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Delhi Metro Rail Corporation

I have not been to any management school. This is all simple common sense, down to earth tactics, nothing else.

— Dr. E. Sreedharan, Managing Director, Delhi Metro Rail Corporation

It was 9:25 a.m. on July 20, 2009. The red numbers blinking on the reverse digital clock showed that 1 year, 2 months and 11 days were left for the completion of Phase II of the Delhi Metro Project, the mass transit system planned for India's capital city, Delhi. While, under normal circumstances, a year would have been sufficient to finish constructing the remaining 76.65 kilometers of the 128.06 kilometers long metro tracks in time for the XIXth Commonwealth Games 2010,[1] the situation was far from normal, and Dr. Ellatuvalapil Sreedharan, the Managing Director (MD) of the Delhi Metro Rail Corporation (DMRC), was worried.

Six people had died with 15 more sustaining injuries when a portion of the bridge under construction on the Central Secretariat–Badarpur line collapsed at Zamrudpur, a locality in South Delhi, on Sunday, July 12, 2009.[2] (See **Exhibit 1** for a route map of Phase I and II of the Delhi Metro.) The situation had worsened, when during a clearance operation the next day, the launcher along with the cranes lifting it, had come crashing down. While no serious injuries resulted, the media had been covering the event live and the footage of the entire disaster was flashing across news channels nationwide. DMRC may have been able to explain away the accident as a one-off incident, had a similar crash not occurred eight months earlier, when a girder[3] launcher collapsed at Laxmi Nagar in East Delhi, killing two people and injuring several others.[4] (See **Exhibit 2a** for pictures of the accident site at Zamrudpur and **Exhibit 2b** for a picture of the accident site at Laxmi Nagar.) Dr. Sreedharan recalled his own remarks on the occasion, "October 19th is the blackest day in the eleven years of DMRC's existence. Though the technical responsibility rests with the contractor, DMRC bears the moral responsibility."[5]

DMRC was incorporated in May 1995 with the sole purpose of building a mass transit system for Delhi. The multi – billion dollar project kicked off in 1998, at which time it was the largest public infrastructure project ever to be undertaken by the Government of India (GoI). With a reputation of delivering on time and within cost, not only had several institutions like the Project Management Institute and the Indian Institute of Bridge Engineers lauded DMRC for its excellence in infrastructure project management;[6] it had also earned significant support from the residents of Delhi during the construction of the first phase of the metro network (see **Exhibit 3**). The events that had

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Professor V.G. Narayanan and Research Associate Saloni Chaturvedi prepared this case. HBS cases are developed solely as the basis for class discussion. Cases are not intended to serve as endorsements, sources of primary data, or illustrations of effective or ineffective management.

unfolded over the last week threatened to undo all the good that DMRC had achieved in the last decade.

Public criticism had mounted over the accident at Zamrudpur, with the media lashing out at DMRC for its negligence caused by haste to meet deadlines. There was also increasing bureaucratic pressure from within the Government to cancel the contract with Gammon, the company engaged in the construction at Zamrudpur and to fire the DMRC engineers managing and supervising the site. Firing Gammon was not an option Dr. Sreedharan wanted to consider. Not only would DMRC lose precious time in trying to re–appoint a contractor, but with all of the experienced contractors tied up in other projects for the up-coming Commonwealth Games, he felt it would also be impossible to find a suitable replacement in time for construction to be completed before the Games. It was crucial to finish on time as the Central Secretariat–Badarpur corridor linked the Jawaharlal Nehru Stadium, the primary venue for the Commonwealth Games, with both Central and South Delhi. Moreover, employee morale was already low as the workforce felt let down by the manner in which the media and public had reacted to the accident, completely ignoring their efforts over the last decade. In this situation, firing the already suspended engineers would only serve to demotivate the workforce further and would not necessarily deflect the negative media attention.

A four-member committee, comprising of Prof. A.K. Nagpal from the Indian Institute of Technology, Delhi, Prof. B.R. Bose from the Delhi College of Engineering, Steven Lowry, Project Director, General Consultants, DMRC and Rajan Kataria, Chief Engineer (Design), DMRC,[7] had been set up on the day of the accident to inquire into the probable causes of the accident.

As he waited for the Committee's final report, Dr. Sreedharan faced a difficult choice. Should he bow to bureaucratic pressure and fire Gammon in order to undo the damage to DMRC's reputation? Would DMRC be able to find a competent replacement in time to open the remaining metro lines for the Commonwealth Games? Was it worth risking the delay, given their record of delivering on time? Pinning responsibility on the four engineers seemed unfair. However, with the media baying for someone's blood, would he be able to save their jobs? In another five minutes, his team of directors and department heads would make an appearance for their weekly meeting, as they had every Monday over the last 12 years. Only today, he did not have a list of discussion points, but a full-blown crisis to manage.

Planning for a Mass Transit System for Delhi

As a norm, planning for a mass transit system for a city in most developed countries usually started when population exceeded one million.[8] With Delhi's population hovering near the 3.5 million mark in 1970, the need for a mass transportation system for Delhi had become critical. The Central Road Research Institute (CRRI), in its study on traffic and travel characteristics of Delhi in 1969–1970 recommended for the first time, the idea for a mass transit system. Based on CRRI's proposal, different government bodies considered several different models for a transit system over 1970 to 1990. The Government of the National Capital Territory of Delhi[9] (GNCTD) commissioned a feasibility study in 1989, which too went through several revisions during 1990 to 1995. (See **Exhibit 4** for a brief timeline.)

In the meantime, Delhi's population had grown from 9.5 million in 1991 to 11.17 million in 1995.[10] Correspondingly, motor vehicle population had grown from 1.8 million in 1990-1991 to 2.4 million in 1994-1995.[11] More people and more vehicles meant increased pressure on existing roadways. However, despite growth in the total number of vehicles, the relative share of taxis and three–wheelers, both important means of public transport in Delhi, had declined. Although the relative

share of buses, the primary means of mass transport, had remained relatively constant over 1990-91 to 1994-95, the number of buses operated by the Delhi Transport Corporation had actually decreased from 4,392 to 3,480 during the same period.[12] With a population projection of 20 million by 2015, Delhi's existing public transport was severely ill equipped to handle the needs of its growing population. With wide roads and a substantial portion of government owned land that could be easily acquired, Delhi was also ideally suited to the construction of a metro system. Projections estimated that the Metro would be able to take 2.2 million commuter trips per day off the roads, reducing the bus requirement by almost 2,600, thus freeing up space for city traffic to flow faster.

The Cabinet of Ministers finally cleared the proposal and DMRC was incorporated on May 3, 1995 to turn the vision of a mass transit system for Delhi into an operational reality.

Delhi Metro Rail Corporation: Inception

DMRC was incorporated with equal equity participation from the GoI and the GNCTD. Such a structure was uncommon as most public sector organizations in India had either a State government or the Central government as the majority shareholder. The structure also dictated that of the sixteen directors, GoI would nominate five and GNCTD another five.

At the time of incorporation, it was estimated that construction of Phase I of the metro network would cost almost 105.7 billion Indian Rupees (₹) ($2.91 billion).[13] DMRC obtained more than 60% of the required funds in the form of a loan from the Japan Bank of International Cooperation[14] (JBIC) in March 1997. However, construction for the first phase had not begun even several months after DMRC and JBIC had signed the loan agreement, as the search committee was unable to locate a suitable candidate to head the project and DMRC. The GNCTD was under immense pressure to get the project rolling and the problem came to head, when JBIC issued an ultimatum to the GoI, that if it did not appoint a chief for the project by October 1997, they would withdraw the loan.

Dr. Sreedharan was part of the search committee and the committee members requested him to travel to Delhi for a meeting to address the situation. Much to Dr. Sreedharan's surprise, the meeting turned out to be with an interview board consisting of the Chief Minister of Delhi, the Transport Minister for Delhi, the Chief Secretary of Delhi and the Lieutenant Governor of Delhi, all of who requested him to head DMRC as MD. This was unexpected for several reasons, first, because Dr. Sreedharan was heading the Konkan Railway Project at that time, a project that was in its last phase and one that he could hardly abandon, and secondly, because Dr. Sreedharan was soon going to turn 65, the official retirement age for government officials.

