRS, handling over 3,30,000 transactions in a day from 34 cities across India in January 1993, is possibly the only one of its kind in the world. It is a complex application implemented in a real time geographically distributed environment. PRS is acclaimed to be a very successful application in a visible and sensitive area of mass customer service. For example, it has drastically improved service times and quality of service [Symatec, 1990]. The justification for this application has been on improving customer service rather than on economic grounds. PRS implementation started in the early 80s, at a time when use of computer technology was just beginning in India. Given that over Rs. 800 million[1] have been spent on PRS until March 1991 (and an estimated Rs. 80 million to be spent in 1992-93) [Indian Railways, 1992(b)] and that the system has been functional for over seven years, it is important to understand the factors that have contributed to the successes and failures. Viewing the application and its growth as a comprehensive project would also provide lessons for large project formulation and implementation in a customer-sensitive area in general and software development in specific.

This paper examines the above issues. It is based on extensive interviews with various executives involved in the implementation and a study of related documents and papers.

Indian Railways

Organization

Indian Railways (IR) is the world's second largest railway system under a single management. The responsibility of the management rests with the Railway Board under the overall supervision of the Ministry of Railways. The Railway Board consists of the Chairman, the Financial Commissioner, and five functional members for Electrical, Engineering, Mechanical, Staff and Traffic. On operational and managerial considerations, IR is divided into nine zonal railways, each of which is headed by a General Manager.

While IR is expected to be financially viable, it is also expected to meet the various socio-economic objectives, often politically driven. Over the years, funds for infrastructure development have become more costly. Until the early 80s, capital at the rate of 6 per cent was available from the Government

[1] One US dollar is now approximately equal to Rs.30. Prior to the devaluation in July 1991, the rate was Rs.18; a gradual rise from Rs.11 in the late 70s.

of India. Subsequently, borrowing from financial institutions had to be resorted to at a rate between 9 per cent and 14 per cent. Nowadays, capital is available at a minimum rate of 18 per cent. The total investment in IR was Rs. 222,000 million as of March 1991 [Indian Railways, 1992(c)].

Operating Performance

The revenue earned by IR during 1990-91 was Rs.125,000 million, yielding a surplus of Rs. 1876 million [Indian Railways, 1992(a)]. Of this, Rs. 34,800 million (28 per cent) came from passenger traffic and Rs. 86,000 million (69 per cent) from freight traffic. IR operated over 7300 passenger trains daily, of which 3300 were suburban and 4000 non-suburban, on a network of 62,000 route km. (Table 1). IR provided for 3858 million passenger journeys during 1990-91, i.e. nearly 11 million a day or the equivalent of 1.2 per cent of the country's population. Of the total daily passenger journeys, 6.6 million (59 per cent) were accounted for by suburban journeys and the remaining 4.4 million (41 per cent) by non-suburban journeys. The average lead of suburban journeys was 26.4 km. while for non-suburban journeys the lead was 147.6 km. In terms of passenger-kilometers, non-suburban traffic accounted for 80 per cent of the total, while in terms of revenue, it accounted for 89 per cent of the total. (This is largely because suburban travel is heavily subsidized.)

Reservation is offered only in the non-suburban segment, mainly in mail and express trains. As shown in Table 1, out of a total of 4000 non-suburban trains run daily, over a 1000 were mail and express trains offering reserved accommodation. Out of 4.4 million journeys undertaken everyday, 0.35 million (8 per cent) were reserved. Assuming that every reserved passenger travelled from the origin to the destination of the train, at an average lead of 800 km for the mail and express trains, the reserved passenger-kilometers form 43 per cent (an upper bound) of the total non-suburban passenger-kilometers. In terms of revenue, reserved journeys contributed Rs. 22,000 million. This forms 71 per cent of non-suburban passenger earnings and 63 per cent of total passenger earnings.

