



UNIVERSITY
OF WOLLONGONG
AUSTRALIA

University of Wollongong
Research Online

University of Wollongong in Dubai - Papers

University of Wollongong in Dubai

2018

Study of Service Operations of Metro: Action research embedded with case study

Niyazudeen Kamarudeen
University of Wollongong in Dubai

Balan Sundarakani
University of Wollongong in Dubai, balan@uow.edu.au

Mohammad Nabhan
Road & Transport Authority

Publication Details

Kamarudeen, N., Sundarakani, B. & Nabhan, M. 2018, 'Study of Service Operations of Metro: Action research embedded with case study', 2nd International Conference on Industrial Engineering and Operations Management Paris, France,, IEOM Society, Paris, France, pp. 771-787.

Research Online is the open access institutional repository for the University of Wollongong. For further information contact the UOW Library:
research-pubs@uow.edu.au

Study of Service Operations of Metro: Action research embedded with case study

Niyazudeen Kamarudeen, Balan Sundarakani

University of Wollongong in Dubai, Knowledge Park, Dubai, UAE – 20183
nk569@uowmail.edu.au , BalanSundarakani@uowdubai.ac.ae

Mohammad Nabhan

Director, Road & Transport Authority, Dubai, UAE
mwnabhan@gmail.com

Abstract

The main objective of this paper is to analyze the operational strategies of metro train service in Dubai. The proposed methodology follows with a literature review, action research and case study approach. The research identifies various service measures the metro rail and challenges of operational expansion process involved towards 2020. The research is therefore limited to the city of Dubai. Further, an in-depth understanding of customer usage behavior related to service operations could extend this research in future. In view of this the research contributes to both the theory and practice of the metro transportation service.

Keywords

Rail service operations, Action research, Dubai Metro case study

1. Introduction:

In this era, metro represents the symbol of how far the country has developed in terms infrastructure and service. This is because, the construction of the metro costs heavy, which requires lot of resources and investment in order to put it in action. The government of Dubai, given its high GDP has preplanned the necessity of building a metro network as a response to the challenges posed by the road networks around the city (Keilo, 2012). The main reason to deploy metro into the city is because of the growing demand for public transport in major cities, along with the huge traffic and pollution problems; which has forced the governments to think about an alternate mode of transport which satisfies the sustainability factors. This can be achieved by the use of environmentally friendly fuels and land use patterns (Subash, 2013). Two of the major problems that the government wants to solve with regards to transportation system are: Firstly, delineating infrastructure in order to coordinate policies at the national level to achieve a sustainable transport system and secondly. enhancing capacity of cities to improve mobility with sustainable operations.

Some of the main goals of sustainable development include economic efficiency and sustainable growth based on conserving resources such as petrol and diesel, energy security, and energy efficiency by consuming as low energy as possible (Subash, 2013). Since the reshaping of the U.A.E in 1971, the three major modes of transportation (Marine, Air, Road) were incorporated in Dubai's Global identity (Keilo, 2012, p.113). As the time went on, the city made a tremendous growth in terms Economy, infrastructure and population. The increasing population was a big concern for the government in the period of growth, just similar to what the major cities around the world had faced. In order to safeguard the growing population from the traffic congestion, and also to build a world class infrastructure in order to develop the then current place into 'the next big city', the government of Dubai has taken a major decision to create a consortium called Dubai Rapid Link (DURL) in July 2005 (Narayanawami, 2017, p. 161). The Dubai metro was inaugurated on 09/09/09, at 09:09pm as the "set to become the longest metro automated network in the world with more than 70KM of track length" (Acuto, 2010, p.274). Jack KEILO (2012) stated that "Opened right amidst the global financial crisis, the Dubai metro plays a major role in the drive of a revived city

image”. Today, the metro is a world class infrastructure that bridges the major commercial and tourist attractions together.

1.1 Evolution of Dubai Metro:

The planning of Dubai metro was a strategic decision taken way back in 1997 by the ruler of that time His Highness Sheikh Mohammed Bin Rashid Al Maktoum (Botelle et al, 2012, p. 115). Later, Dubai metro was established in November 2005 under Roads and Transport Authority (RTA) with a vision to “restructure and integrate multiple public transport modes (such as bus, taxi and marine transport)” (Narayanaswami, 2017, p.160). The contract for the construction of metro was given to the Dubai rapid link consortium which involves Japanese companies including Mitsubishi Heavy Industries (MHI), Mitsubishi Corporation (MC), Obayashi Corporation, Kajima Corporation and Yapi Merkezi of Turkey (Narayanaswami, 2017, p. 161) as represented in Figure 1. The design works were subcontracted to Atkins and Mitsubishi, which was also supported by Thales for the supply of systems software (Botelle et al, 2012, p. 115). All the companies in the consortium had appointed their sub-contractors to fulfill the demands during various stages of the project. The costing of Project was calculated to be 4.8 Billion Euros (Botelle et al, 2012, p. 115).

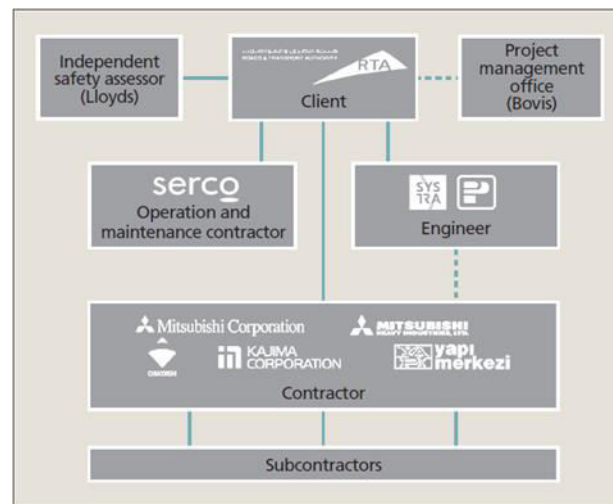


Figure 1. Dubai metro service with stakeholders

During the phase of the project, the population of Dubai was forecasted to 5.25 million in 2020. In order to manage the mobility of these population, the metro will provide an intense relief to the government of Dubai. The Vision that enabled the leaders to foresee such predictions for generations that are yet to come and prepare a plan for a better place to live in is what makes the Great leaders for the country. Therefore, this paper is aimed to address the ‘operations of Dubai Metro’ through “Action” based research method after the comprehensive literature review of service operations.

