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# POSSIBILITIES OF REDUCING TRAIN DELAYS BETWEEN COLOMBO FORT AND MARADANA

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BETWEEN COLOMBO FORT AND MARADANA**

Vithanage Chinthaka Dasun Jayasekara

(138327B)

Thesis submitted in partial fulfillment of the requirements for the  
Degree of Master of Science in Transportation

Department of Civil Engineering

University of Moratuwa

Sri Lanka

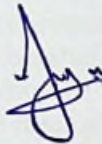
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## DECLARATION OF THE CANDIDATE AND SUPERVISOR

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## ABSTRACT

Sri Lanka Railways (SLR) is operating around 300 passenger train movements daily across its 1400 Km rail network. About 90% of train movements out of this have Maradana or Colombo as the destination or the starting point. It further leads to a figure that around 50 trains which amount to more than 30% of the inbound train service to Colombo is reaching either Colombo Fort or Maradana daily within the morning peak time. All these train movements are using the Colombo – Maradana block section which comprises of only four rail tracks, hence causing a reasonable delay for the morning peak hour train service.

Delay in this particular section is commonly identified as caused by the lack of infrastructure which includes less number of Platforms, inappropriately arranged service feeders (depots) and low flexibility in the signaling system. In addition to this the overlap operation between Colombo and Maradana, which is resulted by always keeping the furthestmost station as the destination or starting point. Overlap operation has created additional train movements which leads the situation to an even worse.

Objective of this research is to find out the root cause for the delay in the Colombo Fort – Maradana section and explore the possibilities of reducing train delays. In this view, the delay portion pertaining to this section is quantified through a survey and it confirms the worthiness of the research. It was then continued to check the actual requirement of continuing the overlap operation and in results, sufficient evidence found for a service restriction. Actual line and platform utilization at present were calculated to find out whether any alterations are required to the systems and operational practices. Train feeding arrangements are also studied for suggesting modifications for the practices in order to catch up the delays. Mainly the issues in reducing the number of train movements in the section and reshuffling the feeding arrangements to achieve this target are addressed in this research.

Key words: Trains, Delay, Platforms, Railway

# DEDICATION

To

**My Loving Parents and Wife**

**Who always persuade me to go forward and wish for my success**

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Passenger count and the passenger survey will not be possible without the assistance of the following officers at Maradana Train Control Office and the Signal Department. Thank you all, Mr. U. G. U. Indika, , Mr. K. L. A. R. Fernando, Mr. B. P. N. Mendis, Mr. K. A. H. Rangajeewa, Mr. K. S. J. Kuruppu, Mr. M. H. I. K. G. Tissera, Mr. J. A. D. T. Sanjaya, Mr. H. M. S. S. B. Herath, Mr. B. V. Gunapala, Mr. S. A Sepali, Mr. K. R. N. Nayanakantha, Mr. W.M.K. Bandaranayake.

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## LIST OF ABBREVIATIONS

ADB	Asian Development Bank
CEW	Chief Engineer (Way & Works)
CTC	Centralized Traffic Control
DMU	Diesel Multiple Unit
ELS	Electric Loco Shed
FOT	Colombo Fort
HLS	Hydraulic Loco Shed
HUN	Hunupitiya
KLA	Kelaniya
KV	Kelani Valley
MDA	Maradana
MLV	Mount Lavinia
MRT	Moratuwa
PND	Panadura
RGM	Ragama
SLR	Sri Lanka Railways
WTE	Wellawatta

# CHAPTER 1

## 1.0 INTRODUCTION

### 1.1 Background

Daily train operation of Sri Lanka Railways (SLR) is around 300 trains of which more than 90% are passenger trains. Passenger trains are operated with more emphasis to cater the morning and evening office traffic. SLR has been able to maintain a reasonable number of trains in both ways in office peak hours but still not catering to the passenger demand; resulting passengers find the service at a very low comfort level. Insufficient infrastructure including shortage of rail tracks and out dated signaling system, inefficient handling and operating practices, disorganized feeding depots, lack of rolling stock and many other factors contributes this scenario.

#### 1.1.1 Operational set up at Colombo Fort and Maradana

Colombo Fort and Maradana are the two main Railway stations at the capital and are the first most railway stations constructed in Sri Lanka. Since any major reconstructions have not been taken place over the decades, the original setup at the commencement of railway transport at 1864 has been continued with developments. All train feeding points, running repair points, locomotive and train maintenance centers and even the freight handling points are situated around these two main stations even today. Train operation handling practices are too continued to be settled down using these two stations as a hub. But of course the facilities, technology, qualitative and quantitative enhancements are updated to cater for the present capacity. The rapid increase of number of trains and the number of train movements and operations over the last few years is now causing obstacles and forces the department to adopt different alternatives. As a result of the rapid increase of train movements, now the train congestion is forming up around Colombo Fort and Maradana. Sri Lanka Railways have to find a way out either by optimizing the resource utilization (short term solution) or step in to a restructuring and reconstruction of infrastructure set up (long term solution).

### **1.1.2 Infrastructure availability**

Colombo Fort and Maradana stations are located adjacent and at about 1.5 km distance apart connected by four tracks in between. Colombo Fort is connected to the coastal line over two tracks (Up and Down) while Maradana is connected to the Main line over three tracks. There are 10 and 11 platforms at Maradana and Colombo Fort respectively. Line flexibility is at an adequate level ; there are more than 100 turnover points around Maradana over which the trains could be deviated from one track to another while Colombo Fort is having more than 25 such points.

Both stations are provided with Centrally Controlled Colour light Signaling including block signaling facility which enables 90 second headway between two stations and 180 seconds headway at entry points to each station from main line and coastal line. Average operational headway in main line is 3 minutes and 45 seconds while 4 minutes and 40 seconds in the coastal line (ADB, 2016).

There are some locomotive and rolling stock maintenance facilities connected to two stations. Three locomotive maintenance sheds (Hydraulic Loco Shed, Electrical Loco shed and Running shed), Three Diesel Multiple Unit (DMU)/Power coaches unit sheds (S11, S9&10 shed and S8 Shed) and one coaches shed (Maligawaththa shed) are connected to Maradana while One DMU shed (S9, 10 &12) having connectivity to both Maradana and Colombo Fort. In addition to this a Goods Shed (Colombo Yard) and a maintenance facility node (Turn table – a Loco turning facility) and track maintenance node (loading yard and CEW siding) is also connected to Maradana. As such, Maradana yard area is having eight connections on left and right each having dependencies over other and hence creating cross movements across the main lines.

### **1.1.3 Present way of operation - Feeding**

Responsibility of train feeding for the service and fleet management is lying with the feeding depot management. Depots are expected to perform the running maintenance and running repairs too. Central Controlling Centre coordinates with the depots to get and send back the empty trains. Controlling center is having the decision power of the operations and hence dominates the feeding and sending arrangements.

Apart from the DMUs and Power sets all other trains (passenger and goods) are formed at the Colombo goods shed and Maligawatta coaches shed with the locomotives provided by the three locomotive maintenance sheds around Maradana namely Hydraulic Loco Shed, Electrical Loco Shed and Running Shed. This combination of 03 Locomotive sheds and 02 coaches and goods wagon sheds creates a considerable number of train movements which most of the occasions lying across the main up and down lines at Main line end of Maradana. This includes the movements to the Track Maintenance nodes (loading and CEW siding) and movements to the maintenance facility node – Turn table where the coaches and locomotives are sent to Turn around the Heading direction.

Shed and yard connectivity is illustrated in the following diagram.



**Figure 1 : Distribution of Feeding Depots and Maintenance Facilities around Colombo Fort and Maradana (Google maps)**

#### **1.1.4 Present way of operation - Scheduling**

Train operation scheduling in Sri Lanka Railways is having more emphasis on catering the office traffic. Therefore it is very common to observe that in any line, the number of the trains will be more towards Colombo Fort and Maradana in the morning and more outwards in the evening. Trains reaching Colombo Fort and Maradana records around 5 minutes headway in the morning peak between 7.30 am to 8.30 am which is considered to be the busiest hour in the network time table and figures out to 13 trains from Main Line and Negombo Line using the Maradana end of admission (3 entry lines) and 10 trains from the coastal line using the Colombo Fort end of admission (2 entry lines). This figure excludes the Kelani Valley line (KV line) intake which is around only 5 trains and does not contribute to the problem.

Next majority apart from the office trains are long distance trains. Long distance trains are more using coaches sets than the office trains. Several long distance trains and suburban trains are too forming up and departing inside the office peak. This factor too contributes to morning rush by increasing the train movements in Colombo Fort and Maradana area.

#### **1.2 Problem Statement**

Significant train delays are being reported between Colombo Fort – Maradana section in the morning peak. Most of the morning peak trains are stopped at the admission signals at Colombo Fort (both from coastal and main line sides) before they are been admitted to a platform. This includes the trains which have reached Colombo Fort or Maradana without any delay on the way.

Delay at the admission signals causes inconvenience to passengers resulting inconsistent reaching times to the destination. Sri Lanka Railways loosing the reliability of operation as a service provider and subject to bitter criticism among public. Further SLR is continuously failing on remedy the issue creating lot of frustration to its customer base.

Daily over 200 000 passengers are reaching Colombo and out of that at least 100 000 passengers travelling on morning traffic become victims of this situation. Average

daily passenger volume (both direction in 2009) between Colombo Fort – Maradana is 136,438 (ComTrans, 2014). If the average delay is taken as one minute per train, this time loss at the admission signals can cause a cumulative loss of more than 1600 (100000x1/60) man hours daily and this excludes the fuel loss. The actual figure is even more than that as the time lost at stopping and starting itself of a train is more than 1 minute. Therefore the issue has a contribution and impact on the country's economy too.

Despite of the delay experienced at admission signals, passengers tend to select Colombo Fort as their preferred terminal. This is mainly due to the road connectivity to the final destination and situation of employment locations and public amenities. Colombo Fort therefore has the most passenger movements among the four main passenger terminals namely Dematagoda, Maradana, Colombo and Secretariat Halt and hence consumes more time than the other main stations for entrain and detrain.

### 1.3 Objectives of the Research

Two objectives are targeted in the research;

- A. To find out the existence of the issue and quantify the actual delay and the impact to daily service.
- B. To find out the root cause for the delay experienced while admitting the morning peak trains to Colombo Fort
- C. To propose alternatives to solve the issue

### 1.4 Scope of the Research

**Project area:** Even though the trains arriving from both directions are getting delayed at the admission, operation at Colombo Fort is not solely responsible for the total train delay. Therefore the accumulation of train delay needs to be monitored over a selected region to quantify the delay pertaining to Colombo Fort Maradana section. Further the delay accumulation data would be required in evaluating the significance of delay occurred in the said section and to assess the impact of same. In this context the scope of the research needed to be widened from Colombo Fort to Panadura in the coastal line and Colombo Fort to Ragama via Maradana. Research area starts



from Panadura in the coastal line and run up to Ragama in the main line. KV line is excluded as it does not contribute for the said delay.

**Level of Infrastructure:** Availability level of infrastructure was explored to find out their contributory level. This includes the available number of platforms at both major stations; Colombo Fort and Maradana, locations of feeding depots, level of automation in the sense of signaling and available number of tracks between and towards the two major stations.