Profile of Reservation

In 1991, over 350,000 berths and seats were available each day for reservation. These were spread over nearly 2000 railway stations, out of a total of 7000 railway stations. Of course, most of the stations offered a reservation quota of less than 10 berths and seats. These 350,000 reservations lead to 450,000 transactions a day, including cancellations and wait list transactions [Saklani, 1991]. Based on 1987 data, when there were a total of 360,000 transactions, 270,100 transactions, i.e. 75% were accounted for by 37 stations, each having at least 1500 transactions a day [CRIS Documents, 1987]. Table 2 gives city-wise profile of reservation volume as of 1987. The four metropolitan cities accounted for over 40 per cent of the transaction volume.

In the manual system, reservation was handled at the major stations by having separate counters for each train. Because of the imbalances of demand at each of these counters and long service times in manual processing, the time spent in the queue by the customer was on an average more than one hour. During peak travel seasons, waiting time in the queue could easily run into a few hours. This was the key reason which motivated the PRS as a computer application.

History of PRS

Early Years

Computerization in IR, as a step towards modernization, had begun early. From 1960 to 1977, IR had been using IBM 1401s in the zonal headquarters and the Railway Board, primarily for freight accounting and pay roll applications. The increasing volume of operations over the years and the consequent complexities necessitated upgradation of the technology and greater computerization. A railway task force was set up in 1977 to study possible areas of computerization. Among many others, it identified freight operations information system (OIS) and PRS as two key applications. A study team in 1979 recommended that OIS be implemented in Madras, Bombay, Calcutta, and New Delhi along with PRS, stating that PRS was financially viable only if it was implemented along with OIS.

It estimated the total project cost (OIS + PRS) to be Rs. 2100 million of which Rs. 1000 million was for communication.

In May 1981, a separate directorate was set up in the Railway Board for implementing OIS and other computer applications. The Director (OIS) reported to the Chairman, Railway Board. In 1982, a study team consisting of representatives from IR, Electronics Corporation of India Ltd., and Department of Electronics represented by CMC, visited five railway systems abroad to study similar applications. Both Electronics Corporation of India Ltd and CMC were public sector organizations in the field of computers. While studying various applications, the team also studied computerized PRS in other countries. The team did not find any PRS with comparable size, complexity, and transaction volumes. This set the grounds for indigenous development of PRS.

During 1983, the Railway Board decided to go ahead with the implementation of PRS, independent of the OIS. The primary reason was that IR saw this as a way to gain the desired push for computerization and visibility. It is also important to note that general elections were expected to be held in 1984. Politically, the application was favourably viewed and supported. Consequently, results had to be shown within a year. PRS development began right away, first at the New Delhi railway reservation center. (Apart from being the city with the highest reservation volume, it is also the nation's capital).

Selection of CMC

When IR floated tenders for development of PRS at New Delhi, CMC was a clear choice. This was because of the prior developmental work done by CMC in the area of computerizing the reservation system. After the visit abroad in 1982 by a CMC executive as a part of the IR study team, CMC developed a prototype PRS with a single train. CMC had an informal arrangement with IR at Secunderabad (CMC's R&D headquarters) where it could study the systems and procedures used for reservations and obtain feedback on its prototype. CMC had earlier developed good relations with IR while working on a UNDP funded project called Project INTERACT aimed at developing software for freight transportation. CMC proactively involved the Railway Board and the Department of Electronics in demonstrating a more complex prototype with user friendly and interactive screens. The prototype gave CMC an opportunity to provide sufficient knowledge and new concepts in application development to the Railway Board who had to develop the technical specifications for the system.

Implementation Strategy

After CMC's selection for software development, IR and CMC worked together for more than fifteen months during 1984-85 to finalize the specifications of the system. The IR team consisted of fifteen personnel from all levels of management including reservation staff, terminal operators, and supervisory staff. CMC had a carefully chosen team of fifteen system analysts and programmers.

The proposed system would be "universal" in that all trains, classes, quota types, and fare categories would be handled by a single database. It was also to be "integrated" in the sense that enquiry, reservation, fare calculation (and cash transaction), and ticketing would all be done in the same counter. To suit customer requirements, the ticket printer would be designed to print in both English and Hindi. The transaction information would be used for chart printing and accounting purposes. The system was to be implemented using imported hardware, since suitable indigenous hardware was not available.