2. Literature Review

2.1 The Metro Industry

The growing demand for the public transports among the major cities around the world has fueled the need for metro transportation (Subash, 2013). The growing demand of these systems can be cited to the problems of traffic and pollution among the major cities. Due to this reason, the private sector participation in the urban rail transit systems has proliferated in the past two decades (Zheng Chang et al, 2017). In the past decade, the extreme rapid growth of transit systems has been in china; where 23 cities built new transit line between 2003-2014 (Zheng Chang et al, 2017). A mega city called Chengdu in western china has been taking steps to transform itself into a world class rail transit Centre, which is because of the fact that rail industry is one of the Five Priority industry in Chengdu (Li Yu, 2016). Moreover, the city also encourages the universities and the surrounding companies to establish products transformation alliance through their respective rail transit scientific research platforms to promote the transformation and the application of technologies in the city (Li yu, 2016).

Zheng Chang et al, (2017) states that “Until the 1990s, most cities (with the exception of Japan) have used the state provision approach. Along with the growth in the number of urban rail transit systems, public-private partnerships (PPPs) have proliferated in the past two decades”. The PPP mode of business has been currently successful in INDIA, where recently the Hyderabad’s metro was declared the best project in the world through PPP Mode (The Economic Times, 2017). In 2016, Asia-Pacific had the highest Compound Annual Growth Rate (CAGR) for Very High Speed (VHS) system in the industry with 6.2% (UNIFE, 2016; Roland Berger, 2016). The forecast has shown 65% growth in metro rail segments, with increased track length of 25,000 Kilometers (UNIFE, 2016; Roland Berger, 2016). In INDIA, 10 urban rail systems have been opened up and additional 40 more units has been planned in the nearby years (Sharma, 2017). UNIFE World Rail Market Study 2016 Reports that “Due to the significant investments in VHS and urban segments, the total market in North American Free Trade Agreement (NAFTA) will amount to nearly 34 Billion Euro in 2021. This summarizes that the rail industry will have a continuous growth that is driven by demand and innovation.

Though the market has segmented growth in the metro industry, their growth can be slightly hindered due to two main factors:

- Escalating problems in obtaining the financial resources for the investment in the transport sector by the cities worldwide (Medda, 2012).
- The pollution due to the emissions and dust from the from the major construction & demolition projects such as metro construction works can often accelerate the issue of air pollution in residential areas. Despite the mitigation plans of tighter emission standards & monitoring, particulates continue to threaten public health (Paschalidou et al, 2016).

2.2 Construction of Metro

Implementation of metro rail projects involves long term construction activities in the work zones that are inevitable (Bhutani et al, 2014). In the construction of metro projects, quality of the construction is a major factor over the product sales. Ravi Bhutani (2014) stated that “Many metro construction enterprises cannot keep pace with the transition conceptually from a planned economy to market economy, and therefore, it is difficult for them to put the development theme of ‘innovation’ into the practice”. Currently, energy and environmental sustainability are the utmost objectives to be considered during the design and construction of mobility systems (rajabi et al, 2016).

The cost of metro construction doesn’t vary just from cities, but also within the cities since it depends on the technical characteristics such as subsoil and housing situations of each project that are linked to local condition (Subash et al, 2015). To be successful, local fiscal taxation and planning framework must support the implementation of land value capture needs (Medda, 2012). The cost of the construction project is a factor that is very exasperating to control. This is because, large projects are characterized by huge variations in the cost that varies from 40%-200% (Subash et al, 2015). Since the cost of metro construction are of high capital investment, the organizations have to take decisions carefully in regard to the working culture, targets, safety and quality.

2.3 Operations of Metro

The most commonly used type of metro stations are underground, at-grade and elevated type stations (Sadhukhan et al, 2016). The operations of the metro can either be handled by the government or by a private entity through contract (Which is commonly known as operation outsourcing). For example, SERCO coordinates the operations of Dubai metro through contract from the Government of Dubai & RTA (SERCO). Similarly, In Australia, the company called ‘METRO’ operates 220 six carriage trains across 965 kilometers of track in the Melbourne City.

The manual operations of metro deploys lots of human error factors especially during the Automatic Train Protection system gets faulty (Yuan, 2017). An example of this can be attributed to the two-train collision that happened in Germany, in the year 2016. The author Tenfei Yuan (2017) stated that these accidents can be analyzed and classified using 5M Model. The metro attracts more passengers than any other mobility vehicle because of the large volume of commuters it can carry and the ability to reach the destination in short duration of time. However, it has to be noticed that along with large scale of passengers, many issues also arrive with it such as platform safety problem, transfer channel congestion and heavy workload for facilities (Lu, 2014, p. 4077). Therefore, it is important for the metro stations to have early warning methodologies in place in order to measure the safety level and consequently gain information before any situations of accidents arises (Lu, 2014, p. 4077).

The operational costs are affected by the increase in systems such as ventilation, lighting, air-conditioning, platform screen doors etc. In order to increase the customer satisfaction, the service in terms of reliability, comfort & quality are employed, which also consequently increases the operating cost (Subash ,2013). It is important to note that 16% of the energy among all the sectors is consumed by public buildings and metro stations are the high traffic publically accessed buildings (rajabi et al, 2016). Therefore, it is important to bring in systems that can help in energy consumption throughout the facilities. For example, the Paris metro systems (RATP) recently has replaced its lightings with LED, this step has been estimated to save almost 50% of total energy consumption (rajabi et al, 2016). Table 1 illustrates detailed literature review and identifies some key research gaps.

Table 1: Literature Review and research gap identification.

Author	Title	Research Method	Research objectives	Major research findings	Identified research gaps
Keilo and Montagne (2012)	Dubai Metro and RTA Dubai Bus: Local Efficiency and the city's Global Image	Qualitative+ Interview	This paper examined the role of two intra-urban public transport systems in the building of Dubai's global identity. A survey was conducted with the people who use both metro and RTA bus.	Modernization of the rail public transport system has been rapidly inserted into the daily routine of the city. The efficient bus system has been eclipsed by the metro in the everyday mobility.	The efficiency in the working of Dubai metro and the structure was not analyzed
Botelle et al (2012)	Dubai Metro: Building the world's longest driverless metro	Case Study	The paper provides an overview of the metro project construction which includes the civil engineering solutions and the architectural contexts.	The mechanical and civil works that constituted in the construction of metro was metro was analyzed	The transition from planning and feasibility to the reality could have been studied.
Rizzo (2013)	Metro Doha	Article	The article reviewed the Doha's past and the urban development, highlighting the Qatar's different urban phases. The impact of Qatar's mega project was investigated by comparing with Dubai's developments.	The results demonstrated how Qatar's recent urban development was modelled from the Dubai's ambitious projects	The design of operational planning of Doha metro was not discussed
Subash et al (2013)	Feasibility study of metro transport: case study Madurai	Case Study	The feasibility of implementing metro in the city of Madurai was studied using tools such as GIS, Global mapper. The cost-benefit analysis was done in order to measure the benefits of costs.	The result indicated the need for the construction of metro in the city	Quantitative studies are needed to investigate the people's necessity and their requirements on metro.