Mr. TejinderKhanna, the Lieutenant Governor of Delhi assured Dr. Sreedharan that these hurdles would be taken care of; all they needed was his commitment to come on board the project. Dr. Sreedharan initially refused the position. However, after much insistence from the members of the search committee, he finally agreed to head DMRC, provided a few conditions were fulfilled. Having worked in the civil services, Dr. Sreedharan knew how bureaucratic red tape could completely de-rail a project. Therefore, he made three demands. One, that he would be allowed to build his own organization without interference; two, that there would be no bureaucratic or political interference in the functioning of DMRC, and three, that he would be given complete powers to make all decisions. With the exception of certain powers that Indian company law prevents from being delegable, all powers of the Board of Directors of DMRC were vested in Dr. Sreedharan when he took over as MD of DMRC in November 1997.

At the time of his appointment, DMRC did not have any offices that it could operate out of. Starting from a small room in the Railway Bhavan, the headquarters of the Ministry of Railways, Dr. Sreedharan began to build the team that would steer the first phase of the project. Being a railway man, Dr. Sreedharan brought men that he could trust on deputation from the Indian Railways to DMRC. Of the six full time directors on DMRC's 16-member board, four had spent their initial years at the Ministry of Railways. By 2009, DMRC was an approximately 5,000 employee strong organization, housed in an impressive eight story building of its own, the Metro Bhavan.

Growing Pains

If this project was being built in the jungles, certain aspects could have probably been ignored. The reality, though, is that this project has been built in the capital city of Delhi with a population of 16 million.

— Anuj Dayal, Chief Public Relations Officer, DMRC

The initial years of DMRC's existence were fraught with challenges. At the time of its incorporation, the only example that India had of a metro was the 25.14 kilometers long Kolkata Metro.[15] However, the first phase of the Kolkata Metro had taken 23 years to construct with costs escalating to almost 14 times the initial estimate. Not only did the construction cause immense inconvenience to the residents of Kolkata, when it was finally ready, the technology was already outdated and almost 25 years behind that used by metro systems around the world. (See **Exhibit 5** for a comparison of metro systems from around the world.) Without any examples to follow, DMRC had to start at the bottom of the learning curve, overcoming several hurdles in order to build its reputation of excellence.

Appointing General Consultants

Once Dr. Sreedharan had put DMRC's basic organizational structure in place, DMRC needed to build its own technical capabilities in order to ensure that the metro network was in keeping with international standards. In order to achieve this, DMRC invited tenders for appointment as General Consultants. Though the bidding started out with the submission of six tenders, soon the bidders had formed into three consortia for which DMRC evaluated technical and financial bids. It then entered into negotiations with the consortium that had the highest ranked bid (comprising Pacific Consultants International (PCI), Parsons Brinkerhoff International, Japan Railway Technical Service, Tonichi Engineering Consultants and Rail India Technical and Economical Services). Although the cost of the contract was estimated at close to ₹4 billion ($96.9 million), the final contract was awarded at ₹2 billion ($48.5 million) as the person-month requirement was brought down from 14,000 to 8,000 during negotiations and a provisional letter of acceptance was issued in June 1998.[16] PCI were also the in-house consultants for JBIC and this led to speculation in the media about whether the appointment had been completely fair and transparent. So intense was the scrutiny that the government took up the matter for an in–depth examination. Dr. Sreedharan stood by the decision and shared every detail when called upon to clarify the process of bidding and appointment, on several occasions. The government finally cleared the selection process and a newspaper that had printed incorrect information on the bidding process, issued a public apology.

Battle of the Gauges[17]

Several technical decisions needed to be taken before construction on the metro lines could begin. The most crucial was whether DMRC should use broad gauge or standard gauge[18] for the Metro. In 1999, 85% of metro networks across the world used standard gauge. Not only was the standard

gauge the choice for metro systems in most developed nations, it also provided better speed, maneuverability and safety, while allowing for sharper and therefore space saving turns on the tracks. However, the Ministry of Railways was in favor of adopting the broad gauge, which it felt would facilitate inter-connectivity of rolling stock[19] between the rail and metro networks and was in keeping with the 'unigauge' policy for India. DMRC was not convinced that inter – running of trains between the metro and railway tracks was feasible. After 18 months of discussions and debate, the situation reached a point where Dr. Sreedharan could either continue to lock horns with the Ministry of Railways and risk further delay, or concede to the Ministry's demand. Dr. Sreedharan chose the latter course of action and on the night of August 4, 2000, the Cabinet of Ministers declared the final decision to use broad gauge. Over time, Dr. Sreedharan was able to persuade the Ministry to reverse its stand and use standard gauge for the upcoming metro lines. Almost 61.4 kilometers of Phase II tracks used standard gauge. Unfortunately, due to the use of different gauges, interchangeability of stock within the two phases of the Metro continued to remain a problem.

Legal Cover

Once officers were ready to start operating the Metro on a day–to–day basis, they found to their surprise that a legal cover for the project did not exist. This left the entire project exposed to all types of litigation[20] – something that could slow progress on the remaining lines considerably. Since the Prime Minister of India was to inaugurate the Metro on a fixed date, an ordinance[a] was promulgated two months before the line was opened on December 24, 2002, and subsequently the Delhi Metro Operations and Maintenance Act was passed during the next session of the Parliament. The Act listed the powers of the metro administration (such as acquiring land and entering into contracts) and provided for, among various other things, the constitution of a Fare Fixation Committee,[21] and the appointment of a Commissioner of Metro Railway Safety.[22]

Tax Concessions

Though Dr. Sreedharan had requested for import and excise duty concessions for the equipment and rolling stock imported by DMRC, neither GoI nor GNCTD provided any tax exemption to it during the initial stages of the project. However, once the first train was ready to be launched ahead of time, and the GoI was convinced that DMRC would be able to deliver on time, it conceded to Dr. Sreedharan's demand, granting the project customs and excise duty concessions amounting to ₹14.07 billion ($289.5 million), in 2002.[23] Additionally the GNCTD waived sales tax and works contract tax to the extent of ₹3.93 billion ($80.9 million).[24] Both GoI and GNCTD provided several other tax concessions as the project progressed.

Land Acquisition and Realignment

A number of people that would be affected due to the proposed alignment of the metro routes protested against the planned routes, demanding realignment. Especially controversial was the metro line near Niti Bagh, an area where a large section of the legal fraternity had their offices. Unhappy with the fact that they would have to relocate to alternate office spaces, a group of lawyers called a meeting to discuss the issue. At the meeting, the Chief Minister of Delhi, Sheila Dikshit supported Dr. Sreedharan, stating that experts proficient at their job had planned the alignment, and while she would do everything in her power to help those inconvenienced, realignment was out of the question. Dr. Sreedharan subsequently dealt with a number of such alignment issues by personally

[a] An ordinance was an emergency law promulgated by the executive branch of government that the legislative branch needed to ratify within six months.

visiting sites, and exploring how DMRC could minimize disruption to the daily lives of people living in nearby areas, without altering the technical plans.

He used a similar approach while dealing with land acquisition issues. Under principles of eminent domain,[25] the Indian Government could easily acquire private land needed for development projects by suitably compensating the landowner. However, by making personal visits and engaging with landowners, Dr. Sreedharan ensured that DMRC acquired only private land crucial to the project. Dr. Sreedharan's personal attention helped curb any mutinous tendencies, thereby avoiding costly and time-consuming litigation in a number of cases. Mr. Agarwal, Managing Director, Transport Corporation of India (TCI), recalled an incident involving TCI's office premises near old Rohtak road. As part of the strip of land needed for constructing pillars on which the metro line connecting the Pratap Nagar Station could be built, DMRC sought to acquire all of TCI's land as three of the 11 planned pillars were adjacent to TCI's property. However, an appeal from TCI that acquisition of the entire parcel of land would affect their business as the office premises included warehouses, and the logistics business was dependent on the operational location, resulted in an intervention and a visit by Dr. Sreedharan. After several consultations, DMRC revised its land requirements to 37.5 feet on either side of the pillars, finally acquiring only 32% of TCI's land.

In a particular instance, the government needed to rehabilitate approximately 300 shopkeepers before DMRC could use the land. Instead of waiting for the relevant government departments to work out how and where they would resettle the shopkeepers, DMRC engaged in discussions with the affected persons and with their concurrence, bought land close by, on which they constructed shops. DMRC then sold these to the displaced traders at a nominal price.