All clearances for the import were obtained well in time through the Department of Electronics. Extensive field testing followed by parallel runs were carried out in New Delhi in early 1985. After further debugging and incorporating suggestions from users, a few popular trains were chosen for computerization. This phase was viewed as the "pilot" project and was implemented by November 1985. The entire New Delhi database was computerized by May 1987 [Moorthy, 1993].

By 1988, IR had decided to have three more computer systems in the metropolitan cities of Bombay, Calcutta, and Madras. Even though two or more separate passenger reservation systems based on organizational boundaries or class or travel used to exist in many cities in the manual system, in the computerized system there was only a single node for the city with only one database. For example, in the manual system in Bombay, there were separate reservation systems for Central and Western Railways and for first class and second class travel; in the computerized system, Bombay has been treated as a single node having only one database.

For other major stations, IR deliberated between providing stand-alone computer systems versus remote terminals connected to the existing computer systems. Provision of remote terminals would involve close coordination with the Department of Telecommunications for using communication channels. IR's own channels were inadequate for the planned load. In 1989, IR decided to have only one more stand alone computer system at Secunderabad. All other stations were to be connected as remote terminals to these five computer systems with the reservation database residing in the corresponding host computers. All the computerized stations would have access to the entire database of the host computer.

The systems at New Delhi, Bombay, Calcutta, and Madras used imported VAX systems. Hardware upgradations had been made to these systems to suit the growing requirements. Since import of hardware was a matter of concern to government and there was a desire to experiment with indigenously manufactured hardware, an indigenous computer system was chosen for Secunderabad.

The actual number of cities served had increased to 22, covering 66 per cent of the reservation requirements by mid 1990 and to 34 covering 74% by January 1993. As of 1992, 44 stations had been sanctioned for computerization accounting for 80 per cent of the reservation volume. According to the Eighth Five Year Plan (1992-1997), all other locations with a reservation quota of more than

1500 were to be computerized through remote terminals. This would bring the computerization to 60 stations, covering 85 per cent of the total reservation volume [Sharma, 1992].

While deciding the host computer to which the stations would be connected, IR went more by technical and service considerations than organizational considerations. For example, Jaipur (Western Railway) was connected to New Delhi (Northern Railway), rather than Bombay (Western/Central Railway) since it was closer to New Delhi and there was greater traffic between Jaipur and New Delhi than between Jaipur and Bombay. Consequently, customers at Jaipur and New Delhi would have greater benefit by having access to these two databases. Similarly, Bhopal (Central Railway) was connected to New Delhi rather than to Bombay.

To further improve the service levels by providing better access to customers, remote terminals from the host computers were provided at satellite locations in the metropolitan cities. Satellite locations were also provided at major stations (whose reservation databases were on other host computers) to enable customers have access to a larger number of reservation databases. This access was provided through a terminal which was separate from the terminals at that station connected to its host computer. The next stage in increasing the access was to connect important stations which did not have computerized database through the existing teleprinter network to the host computers at Bombay, Delhi and Madras. As of January 1993, 48 stations had access to this network. Customers at such locations could seek a reservation in the train databases residing in these computers. However, the access was not online and confirmation for the reservation was provided after a day.

For example, PRS at New Delhi has twin VAX 8600 and one VAX 6240 which enables the system to handle up to 400 terminals. Currently about 300 terminals are hooked to the system. Of these, about 100 are in the main reservation center, another 100 are spread out over ten other satellite locations in the city, and the remaining 100 are distributed between nine centers having reservation quota and four other centers having reservation quota on other host computers (Ahmedabad, Bombay, Calcutta, and Madras). Apart from this, 48 stations are connected by the teleprinter network. The host computer has a database of about 300 trains. The 300 terminals enable 210 counters to be operated with an average counter transaction volume of 70,000 per day. Since one person in the queue accounts for an average of 1.8 transactions, about 185 persons are serviced through one counter in a day (11.5 working hours). Figure 1 gives a schematic representation of the Delhi PRS and examples of various types of remote connections.