Parahoo et al (2014)	Satisfaction of Tourists with Public Transport: An Empirical Investigation in Dubai	Qualitative + Interview	The study developed and empirically examined the parsimonious conceptual model of tourists' satisfaction using Public Transport	On the basis of the research, many recommendations were given on the improvement of public transport system.	Qualitative techniques can be used to identify the expectations of the tourists and to identify the core concepts within reputation so as to meet the needs of tourists.
Sadhukhan (2016)	Commuters' willingness-to-pay for improvement of transfer facilities in and around metro stations – A case study in Kolkata	Random Parameter Logit Model (RPL) + case study	The research focused to investigate the perception of commuters of Kolkata city in terms of their willingness-to-pay for improvements in transfer facilities	The work indicates that the metro commuters have the willingness-to-pay for the improvement of facilities in the metro. Therefore, the author instigates the need for improvement.	Series of recommendations were suggested, and no further scope was disclosed.
Rajabi and Behairy (2016)	Benchmarking Energy Management Systems in Metro Station	Quality Function Deployment	The study focuses on developing a benchmarking technique to measure the degree to which energy management systems are utilized in metro stations by reviewing the broad literature in energy management in the transportation and construction sectors and exploring the techniques used to reduce energy consumption	The QFD matrix was used to find the relative importance of five energy management strategies with respect to the prioritizations of the main categories of energy management.	Series of recommendations were suggested and no further scope was disclosed.
Yuan et al (2017)	Research on Identification and Classification of Human Factors of Metro Operation Without ATP	Literature Review + Field Survey	The research adopted the 5M Model to identify and classify the human error factors involved in the metro operation.	According to this study, the human error factor in non-ATP situation is affected by man, mission, machine, media and management factors.	Future work is proposed to develop a method of discriminating the relations among the humans to predict the human error probability based on the real observed data.

Yilmazer and Bora (2017)	Understanding the indoor soundscape in public transport spaces: A case study in Akkopru metro station, Ankara	Quantitative Analysis	This study examines the relationship between space recognition and soundmarks using sound recordings and public participants.	The study reveals that there is a statistical significant relationship between auditory perception and different space types.	Sound inscape variables can be taken into the consideration in indoor spaces, which will be necessary to approach international standards.
--------------------------	---	-----------------------	---	---	--

3. Operational Strategy

3.1 Operations of Dubai Metro

The public transport system of Dubai is labelled as one of the most advanced public transport system in the Arabian Peninsula, which can be attributed to the availability of fruitful combination that involves modern taxi fleet, evergreen water taxi, Splendid bus service, and finally the automatic metro that connects major business districts and employment hubs (KEILO et al, 2012, p.114). Since the inception of metro service, more than 180 million riders have estimated to travel using the metro (Dubai Statistics Centre). This number shows how the metro operations has been conducted smoothly over the years. The Figure 2 below shows the Number of trips that has been made by the passengers via the two lines (Red & Green)

The Figure 2 summarizes the staggering amount of people using the metro for their movement. The metro is installed with 142 seats and can carry up to 897 passengers (Arabian Business, 2009). It is still believed that the metro is under-utilized as in its full operation, Dubai Metro is projected to carry approximately 1.2 million passengers on an average day, and 355 million passengers a year (Dubai Metro Network - Railway Technology, n.d.).

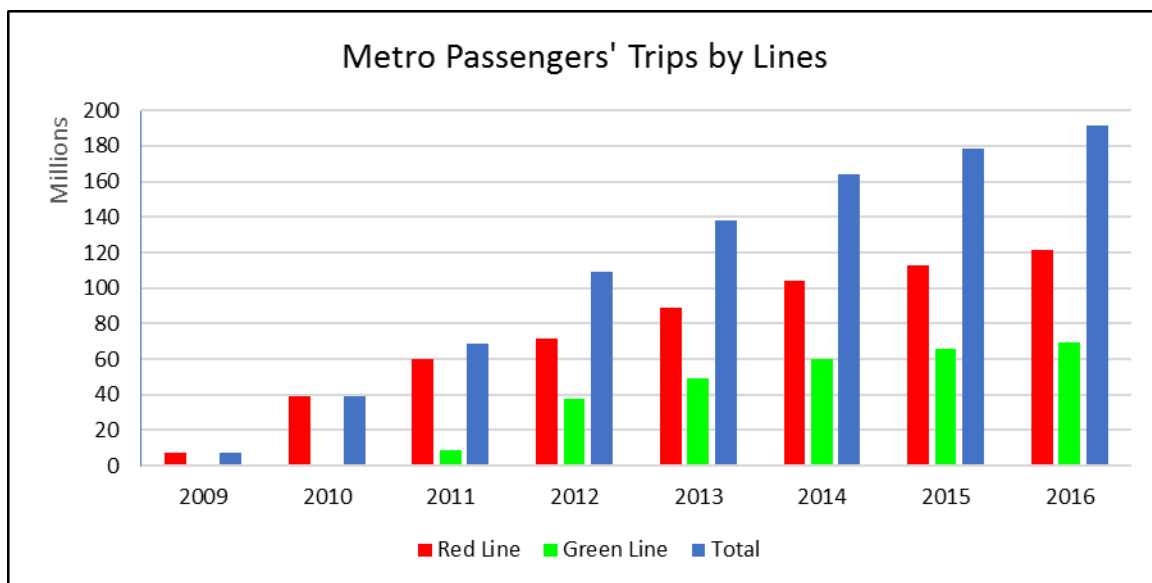


Figure 2. Metro service users of both green line and red line

Source: Dubai Statistics Centre, 2018

Dubai Metro runs on light rail transit (LRT) system because it offers greater flexibility in achieving sharper curves steeper grades. Moreover, the LRT system can easily run within the city which makes it very feasible especially for a small city like Dubai (Narayanaswami, 2017, p. 161). The rail systems installed in the metro network ranges from the world's largest internet protocol camera network, supported by an extensive and fully integrated networkwide operation control system integrating communications and facilitating advanced operational management, to the provision of some of the most advanced maintenance systems available (Botelle et al, 2012, p. 122). The operations cost of Dubai Metro which includes Staff, Power and Maintenance amounts AED 575 Million per year (Dubai Metro Network - Railway Technology, n.d.).

Serco is an UK Based traffic management service provider that handles the operations of Dubai Metro. In 2013, SERCO signed contract worth 355 MILLION EUROS deal for the management of metro operations until 2019 (Serco, media releases, 2013). Apart from Dubai Metro, SERCO also handles the operations of Dockland Light Rail, Copenhagen Metro, Mersey Rail in Liverpool, Manchester Metro link, Northern Rail in UK, Great Southern Rail (Arabian Business, 2009).