**Operational practices:** Operational related practices including fleet management , line utilization and train scheduling too were explored under the research.

Another main concern under this will be the overlap operation of trains between Colombo fort and Maradana which may contribute for the delay because of the generation of additional movements as a result. Trains running towards main line (Badulla and Jaffna) are started from Colombo Fort while the trains starting towards coastal line (Galle and Matara) tend to start from Maradana. Similarly trains arriving from coastal line runs up to Maradana while trains arriving from main line runs up to Colombo Fort. This has been the railway practice for over the years and would have adhered for the benefit of the passengers.

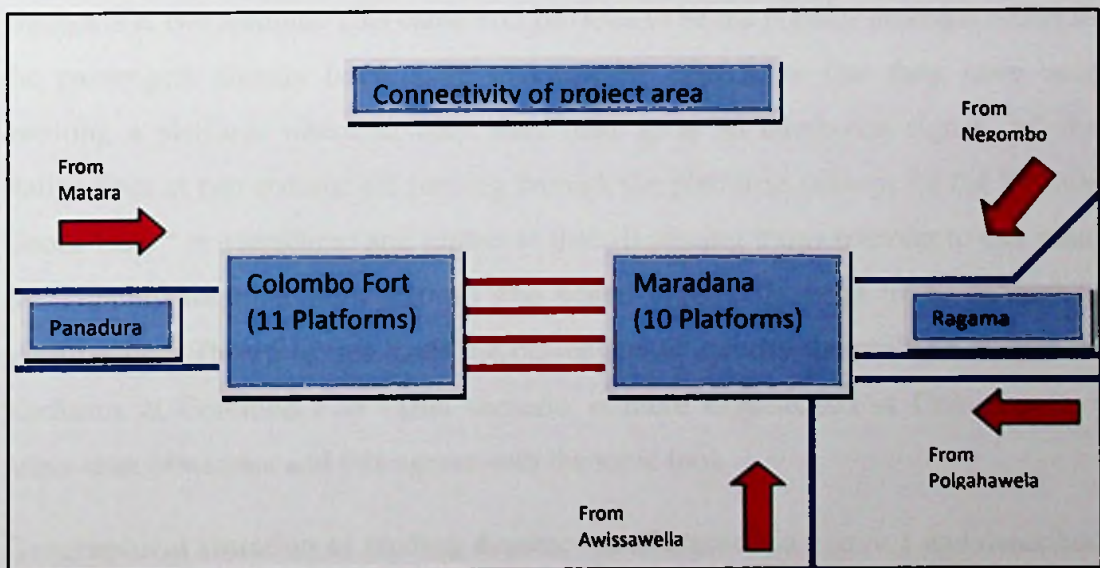


Figure 2 : Connectivity layout of project area



## 1.5 Hypothesis

Probable causes for the delay at Colombo Fort – Maradana were identified as per the common view.

**Overlap operation:** As illustrated in figure 2 , Colombo Fort and Maradana are two close by stations and connectivity is through four (04) access lines in the mid area (this is the same area where the trains are getting delayed when admitting to Colombo Fort). Practice of starting and ending of trains from and to, the furthest station causes an additional occupation time of access lines and increase the number of train movements. This can result in an increased demand for the platforms. Further could be explained as an increased demand for the Colombo Fort platforms as the morning peak creates a converging traffic towards Colombo Fort in the morning. While the trains from main line approaching to Colombo, there can be trains at Colombo Fort platforms awaiting the access line for starting towards main line or to reach their respective sheds around Maradana. This increases the demand for access lines as well as for platform lines. Negotiation give rise to hold the trains either at platforms or at admission signals till the demanded passage gets free.

Therefore the overlap operation creates can be a probable cause for the problem.

**Lack of Platforms:** Most discussed among the public is the insufficient number of platforms at two stations. This cause will obvious to be the popular amongst others as the passengers already have come to know by experience that they have been awaiting a platform whenever they were held up at an admission signal. All the station lines at two stations are running through the platforms (except for the “ Down Goods Line “ at Maradana) and further to that all passing trains relevant to this issue are stopping trains at both stations and hence necessarily need to go through a platform line. Therefore this leads the passengers to identify the problem as lack of platforms at Colombo Fort (This scenario is more experienced at Colombo Fort rather than Maradana and this agrees with the topic too).

**Geographical situation of feeding depots:** As illustrated in Figure 1 and described in chapter 1.1.3 geographical situation of yards, sheds and maintenance facilities already generates additional movements around Colombo Fort and Maradana

stations. These additional movements hinder the through movement across Maradana and hence slow down the trains to get rid from the four access lines between Colombo Fort and Maradana. Further to that above situation results the four access lines more occupied. Additional occupation could consist of six main movement categories; trains getting admitted to Colombo Fort (passenger), Trains starting towards mainline from Colombo Fort (passenger), Trains admitting for forming up trains(empty), Trains starting towards coastal line (passenger), Trains running towards Maradana from coastal line (passenger) and trains leaving to depots (empty).

Two empty train movements are totally unacceptable at a peak hour but still takes place due to poor location of feeding depots resulting unnecessary rush at the four access lines. This situation too can contribute a lot as cause for the problem.

Accordingly following facts may become probable causes for the delay experienced while admitting the morning peak trains to Colombo Fort.

- a. Overlap operation
- b. Lack of platforms
- c. Geographical situation of feeding depots

## **1.6 Methodology**

Research will be carried out under two stages to reach the objectives of the project.

A quantitative approach is planned at the first stage to find out the importance of the research. Existence of the problem will be verified using actual data and Impact of the delay will be quantified.

After establishing the existence of the problem, possible causes will be researched at the second stage to find out the contributory level of them which were discussed under project hypothesis.

### **1.6.1 Confirmation of existence of the problem**

**Explore the delay accumulation:** A two day survey is carried out using actual data from the SLR sources to find out actual delay of arriving trains both from main line and coastal line directions. For this two consecutive days were selected to omit any day related extraordinary consequences. Further the delay was monitored from the entry points to the metropolitan region (Ragama and Panadura) and accumulation of delay is calculated up to Maradana and Colombo Fort as applicable for two entries.

**Quantify the delay and find the impact:** On the results of above, percentage delay pertaining to this section was calculated over the total delay of each train to figure out the delay contribution of the section and hence to find out the impact on the overall train service. This approach will finally lead to determine whether this study really addressing an existing issue.

This is proven to be addressing and comprehensive description will follow in succeeding chapters.

### **1.6.2 Solution research**

**Passenger survey for overlap operation:** Passenger survey has been carried out to check whether the overlap operation is really required and is that really serves the passenger requirements rather than satisfying the operational needs. This was done in two means; getting a questionnaire answered by the passengers and counting the passengers getting down after using the overlap operation (benefitted number of passengers). Objective was to find out the percentage of passengers travelling across the main stations using the overlap operation.

Passengers getting down at Maradana coming passed Colombo Fort was counted to check the overlap usage of coastal line. This method was not practical over the main line as the continuation of arriving trains runs up to several destinations passing Maradana (overlap operation) whereas in the coastal line almost all the arriving trains ends at Maradana, single destination after completing the overlap. Therefore a different method; a questionnaire survey has been carried out to find out the successfulness of the overlap operation on the main line.

**Track and Platform utilization:** Train occupational data of platforms and admission lines (coastal line and main line directions) at Colombo Fort was calculated using track occupational data obtained from the Railway Signal Department data bases. Platform utilization was checked by mapping the occupation time and free time of platforms to determine whether the lack of platforms is a contributing factor for the said delay.

**Fleet arrangement:** Arrangement of feeding depots and SLR practices were studied for finding out the contributory level of the fleet arrangement for the said delay problem. It was explored with an emphasis for the coastal line as sufficient evidence was revealed at the initial surveys for the problem research to convince that reshuffling of coastal line fleet arrangements would deliver successful results in solving the delay under discussion. Hence coastal line feeding arrangements were closely studied.

Accordingly Feeding depot locations and fleet arrangement was checked against the possibility of re-shuffling and relocation.

## **CHAPTER 2**

### **2.0 LITERATURE SURVEY**

#### **2.1 Trains Vs. other Modes of Inland Transport**

Train has become the end to end leading inland transport provider because of the salient features posses and will continue for the future in the same phase of development. Speed, convenience, Cost effectiveness and scheduled nature of operation have put the train on top of the other inland transport modes. Not only for the passengers but this concept applies for the freight as well. Sri Lanka Railways has the same experience over the other modes specially for long distance.

Further detail of trip distance by mode indicates that railway users have the longest trips in which the average distance is about 25 km (ComTrans, 2014).

Rail transport plays an important role in the development of a country. The rail transport network is considered as one of the important modes of public transportation to meet the diverse expectations of urban economic activities due to the fast growing population growth of the nation. For most countries, it is a major service provider for both passenger and freight transportation (Alwadood & Shuib, 2012).

#### **2.2 Delay**

Being the delay between Colombo Fort and Maradana is the topic of the research, a broad investigation on contributory factors by which such delays shall result and study on the term “delay” itself on relevance to the train operation is required to be carried out. There are certain terms bounded with term “Delay”. Schedules, timetables and disruptions are some of them.

##### **Schedules and time tables :**

A schedule is a broader version of the time table. When a train is concerned the timetable provides the information of running times of train including the expected times of other time related activities such as arrival time, departure time, entrain , detrain, etc. Schedule provides information on expected times and sequences of

predetermined events or a series them. To add to the above explanation on timetable, schedule can include the planned arrangement of forming the train set, feeding depot, arriving platform, waiting time at the yard exit, expected time of the crew arrival and much more where timetable becomes a subset. What prevent the events taking place on schedule are disruptions and such prevention not necessarily need to be a time related but can be a prevention of the sequence of events. There are many various definitions on these delay related terms.

### **Disruption**

Occasionally, there occur unexpected events which lead to the inability of train to run within their Scheduled timetable. Such event is termed as disruptions. Disruption is defined as an event or a series of events that renders the planned schedule for aircraft, crew or other time table to be infeasible. Service disruptions in most cases often lead to non-adherence scheduled time table and thereon leading to service delays. Rail service disruptions do not only occur in less developed countries, but also in highly developed countries where the services are advanced and equipped with sophisticated technology and infrastructures (Alwadood & Shuib, 2012).

### **Disruption results delays**

Delay of a train can be defined in various ways and delay is identified in different categories.

If, on some segment of its journey, the actual running time of a train exceeds the scheduled running time, a delay occurs. It is called a primary delay, if the cause of disruption lies within the process itself. Through the interdependence in the operations this delay may be passed and thus cause delays in other processes which otherwise would have been on time, resulting in secondary delays (Meester & Muns, 2006).

Cascades were usually coded as transportation delays instead of their root cause. The type of delay which resulted from earlier delays of other trains, however does not depict the true situation of the problem. This will unintentionally leave the real root of delay causes unnoticeable (Alwadood & Shuib, 2012).