Tunneling Issues

Approximately 13 kilometers of the 65 kilometers of Phase I was built entirely underground. At Chawri Bazar,[26] the entire station was built inside an underground tunnel at a depth of 25 meters. (See **Exhibit 6** for a picture of Chawri Bazaar Tunnel during construction.) While digging around the Naya Sadak area in old Delhi for the line connecting Delhi Main to Chawri Bazaar, initially the construction contractors used the Tunnel Boring Method (TBM). However, the digging faced several delays, as the Tunnel Boring Machine could not cut through the rocks. After extending the contractor's deadline by several months and bringing in an extra machine, progress remained limited due to the hard and abrasive nature of the rocks in that area. Finally, with DMRC pushing for it, the contractors discarded TBM and switched to the New Austrian Tunneling Method,[27] in order to complete the tunneling within the allocated deadline. The construction team had to reconfigure the entire approach while dealing with several challenges like water seepage within the tunnel. Had DMRC waited to renegotiate the construction contracts, it may not have been able to operationalize the line within the allocated time of two years. Instead, DMRC used its existing goodwill to convince the contractors to proceed along the new approach, and completed the section by September 2004. This was accomplished without disturbing the over ground historical surface of the Chawri Bazaar area.

The Metro Man

Born and brought up in the Palakkad district of Kerala, Dr. Sreedharan was said to have been fond of building mud houses and bridges even as a child. After finishing his schooling, Dr. Sreedharan studied at the Victoria College at Palakkad and thereafter graduated from the Government Engineering College at Kakinada, Andhra Pradesh. He then taught civil engineering at the Government Polytechnic, Kozhikode, Kerala, for a brief period, before continuing on to a

yearlong apprenticeship with the Bombay Trust. It was soon after his internship ended that he joined the Indian Railways.[28] A job with the Railways had always been his first choice. "Those days, Railways was the first choice for any bright engineer and I was no different. It was challenging and prestigious," reminisced Dr. Sreedharan.[29]

In 1963, a tidal wave washed away a large portion of the Pamban Bridge linking Mandapam and Rameshwaram in Tamil Nadu. The State Government fixed a target of six months for restoring the bridge. The Railway Board brought this deadline forward to three months and put 31-year-old executive engineer, Sreedharan in–charge of the project. Under his supervision, the project team rebuilt the bridge in just 46 days. His reputation for meeting deadlines built up through his career at the Indian Railways and finally led to his appointment as head of the Konkan Railway Project in 1990. Attached to this appointment was the pre–condition that the Government could not remove him from the project until it was completed. The 760 kilometers long railway project was both a financial and an engineering challenge, with naysayers foretelling that it was impossible to build such a railway network over the rough Konkan terrain. Under his direction, the project was completed within the stipulated time of seven years.

Along with his reputation for meeting deadlines, Dr. Sreedharan was also known for his integrity and inflexibility on certain issues. For example, despite DMRC acting as adviser to the Andhra Pradesh Government, Dr. Sreedharan had openly criticized granting the Hyderabad Metro Rail Project to the Maytas Infra led private consortium. The consortium's bid stated that it would not charge the State Government for the franchise, but would pay it ₹303 billion ($6.98 billion) over 35 years.[30] This was in stark contrast to the government funded Bengaluru Metro as well as the government subsidized Mumbai Metro. Dr. Sreedharan alleged that such a financial model was possible only because the State Government had given 296 acres (approximately 1.2 square kilometers) of prime land free of cost to the consortium and that the consortium would probably exploit this for real estate development. He also suggested that the consortium's desire to connect their private land, and then profit from the real estate price escalation had possibly motivated the proposed extension of the metro route.[31] In response to his allegations, the Andhra Pradesh Government had threatened to file a suit of defamation against Dr. Sreedharan.

Despite constantly being in the public eye, Dr. Sreedharan was known for his simple living and spiritual leanings. His daily routine included reading portions of the *Bhagvad Gita*, a 700 verse long philosophical text from the Indian epic, *Mahabharata*, and meditating for two hours every day.

Unique Management Style

I think my biggest advantage, biggest achievement is to bring into this organization a very unique work culture and at every opportunity that I get, I try to instill this work culture in my employees.

— Dr. E. Sreedharan

It was estimated that the project would lose approximately ₹14.5 million ($0.3 million) for each day that it was delayed. This figure was drilled into the consciousness of every employee and contractor in order to minimize delays. The promise of 'within cost and on time, every time' was not just a slogan for the employees at DMRC, but a way of life. (See **Exhibit 7** on Large-scale projects around the world). Dr. Sreedharan personally spent half an hour with every individual who joined DMRC, briefing the individual on what the organization would expect of him or her and on what their attitude towards work should be. The four most important values on which DMRC operated were Punctuality, Integrity, Professional Competence, and Social Accountability. Dr. Sreedharan had tried to instill these values in each employee at DMRC through his own unique methods.

Punctuality

The trains at Delhi Metro had a record of 99.9% punctuality. This meant that only one in every 1000 train trips deviated from schedule. According to Dr. Sreedharan, "Punctuality is important as ultimately our job is to run trains and unless we are punctual, we can't expect our trains to be punctual."

There was a reverse clock in every office and on site, which recorded the number of days left for that particular section of the project to be completed. The clocks were all connected by satellite in order to ensure that everyone was functioning on exactly the same timeframe. The project team at DMRC followed a detailed process to ensure adherence to timelines. They would create an initial baseline diagram for themselves regarding the different contracts that they needed to finalize for each line, the proposed schedule, as well as the material and equipment to be procured. The team would analyze the layout for each corridor to anticipate possible hurdles (such as land that needed to be acquired as well as permissions and clearances that needed to be obtained). They then built key delivery dates into contracts and ensured that these were strictly adhered to. The team also built a margin into every deadline such that the internal deadline was much closer than the delivery date promised to the government. Dr. Sreedharan explained,

> This is how we are able to open every section two to three months ahead of our schedule all the time . . . After all, our philosophy is that time is money in a project. Most people, particularly in government projects, are not bothered by this as money always comes from the government. However, in our case, we are borrowing money from Japan and we have to pay back that money. The realization that we have the responsibility to service and pay back that loan keeps everybody on their toes.

An aspect of the organizational structure that played a key role in maintaining these timelines was the quick decision making process. DMRC, as compared to other government agencies, had been created as a much leaner organization with only a handful of people responsible for decision-making, and a single point of clearance. "Here the final clearances for all major decisions are at my level. Nothing goes beyond this room," stated Dr. Sreedharan.

Though the final say rested with Dr. Sreedharan, there was a liberal delegation of powers at every level. Consensus was equally valued at DMRC. All the heads of departments and directors met in the MD's office at 9:30 on Monday mornings. There was no fixed or pre–decided agenda for this meeting. The team would discuss the problems they were beset with and a decision would often be arrived at during the meeting itself, with documentation to support the decision collated as a next step. The meeting also served the dual purpose of bringing the various departments at DMRC up to speed regarding the work that their colleagues were involved in, and the issues that they were facing. A variation of this Monday morning ritual was held on the first Monday of every month, when all middle level executives were also invited to the meeting. The monthly meeting served as a platform to highlight the organization's priorities, targets, and plans. Similar weekly meetings were also held with contracting agencies to review problems, resolve design issues, and monitor progress through each stage of construction.

Integrity

In Dr. Sreedharan's words, "Integrity doesn't stop at honesty or lack of corruption. It goes much beyond that. It is the quality of having good moral values. Anything that you do, you should do it in an upright fashion, in a transparent fashion." DMRC's operations ran on contracting, which had immense scope for corruption. However, according to Dr. Sreedharan, despite the legacy of scams

and corruption that various governments had endured, DMRC had remained unscathed and retained its reputation for integrity.

Dr. Sreedharan had built a "zero tolerance for corruption" attitude into DMRC's work ethic. If someone was found deviating from the path of honesty, immediate action was taken and the person's association with DMRC terminated. This institution of honesty, of knowing that each and every person's integrity was above board, also helped in speeding up the decision making process. According to Dr. Sreedharan, he had complete confidence in his employees. He attributed his ability to take decisions on the most complicated matters within minutes, to this sense of trust.

Dr. Sreedharan interviewed each member of the top management personally. Not only were the candidate's record of accomplishments and history examined, only people that either Dr. Sreedharan had an association with, or those whose integrity erstwhile colleagues at Indian Railways had vouched for, were brought on board. In Dr. Sreedharan's opinion, "If a man doesn't know his job, you can train him or hire somebody else to help him, but if a man is not basically honest then it's very difficult to manage."