The entire computerized PRS thus functions as five stand-alone systems. The stand-alone architecture does not allow reservation at a terminal from databases in two different host computers. The provision of remote terminals at major stations from more than one host computer partially takes care of this, though the customer has to stand in two or more queues. IR now plans to interlink the five host computers using networking software and distributed transaction processing. This will provide access to databases in all the five host computers at any terminal in the country. The system can then be visualized as covering 85 per cent of the reservation quota on IR, with the database distributed over five computer locations, providing reservation access all over the country.

One of the problems of the proposed configuration would be the ability of the indigenous system at Secunderabad to interlink with the existing VAX systems at the other four centers. To facilitate networking, IR has decided to procure VAX based systems which are now indigenously available for Secunderabad. Apart from networking, this system would also take care of the additional stations to be handled by the Secunderabad host computer. The existing indigenous system would continue to be used and be linked to the new VAX system through appropriate hardware and software [Jain and Raghuram, 1992 (b)].

Over the years, the software written by CMC in 1985 had been revised in 1987 and 1990 to correct shortcomings and suit the evolving architecture. The current version was written to facilitate the handling of transactions at remote locations. In 1986, the Railway Board set up an autonomous society called the Center for Railway Information Systems (CRIS), with the objective of planning and implementing the OIS and other computer applications for IR. CRIS helped in modifying and managing the software for the Secunderabad system, since the PRS software had to be modified to be implemented on the indigenous machine. Over a period of time, CRIS acquired the necessary professional skills, and has now undertaken the development of the future version of the software which will take into account networked architecture. CMC, however, continues to provide maintenance support for the software and hardware at the four VAX locations and all their remote centres.

The detailed implementation strategy at a reservation center involved computerizing trains in a phased manner. The first few trains to be computerized were the less popular ones. This enabled removal of bugs with least discomfort to customers. Once the system had stabilized, the remaining trains were computerized in order of their popularity.

To ensure system reliability, redundancy has been built at all levels: computing power, electricity supply, and communication lines. Operationally, the reservation status for the next three days is printed out at the end of the day to enable a transfer to the manual system in the event of breakdown.

In terms of staffing, two issues were important. One was the training of the reservation office staff to operate the computerized system and the other was redeployment of surplus staff. CMC and later on CRIS were engaged to provide the training. The strategy adopted was to first train a nucleus staff who later on trained their colleagues. This increased staff involvement in the implementation. Even though the workload decreased in terms of the post-shift accounting effort, the number of counters was not reduced. Instead, the counter and back-office staff were given the benefit of working six hour shifts rather than eight hour shifts. The surplus staff was essentially in the category of typists who prepared reservation charts and who were no longer required since printers could take over the task. They were redeployed as additional ticket checking staff.

Efforts were taken to design the counter ergonomically for both customer and staff. While air-conditioning was necessary for the computers and terminals, it was decided to extend it to the reservation hall also. Though all terminals were universal, a separate queue was maintained for each terminal. Customers could choose any one of the queues. Some terminals were assigned for specific tasks/customer segments. For example, a few terminals were assigned for enquiry to reduce the enquiry time at the reservation counter. In some stations, large display screens were subsequently interfaced with the computer system to allow the customer to view the current reservation availability. At certain reservation centers, a separate counter was provided for women. The New Delhi reservation center experimented for a while with separate counters for second class and upper class reservations. In general, IR has used the "universality" of counters to the extent possible to balance the load at the counters. Easy and precise availability of the reservation status resulted in IR providing information to newspapers, bulletin boards at reservation centers, and online telephone enquiry service for wait listed passengers. More information such as train departure times at train starting and journey commencing station are available on the ticket, than in the manual system.

In terms of the organization for managing PRS, the OIS Directorate looked after policy issues while CMC and later on CRIS were the implementing agencies. Each host computer center was assigned to a specific railway and managed as a facility under a Chief Commercial Manager of that railway. The reservation centers continued to be under the respective railways even if they were hooked to a host computer in a different railway. This enabled the reservation staff to continue their affiliation with their own railway and provided for better management control of the infrastructure in the center.

Coordination problems were sorted out by periodic meetings of the Chief Commercial Managers and representatives of CMC and CRIS.