On a general level, Delays can be categorized into two different groups: Primary delays and secondary delays. Primary delays are delays caused by the technical systems, human behavior or other external factors such as severe weather conditions. Examples of sources of primary delays are faults on switches, signaling and rolling stock or stops taking longer time than planned. Primary delays can be influenced by choice of technology, education of personnel, weather conditions, wear and maintenance of infrastructure and rolling stock. A secondary delay occurs when the source of the delay is another train. The most common reason for this delay transfer is that several trains need for same resource at the same time and thus have to wait for it to get free. Such resources can be signal block sections, switches or platform tracks at stations. A source for secondary delay is not due to lack of resources is when a connecting train gets delayed because it awaits the late arrival of another train (Lindfeldt, 2012).

### **Delay affects badly on the image of the operator**

All the salient features of a rail transport are bounded by the punctuality. Trains bring Speed, Cost effectiveness and comfort because of the scheduled operation. Loosing punctuality will result losing everything else.

Train service is highly affected by unavoidable disruptions representing the operational difficulties, such as traffic, load, accidents, maintenance problems or other operational difficulties. These factors are regarded as the common drivers affecting the punctuality of the service rendered. When disruptions occur, trains become oversaturated, bottle necks are created, travel times are extended thereby causing annoyance among the passengers. (Alwadood & Shuib, 2012)

### **Catching up “Delay”**

There are delay catch up strategies like “Allowance and Buffer time” allowing or adding time onto the timetable making timetable softer.

**Buffer Time** is the time between trains in the time table. Larger buffer times reduce the probability of delay transfer between trains but also decreases the capacity. The amount of buffer time needed between trains depends on signaling system, infrastructure layout and expected severity of the delays. Often, minimum values for

buffer times in different situations are used in the timetable construction, e.g. at crossings and overtaking . (Lindfeldt, 2012)

**Allowance** is extra time in the timetable that is added to the scheduled timetable of trains. It can both be used to extend the running time between stations, running time allowance, or to make longer stops, allowance at stations. In both cases, the allowance can be used by the train to recover from suffered delays (Lindfeldt, 2012).

### **2.3 Other Contributory Factors for Delay**

Apart from the above categorization of delay, there are many contributory factors for delay accumulation. Designing parameters of the time table and the flexibility of track and signaling layout can contribute a lot on coping up with delay. Above described catching up methods and catching up operations may not be feasible if the yard designing or the timetable planning is not up to the mark.

All factors are interdependent. Capacity of a railway line affects the headway of same and the track layout affects the safety of operation and safety acceptance affects the signaling system. All these in combination affects the flexibility of specially at a junction station.

#### **Headway and Capacity**

Improper design of “Headway”; the minimum allowable time distance between two consecutive trains on the same direction without having due concern to the capacity too is a contributory factor for delay.

Shorter block sections give shorter minimum headway times, and given a limited number of block sections on a line section, they should be designed so that they have as equal occupancy times as possible. This implies that the block sections should be shorter where the trains are moving slower (Lindfeldt, 2012).

The most important factor for the capacity is the number of tracks on the line. The most common configurations are Single, Double, and quadruple tracks. In general the capacity of a double track is four times that of a single track, and a quadruple track there times that of a double track given a fairly heterogeneous traffic (Lindfeldt, 2012).



### Flexibility of signaling system

Signalling combined with track layout can be crucial to capacity (Lindfeldt, 2012).

Signalling incidents on average affect more than twice as many trains as rolling stock incidents (Figure 3) and cause at least 50% more total train delay time per incidents than passenger incidents (Figure 4) (Barron, Melo, Cohen, & Anderson, 2013).

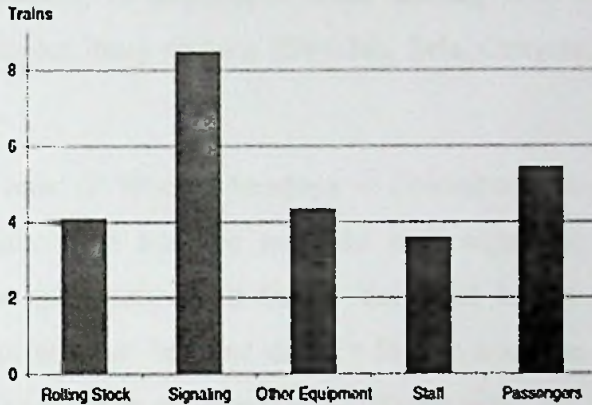


Figure 3 : Average no. of trains affected per incident in a metro system (Barron, Melo, Cohen, & Anderson, 2013)

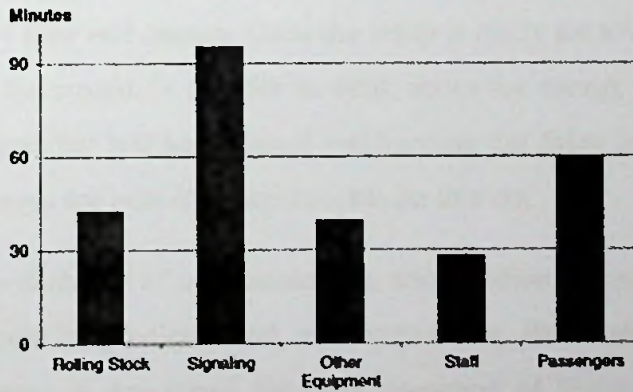


Figure 4 : Average train delay per incident in a metro system (Barron, Melo, Cohen, & Anderson, 2013)

Signalling therefore play an important role on delay accumulation. Optimization of the existing track layout or the operational practices will not be possible without a Proper engagement of the signaling system. Sometimes the signaling system may

first need to up graded than a track layout in view of resulting the optimum output of the existing setup. This suggests that any study focused on train delay shall pay a sufficient consideration on the existing signaling system.

#### **2.4 Robustness against Delay**

When two trains come too close together on a shared infrastructure part, a conflict occurs with delay propagation as a consequence. Increasing the time span between these two trains works beneficial for the robustness of the system. Doing this for all pairs of trains, however, is impossible when dealing with highly used railway bottlenecks like complex, busy stations (Dewilde, Sels, Cattysse, & Vansteenwegen, 2013)

This is the exact case at When Maradana – Colombo Fort section considered. Situation at Colombo Fort may be possible with adjusting the timetable with increasing the time span between trains as described in the chapter 2.2 under “Allowance and Buffer time” but that doesn’t fit into a station like Colombo Fort. There the situation needs to be addressed in a different way.

#### **2.5 Delay Consumes Energy**

Although the expected level is not yet arrived, the next step a railway system will into is the conservation of energy through delay mitigation. Stopping and start consumes much of time and energy. Once the setup is ready for avoiding the queuing up of trains then the system is eligible to think about the energy efficiency; not by infrastructure change but just be punctual and keeping the delay in control. Efficient and punctual railways are now into experiments on this era.

With the broad availability of communication and position technology, the time of signal changes could be predicted and convey to trains. Based on this information, Green Wave strategy is developed for daily operation of Dutch railway network. Green Wave strategy means anticipating slow down the train in front of conflicting area to make the train face only Green signal aspects. Computational experiments turn out that the Green Wave strategy is an effective way to reduce energy consumption (Yun, Tinkin, & Baohua, 2011)

## CHAPTER 3

### 3.0 METHODOLOGY

A two day survey has been carried out both for trains arriving from the main line and trains arriving from the coastal line. Train service was monitored from the entry points to the metropolitan areas from two directions and delay accumulation was calculated. Since the research focuses on the morning peak, only a limited span; trains scheduled to arrive Colombo Fort from 0600hrs to 0900hrs was monitored.

Delay at the entry point was taken as the reference. It was not practical to explore the delay on individual train basis; therefore the total delay of all trains at the referred point was mapped. Accordingly the result shows a collective picture of the morning traffic and some trains which have reported right time arrival are not distinguished as a result. But analysis of individual trains will be carried out at 3.2 in calculating the percentage delay.

Sample days for the delay survey were 26.06.2014 and 27.06.2014.

#### 3.1 Explore the Delay Accumulation

Collective delay is mapped separately for Main line and Coastal Line and the trains in concern are as follows (Table 1).

Table 1 : Peak traffic schedule at Colombo Fort

Main Line		Coastal Line	
Train Number	Scheduled arrival at Colombo Fort	Train Number	Scheduled arrival at Colombo Fort
1507	05:38	8309	06:22
1512	05:57	8311	06:54
1516	06:21	8310	07:02
3800	06:28	8317	07:22
1518	06:33	8316	07:35
3801	06:57	8320	07:40
4856	06:57	8063	07:45
1527	07:22	8313	07:50
1528	07:35	8327	07:52
3803	07:35	8326	07:56
1535	07:40	8324	07:57
3805	07:30	8097	08:10
4857	07:40	8328	08:23
1531	07:52	8325	08:29

1530	08:01	8333	08:33
1537	08:01	8059	08:43
1525	08:03	8335	09:01
1538	08:05		
3809	08:05		
1526	08:11		
3808	08:21		
1529	08:24		
1534	08:25		
1542	08:33		
4859	08:35		
1536	08:40		
3810	09:00		

(SLR time table)

### Main line

Main line Delay accumulation on 26.06.2014 and 27.06.2014 is illustrated bellow (Figure 5 and Figure 6). Total delay of all peak trains were calculated in relevant to different sections leading destination starting from Ragama. Sections will be Ragama (RGM) – Hunupitiya (HUN), HUN – KLA (against Kelaniya), KLA – MDA (Maradana) and MDA – FOT (Colombo Fort). Intention is to compare the cumulative delay pertaining to Colombo Fort – Maradana section other preceding sections.

Accordingly cumulative figure of delay of all peak trains between RGM – HUN was 29 minutes and trains has further recorded 23 minutes delay between HUN – KLA and subsequently 75 minutes further between Maradana and Colombo Fort (Figure 5).

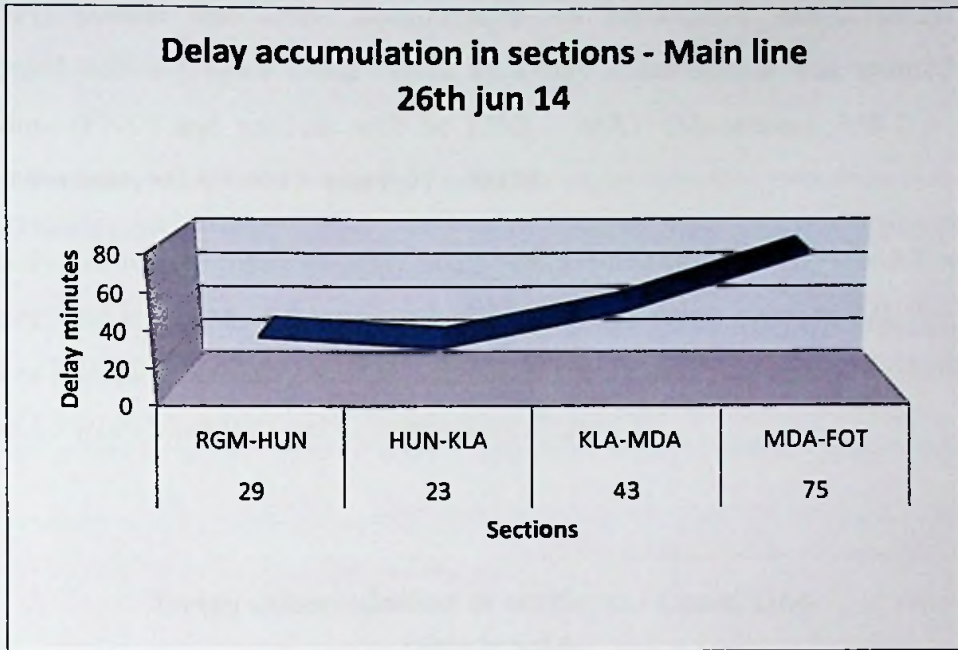


Figure 5 : Delay accumulation of Main Line trains between RGM and FOT on 26.06.2014 (SLR train records)

Same pattern is repeated on the following day with a deviation at KLA – MDA section but still the MDA – FOT records the higher accumulation with a very close figure to the previous day (Figure 6).