His personal integrity was also reflected in the events that followed the accident of July 12, 2009. Though Dr. Sreedharan was in Bengaluru at the time of the accident, he had returned to Delhi the very same day and feeling that as head of DMRC, he had to take complete moral responsibility for the mishap, had resigned from his position. However, he had withdrawn his resignation the next day, at the behest of Dikshit, Khanna, and the Urban Development Minister, S. Jaipal Reddy. While publicly addressing the issue, Minister Dikshit remarked, "We respect his sentiments. But we also know that the Delhi Metro and the country need him. Not only does he do good work for Delhi but also for the country."[32]

For his part, Dr. Sreedharan accepted that, "if I run away from my responsibilities, the project may not get completed . . . [so] I decided to come back and see that the project is completed before the Commonwealth Games."[33]

Professional Competence

Gyanameva Balam [Knowledge is Strength]

— Sanskrit Scripture displayed behind Dr. Sreedharan's desk.

Having an in depth knowledge of what the job entailed, and working to acquire the skills necessary to carry out one's responsibilities were two attributes that were extremely valued at DMRC. Cognizant of the fact that India did not have any expertise in putting together a mass transit system, DMRC had engaged the PCI led consortium as general consultants before it began work on Phase I. Further, during the early stages of the project, DMRC sent teams abroad to observe metro systems in countries like Singapore, Hong Kong, Egypt (Cairo), and Brazil (São Paulo) and to learn the best practices that would be suitable for the Delhi Metro. DMRC had also entered into a training agreement with Hong Kong's Mass Transit Railway Corporation. Sixty five officers, for a duration of anywhere between 45 days to three months, were sent to Hong Kong for training on every aspect of a mass transit system – driving, station management, ticket issuance, maintenance of signaling systems and rolling stock, among others. During Phase II of the project, staff built up their knowledge and reliance on external expertise slowly reduced. In order to encourage people to do their job well, the management at DMRC had given employees the freedom to adopt different means to increase their technical competence, whether through subscription to related literature or pursuing courses that would aid them in this endeavor.

DMRC had also set up a training school for their staff at Shastri Park.[34] The school's objective was "to harmonize and control training processes in order to enhance overall productivity, develop competence for various job profiles and to provide training keeping abreast with changes in technology and continuously improving training processes." The school trained not only DMRC staff but also staff from other metro projects. Training lasted from anywhere between two days for a refresher course for Station Controllers to 24 weeks for an induction course for Maintenance Supervisors of Signaling. The schools were equipped with train simulators that gave the driver a real – life like experience during the training.

Social Responsibility and Accountability

We knew that the money we were spending was the taxpayer's money. It was not the government's money. So we had the responsibility to see that the money was best spent to the advantage of the people.

— Dr. E. Sreedharan

In order to achieve its goal of being socially responsible, DMRC had taken several measures to ensure that on site work caused as little as possible disruption to the lives of Delhi's residents. Before work started on any site, it hired a traffic expert to study the roads surrounding the construction site and suggest minimally disruptive diversions. At times, DMRC had also resorted to acquiring land adjacent to the roads and widening them before commencing construction. The team would also discuss the issue of traffic congestion and diversion with the police and take into account their suggestions to reduce bottlenecks and slowdowns, as far as possible. During the initial stages of the project, contractors found that the police would interfere and disrupt work. Following which, the contractor would have to negotiate with, and in certain extreme cases even resort to bribing the police to re–start the work. To ease its interactions with the police, DMRC had engaged retired police officers that acted as a liaison between DMRC and the police department. DMRC's tactic of involving the police from the beginning meant that they could not interrupt the work at a later stage as DMRC officials had already briefed and brought them on board.

Further, before commencing construction in any area, a community interaction was organized. DMRC would invite residents, politicians from the area, and even the press to attend such sessions. The briefing served the purpose of informing locals of the work to be undertaken and of how this might affect their daily lives. People were encouraged to voice their opinions and suggestions to reduce potential disruptions and wherever there was merit in a suggestion, DMRC adopted it. Further, the Chief Engineer for the area was introduced to the community as a person they could contact in case of any problems. According to Dr. Sreedharan, during his 12-year long association with DMRC, they had never had to stop work on a site because of disruptive acts or protests. The community buy-in that these interactions ensured, even before construction work began, was largely responsible for this record. The other strategy that DMRC had adopted was of diverting utilities before the construction began, so that water lines, telephone lines, and power cables remained intact as work progressed. As the lines criss-crossed and catered to different parts of the city, the DMRC team conducted a careful examination of the layout before undertaking diversions. In areas where trains passing through tunnels would have caused vibrations in the nearby homes, DMRC ensured that the construction team used special vibration absorbing pads below the tracks to negate these effects.

Another technique that DMRC used to keep the community informed and on board was through regular press releases regarding its public initiatives. Though as a norm, DMRC did not give interviews, it kept the media updated and involved through the Chief Public Relations Officer (CPRO). In order to ensure that the media released only accurate information to the public, the first

thing that Dayal did on the morning of July 12, 2009 was call a press conference to provide a clear outline of facts surrounding the accident. Subsequently, he kept the press informed through the day and as the inquiry into the accident progressed.

In an effort to ensure that fares remained stable, the Delhi Maintenance and Operations Act provided for a Fare Fixation Committee, comprised of a representative of the GoI, a representative of the GNCTD and a retired or sitting judge of a High Court. The objective behind establishing this three member committee was to ensure that political interference in fixing fares was reduced as far as possible and that fares while maintaining affordability, were fixed based on actual cost considerations. Even based on market considerations, at ₹6 ($0.12) for the shortest trip and ₹22 ($0.45) for the longest trip, the fare structure for the Delhi Metro was one of the lowest in the world. [35] (See **Exhibit 5** for a comparison of fares across metro systems.)

As part of the culture and ethos of social responsibility, DMRC also undertook to re-develop the Central Park at Connaught Place, one of the largest business centers in Delhi, complete with fountains, spending an extra ₹60 million ($1.32 million) to beautify the area around the Rajiv Chowk metro station.[36] Not only did the park add an aesthetic dimension to the area, it also acted as a green lung in the middle of a bustling commercial district. In several other stations, DMRC constructed over–bridges to ensure that pedestrians could access the station from both sides of the road.

DMRC's positive image and reputation helped it to acquire land needed for the project and as a measure of generating further goodwill amongst the stakeholders, DMRC built various amenities such as schools, animal shelters and shopping areas, for the displaced.

DMRC's effort to be socially useful encompassed environmental responsibility as well. For every tree that they cut during the project, DMRC planted 10 additional trees. DMRC was awarded ISO 14001 Environment Management System Certification and was the first metro to be registered with the United Nations Framework Convention on Climate Change (UNFCC) under the Clean Development Mechanism, enabling it to claim carbon credits. For its use of the regenerative braking system,[37] DMRC earned 400,000 Certified Emission Reductions for a ten year period (December 2007 to December 2017) that translated into a gain of approximately ₹12 million ($0.3 million) per year.[38]

DMRC's commitment to serving the public ensured that it completed the work on Phase I of the project nearly two years and nine months ahead of schedule.

People Orientation at DMRC

DMRC had appointed most of its employees through a competitive examination held across India. It would invite interested candidates to take a written test and then interview the selected individuals. For positions like that of the train driver, candidates needed to clear a specially designed psychological test as well. DMRC had also taken certain individuals on deputation from different government departments. In certain cases, it had also appointed as consultants, experts that had retired from the government or from a public sector undertaking.

As a way of keeping the work force motivated, the management at DMRC initiated knowledge sessions for officers. Usually around 100–110 officers attended these sessions that were held on the last Friday of every month. Each session usually consisted of two presentations on either technical training or managerial and soft skills. The Human Resources (HR) team also introduced a quiz on different subjects, as part of the program, to keep the session interesting. The HR team had also initiated a similar program in the form of competency-building workshops for non–executive staff.

These workshops functioned as motivational training sessions and focused on topics such as happiness, spirituality, forgiveness, mind power, stress management, efficiency improvement, and team building.

An electronic grievance redressal system was available for employees to register their complaints through email. Replies to registered complaints were sent out within seven days. These measures ensured that despite having close to 5,000 employees, there were no significant labor disputes. The Delhi Metro did not even have a recognized union; it did however have two staff councils with 10 elected members each that represented the employees. Management usually consulted the staff councils on decisions regarding all HR policies.

Though DMRC followed pay scales prescribed by the Department of Public Enterprises, actual salaries amounted to approximately 10% more than salaries paid by the Indian Railways across comparable levels. Rewards, along with assured statutory benefits also contributed to employee satisfaction. In addition to these institutional modes of motivation, the open collegial environment where the staff could meet and interact with the senior management on a day–to–day basis worked to keep employee morale high.