Currently, there are 29 stations spread through 52.1 Km in Red Line, and 18 stations spread through 23 Km in Green line. The red line is being currently undergoing extension of 8 more additional stations spread through 15 Km in order to connect the EXPO 2020 site and is expected to be operational in the early 2020 before the start of EXPO 2020 (Shahbandari, 2017). The metro services is also supported by the Tram services that loops around Jumeira Beach residence and Al Sufouh Tram station.

From Saturday to Wednesday, the red line starts its operations at 5 AM in the morning, while the green Line starts its operations at 5.30 am in the morning till midnight. On Thursday, the metro has its operations extended till 1 am after midnight, and on Friday, the operation starts at 10 am till 1 am after midnight. The Dubai Tram has its operations from 6 am to 1 am from Saturday to Thursday and 9 am to 1 am on Friday. When the passenger feels that he could not reach his/her complete destination using metro, RTA provides bus services from almost all the metro stations to travel into the longer streets of the city. The RTA bus comprehends the part of metro system in the form of feeders that fills the gap between the major metro lines and the rest of the city (Jack KEILO et al, 2012, p.117). RTA also provides concessions to its passenger who travel by bus immediately after they exit the metro to get into the city that is not accessible by the metro. This encourages people to use public transports instead of their own private transport, which in turn helps in curbing the problems related to traffic and pollution.

In September 2017, Khaleej Times published an article about its visit to the Operations Control Centre (OCC) that is situated in the Rashidiya depot. Nilanjana Gupta (2017) mentioned that "The Operation Control Centre (OCC), considered to be the 'brain' of the Dubai Metro, is located at the Rashidiya depot. What's surprising is that just 15 people, including four train controllers, run the entire system. There's also a backup of the Operation Control Centre in Jebel Ali". Moreover, Mohammed Al Mudharreb (Director of Rail Operations, RTA Dubai) during his interview with the Khaleej times explained that a lot of human error is removed from the system due to the punctuality and the adherence to the time management by the driverless metro. He claims that there is no system in the world that is capable of running with an aggressive headway of 2 and a half minutes with drivers, similar to what the Dubai metro has achieved.

3.2 Facilities in the metro

Some of the important services and facilities provided by the Dubai metro are:

- **WIFI on the move:** Wifi network is available through the entire network of metro. Moreover, mobile phone coverages are also available without in signal interferences (RTA).
- **CCTV Cameras:** More than 3000 CCTV Cameras are installed for public surveillance around the metro (RTA).
- **Emergency call Box:** Emergency call system is installed in all the trains that are operating inside the stations (RTA).
- **Radio Link:** A radio system is integrated between the metro and the emergency callers (RTA).

- Metro police: A dedicated team of police officers are always around the station to serve the passengers with safety and security.
- Tactile guidance path: The visually impaired people will be served with contrasting tactile guidance path inside the metro facilities and station (RTA).
- Platform alerts: Passengers will be updated with the timing of metro and their arrival with voice updates. Platform alerts such as audible beeps will be given when doors open and close, with corresponding flashing light signals (RTA).
- Service Classes: Gold class section that gives utmost pleasure of travelling, installed with leather seating, luggage space and high level of privacy. Woman class provided for women and children has more space for strollers and bags. The silver class is the normal class section for all the other passengers for an economic travel.
- Closed circuit television: The TV installed shows the route map, upcoming destinations and the current destination of the metro. This provides passengers with constant information of their location.
- Themed Stations: Georgia Bobley (2016) stated that “Every station is designed to mimic one of five themes important to the UAE-- heritage, earth, air, water, and fire. For example, the Rashidiya station features cloud-like architecture, while the Burjman station is intended to make commuters feel like they're underwater. At the Mall of the Emirates, the color scheme of the Metro station is supposed to match the fire tones of a volcano”.

3.3 Safety & security of Dubai Metro

In 5th April 2018, SERCO Middle east received an acknowledgement award for their dedicated road safety initiatives providing industry solutions to reduce road accidents and fatalities at the Global Infrastructure Congress (GIC) (SERCO). Therefore, the level of safety and security systems implemented by the organization for the metro services can be expected to be top notch. SERCO has stated in their website that the safety of the customers are their first priority. During the events that will attract more passengers, Serco prepares special plans for crowd control measures, provision of additional trains, increase train frequency, and deployment of additional frontline and security staff (Arabian Business, 2009). In order to have smooth and uninterrupted metro services, it is important to conduct preventive maintenance for the metro trains. There are three maintenance depots situated in Red Line at Rashidiya & Jebel Ali with the capacity to handle 104 trains together, and the other one in green line at Qusais with the capacity to handle 60 trains for the maintenance service (Botelle et al, 2012, p. 121). Condition monitoring alarms will be used for safety critical equipment.

Dubai Metro is designed to meet the international safety standards and the safety of the metro is monitored by an Independent Safety Assessor (ISA) (Sambidge, 2009). Some of the safety and security plans of the organization include:

- Patrolling of trains and stations
- Access control for 24*7
- Security risk management
- Contingency plans for breakdown
- Enforcement of railway bylaws
- Monitoring by officials
- Monitoring through CCTV
- Emergency call points
- Preventive maintenance

During any emergency situations in the ground, in case when the emergency alarm is raised, Mohammed Al Mudharreb (Director of Rail Operations, RTA Dubai) stated that the train controllers in the Operations Control Centre (OCC) are the first responders to the queries given by the passengers onboard. Moreover, he added that If there is a security threat or any injured people onboard, the train controller can immediately stop the entire service by pressing the red emergency button. The security measures undertaken by SERCO is evident that they place safety of the passengers on top of anything else.

3.4 Quality Management

Every machine needs to be properly maintained in order to have a long-life. This includes the various machinery which propels the metro. The interior cabin of the metro needs to be cleaned on a daily basis to keep it in top-notch condition. This is to ensure the high standards of quality are met every time the metro is being used. Reliability is considered to be a prominent factor which identifies transportation quality and also consequently influence the passengers' choice of travel (Subash, 2013, p.75). The surveys also indicate that passenger's satisfaction of mobility services is affected by reliability, travel comfort, station organization and information, service schedule, price-quality ratio, ticket service and accessibility (Subash, 2013, p.75).