Successes and Failures

While analysing the successes and failures of PRS, it must be borne in mind that the application was primarily motivated by service considerations, rather than economic. From this perspective, PRS may be viewed as a "very successful" application. We examine the successes and failures from process and outcome perspectives, based on its impact on customers, employees, and management at IR.

Customer

For the customer, the most obvious advantage has been in the reduction of mean time for making a reservation. Based on a study of the Delhi PRS (Symatec Associates,1990), mean waiting time has declined from 70 minutes to 24 minutes. This has been quantified as an average annual saving of Rs. 100 million to the economy. In major metropolitan cities, satellite locations have reduced the average travel distance for reservation. In New Delhi, distance has been reduced from 7.3 km to 5.9 km.

The customer is now able to make reservation in a better atmosphere (air-conditioned and less congested) and has better access to information (reservation enquiry, visual display, daily print-outs, newspaper, and telephonic enquiry to wait listed passengers).

Access to more than one reservation database allows customers to make return and onward reservations in the same reservation centers (though sometimes in different queues). This has tremendous value for the planning of an entire itinerary.

Corruption in the manual system owing to access to seats/berths obtained from cancellations has been eliminated since the computer enforces an automatic sequential order.

In comparison with the Indian Airline reservation system which was implemented earlier, PRS was far more successful, primarily because of its integrated nature of service (reservation, ticketing and cash transactions at the same counter). PRS became a model for computerization of reservation in bus transportation.

Subsequently, Indian Airlines has improved its system and provides terminals to travel agents, thus increasing access to customers. Though technologically possible, IR has not extended the reservation facility to travel agents.

Communication failures have often resulted in holdup of reservation, causing inconvenience to customers. Having separate queues for each counter often results in higher variance in time spent in the queue.

Employees

IR ensured that the employees did not view PRS as an employment threat by following an openly stated policy of training the existing reservation staff to operate PRS and redeploying the surplus staff.

PRS has removed the drudgery of manual tasks (ticket issue, handling of multiple registers, etc.) for the reservation clerk. The complexity of fare calculation in the manual system often resulted in errors by the reservation personnel which has been largely eliminated now. Post-shift reconciliation of accounts has become smoother and faster. Consequently, the working hours have been reduced from eight to six, without reducing the salary of the operating staff.

The design of the work space and air-conditioning have improved the work environment for the employees.

Management at IR

Implementation of PRS gave management the visibility it was seeking and public's perception about IR's management capability improved. The public also viewed this application as a manifestation of management's concern for them.

This application gave a boost to computerization efforts within IR. It gave management confidence and improved the professional capability of the executives for implementing future computerization projects.

Unlike other public systems where large scale computerization has not taken off because of employee resistance, IR has been successful in taking along the employees. This removed any apprehensions about employee resistance for future computerization.

Even though no cost-benefit analysis of this application had been done, post implementation studies suggest that IR would have needed 33 per cent more staff to handle the additional volume of work at 1985 service levels. To achieve 1989 service levels, additional staff requirements would have been 75 per cent. Even then, some of the services like return and onward reservations would not have been possible [Symatec Associates, 1990]. However, costs due to airconditioning and maintenance of hardware and software are significant additions.

PRS is a rich source of information for planning and optimization of train services. However, IR has not yet exploited this. In fact, since the system design itself had failed to consider this, no provision has been made for generation of suitable reports.

The decision to have indigenous hardware has created problems for networking of the Secunderabad PRS with the rest of the system. In order to justify the earlier investment in this system, attempts are being made to "patch up" incompatible systems, with possible implications on reliability and service level.

Even with the success of PRS, IR has not yet been able to get the freight OIS project to a take-off stage. This is all the more ironic, since originally PRS was justified only as an add-on to OIS.

Lessons

Project Formulation

Since applications such as PRS are usually large, involve heavy financial outlays, complex, and one of a kind, they need to be marketed to decision makers at the highest level for their support. This is best done by viewing the project as consisting of many phases, each being logically complete, with lower financial outlay and capable of delivering visible results in a relatively short timeframe. This may have to be done even at the cost of certain economies which could accrue if the application was viewed as a single large project (Jain and Raghuram, 1992 (a)). For example, PRS could have been formulated as a single large networked application (towards which it is currently evolving - like the reservation system of Indian Airlines) costing nearly Rs 1000 million. In such a case, it would almost surely not have taken off. Instead, the application initially formulated as a PRS for New Delhi was implemented at a cost of less than Rs 100 million.