Traces of the deeply spiritual philosophy that underlay Dr. Sreedharan's management practices were visible in the quotes from the *Bhagvad Gita* found printed in the monthly newsletters and bulletins.

Financial Engineering

In the words of Dr. Sreedharan, the Delhi Metro Project was a "financial success". DMRC had begun making an operational profit from the very first day that the trains began plying. It was one of the only five out of 130 metros in the world making operational profits in 2008. Its operating ratio[39] stood at 0.52 in 2008. This was a substantial reduction from an operating ratio of 0.64 in 2007.[40] Despite fares remaining constant, earnings per commuter also increased from ₹8.88 ($0.20) to ₹11.27 ($0.27) between 2005-2006 and 2007-2008.[41]

There were several reasons that contributed to the financial viability of the Delhi Metro Project. GoI and GNCTD had granted DMRC tax concessions, which amounted to almost 18% of the total cost of the project. Since most of the land acquired for the project was through the government, DMRC was able to negotiate concessional rates, which helped reduce capital costs by a substantial amount. In addition, DMRC had also undertaken property development at a number of stations like Rajiv Chowk and Huda City Centre, leasing out spaces to restaurants and retail outlets. This accounted for almost 20% of total revenues generated. DMRC had also begun consultancy services for metros planned for the cities of Hyderabad, Chennai, Bangalore, and Kolkata, etc. This too acted as an additional source of income (see **Exhibits 8a** and **8b** for DMRC's financial performance). Power, staff and materials each contributed to approximately a third of operational costs. DMRC had negotiated an agreement with the government, where power was supplied to it at a 'no profit, no loss basis.' Further, DMRC had been engaged in steadily increasing capabilities so that it operated through a leaner workforce. For example, while the global standard of employment for metros was 45 employees per route kilometer,[42] in 2007–2008, DMRC had reduced this to 39 employees per route kilometer.[43] All of these cost cutting and income generating measures enabled DMRC to begin repaying its loan to JBIC in 2007.

The Future

Despite the apparent success of the Delhi Metro, critics had condemned DMRC on several counts. They speculated that the financial model was flawed and real costs hidden since DMRC had obtained land from the government at substantially lower costs than market rates. Further, concessional funding from the JBIC skewed the assessment of Delhi Metro's financial success (JBIC provided 60% financing for Phase I at an annual interest rate of 1.3% – 2.3% and 49.19% financing for Phase II at 1.2% – 1.4 %).[44]

Critics were also skeptical about the 50:50 ownership pattern of the DMRC, a model they thought unsustainable and held together only because Dr. Sreedharan was at the helm of affairs. According to them, the moment Dr. Sreedharan retired, conflicting opinions between the GoI and the GNCTD would cause the structure to collapse.[45] However, Dr. Sreedharan believed that DMRC was more than capable of functioning successfully even after he retired. According to him, "people know that one day or the other I have to leave. I have not come to the stage of indispensability. I can be dispensed with…I have built up the organization in such a way that there are people to take over from me without any difficulty."[46]

Handling the Crisis

Despite the accolades earned, the history of trust in the organization, and the many milestones achieved, the accident of July 12, 2009 had left DMRC's image and employee morale, cruelly shaken. Every newspaper headline demanded an explanation. There were reports of a crack that residents had spotted on one of the pillars at Zamrudpur in April 2009. Though DMRC had engaged a structural consultancy firm, Tandon Consultants, to check the crack, and they had confirmed that it was merely a surface crack; speculations abounded regarding its role in the crash.

A few days after the accident, Dr. Sreedharan had asked Vijay Anand, Director (Projects), who was in-charge of overseeing designs, to go on leave. Vijay Anand suggested that he go back to the Railways (from where he was on deputation) instead, and Dr. Sreedharan had agreed to his proposal. The Chief Engineer (Designs), Rajan Kataria, and the Deputy Chief Engineers in charge of the site had been suspended.

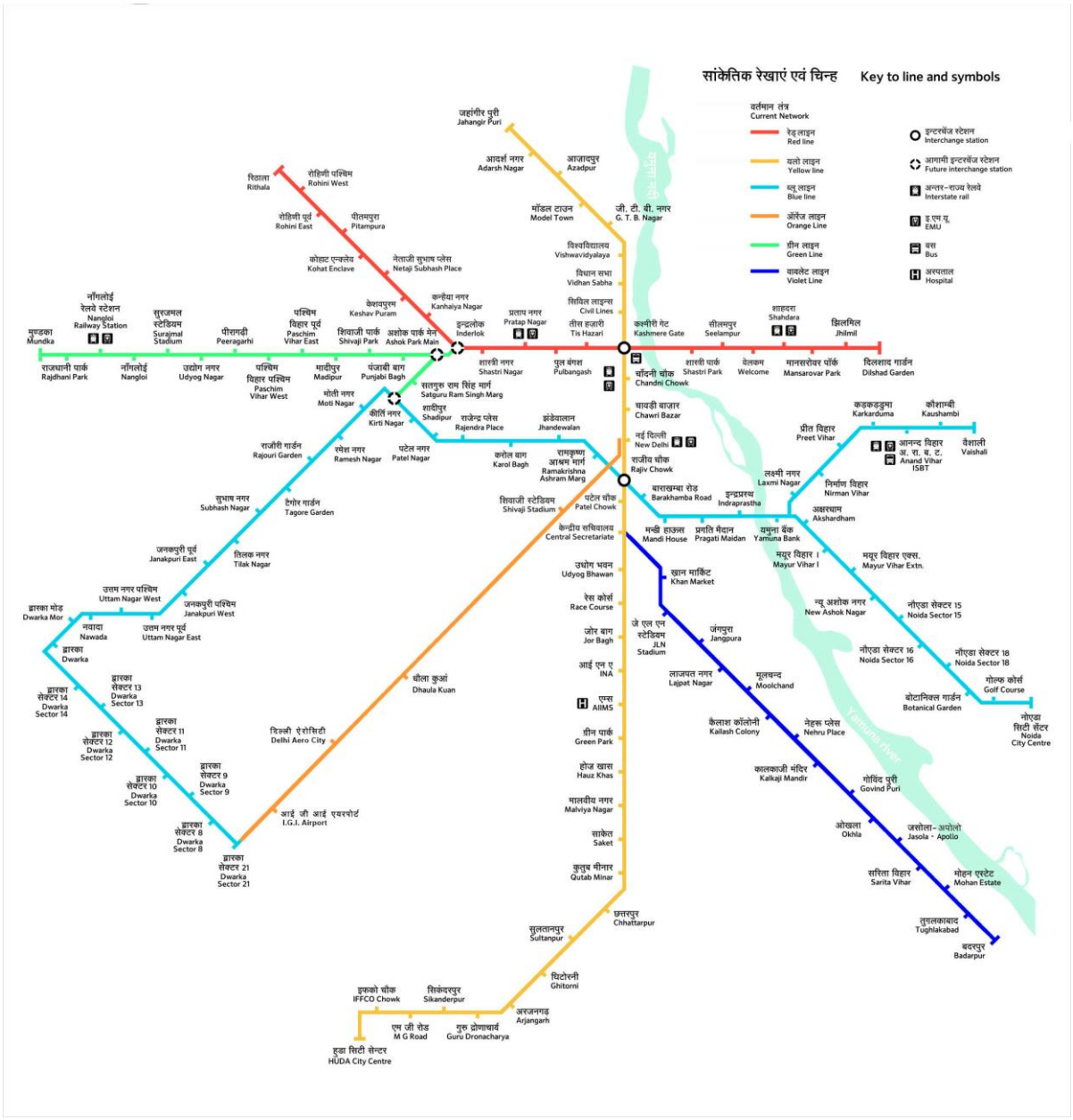
With the release of the Inquiry Committee's report, a somber mood had settled over the DMRC office. From their investigation, the Committee had found that deficiencies in both design and material had caused the girder to collapse. The report stated that the strength of concrete was not up to standard despite the cement being of the required quality. The Committee also found that the design of the cantilever[47] on top of pier-67, the pillar on which the girder was resting, was not sufficient to bear the load it was meant to carry. As per the report, the steel reinforcements inside the cantilever were not positioned correctly and certain load bearing points were missing the reinforcements completely.