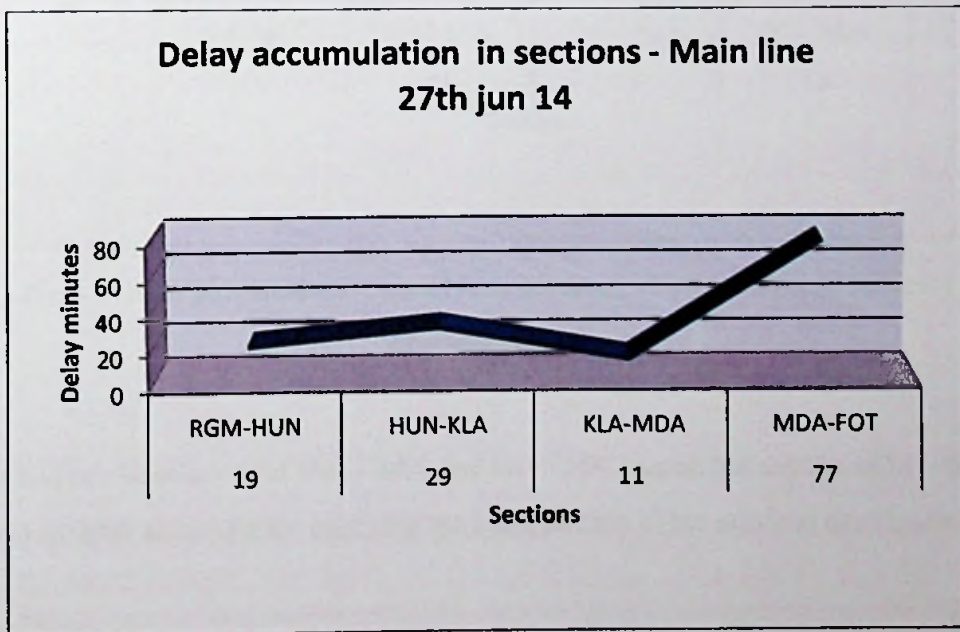
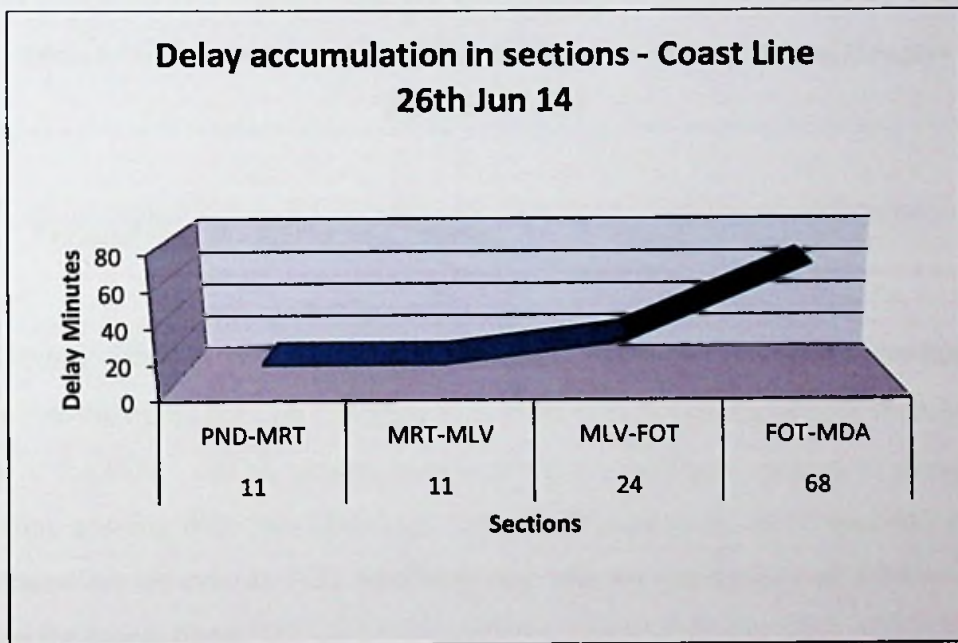


Figure 6 : Delay accumulation of Main Line trains between RGM and FOT on 27.06.2014 (SLR train records)

## Coastal line

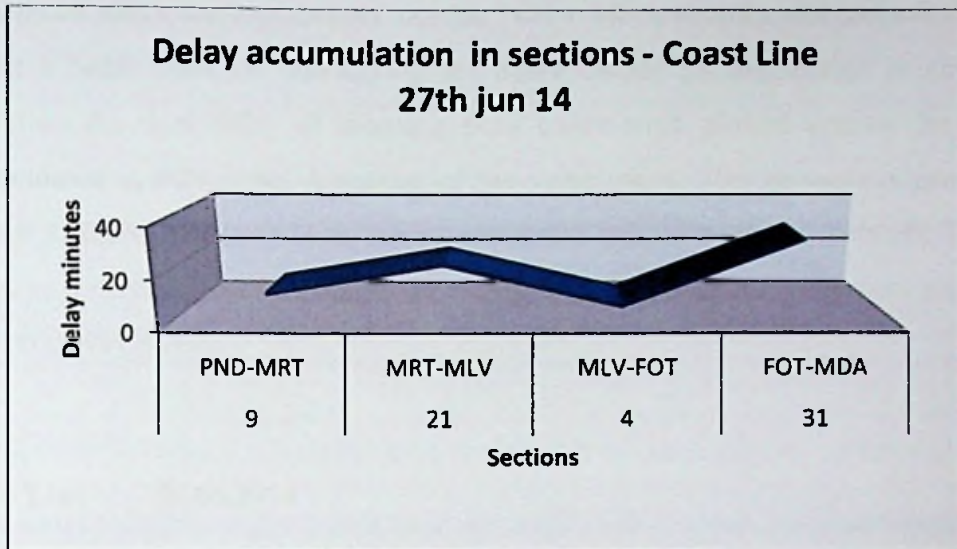
Similarly coastal line Delay accumulation on 26.06.2014 and 27.06.2014 is illustrated bellow (Figure 7 and Figure 8). Delay accumulation was counted from Panadura (PND) and sections will be PND – MRT (Moratuwa), MRT – MLV (Mountlavinia), MLV – FOT and FOT – MDA.

Similarly cumulative figure of delay of all peak trains between PND – MRT was 11 minutes. and trains has further recorded 24 minutes delay between MLV – FOT minutes including the delay at FOT admission signals and subsequently 68 minutes further between Maradana and Colombo Fort (Figure 7).



**Figure 7 : Delay accumulation of Coastal Line trains between PND and MDA on 26.06.2014  
(SLR train records)**

There had been deviations at MRT – MLV and MLV - FOT section but still the MDA – FOT records a higher accumulation following the same pattern of the previous day Figure 8.



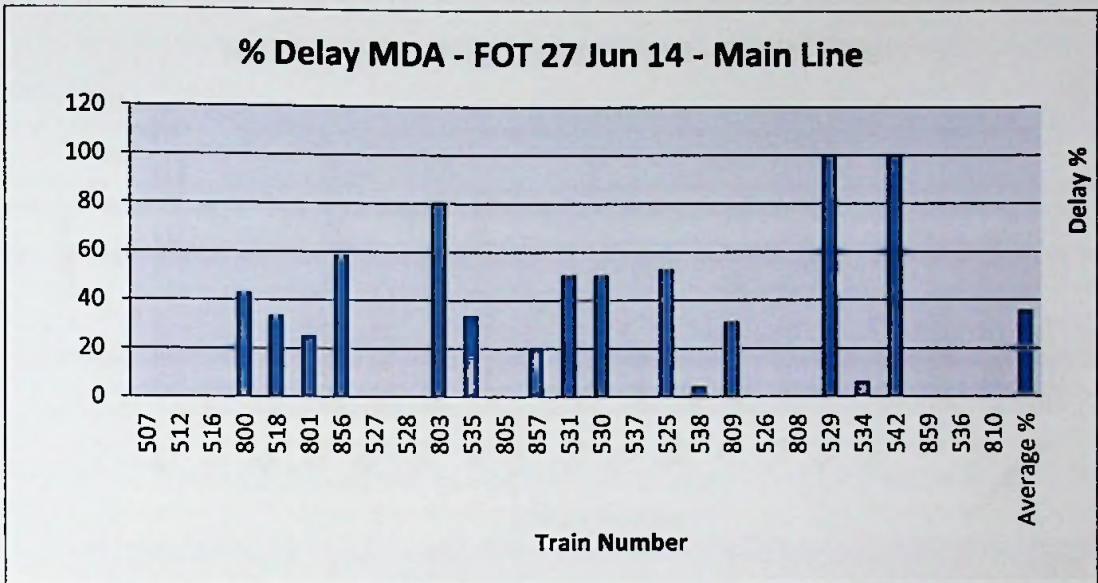
**Figure 8 : Delay accumulation of Coastal Line trains between PND and MDA on 27.06.2014  
(SLR train records)**

### 3.2 Quantifying the Delay and Impact

**Percentage delay in the FOT – MDA section:** Sufficient evidence were found to prove that the trains arriving Colombo Fort from both directions records their highest delay at the FOT – MDA section despite of the two different natures of demand of the trains arriving from two directions; main line trains awaits platforms and coastal line trains are already at FOT platforms but seeking permission to FOT – MDA section for access lines.

Above presentation of data were focused on the cumulative delay. Hence the quantifying could be done on the basis of morning peak delay over the total daily train delay which will not give a productive outcome when the topic is concerned. Obviously morning peak delay will be a high figure still makes no sense as the delay outside the peak is different from the delay inside the peak. Minute (Time) value is very high at the peak and low at off peak and sometimes could be negligible on particular time spans on particular trains, all nevertheless be calculated to be contributed in the daily delay with the same weightage.