Political Support

An important aspect of project implementation is the political support that can be generated. Support could be a function of the people in power, the timing of major political events, and the political mileage that can be extracted from the application. For example, even though PRS was conceived in 1979 and only as an add-on to OIS, general elections in 1984 gave the impetus for PRS to be implemented independent of OIS. Politically, it was perceived to be a visible symbol of modernization.

Organizational Support

The size and complexity of the application implies that the application would require continuous organizational support. In the case of PRS, the Directorate of OIS provided a channel for managerial focus. Subsequently, setting up of CRIS enabled further expansion of PRS. Periodic meetings between the Chief Commercial Managers of all the user railways, CMC, and CRIS helped in smooth implementation.

For successful implementation, it is imperative to win support within the organization, especially from employees. In many developing countries, introduction of IT on a large scale raises fears, perceived or real, about threats to employment. In the case of PRS, an openly stated policy, appropriate training, and redeployment removed any such fears and ensured employee support.

Project Management

It is necessary to have formal systems for the successful management of large IT projects. Systems are needed to facilitate requirement analysis, user involvement, quality assurance, software engineering, training, testing, and post-implementation review. In implementing PRS, IR ensured that a core team of its executives and CMC interacted continuously on the above aspects. Continuity of the project team also ensured that the participating team acquired stakes in successful implementation. Another mechanism used for this was to carve out the project team for a subsequent phase from the existing working team.

Successful implementation of large IT projects requires examination and suitable redesign of existing structures and systems. User involvement and clarity of goals are imperative for this process. In the case of PRS, clarity of goals enabled traditional organizational boundaries to be transcended. For example, while two separate reservation systems used to exist in Bombay (Central Railway and Western Railway), they were treated as a single node for PRS.

An example of user involvement resulting in a change of system to the benefit of the customer is the wait list enquiry and information system which was non-existent before computerization.

Management of Technology

IT projects generally require induction of new technology in the organization. Many developing countries do not have the capability for indigenous production of such technology. IT applications could be used as opportunities for development of indigenous capability [Jain and Raghuram, 1992 (a)]. However, chances of success of the application are greater if indigenous capability is attempted to be developed in areas where some inherent strengths can be exploited. For example, developing countries with sufficient trained manpower, but poor infrastructure could develop software capabilities. Further, if indigenous technology development is attempted in a phased manner, then greater efforts have to be put in integrating the indigenous component with the imported component for a successful application.

In PRS, IR decided to develop the software indigenously. This proved to be a success. When in the hardware component, indigenous technology was to be encouraged by introducing it in one of the PRS centres, the integration with the rest of the systems proved to be a bottleneck.

Coordination Between Various Agencies

In the context of developing countries, large IT projects, especially those in the public sector, involve coordination between a number of different organizations. This needs to be handled preactively. In the case of PRS, active coordination between CMC, Railway Board, CRIS, Department of Electronics, and Department of Telecommunications ensured timely completion of the project and the desired results.

In conclusion, the PRS, being a 'succesful' implementation of an IT project in a developing country, offers many lessons for implementation of similar impact making projects. This project also emphasises the point that a primary service objective which public systems are often forced to take, but are used as an excuse for inefficiency, can be converted as an opportunity for 'development'.

REFERENCES

1. CRIS Documents 1987, (New Delhi: Centre for Railway Information System)

2. Gupta, N.C., "System Analysis and Design Consideration for Large Integrated Computer Networks in Developing Countries," Information Processing, 1983, pp 833-38.

3. Indian Railways Annual Report and Accounts 1990-91, (New Delhi: Railway Board), 1992(a).

4. Indian Railways, Budget Documents 1990-91, (New Delhi: Railway Board), 1992(b).

5. Indian Railways Year Book 1990-91, (New Delhi: Railway Board), 1992(c).

6. Jain, R. and Raghuram, G. "Implementation of the Operations Information: The Case of Indian Railways" in Bhatnagar, SC and Odedra, M (eds), Social Implications of Computers in Developing Countries, New Delhi: Tata McGraw Hill, 1992 (a), pp 218-32.