As a matter of practice, the construction company was required to develop its own designs, which it then submitted to DMRC for verification. In this case, Arch Consultancy Services, Gammon's design consultants, had come up with the design of pier-67. The Committee also found that the design copies for the pillar were just 'advance copies' and had not been authenticated by DMRC's design section.

With political forces looking for someone to lay the blame on, would merely discovering the real reason for the accident be enough? Someone would have to be held responsible for the accident. The only question that remained was who would it be? Gammon? Arch Consultancy? Or the engineers?

Ultimately, though, DMRC was responsible for the project and it needed to recover, to bounce back in order to complete the construction of Phase II. Dr. Sreedharan needed to regain the public's trust, re-motivate his workforce and quickly get the project back on track in order to be ready before the Commonwealth Games.

Exhibit 1 Route Map of Phase I and Phase II the Delhi Metro



Source: Company Website.

Exhibit 2a Accident Site at Zamrudpur

Source: Company Documents.

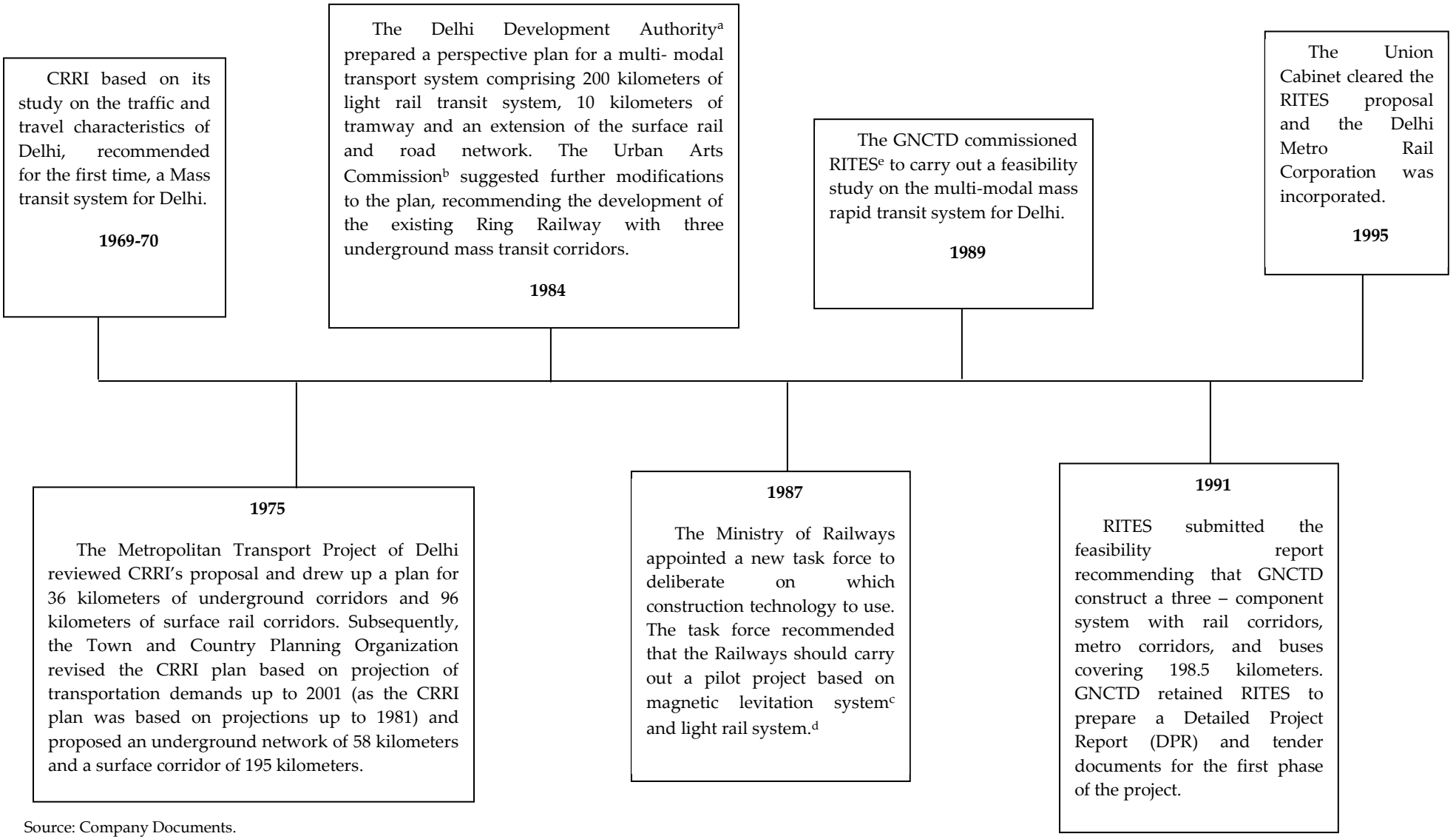
Exhibit 2b Accident Site at Laxmi Nagar

Source: Company Documents.

Exhibit 3 Delhi Metro

Source: Company Website.

Exhibit 4 Timeline: Planning for a Mass Transit System for Delhi



Source: Company Documents.

[a]The Indian Government through an Act of Parliament established the Delhi Development Authority in 1955 as the planning agency for Delhi, responsible for construction, development and maintenance of residential and commercial areas as well as public parks and heritage monuments, amongst others.

[b]The Indian Government through an Act of Parliament established the Delhi Urban Arts Commission in 1973, an advisory body, to provide advice and guidance with regard to issues concerning the preservation, development and maintenance of the aesthetic quality of urban and environmental design within Delhi.

[c]Magnetic levitation transportation systems used magnetic fields to suspend, guide and propel vehicles.

[d]Light rail urban transport systems used electric rail cars and were of lower capacity and speed as compared to traditional metro and heavy rail systems.

[e]Incorporated in 1974 as a Government of India Company, RITES Ltd. (earlier known as Rail Indian Technical and Economic Services) provided engineering, consultancy and project management services in the transport infrastructure sector.

Exhibit 5 Comparision of Metro Systems (As of November 2011)

Transport System	Opening	Mode of Transport	Ownership Structure	Total Length (kilometers)		Fare	Daily Passengers	Lines	No. Of Stations	Funding	Gauge Adopted	Status
				Under construction	Built							
Delhi Metro	2002	Rapid Transit, Feeder Buses	State Owned (Delhi Metro Rail Corporation: 50% owned by the GNCTD and 50% by GoI)	112.17 km (phase III); 108.50 km (phase IV)	189.63 km	Min: $0.16; Max: $0.6.	1.7 million	6	142	Partly funded by the GoI and GNCTD; remaining funds obtained as soft loans from JBIC	1435 mm and 1676 mm	Phase III under construction; Phase IV planned
Kolkata Metro	1984	Rapid Transit	State Owned (undertaken by the Indian Railways)	17.7 km extension of the North – South as well as 14.67 km of the East – West line under construction	25.135 km	Min: $0.08; Max: $0.16	0.5 million	1	23	State funded through the Indian Railways	1676 mm and 1435 mm	Extension of North – South line underway; East – West line under construction; 4 other lines planned
Hong Kong Mass Rapid Transit	1979	Rapid Transit, Light Rail, Regional Rail, Airport Link, Inter – city Rail, Feeder Bus	Initially State Owned (Mass Transit Railway Corporation (MRTC) with Government of Hong Kong as major shareholder); 23% shares sold through IPO in 2000. In 2007, the operations of MRTC and the Hong Kong Government owned Kowloon-Canton Railway Corporation	10 km extension of Island line as well as 2.6 km extension of Kwun Tong Line underway	218.2 km (Rapid Transit and Light Rail)	Min: $0.45 Max:$6.30	3.94 million (Rapid Transit); 0.56 million (others)	10 (Rapid Transit); 12 (Light Rail)	84 (Rapid Transit); 68 (Light Rail)	Initial capital from the Government; remaining funds raised in the open market	1432 mm and 1435 mm	Work on the 26 km Hong Kong section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link underway