Many modern equipments are in place to improve the quality of service throughout the metro. For example, low noise motors, viaduct enclosure designs and anti-vibration measures in track systems are used to reduce the overall noise propagation (Sambidge, 2009). In Japan, the improvement in service quality has led to an increase in 14% of commuters using train (Parahoo, 2014, p.1007), this statement is evident to prove that service quality is one of the key elements that the riders look for. Therefore, it is important for RTA & SERCO to maintain a high level of service quality from inception to completion. The constant maintenance of service quality is a difficult task to achieve. In order to achieve the maximum service quality, there certain procedures and standards has to be adopted. There are certain key areas that are critical to service quality. The following key areas are duly checked as and when required to keep metros in optimum condition and to avoid any breakdowns during peak hours (Kumar, 2013)

Inspection

All the metro trains are inspected on a daily basis once the metro stops at the Rashidiya depot after a long 19-hours non-stop journey. Inspection check is done on the mechanical and electrical systems and also on basic inspection is carried. Any defect that is observed will be immediately reported to the maintenance section.

Cleaning

The metro trains are washed and cleaned in the depot every two days. This is carried out at the automatic washing bays which works similar to the automated car washes. Detergents are used to remove the dust and dirt. The entire cleaning process is environmental friendly and about 80 percent of the water consumed is recycled. The average washing time is expected to be around 5 minutes.

Wheels profiling

Wheels profiling is not a regular process and is done only when the wear of the tires reaches a certain limit. A wheel profiling facility known as the wheel lathe is used for this purpose. It can take up to two hours to profile each wheel. The entire process of wheel profiling could take up to two days per train.

Track Maintenance

Just like the wheels, even the tracks are checked on a regular basis to identify wear and tear. For the smooth running of the train, a sophisticated device called the track monitor is used to check the conditions and the worthiness of the track. Any defects are immediately checked and corrected. This process is done annually.

Sweep Trains

Half an hour before the metro becomes operational every day, sweep trains rolls out of the depot and cover the entire red line and green line to ensure there is no obstacle on the track. The operational Control Centre monitors the movements of the sweep trains. Any obstacles found are immediately removed from the track before the operation of the train.

Various Personnel in a metro station

The operational activity of Dubai metro starts at 5.30 marks the beginning of the first shift. The operations starts with the station master assigned to each station opening the lock doors. He then activates various metro facilities in

his station along with the computers and other IT equipment which is connected to the central controlling center. He then aligns his team and plans for the day are communicated. He is also responsible for handling various complaints received from metro passengers and provide solutions on a timely manner.

There are information assistants placed in all the metro stations. The major responsibility of these personnel is to assist passenger, helping them in using kiosks, assisting during peak hours at the ticket counter etc. Security officers assigned to each station plays a key role in ensuring a safe and smooth experience for all the passengers and also for the safety of the metro station administrative staffs, metro facilities etc. The maintenance and cleaning personal assigned to each station takes care of various maintenance works in the station on a daily basis and also to keep the metro station clean and tidy to enhance customer experience. Dubai Metro can be considered as the perfect example for the Triple Bottom Line. The scope of the Dubai metro is much bore the bottom line of a traditional business, which is Profit/Loss. Dubai Metro has taken various aspects in to consideration for its long-term sustainability.

Economic Prosperity

Dubai Metro is expected to break even by the year 2017. The reason for achieving the break even for such a huge and complex project is due to the exponential growth of metro users and also the incorporation of various alternative revenue model such as Station Naming Rights, leasing retail outlets inside the metro station and advertisements (McGinley, 2012).

Dubai metro not only makes profit, it promotes economic prosperity of the society in general by providing affordable transportation to all the residents of Dubai. The daily transportation cost has been steeply reduced for the residents since the operation of Dubai Metro (McGinley, 2012).

Social Responsibility

Dubai metro is socially responsible in its various activities. It provides huge employment opportunities, provides safe and happy work environment to its staffs. Dubai Metro, under the umbrella of RTA has been involved in various National, International, Educational, Social and Environmental CSR activities for social welfare ("Roads & Transport Authority - Corporate Social Responsibility," n.d.).

Environment Stewardship

Dubai metro has undertaken various initiative to address the global concern of saving energy whenever and wherever possible. Some of the way Dubai metro does this is through recycling 80 percentage of the water that is used for cleaning the trains, switching off escalators during non-peak hours and also by efficiently using the benefits natural light in all the metro stations.

3.5 SCOR Model

The SCOR model can be used to describe the activities and operations of a business for the purpose of satisfying the customers Demand (Apics, 2017). The model works on analyzing five categories such as Plan, Source, Make, Deliver and Return. The SCOR Model can be used to analyze the process detail of any level (Scrs sme, n.d.). The model also helps in solving the issues related to the supply chain process. Apics (2017) has investigated some of the advantages of the SCOR model which Includes:

- The scope of SCOR Model can be applied to the Entire Supply chain
- Helps in improving the performance, process, practice and skill metrics oriented with supply chain
- Helps in Benchmarking
- Focus on creating value for customers by improving the performance
- Provides metric and activity alignment across the organization

Although there are several metrics provided by the SCOR model, the most widely used metrics are cost, price, flexibility, delivery, quality, number of products delivered, and the time taken for the delivery of product and service (Sundarakani et al, 2018). Now, let's look each component of the SCOR model associated with Dubai Metro:

PLAN	SOURCE	MAKE	DELIVER	RETURN
<ul style="list-style-type: none"> •Construction Planning •Strategy Planning •Design planning •Route Planning & optimization •Daily Operations •Technology •Forecast of Demand •Logistics Network •Staff Scheduling 	<ul style="list-style-type: none"> •IT Support/System •HR Support •Trains •Rail tracks •Contractors/Sub-contractors •Suppliers 	<ul style="list-style-type: none"> •Personalized and integrated IT system •Rules and regulations of using the metro •Sustainable measures •policy 	<ul style="list-style-type: none"> •Smooth transport of passengers •Sustainable transportation •Special discounts for students and people with special needs •Administrative Services •Safety & Security 	<ul style="list-style-type: none"> •Customer feedback •Damaged assets such as trains, tracks, IT systems, AC etc. •Human Resource

Figure 3. Supply Chain Operations Reference (SCOR) model applied in metro service

The above model depicts the process in each stages of the operations. This mapping of process will help in analyzing the operational issues and the gap that is required to be filled.

4. Competitive Strategy

The competitive strategy of Dubai Metro has been fabulous, which has enabled them to retain such a huge Brand Value around the world. Let's look at the factors in which Dubai Metro has excelled so far:

- **Timeliness:** Dubai metro has the shortest waiting time compared to all the metros around the world (Boble, 2016). At peak times, the average waiting time for the train is 3 minutes, which is best when benched with several other metro services.
- **Service Quality:** As a regular metro commuter, the experience of travelling is very pleasant. From the beginning of the service till the time of exit, the air-conditioned facility gives relaxed feeling to walk around. Some of the main factors of quality provided by the system includes travel comfort, service schedule, accessibility, safety and security.
- **Driverless metro:** The number automated metro systems around the world is growing steadily. This is due to the efficiency of service that is achieved through Automated metro. Apart from saving energy, the automated metro has a distinct quality of being "Punctual".
- **Seamless Integration:** The metro is Integrated with different types of transport like RTA Bus & Taxi Services. It is quite common around the world that the metro cannot be linked to all the destinations of the city. But the RTA has ensured that people get the service to reach their final destinations easily and efficiently. When a passenger exits the metro, he/she has a bus & taxi service ready to take him/her to the appropriate destination.
- **Technology & Innovation:** Even though the most advanced systems are installed in the facilities, the organization continuously conducts research to achieve sustainability in its operations.