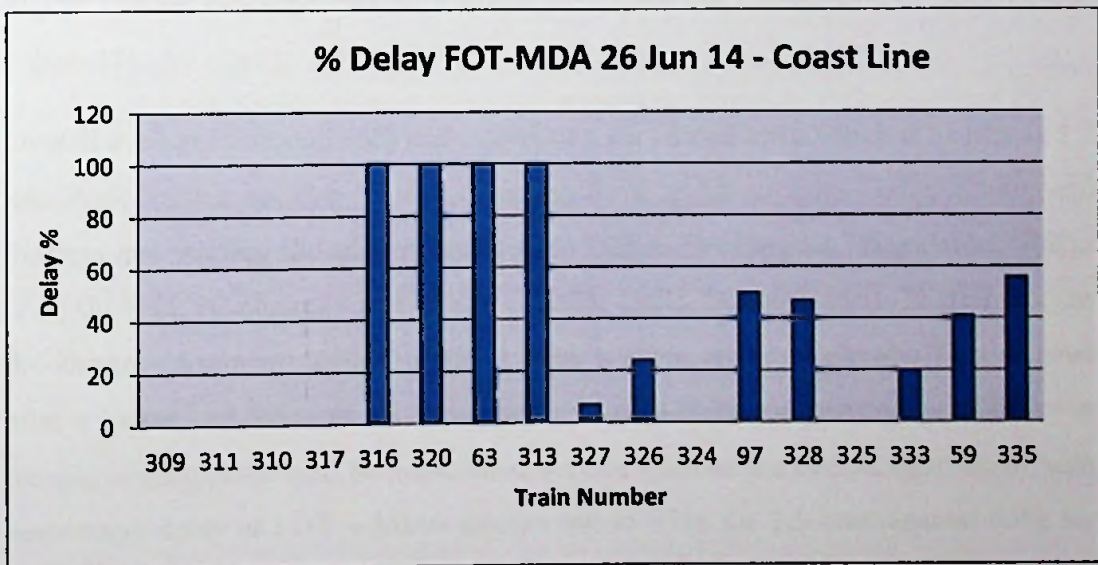
**Main Line - 27.06.2014**



**Figure 10 : Percentage delay of each Main line train in FOT – MDA Section on 27.06.2014  
(SLR train records)**

Following the previous day there are 3 trains which has recorded all their delay (100%) in the FOT – MDA (Trains 529 and 534). Average delay is 35% (Figure 10).

**Coastal line - 26.06.2014**



**Figure 11 : Percentage delay of each Coastal line train in FOT – MDA Section on 26.06.2014  
(SLR train records)**



Coastal line - 27.06.2014

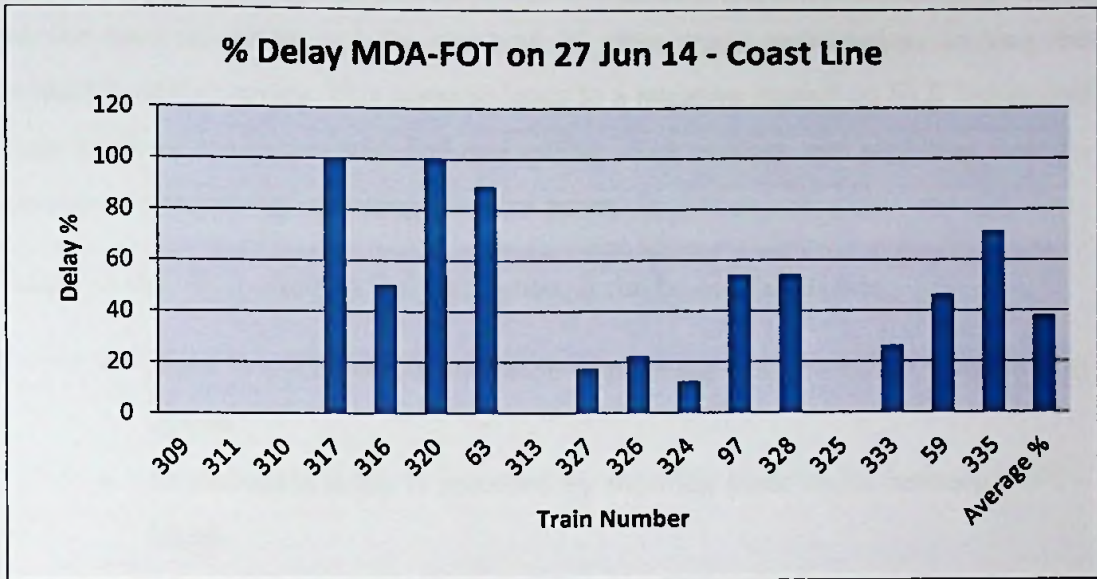


Figure 12 : Percentage delay of each Coastal line train in FOT – MDA Section on 27.06.2014

(SLR train records)

### 3.3 Establishing the Existence of Research Problem

Considerable percentage of the delay of peak service trains are recorded between FOT and MDA. Average percentage on main line is 34 % and 35.6% (Figure 9 and Figure 10) for two days and 37.9% and 37.7% for the coastal line (Figure 11 and Figure 12).

Overall average is around 35% and occurs at a very small span which is as low as 1.5 km. Peak service consists of trains starting from as far as from Galle, Kandy and Puttlam and starting distance range is from 30Km (Veyangoda, Kaluthara), 70Km (Polgahawela, Aluthgama) to 100 Km (Kandy, Galle, Bangadeniya). Therefore even the shortest distance traveled trains at Peak service arrives Colombo Fort at least after a journey of 30km at a average delay of 65%. Increase percentage of delay at the converging point is to be understood but not without the due recognition of high percentage delay at FOT – MDA figures out to 35% for 1.5 kms against 65% for 30Kms.

It is totally unfair and frustrating in the passengers' point of view to keep them waiting after reaching Maradana or the coastal line admission at Colombo Fort at a

considerably low delay, zero sometimes. Waiting time varies can be low depending on the time of arrival and the reaching of other trains nevertheless loosing the reliability of the service. This scenario leads to a negative impact on SLR image and loses much of manpower with fuel and rolling stock wastage and signaling wastage too due to unnecessary operating of signal gears.

Based on the above analysis and description, it can be concluded that;

- There is a problem at admission of morning peak trains at Colombo Fort station.
- Considerable delay is recorded by morning peak trains between FOT – MDA.
- Delay is quantified to be not less than 30% out of total delay recorded by peak trains for the full journey.

Conclusions were arrived using the actual data and with the intention of quantifying the depth of the problem. Therefore sufficient evidence revealed to establish the existence of the research problem and justify the importance of research.

## CHAPTER 4

### 4.0 RESULTS

Following the project hypothesis, following probable causes will be checked against their actual contribution or existence. The level of contribution will also be investigated under the research, if the probable causes found to be contributing.

- a. Overlap operation
- b. Lack of platforms
- c. Geographical situation of feeding depots

Different methods were used in checking the existence and contribution of above a, b and c.

Accordingly the overlap operation can be an operational requirement itself or existing due to passenger benefit. Operational aspect of this will be explored under the “fleet arrangement and geographical situation of feeding depots” in chapter 4.3 and the passenger demand on the overlap operation will be discussed under chapter 4.1.

#### 4.1 Delay Contribution by Overlap Operation

Contribution of the overlap operation could be checked based on the level of service conducted in the overlap area. Following kind of services (Table 2) are to be performed over the overlap area ; the four access lines between Colombo Fort and Maradana.

Table 2 : Train occupation data for FOT – MDA section in morning peak

Category	Description	Direction	Occupancy	No. of trains
A	Trains starting from FOT towards main line	Up	Loaded	19
B	Trains arriving from coastal line and leaving FOT towards MDA	Up	Loaded	17
C	Trains arrived from main line and leaving FOT towards depots. (after completing the service)	Up	Empty	15
D	Trains starting from MDA towards coastal line	Down	Loaded	13
E	Trains reaching Colombo Fort from main line	Down	Loaded	19
F	Trains reaching Colombo Fort from feeding depots (forming the trains towards main line)	Down	Empty	16

(SLR time table)

Train dispatching schedule for the peak hour was checked against the above movement categories for finding out the contributory level of the overlap operation. Trains from main line and the coastal line were only considered and Kelani Valley (KV) line was exempted. There are 99 train movements need to be performed over these access lines within the morning peak (06.00 to 09.00hrs). Out of the total of 99, there are 31 empty trains against 68 loaded trains.

It was observed that the out of four access lines between FOT and MDA only three lines are functioning efficiently and the newest line (fourth line) is yet to be modified in signaling aspect to make the line fully available. At the moment the fourth line is operating in a restricted version with having less flexibility in terms of connectivity and Block occupation. Fourth line is connected to only Number 10 platform at MDA and to Number 9,10 and 11 platforms at FOT. In addition to this there is a limited connectivity from the fourth line to other three lines only for the up direction and only at the FOT end. This low flexible and low available fourth line hence used almost only to tackle the Kelani Valley line operations. Platform connectivity at FOT to access lines is illustrated in Figure 13.

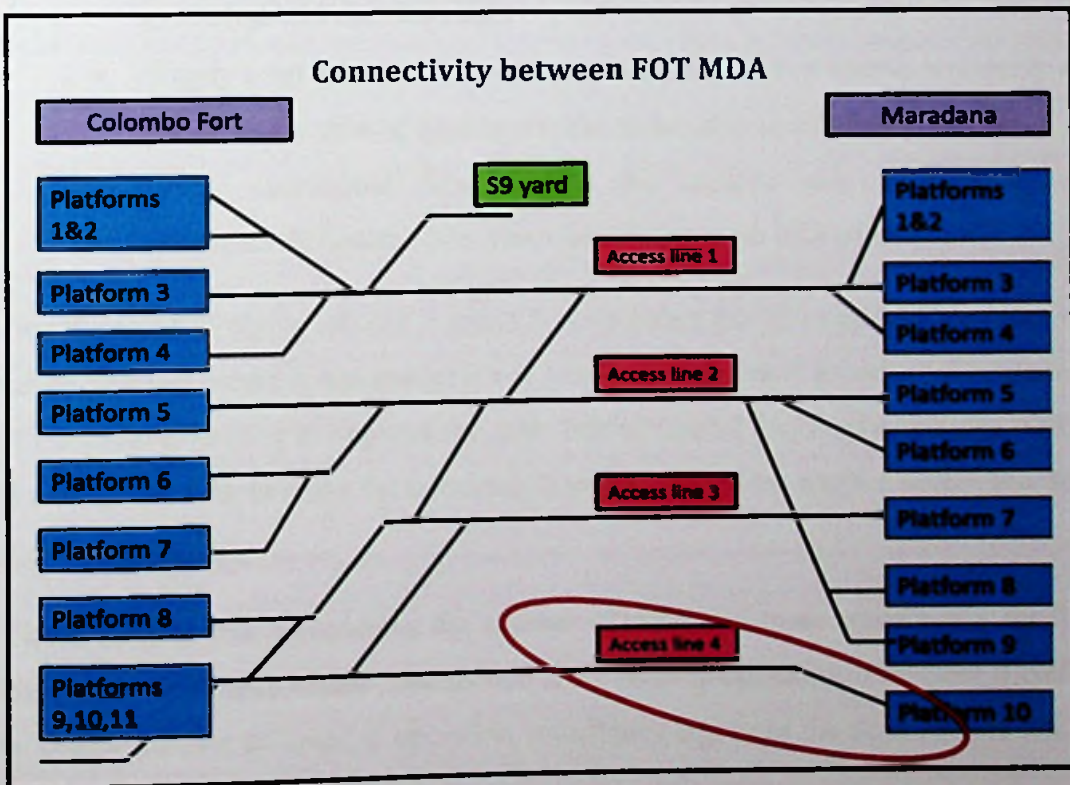


Figure 13 : Connectivity between FOT – MDA

Therefore almost all of above 99 train movements need to be established over the 3 access lines. This suggests that one access line need to handle an average of  $99/3$ ; 33 train movements within  $60 \times 3$ ; 180 minutes. Thirty three trains in 180 minutes will lead to only 5 minutes gap between two consecutive trains.