Transport System	Opening	Mode of Transport	Ownership Structure	Total Length (kilometers)		Fare	Daily Passengers	Lines	No. Of Stations	Funding	Gauge Adopted	Status
				Under construction	Built							
			were merged									
Sãu Paulo Metro	1974	Rapid Transit	State Owned (Companhia Do Metropolitano De São Paulo, a division of the São Paulo State Secretariat for Metropolitan Transport) Line 4 is now operated by ViaQuatro, a private company under the supervision of the Companhia	23.8 km extension of Green line (2A) and 11.7 km extension of lilac line (5) underway	74. 3 km	$1.65 (for any length)	4 million	5	64	State Funding; Line 4: Loan from Inter-American Development Bank and JBIC	1600 mm	5 new lines planned
Boston 'T'	1897	Commuter Rail, Rapid Transit, Light Rail, Bus, BRT, Trolleybus, Ferry boat	State Owned (Massachusetts Bay Transportation Authority (MBTA): operates under the Massachusetts Department of Transport)	32 km extension of commuter rail from Providence to Wickford Junction under construction	64 km (Subway)	Min: $1.70 Max: $7.75	1.34 million	4 (Subway); 5 (Light Rail and Trolley)	60 (Subway); 53 (Light Rail and Trolley)	Combination of Federal funds, MBTA funds and funds from the Commonwealth of Massachusetts	1435 mm	Extension of Green Line underway; extension of several other lines planned
London Underground	1863	Rapid Transit	State Owned (London Underground Ltd. controlled by the public authority, Transport for London)	-	402 km	Min: $2.07 Max: $30.22	3.04 million	11	270	State funded; failed attempt at PPP;	1435 mm	Plan for Northern Line Extension
Beijing Metro	1969	Rapid Transit	Partly State Owned (Beijing Mass Transit	83 km	337km	Flat Fare of $0.32 except for the	7.57 million	14	172	Combination of State Funds through	1435 mm	19 new lines planned, of which 8 are

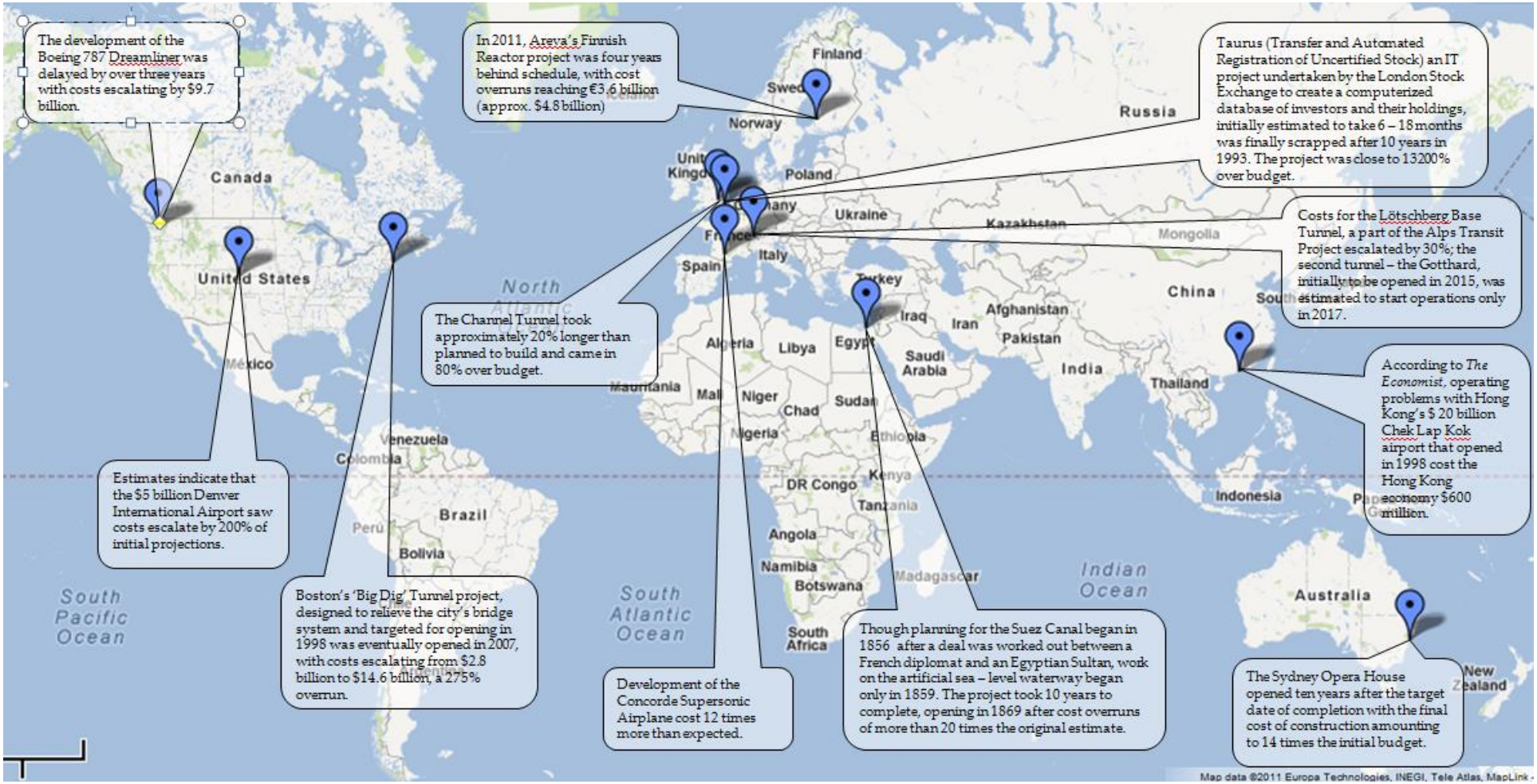
Transport System	Opening	Mode of Transport	Ownership Structure	Total Length (kilometers)		Fare	Daily Passengers	Lines	No. Of Stations	Funding	Gauge Adopted	Status
				Under construction	Built							
			Railway Operation Corporation) and partly owned by the Beijing MTR Corporation a Public – Private Joint Venture with the Hong Kong MTR			Airport Express which costs $3.94				Municipal Authority budgets, development assistance loan from Japan and commercial loans from state Banks. Additional funds obtained as part of the stimulus package issued by the Government in 2008		under construction

Source: Casewriter, based on data from http://www.delhimetrorail.com, http://www.indianexpress.com, http://www.mtp.indianrailways.gov.in, http://www.articles.indiatimes.com, http://www.rediff.com, http://www.urbanrail.net, http://www.thetransportpolitic.com, http://www.mbta.com,http://www.mtr.com.hk, http://www.metro.sp.gov.br, http://www.tfl.gov.uk, http://www.railway-technology.com.

Exhibit 6 Chawri Bazaar Tunnel under Construction

Source: Company Documents.

Exhibit 7 Large-scale Projects Around the World



Source: Casewriter, based on data from Google Maps, http://strategicppm.wordpress.com, http://af.reuters.com, http://www.constructionmanagement.net, http://www.projectcasestudies.com/,http://www.bloomberg.com, Underestimating Costs in Public Works Projects: Error or Lie? (APA Journal), IT Project Management: Infamous Failures, Classic Mistakes, and Best Practices (MIS Quarterly Executive), Challenges and Geologyof the Lötschberg Base Tunnel (Swiss Bull.agnew. Geol) and Innovation in the Built Environment.

Exhibit 8a DMRC Balance Sheet FY2009 (US$ million)

Particulars		As at 31.03.2009		As at 31.03.2008
Source of Funds				
Shareholders Funds				
Share Capital		1,298		1,216
Share Application		0		36
Deferred Government Grants		376		292
Loan Funds				
Unsecured Loans		2,243		2,126
Net Deferred Tax Liability		47		50
Total		3,964		3,720
Application of Funds				
Fixed Assets				
Gross Block	2339		2684	
Less: Depreciation	216		203	
Net Block	2123		2481	
Capital Work-in-Progress	1335		606	
Construction Stores & Advances	368		439	
		3,826		3,526
Current Assets, Loans & Advances				
Inventories	6		15	
Sundry Debtors	30		7	
Cash & Bank Balances	387		415	
Other Current Assets	3		7	
Loans & Advances	72		77	
	498		521	
Less: Current Liabilities & Provisions				
Current Liabilities	373		356	
Provisions	23		26	
	396		382	
Net Current Assets		102		139
Profit & Loss Account		34		54
Total		**3,962**		**3,719**

Source: Company Documents.

Exhibit 8b DMRC Profit and Loss Account FY2009 (US$ million)

Particulars	For the year ended on 31.03.2009	For the year ended on 31.03.2008
Income		
Traffic Operations	77	79
Consultancy	6	3
Real Estate	48	30
Others	11	14
Total	**142**	**126**
Expenditure		
Traffic Operations	45	50
Consultancy	0	1
Real Estate	1	2
Decrease in inventory (Land)	5	0
Total	**51**	**53**
Profit before Depreciation & Interest	**91**	**73**

Source: Company Documents.