5. Route to EXPO 2020 and other future prospects

"It's the beginning of an exciting journey", states RTA in its Website. The metro extension work in Red line is mainly targeted to connect the cities to the EXPO 2020 site. Seven new stations are built, beginning from Nakheel Harbour, Tower Station and extending it all the way to the EXPO 2020 Dubai Station (RTA). Parsons in its websites has revealed some of the components of this project, which includes:

- 11.8 Km of elevated guideways and 3.2 Km of tunneling totaling to 15 Kilometers of extension

- Seven LEED Gold stations are installed, which consists of three elevated stations, two underground stations, one interchange station and one “Special Event Expo Iconic” Station.
- Fifty additional set of trains, in which 15 is distributed to expo 2020 route, and the other 35 trains for improving the overall service of the Dubai Metro.
- Construction of three Main Power Supply Stations (MPS) and one Traction Power Supply Station (TPS).
- Expansion of Jebel Ali Depot (maintenance and storage) to accommodate the new rolling stock.

Mattar Al Tayer (Director General and Chairman of the Board of Executive Directors of RTA) revealed that the station designs are inspired by the designs of aircraft because he believed that the invention of an airplane brought an epoch-making change to human civilization, with respect to the way people moved and communicated. He also added that the expo station has been designed following two main factors, i) The visitors of EXPO 2020, ii) Future footfall. After the completion of the project, the total route length of Dubai metro will be increased to 90 Km (shahbandari, 2015).

Shahbandari (2015) stated that two more extensions have been approved, but the date of inception has not been revealed yet. The project involves a 3.5 Km extension in Red line from Rashidiya to Mirdif and a 20.6 Km extension in the green line from Jaddaf to Academic city. Apart from Red and Green lines, three additional lines (Purple, Blue & Gold) are in plans to be constructed by 2030 (Zarooni, 2013). Mattar Al Tayer (Director General and Chairman of the Board of Executive Directors of RTA) has revealed that the blueprint of the train network is in three phases: 2020, 2025, 2030, which is an action plan to mitigate the urban growth in the emirate. The phases of works as revealed by the RTA Chairman are (Zarooni, 2013):

- The first phase of the project covers 24.1 Kilometer with 12 Stations, which is done keeping in mind for the Dubai’s estimated population of 3.1 Million in 2020 by RTA.
- The second phase of the project covers 91 Kilometers With 51 Stations, which is expected to cost AED 45 Million. The population of Dubai is estimated to be 4.1 Million in 2025.
- The work on the final phase will begin based on the assessment of the completed projects (Phase 1 & phase 2). If the population of Dubai crosses 6 million, then the additional of 221 Kilometers along with 69 stations will be constructed.

Altogether, the length of the route will amaze 421 Kilometers with 197 Stations. The numbers presented by the RTA director already looks “extra-ordinary” and once the plans get implemented, Dubai will stand on top of the world in terms on transportation facilities. What is interesting to note is, we can see the history repeating itself. As mentioned earlier, the previous ruler of U.A.E; His Highness Sheikh Mohammed Bin Rashid Al Maktoum in 1997 has laid the foundations for bringing the metro inside the country to curb the traffic congestion that will take place in future due to the increase in population. This pre-meditated thinking has been passed on to the leaders of today, which can be seen in the actions of the future plans that has been proposed by the leaders.

6. Challenges

Every major project will face numerous challenges no matter how efficiently it is planned. The same goes with Dubai Metro; highlighted below are some of the challenges faced during the construction phase:

- A Large number of stakeholders were involved, including various stake holders from outside RTA, resulting in difficulty in communication, decision making etc.
- Constant change in requirement lead to delay in planning.
- Changes in design since the inception of project.
- The contract between main contractors and sub-contractors had number of clauses. Some of the clauses were found to be impractical and ambiguous resulting in difficulties in administration.
- Short period of construction – 49 months for the red line
- Tunneling under established streets and building.

Nevertheless, these challenges were appropriately tackled by the various companies who encountered them.

Challenges during the project phase are one aspect while challenges during the daily operations are on whole new level. Some of the everyday challenges are highlighted below:

- During peak hours, the lift gets occupied with heavy crowds, which makes it tougher for the disabled, and mothers with baby carriages to use them. A guard can be put in place to check and monitor this problem.
- Inorganization, pushing and shoving of people with no respect to woman and baby strollers can be seen frequently in the metro station.
- Since there were no women lines, during peak hours, it can be noticed that women feel uncomfortable and they get crushed in the crowd of men and women.
- When you get inside, there is no way you can walk through the train to get to the woman's section or even the Gold compartment during peak hours because it's very crowded.
- Since only small hand bags are allowed, the people who goes for grocery shopping for a family cannot bring their purchased items on the metro with them. On an average people will have 3 to 5 bags of grocery.
- In case of maintenance, due to the massive connections of pipelines and cables, Time plays an important factor.
- The placement and the number of automatic fare collection machines placed in the stations are not clearly specified.
- Achieving Energy and environmental sustainability in mobility system design and mass transit systems (Rajabi et al, 2016, p.1088)

The government of Dubai is very progressive, and the population of the city is forecasted to increase from 1.8 million in 2011 to around 3.1 million by 2020. The transportation model has to be re-planned sooner than later. A large number of stakeholders are involved in this project. Many of the stakeholders were from outside the RTA, resulting in more difficult communication. Constantly changing requirements and circumstances made traceability a challenge (Hamdy, 2014).

7. Recommendations

Strong leadership is probably the most important success factor in the completion of mega projects such as Dubai Metro. Mega projects need motivated leaders who embrace excellence and empower their teams. Metro Projects should be managed as a portfolio of programs, projects, and related technical work (Hamdy, 2014).