FOT – MDA section is designed for 1.5 mts. headway and the ask is 5 mts. which obviously seems possible. But it has to be analyzed that whether this 1.5 mts headway really exists or possible over the actual conditions and nature of operations.

The 1.5 minutes headway of the FOT – MDA section is not practical due to;

- Trains leaving 1.5 mts headway section will approach on to 3 mts. headway sections (both towards main line and coastal line directions). This results either trains passing 1.5 headway section to stagnate at platform lines or convert the 1.5 headway section in to a 3 minutes practical headway section.
- 1.5 minutes headway could be achieved only by a single direction traffic and would be higher than 1.5 for bi-direction traffic. The traffic in concern is a bi-direction one.
- Empty train movements are always bounded with a operational delay of changing the crew or changeover the same crew to other direction.
- Above operational delay applies for coaches sets in changing or runaround the locomotive which takes more time than of train crew.

Therefore due to above reasons it could be concluded that the required headway of the operational nature is not available nor practical. This leads to reduce the number of train movements or to improve the main line or coastal line headway times which is a long term task to make the operation is viable. Providing another access line too is a long term task.

Viable solution will be reducing the number of trains and mass contribution for the high number of trains within peak service is the overlap operation. Therefore it could be concluded that the overlap operation contributes highly in the peak service delay and hypothesis is accepted.

## 4.1.1 Explore the necessity for overlap operation

### 4.1.1.1 Main line Overlap operation

A passenger survey through a questionnaire was carried out in the main line to check the passenger demand for continuing the main line trains passing Maradana. There are several popular destinations applicable for the main line passengers travelling from Polgahawela and Puttlam direction, out of which majority was beyond Maradana (Colombo Fort and other). But in the questionnaire Kelaniya and Dematagoda were also included among the options as the information was required for some other study in a different scope.

### Questionnaire

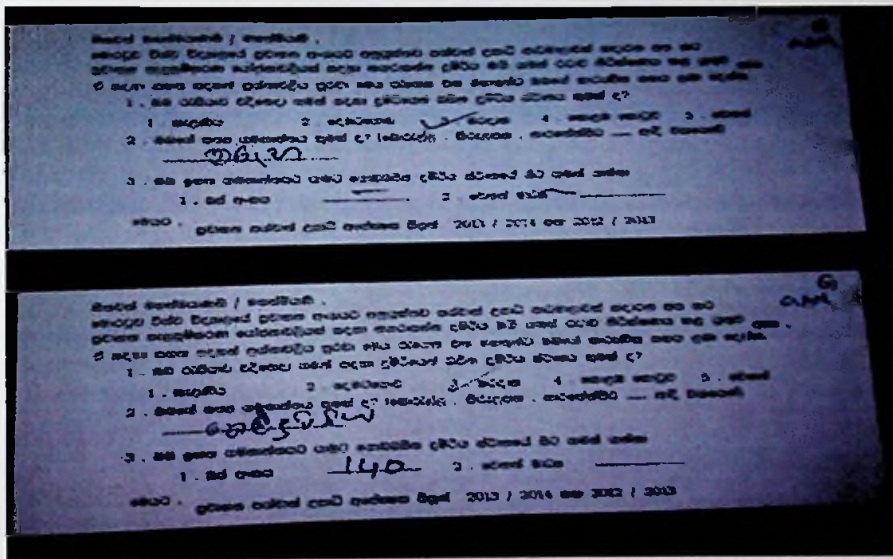


Figure 14 : Sample questionnaire sheets collected back at the survey

There were several options given in the questionnaire to select the station from which the particular passenger is getting down. Options were;

- a. Kelaniya - Not relevant to this research
- b. Dematagoda - Not relevant to this research
- c. Maradana
- d. Colombo Fort
- e. Other

Respondent had to write the actual destination in addition to the options. Passengers' true requirement was taken as a combination of the getting down station and the true destination. Text was used to track the passengers in "Other " category. Accordingly the passengers respond (text) in coastal line destinations while getting down before Maradana was calculated under beyond Maradana Category. This is to find out the number of passengers who get down from Kelaniya and Dematagoda really need access beyond Maradana (presently they might get down before Maradana due to last mile connectivity issues).

### Target population

Questionnaire was distributed among the passengers at the queue for obtaining the monthly season ticket in a first day of a month. This approach assured that the respondent is a daily traveler. Only the metropolitan stations were covered due to the practical difficulties and a person was deployed to record the response for the ease of respondent. Sample of responses are shown in Figure 14.

**Table 3 : Sample population**

Original Station	Aprox. no. of passengers (daily count)	Sample captured	Percentage
Ragama/Ja-Ela	11000	788	7.2%
Gampaha	6500	214	3.3%
Ganemulla	4500	243	5.4%
Veyangoda	8000	194	2.4%
Mirigama	2500	202	8.1%
<b>Sub Total</b>	<b>32500</b>	<b>1641</b>	<b>5.05%</b>

(Survey data collection)

Target was to capture the responses of at least five percent of the daily passengers and was collectively achieved but except at Veyangoda. Approximation of number of daily passengers was taken from the Station Master through his experience. Analysis of the survey population is given in Table 3.

Survey results are shown bellow in the Table 4.

Table 4 : Survey results

Origin	Aprox. no. of passengers (daily count)	Destinations				Station Total	Invalid
		Before Maradana (KLA and DMA)	Maradana	Colombo	Beyond Colombo		
Ragama/Ja-ela	788	108	207	223	227	765	23
Ganemulla	243	55	56	49	75	235	8
Gampaha	214	63	70	35	34	202	12
Veyangoda	194	78	48	57	6	189	5
Mirigama	202	61	39	51	35	186	16
Sub Total	1641	365	420	415	377	1577	64

(Survey data collection)

When the results are further analyzed to check the passenger demand for continuing the main line trains passing Maradana, it could be presented as in Figure 15 below.

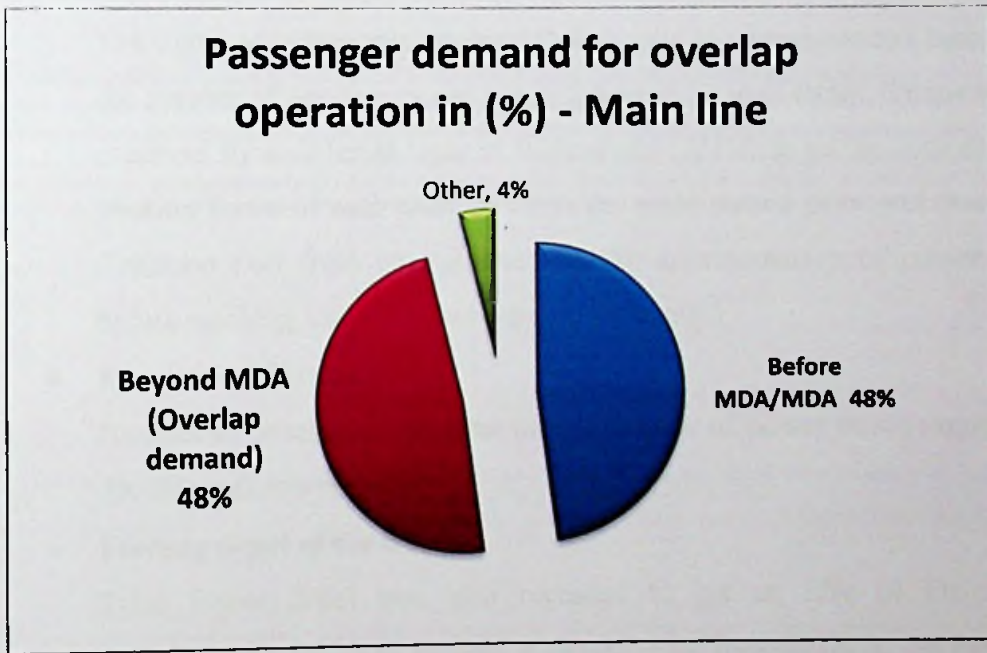


Figure 15 : Passenger demand for overlap operation – Main line (Survey data collection)

Statistics clearly shows that there is a high demand for continuing the main line trains up to Colombo Fort passing Maradana. 48% of sample passengers from main line are continuing up to Colombo Fort.



#### 4.1.1.2 Coastline overlap operation

Passenger demand for continuing the coastal line overlap operation up to Maradana passing Colombo Fort was checked using a passenger count. Passenger count was taken at Maradana station on a weekday at the peak service; trains reaching Colombo Fort between 06.00 hrs and 09.00 hrs similar to the other parallel surveys and studies/analysis. According to the exit gate setup at Maradana, exit gates could be reached only by using the stair cases. Therefore the passengers coming out through the stairs towards the exit gates were counted using multiple counters to cover up the two exit gates, two stair cases and trains reaching with close time gaps.

In addition to the number of passengers coming out, following information too were collected to be used in the analytical purposes.

- **Approximate number of total passengers reaching Colombo Fort by each train :**

The figure of passengers reaching Colombo is an approximation based on the number of passengers per coach followed by load factor. Trains were observed by a different team at Wellawatta (WTE) to get an idea of the packing factor of each train. WTE is the main station prior and close to Colombo Fort from coastal line and the approximation of passengers before reaching Colombo was done accordingly.

- **Formation of trains:**  
Number of coaches (or number of sets in case of power sets - single set /Double set) was recorded.
- **Feeding depot of the train:**  
Train feeder depot was also recorded to get an idea of the fleet management which will be used in checking the hypothesis "C" as well as for making suggestions for alternatives. Type of the power sets and type of the locomotive was recorded for this purpose.

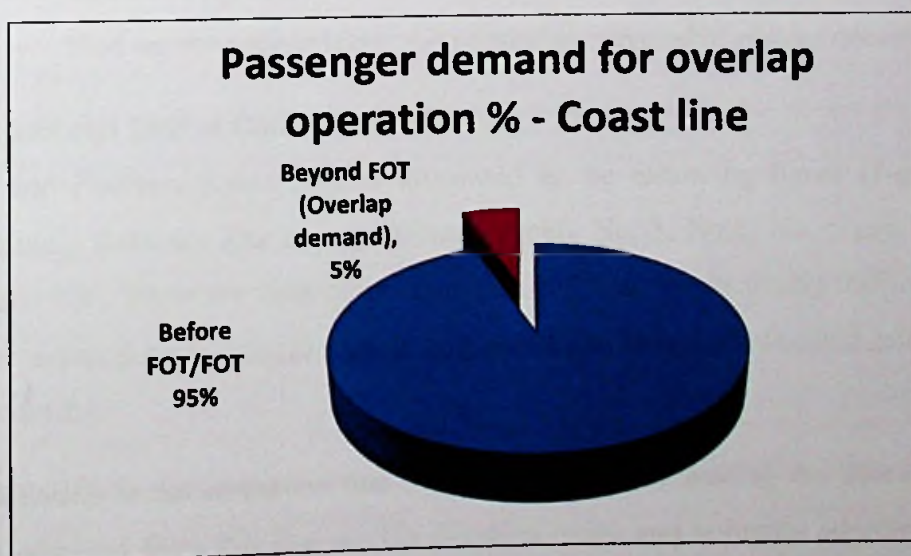
Results of passenger count and data collection are appended in Table 5.