Endnotes

[1] The Commonwealth Games were an international, multi- sport event that took place every four years with participating athletes from the Commonwealth of Nations. Delhi had won the award to host the XIXth Commonwealth Games during October 3 – 14, 2010.

[2] The launching girder supporting the bridge had lost balance, causing it to crash. A launching girder was a piece of equipment used for placing concrete segments to form viaducts or bridges. They were especially useful in marine or congested urban conditions as they were capable of moving themselves forward to the next span (the distance between the two intermediate supports of the bridge).

[3] A girder was a long strong iron or steel bar used for building bridges and the framework of large buildings.

[4] A technical inquiry committee found that the construction company Afcons Infrastructure Ltd. had been negligent in the construction of a column, which had led to the crash. Following the committee's findings, DMRC had issued a show cause notice to the contractor (for blacklisting it) while allowing it to temporarily continue ongoing work on two other lines.

[5] "Metro blames contractor for Laxmi Nagar mishap," *The Hindu*, November 5, 2008, http://www.hindu.com/2008/11/05/stories/2008110562450300.htm, accessed September 2011.

[6] Dr. E. Sreedharan was honored with the award of 'Champion of Project Management in India' by the Project Management Institute of India in 2008, and DMRC was awarded the National Award in 2000 by the Indian Institute of Bridge Engineers for using the most innovative construction engineering techniques for the Metro Rail Bridge across the Yamuna.

[7] Midway through the investigations, Rajan Kataria was dropped from the Committee.

[8] Vukan R. Vuchic, *Urban Transit Systems and Technology*, (New Jersey: John Wiley & Sons, Inc., 2007), p. 436.

[9] Prior to 1991, Delhi was a Union Territory. Union Territories, unlike States were not governed by their own government but by the Central government (i.e. the Government of India) through an Administrator or Lt. Governor, appointed by the President of India. The National Capital Territory Act, 1991, enforced in 1993 introduced a system of diarchy whereby the elected government (i.e. Government of the National Capital Territory of Delhi) would operate much the same way as a State government. However, the Central Government would continue to govern matters of law and order.

[10] *Economic Survey of Delhi 2001 – 2002*, Chapter 3 (New Delhi: Department of Planning, Government of NCT of Delhi, 2002), http://delhiplanning.nic.in/Economic%20Survey/Ecosur2001-02/PDF/chapter3.pdf, accessed September 2011.

[11] *Economic Survey of Delhi 2001 – 2002*, Chapter 12 (New Delhi: Department of Planning, Government of NCT of Delhi, 2002),http://delhiplanning.nic.in/Economic%20Survey/Ecosur2001-02/PDF/chap12(table).PDF, accessed September 2011.

[12] Ibid.

[13] An exchange rate of approximately $1 = ₹36.32, which is the calendar year average for 1997, has been used for the conversion from Indian Rupees to U.S. dollars.

[14] Though JBIC merged with the Japan International Cooperation Agency (JICA) on October 1, 2008 and was renamed JICA; in order to maintain consistency the loan making entity will be referred to as JBIC throughout this case.

[15] The Kolkata Metro was the rapid transit system serving the city of Kolkata, the capital of West Bengal, a state located in the eastern part of India.

[16] An exchange rate of approximately $1 =₹41.27, which is the calendar year average for 1998, has been used.

[17] Gauge referred to the distance between the two load bearing rails on a railway track.

[18] According to International Standards, standard gauge was 4 feet and 8.5 inches (1435mm), while broad gauge referred to anything greater than standard gauge (usually 5 feet 6 inches or 1676 mm in India).

[19] Rolling stock was the carriages, engines, trains, etc. used on railway tracks.

[20] Without a legal Act or cover that laid out DMRC's powers and provided rules regarding operations and maintenance, all aspects of the project, such as the extent of DMRC's liability for accidents and the range of compensation, DMRC's authority to appoint contractors and the method used to determine fares would have been open to question through litigation.

[21] Please refer to page 11 for details on the Fare Fixation Committee.

[22] The Commissioner of Metro Railway Safety was responsible for periodically undertaking safety inspection of the Metro carriages and lines and holding inquires into accidents associated with the Metro, among others.

[23]An exchange rate of approximately $1 =₹48.6, which is the calendar year average for 2002, has been used.

[24] "Delhi Metro gets Rs 1,407 cr duty waiver," *The Times of India,* December 17, 2002, http://articles.timesofindia.indiatimes.com/2002-12-17/delhi/27295045_1_metro-rail-excise-duty-delhi-metro, accessed September 2011.

[25] Under principles of eminent domain, the state can acquire or seize a citizen's private property, with or without the owner's consent, usually for public purposes, by providing due monetary compensation.

[26] Chawri Bazar was a hustling bustling wholesale market, initially set up as a hardware market in 1840.

[27] The Tunnel Boring Method was highly mechanized and therefore capital intensive, suitable for drilling through reasonably similar rock mass. As compared to the TBM, the New Austrian Tunneling Method, suitable for complex geological conditions relied on the mapping of rock conditions as construction progressed. Based on the classification of rocks, engineers would decide on the kind of support to use at various points in the tunnel.

[28] UrmilaRao, "India's best students: Meet the Metro Man," *Careers360 Features*, March 9, 2010, http://www.careers360.com/news/3962-India-s-best-students-E-Sreedharan, accessed September 2011.

[29] Rajat Guha and Soma Banerjee, "Metro Man Sreedharan putting India on fast track," November 20, 2008, *The Economic times,* http://articles.economictimes.indiatimes.com/2008-11-20/news/28385290_1_e-sreedharan-metro-man-metro-project/2, accessed September 2011.

[30] Kiran Kaushik, *The Satyam Saga*, (New Delhi: Business Standard Ltd., 2009), p. 14.

[31] Ibid.

[32] "Delhi Metro: Yet Another Accident Injures 6," *Outlook India,* July 13, 2009,http://news.outlookindia.com/item.aspx?662628, accessed September 2011.

[33] "Walk the Talk: Interaction with Dr. Sreedharan," *Indian Express*, July 20, 2009, http://www.indianexpress.com/news/people-have-accepted-that-the-dmrc-is-infallible...-if-something-goes-wrong-they-get-jolted.-that-is-what-has-happened-here/491436/, accessed September 2011.

[34] Shastri Park was a locality in northeast Delhi. It had a Metro station of the same name (one of the first few stations to be operationalized by DMRC), as well a coach maintenance depot and an Information Technology park developed by DMRC.

[35] An exchange rate of $1 = ₹48.36, which is the calendar year average for 2009, has been used. Fares were raised in November 2009 to ₹8 ($0.17) for the shortest and ₹30 ($0.62) for the longest trip.

[36] An exchange rate of $1 = ₹45.33, which is the calendar year average for 2006, has been used.

[37] The regenerative breaking system used an energy recovery mechanism whereby it converted the energy released during slowing down into another form, either for storage or for immediate use.

[38] An exchange rate of $1 = ₹41.29, which is the calendar year average 2007, has been used.

[39] Operating ratio represented operational expenditure as a proportion of total income.

[40] A. K. Bhattacharya, "In Defense of Delhi Metro," *Business Standard*, August 13, 2008, http://www.business-standard.com/india/storypage.php?autono=331266, accessed September 2011

[41] Bijith R., "Operating Profits: DMRC among top 5," *Business Standard, August 18, 2008,* http://www.business-standard.com/india/news/operating-profits-dmrc-among-top-5/331732/, accessed September 2011.

[42] A route kilometer was the distance by rail between two points on the railway network irrespective of the number of lines connecting them.

[43] Ibid.

[44] "Delhi Metro pays back over Rs. 567 crore in loan and interest to JICA," *Economic Times*, August 7, 2010, http://articles.economictimes.indiatimes.com/2010-08-07/news/27608200_1_phases-jica-loan-amount, accessed September 2011.

[45] A. K. Bhattacharya, "In Defense of Delhi Metro," *Business Standard*, August 13, 2008, http://www.business-standard.com/india/storypage.php?autono=331266, accessed September 2011

[46] Dr. E. Sreedharan, interview by D. Murali, *Hindu Business Line*, July 15, 2010, available at http://www.youtube.com/watch?v=7JB8tZBxgxs&feature=plcp&context=C257f3UDOEgsToPDskJLbDzk6DxqkD6LavKqsNBR, accessed November 2011.

[47] A cantilever was a beam anchored at only one end.