The client should therefore follow some of best practices in the form of:

- Comprehensive and rigorous risk management with regular updates and follow-ups; and
- Developing own procedures for quality management;
- Emphasize on personal safety considerations since Dubai is branded as one of the safest cities in the world (parahoo et al, 2014);
- Innovative techniques should be used to ensure that the available resources are utilized to their full potential.;
- Achieving the targets of Key Performances such as Train punctuality (99%), Train availability (99%), Equipment availability (99%) (Sambidge, 2009);
- In order to achieve high service quality, it is important to build a service culture by careful selection of staffs and provision of customer service training to all the service staffs (Sambidge, 2009);
- Improvements in public relations and promotion of Corporate Social Responsibility (CSR) activities in order to enhance the reputation of the firm;
- Performance monitoring can be implemented through the existing customer satisfaction survey kiosk that is placed in almost all metros;
- Though the tourists were overwhelmingly impressed with the service of Dubai metro, it is important to focus continuous improvement to meet the changing needs of the tourists (parahoo et al, 2014);
- Parking lots can be created in the heavily populated regions such as Burjman & Union in order to attract the car owners & users.

- Some people get confused on to reach their final destination when they travel through metro. They are not sure about if they can take a bus or a taxi to reach their destination. Since Bus service costs less than hiring a taxi, a route map can be created and implemented by integrating Metro, Bus and taxi together so that people can plan their travel efficiently and effectively.
- Earlier, RTA provided free rides on November 1 across all the mobility services on the occasion of “Transportation Day” in order to urge people to use public transportation. Similar initiatives can be done on public holidays at least once or twice a year in order to attract the executives of both public & private sector to go sustainable.
- Energy management can be done by constructing a System Application Matrix (SAM) using Quality Function Deployment Approach (QFD) and Analytical Hierarchy Process (Rajabi et al, 2016, p.1088).
- After contract completion of SERCO in 2019, RTA can try to manage the operations by itself. This will RTA to save money and help in faster Decision making.

For successful implementation of any metro project, which by its very nature is highly technical and complex, huge in size and to be executed in difficult urban environments, political will and commitment is necessary. Decisions are to be taken fast and the implementing agency must have the required work culture, commitment to targets, safety, quality and cost consciousness. Metro projects are highly capital intensive. On account of the high costs involved and the need to maintain a fare structure within the affordable reach of ordinary citizens, metro projects are not ordinarily financially viable. Let’s look at some of the factors that will be critical for the successful implementation of upcoming metro projects in Dubai:

- Developing a top-level project management plan that can be integrated with the activities of all stakeholders, including the work breakdown structure (WBS) and the organizational breakdown structure (OBS) (Hamdy, 2014);
- Auditing the work of the engineer and the project management company to ensure they are fulfilling their assigned roles within the project;
- Maintaining strong leadership and motivation throughout the project;
- The project can be managed as a portfolio of programs and related technical work (Hamdy, 2014);
- The responsibility of each persons involved in the project has to clearly mentioned, and the person accountable for each of the works involved in the project has to be clearly defined.
- Innovative techniques and IT systems can be used to check monitor the availability of resources and assets in the project, so that they can be utilized to their full potential; Which will also in turn help in saving cost.
- Developing and following a quality management plan (Hamdy, 2014);
- Incorporating sustainable measures and operations.
- Reducing the pollutants and the pollution as much as possible during the course of construction

Additionally, some of the lessons can be taken from the previous construction of Dubai metro Red & Green line. The mistakes and accidents that took place during the earlier project can be noted to improve the overall quality of the project.

8. Conclusion

Dubai has undertaken an impressive urban revolution in terms of infrastructure and development which makes them stay in the race of being one of the most advanced cities in the world. Though metro was built as a response to the growing traffic congestion in the city, it has also boosted the economic development of Dubai in terms of tourism and business travel. Dubai metro has been benchmarked by many countries, for instance, Rizzo (2012) stated that Doha has learned from the Dubai’s usage of Japanese technology for the construction of metro in a bid to serve the city for the upcoming 2022 football world cup. This statement can be used as a reference to prove how the world complements Dubai metro. All these complements and admirations can be credited to the dedication shown by the

Leaders of Dubai and the U.A.E. This paper thus contributes to the theory of service operations and could further be extended by empirical research.

References

- Acuto, M. (2010). High-rise Dubai urban entrepreneurialism and the technology of symbolic power. *Cities*, 27(4), 272-284. doi:10.1016/j.cities.2010.01.003
- Anantsuksomsri, S., Tontisirin, N., 2015. The impacts of mass transit improvements on residential land development values: evidence from the Bangkok Metropolitan Region. *Urban Pol. Res.* 33 (2), 195–216.
- Andy Sambidge, 2009. 50 things you need to know about Dubai Metro. *Arabian Business*. Retrieved From: (<http://www.arabianbusiness.com/50-things-you-need-know-about-dubai-metro-12993.html>) (accessed on May 24, 2018)
- Apics, 2017. SCOR Overview. Retrieved from: https://www.apics.org/docs/default-source/scor/scor_overview-participant-workbook.pdf?sfvrsn=2 (accessed on May 24, 2018)
- Balan Sundarakani, Hira Abdul Razzak & Sushmera Manikandan (2018), Creating a competitive advantage in the global flight catering supply chain: a case study using SCOR model, *International Journal of Logistics Research and Applications*, DOI:10.1080/13675567.2018.1448767
- Bhutani, R, Ram, S, & Ravinder, K 2016, 'Impact of Metro Rail Construction Work Zone on Traffic Environment', *Transportation Research Procedia*, 17, International Conference on Transportation Planning and Implementation Methodologies for Developing Countries (12th TPMDC) Selected Proceedings, IIT Bombay, Mumbai, India, 10-12 December 2014, pp. 586-595,
- Botelle, M., McSheffrey, P., Zouzoulas, P., & Burchell, A. (2012). Dubai Metro: building the world's longest driverless metro. *Proceedings of the Institution of Civil Engineers - Civil Engineering*, 165(3), 114-122. doi:10.1680/cien.11.00071
- Dubai Metro expansion mock-up revealed ahead of Expo 2020. (2017, July 18). Retrieved from <http://www.arabiansupplychain.com/article-13381-dubai-metro-expansion-mock-up-revealed-ahead-of-expo-2020/>
- Dubai Metro Network - Railway Technology. (n.d.). Retrieved from <http://www.railway-technology.com/projects/dubai-metro/> (accessed on May 24, 2018)
- Dubai Metro Network - Railway Technology. (n.d.). Retrieved from <http://www.railway-technology.com/projects/dubai-metro/> (accessed on May 24, 2018)
- Dubai Tram. Dubai Online. (n.d.). Retrieved from: <https://www.dubai-online.com/transport/tram/> (accessed on May 24, 2018)
- Eight important facts about the Hyderabad Metro, politics and nation, 2017. *The Economic Times*. Retrieved from: (<https://economictimes.indiatimes.com/news/politics-and-nation/eight-important-facts-about-the-hyderabad-metro/operations-to-start-from-november-29/slideshow/61831640.cms>) (accessed on May 24, 2018)
- GEORGIA BOBLEY, (2016). 7 Things You Never Knew About the Dubai Metro. Retrieved from: <https://me.popsugar.com/how-to/Facts-About-Dubai-Metro-42235389> (accessed on May 24, 2018)
- Hamdy, K. A. (2014). Lessons learned from the Dubai metro project. Paper presented at PMI® Global Congress 2014—North America, Phoenix, AZ. Newtown Square, PA: Project Management Institute.
- L. Ying, "Study on the Third Party Logistics Outsourcing of Metro Construction Enterprises' Supply Business," 2011 Fourth International Symposium on Knowledge Acquisition and Modeling, Sanya, 2011, pp. 303-306.
- Lu, K, Han, B, & Li, D 2014, 'Early Warning Methodology for Urban Rail Transit Operation Safety: Empirical Study from Guomao Station, Beijing', *Applied Mechanics & Materials*, no. 543-547, p. 4077.
- Metro moves you around Melbourne. Who Are we. Retrieved from: (<http://www.metrotrains.com.au/who-we-are/>) (accessed on May 24, 2018)
- 'Metros' 2007, *Railway Gazette International*, 163, 6, p. 42, Business Source Complete,