**Table 5 : Passenger count results and recorded train data**

Train No.	Type of set/train	Train size	MDA arrival (WTE count)	No. of Pass. reach. FOT	No. of Pass. Reaching MDA	Beyond FOT % (overlap demand)
8309	S10 set	Single set	06.26	500	90	5.75 %
8311	Coaches set	10 coaches	07.07	3000	190	
8310	S8 set	Single set	07.15	1750	50	
8317	Coaches set	8 coaches	07.22	2100	122	
8316	Coaches set	8 coaches	07.35	2100	152	
8320	S10 set	Double set	07.40	4200	201	
8363	S8 set	Double set	07.45	3500	428	
8327	S11 set	Double set	07.55	3500	180	
8328	S11 set	Single set	08.23	1750	136	
8333	S11 set	Single set	08.55	1750	60	
8059	S11 set	Double set	09.00	3500	230	
8335	S10 set	Single set	09.05	2100	102	
8325	S10 set	Single set	08.30	2100	13	
8313	S10 set	Single set	08.00	2100	175	
8324	S9 set	Double set	08.02	3500	15	
8326	S11 set	Single set	08.10	1750	97	
8097	S11 set	Double set	08.13	3500	211	
Sub total				42700	2452	

(Survey data collection)

Graphical presentation of data in Figure 16 below illustrates the demand for overlap operation more clearly.



**Figure 16 : Passenger demand for overlap operation – Coast line (Survey data collection)**

Statistics clearly shows that there is no demand for continuing the Coast line trains up to Maradana passing Colombo Fort. Only 5% of sample passengers from coast line are continuing up to Maradana.

Therefore based on the above results, it could be concluded that demand for the overlap operation exists only for the trains from main line. Percentage of 48 is a considerable figure and therefore SLR will have to continue the overlap operation for the main line in the morning peak. Whereas in costal line, only 5% of passengers are continuing and the extension of the overlap operation seems in no use.

#### **4.2 Track and Platform utilization**

Objective under this chapter is to determine whether there is a shortage of platforms at Colombo Fort which is noted as a probable cause for the train delay. The level of utilization of platforms and tracks will also be investigated. Results will be used to test the hypothesis and to reveal any contributory factors towards the delay under discussion. Following approaches will be taken to investigate.

- Identify the entry and exit lines at Colombo Fort
- Check the trains queuing up at FOT admission signals
- Check the occupation and free time slots of main platforms at FOT.
- Explore the target platform availability against queuing up of trains at admission signals
- Find out the actions taken and possibilities available against queuing up

#### **Entry and exit lines at Colombo Fort**

Track and Platform layout plan is illustrated in the following figure (Figure 17). Accordingly there are four main platforms namely No. 3, No.4, No. 5 and No.6 at Colombo Fort. There are three main admission paths for the incoming traffic (as the case of morning peak service) namely Up admission, Down admission 1 and Down admission 2.

Up admission is the admission line from the coastal line passing the Slave Island. Trains admitted from this line are Up direction trains and normally admitted on to platforms no. 3 and 4 which are usually used as up platforms and the practice has

been adopted by the passengers too. Therefore it has become a common practice to admit up trains on these platforms.

Similarly the down trains arrive passing Maradana are used to be admitted on to platforms no. 05 and 6. But unlike in coastal line direction, there are two admission paths from the main line and they are Down admission 1 and Down admission 2.

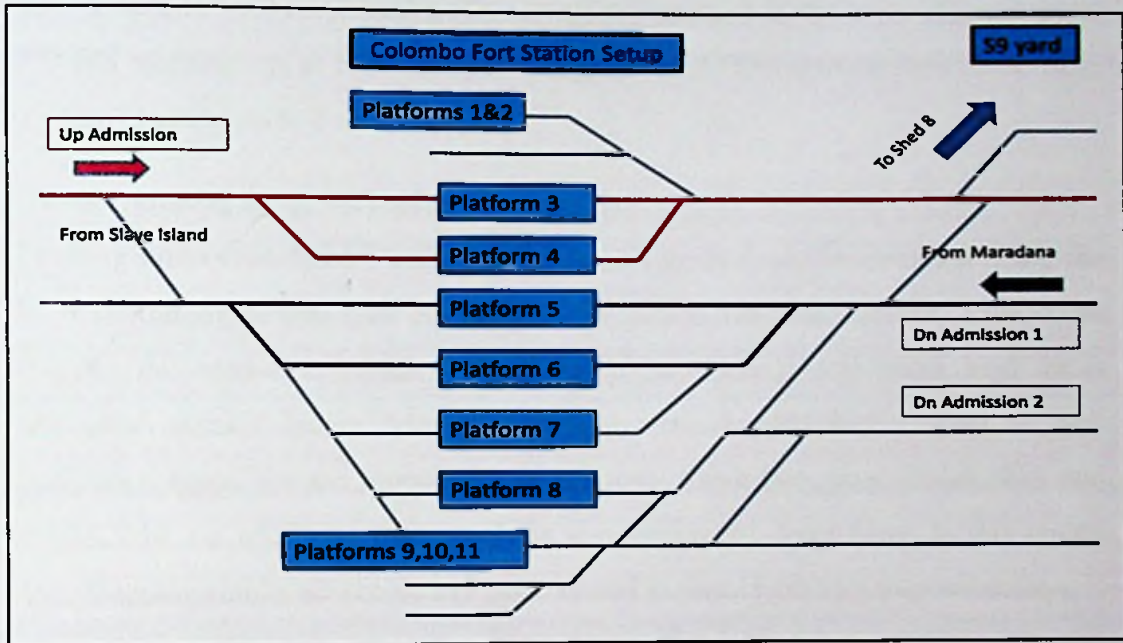


Figure 17 : Track and platform lay out plan at Colombo Fort

As illustrated in the Figure 17 Up admission signal is having access to almost all the platforms, but the default admission lines are No. 3 and 4. Platforms No. 5 and 6 are the default admission lines to down admission 1, but having access to all the platforms from 5 to 11. Down admission 2 is having a limited access and platform No.8 onwards are accessible.

Apart from the default admissions which doesn't involve any cross movement, all other admission choices are imposing restrictions on the opposite side admission signals by blocking the signal permission. As an example whenever a train from up admission signal is admitted to No. 5 line onwards, there is a restriction on Down admission 1 and sometimes even on Down admission 2 (depending on the admitted platform) to block the signal permission until the train from up admission arrives the platform. This is a restriction imposed by the signaling system for the safety

purposes and called “**prevention of simultaneous admission**”, results due to lack of overshooting provisions at FOT yard.

The above scenario called the **prevention of simultaneous admission** cases to hold the trains at admission signals even though the platforms are available.

Therefore there is a great possibility of seeing this as a “**lack of platforms**” which is not evident to be the true cause. This is again discussed in the same chapter under “Trains queuing up at FOT admission signals” and “Occupation pattern of main platforms at Colombo Fort”.

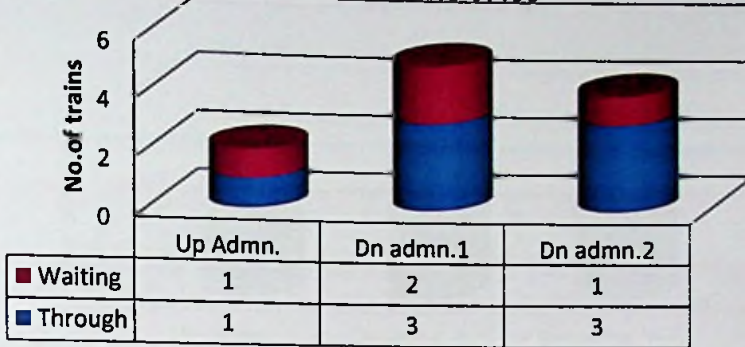
### **Trains queuing up at FOT admission signals**

Waiting times recorded by trains at admission signals could be obtained using the SLR central signal data base entries with the section time calculations. Then trains passing the admission signals without delay (no waiting) and trains held up at admission signals due to delay in admitting were mapped with respect to each admission signal for the morning peak service. Same two days; 26.06.2014 and 27.06.2014, on which the delay analysis was performed, were taken in this regard too. Mapping results are shown in Figure 18 and Figure 19 for two respective days.

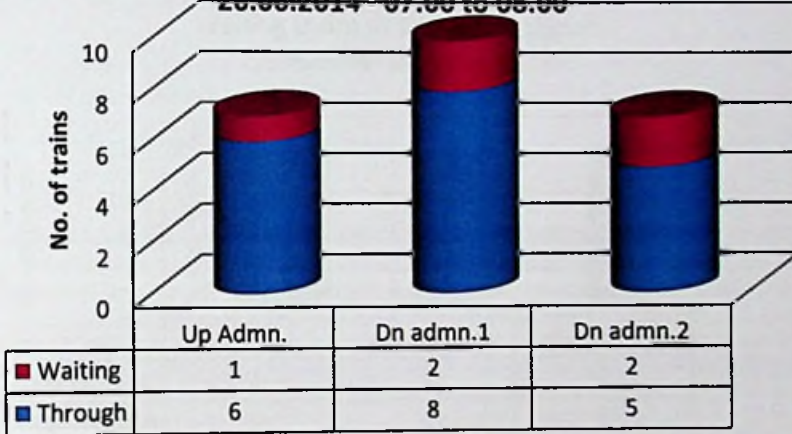
Number of waiting trains was evident to be increasing between 08.00 and 09.00 in both days. Number of total trains in the particular time slot were similar and waiting percentage was 48% on 26<sup>th</sup> and 60% on 27<sup>th</sup>. Waiting time is not evident in the chart but the waiting percentage suggests that platforms are not available for the waiting trains to be admitted.

According to Table 2 followed by the description in the chapter 4.1, there need to be 33 trains (according to the average) around the area within the hour of 08.00 – 09.00 of which the mapping is done. But the number of trains passed or held up at the admission signals in the 08.00 – 09.00 timeslot is 29 trains on 26<sup>th</sup> and 25 trains on 27<sup>th</sup>. This suggests some six trains should be either at platforms or moving. Therefore it is extremely required and interesting to check the platform occupation level in the given hour. If the platforms are fully occupied then there is an evidence for “**lack of platforms**” despite of the analysis in preceding chapter (Chapter 4.2 ).