7. Jain, R. and Raghuram, G., Passenger Reservation System at Secunderabad, Case Study No. 4(CISG), (Ahmedabad: Indian Institute of Management, 1992(b)).

8. Madon, S., "Computer Based Information System for Development Planning: A Case Study." in Bhatnagar and Odedra, op.cit. pp 209-17.

9. Moorthy, R. "Marketing in Spearhead Strategic Development Organizations," Unpublished FPM Thesis (Ahmedabad: Indian Institute of Management, 1992).

10. Saklani, R.D. "Implementing Large Software Project," Unpublished Communication, 1991.

11. Sharma, R.C., "Passenger Reservation System: Today and Tomorrow," CRIS Journal, November 1992, pp 67-72.

12. Symatec Associates, Socio-Economic Impact Analysis of Computerized Passenger Reservation System at New Delhi (New Delhi:Symatec Associates, 1990).

Table 1: Profile of Passenger Traffic Segments

	Suburban	Non-suburban			Other (Parcel, Luggage etc.)	Total
		Unreserved	Reserved	Total		
Average No. of Trains per day	3300	3000	1000*	4000	-	7300
No. of Passengers per day (million)	6.60	4.05	0.35	4.40	-	11
Percentage	58.6	38.1	3.3	41.4		100
Average Lead (kms)	26.4	91.0	800+		-	76.6
Annual Passenger Kms (billion)	59.6	133.9	102.2	236.1	-	295.7
Percentage	20.2	45.3	34.6	79.9		100
Annual Revenue (Rs. billion)	3.6	5.8	22.0	27.8	3.4	34.8
Percentage	10.3	16.7	63.2	79.9	9.8	100

* These trains usually carry unreserved accommodation too.
+ Assumed based on average train lead.

Source: Indian Railways Annual Report and Accounts, 1990-91.

Table 2: Citywise Profile of Reservation (1987)

Sr No	Station	Transaction Vol (Daily)	%age of total reservation	Cumulative %age	Sr No	Station	Transaction Vol (Daily	%age of total reservation	Cumulative %age
1.	DELHI	45000	13	13	20.	GORAKHPUR	2600	<1	66
2.	BOMBAY	40000	11	24	21.	NAGPUR	2500	<1	67
3.	CALCUTTA	35000	10	33	22.	VIJAYAWADA	2500	<1	67
4.	MADRAS	29900	8	42	23.	TIRUPATI	2400	<1	68
5.	HYDERABAD	13900	4	46	24.	GUWAHATI	2300	<1	69
6.	AHMEDABAD	11300	3	49	25.	INDORE	2200	<1	69
7.	BANGALORE	8500	2	51	26.	TRIVANDRUM	2100	<1	70
8.	LUCKNOW	7100	2	53	27.	DEHRADUN	1900	<1	70
9.	BHOPAL	5400	2	54	28.	MADURAI	1800	<1	71
10.	PUNE	5100	1	56	29.	RAJKOT	1800	<1	71
11.	VARANASI	4600	1	57	30.	BIKANER	1800	<1	72
12.	VADODARA	4400	1	58	31.	GWALIOR	1800	<1	72
13.	KANPUR	3800	1	59	32.	ERNAKULAM	1700	<1	73
14.	JODHPUR	3700	1	60	33.	JABALPUR	1600	<1	73
15.	JAIPUR	3700	1	62	34.	WALTAIR	1600	<1	74
16.	TIRUCHI	3600	1	63	35.	MANGALORE	1600	<1	74
17.	PATNA	3600	1	64	36.	LUDHIANA	1500	<1	75
18.	JAMMU TAWI	3200	1	64	37.	BILASPUR	1500	<1	75
19.	COIMBATORE	3100	1	65		Total (for 37 cities)			270100
	TOTAL DAILY TRANSACTIONS						360000		

Source: CRIS Documents (Internal), 1987.