- Moreno, MA, Lara, L, & Rojas, O 2016, 'Financial Components Operations Reference Model: a SCOR-based financial model', International Journal of Combinatorial Optimization Problems & Informatics, vol. 7, no. 1, pp. 10-19.
- Mustafa Al Zarooni, (2013). Dubai Metro on expansion track – Khaleej Times. Retrieved from: <https://www.khaleejtimes.com/nation/transport/dubai-metro-on-expansion-track>
- Narayanaswami, S. (2017). Urban transportation: innovations in infrastructure planning and development. The International Journal of Logistics Management, 28(1), pp.150-171.
- Newman, P., Davies-Slate, S., Jones, E., 2017. The Entrepreneur Rail Model: funding urban rail through majority private investment in urban regeneration. Res. Transport. Econ. <https://doi.org/10.1016/j.retrec.2017.04.005>.
- Nilanjana Gupta, (2017). Video: This is how Dubai Metro's driverless trains run like clockwork, Khaleej Times. Retrieved from: <https://www.khaleejtimes.com/news/transport/video-how-dubai-metro-runs-the-worlds-longest-driverless-train-system>
- Operating world's longest fully automatic driverless train system. SERCO. Retrieved from: <https://www.serco.com/sector-expertise/transport/dubai-metro>
- Paschalidou, A, Kassomenos, P, & Kelessis, A 2016, 'Tracking the association between metro-railway construction works and PM levels in an urban Mediterranean environment', The Science Of The Total Environment, 568, pp. 1326-1332,
- 'Research on the identification and classification of human error factors of metro operation without ATP' 2017, 2017 2Nd IEEE International Conference On Intelligent Transportation Engineering (ICITE), Intelligent Transportation Engineering (ICITE), 2017 2Nd IEEE International Conference On, p. 291,
- Route 2020, Journey into the future (.n.d). RTA. Retrieved from: <https://www.rta.ae/links/rail/en/about-metro.html> (accessed on May 24, 2018)
- Route 2020: Red Line Extension to Expo 2020 Site – Dubai, UAE, (n.d.). Retrieved from: <https://www.parsons.com/project/route-2020/> (accessed on May 24, 2018)
- SCRC SME, 2004. The SCOR Model for Supply Chain Strategic Decisions. Retrieved from: <https://scm.ncsu.edu/scm-articles/article/the-scor-model-for-supply-chain-strategic-decisions>
- Serco signs £355m Dubai Metro contract extension, 2013. Serco, media releases. Retrieved from: <https://www.serco.com/me/news/media-releases/2013/serco-signs-355m-dubai-metro-contract-extension> (accessed on May 24, 2018)
- SERCO, (2018) Serco Wins the Road Safety Award at the Global Infrastructure Congress (GIC). Retrieved From: <https://www.serco.com/me/news/media-releases/serco-wins-the-road-safety-award-at-the-global-infrastructure-congress-gic>. (accessed on May 24, 2018)
- Shafaat Shahbandari, (2015). Dubai Metro's Route 2020 station revealed. Retrieved from: <https://gulfnews.com/news/uae/transport/dubai-metro-s-route-2020-station-revealed-1.1638839>, (accessed on May 24, 2018)
- Shafaat Shahbandari, (2017). Dubai Metro Route 2020: Shaikh Mohammad launches drilling work. Retrieved from: <https://gulfnews.com/news/uae/transport/dubai-metro-route-2020-shaikh-mohammad-launches-drilling-work-1.2112061>, (accessed on May 24, 2018)
- Zhong, H., Li, W., 2016. Rail transit investment and property values: an old tale retold. Transport Pol. 51, 33–48

Biographies

Niyazudeen Kamarudeen is a Post Graduate Researcher in the Faculty of Business at the University of Wollongong in Dubai. He received her Bachelor Degree in Mechanical Engineering from the Anna University, India and doing a Master Degree in Engineering Management from the University of Wollongong in Dubai. His current

research interests include Operations Management, Sustainable Supply Chain Management and Service operations management.

Balan Sundarakani is an Associate Professor and Program Director for Master of Science in Logistics in the Faculty of Business and Management at the University of Wollongong (Australia) in Dubai. He has 15 years of teaching and research experience in the area of Supply Chain Management across the various universities including the National Institute of Technology (NIT), Tiruchirappalli, Indian Institute of Technology (IIT), Roorkee, Hindustan University, Chennai and the National University of Singapore (NUS), Singapore and the Chair of Logistics Management in Swiss Federal Institute of Technology (ETH), Zurich, Switzerland. He earned a B.Engg (Distinction) in Mechanical Engineering from M.S University and a M.Engg (High Distinction) in Industrial Engineering from the National Institute of Technology-Tiruchirappalli, a PhD in Supply Chain Management from the Indian Institute of Technology-Roorkee, India and a Post-Doctoral Research Fellowship from the Logistics Institute Asia Pacific, NUS Singapore. So far, he has completed research and consultancy projects for the UOW Dubai, EDB Singapore, IBM, DHL, Ministry of Defence Singapore, Dubai Trade, JAFZA, and RTA Dubai. The total worth of his research and consulting projects are valued around S\$2 Million plus AED 85,000. He has received the prestigious A*Star Fellowship Singapore, MHRD Fellowship India, University Rank and College First Rank.

Mohammed Nabahn is a Director of the Road and Transport Authority (RTA) of Dubai, the United Arab Emirates. He previously worked as a Manager, Operations at the DP World port, one of the leading container port operators worldwide. He holds a Bachelor degree in Information Technology from the AUD Dubai and a Master degree in logistics from the University of Wollongong in Dubai. He has more than 10 years of experience in the field of port operations, road safety monitoring, operations strategy development and supply chain strategy implementation aspects.