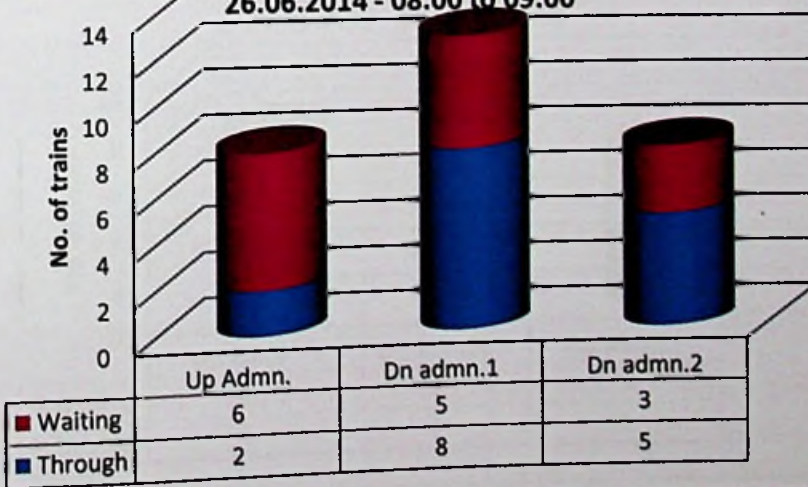
**Waiting trains at admission signals  
26.06.2014 - 06.00 to 07.00**



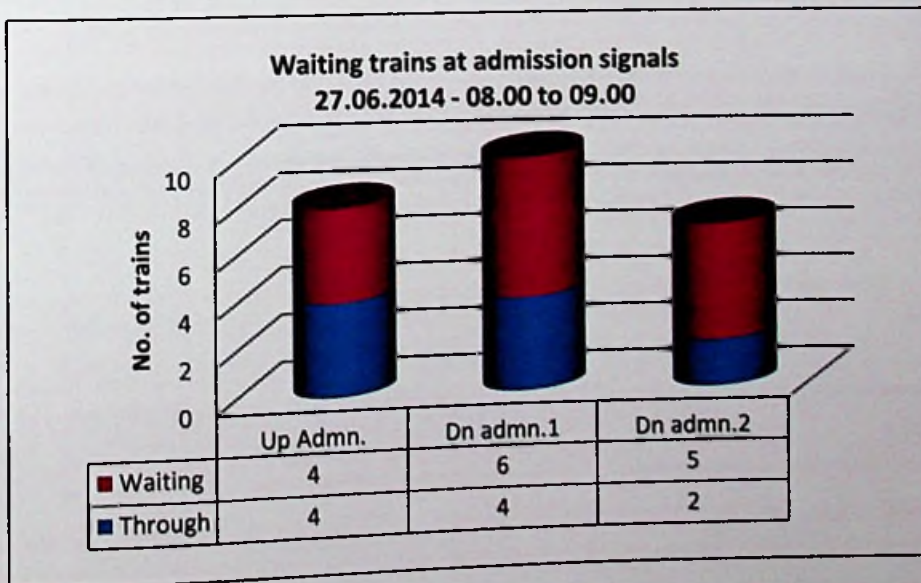
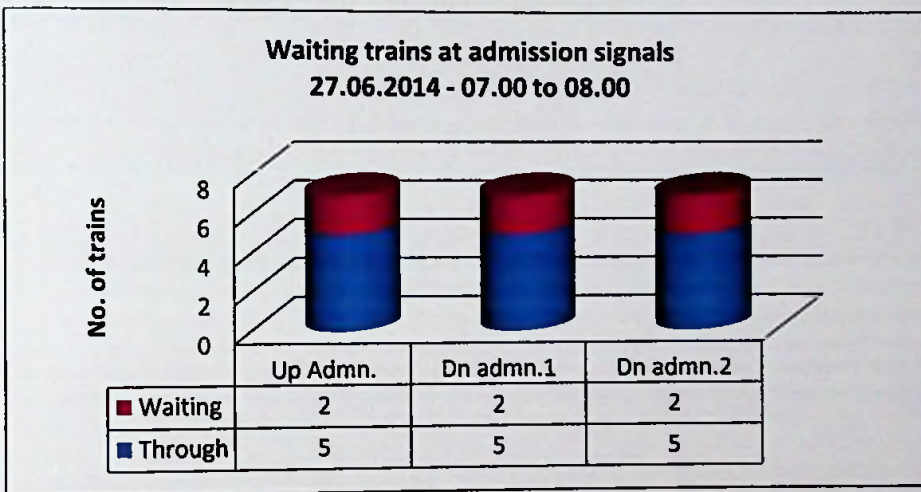
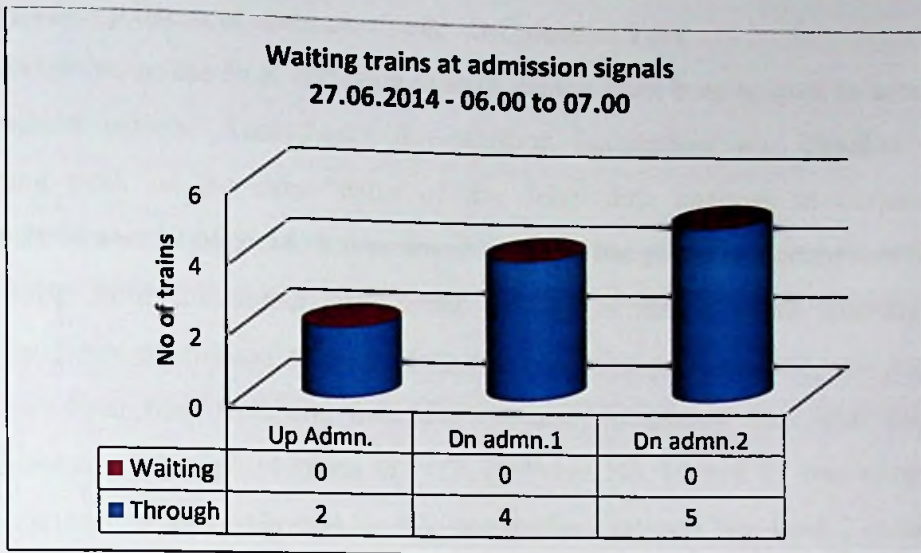
**Waiting trains at admission signals  
26.06.2014 - 07.00 to 08.00**



**Waiting trains at admission signals  
26.06.2014 - 08.00 to 09.00**



**Figure 18 : Waiting trains at FOT admission signals on morning peak – 26.06.2014  
(SLR CTC signal data base)**

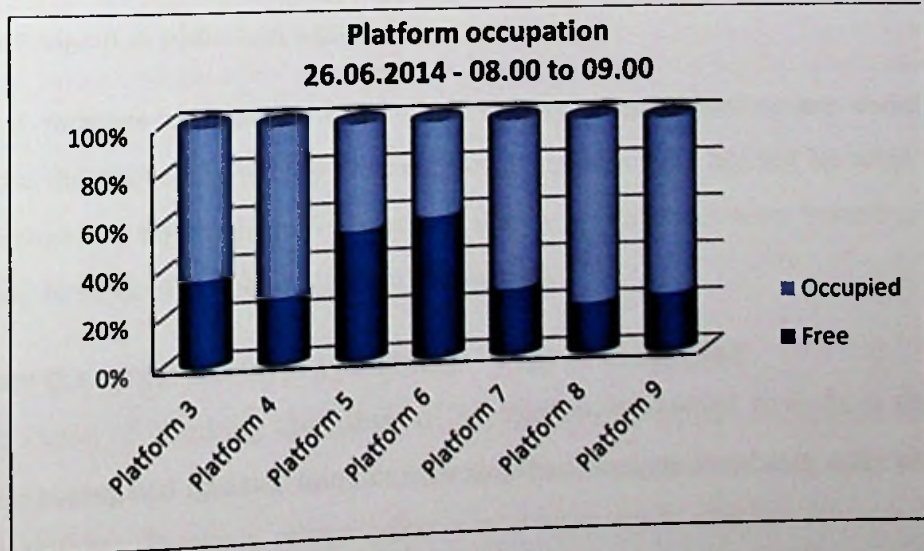
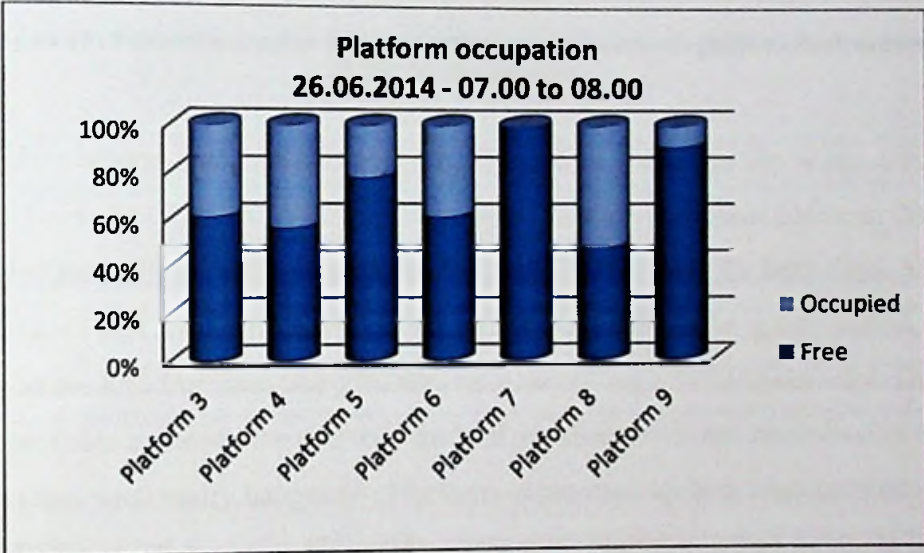
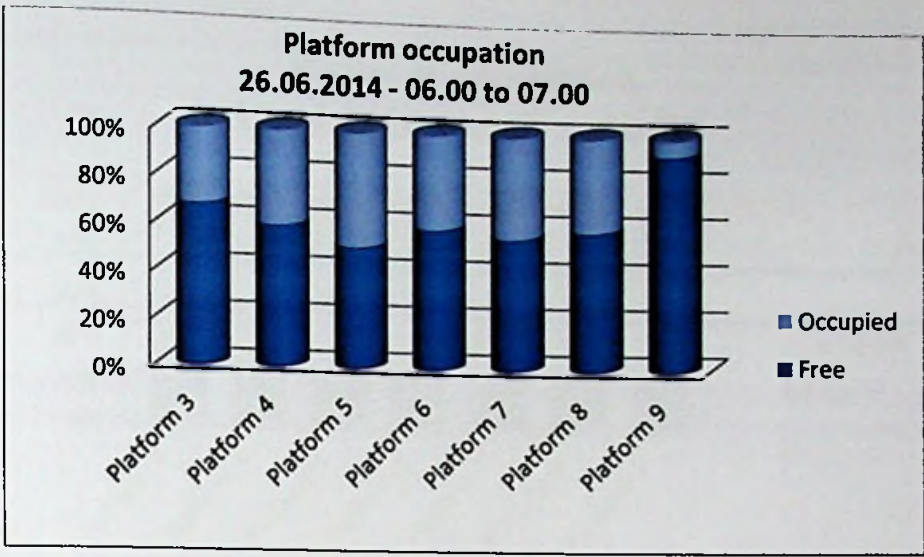


**Figure 19 : Waiting trains at FOT admission signals on morning peak – 27.06.2014  
(SLR CTC signal data base)**

### **Occupation pattern of main platforms at Colombo Fort**

Data recorded in the SLR signaling system central data base is used to analyze the occupation pattern. Accordingly the platform occupation was checked for the morning peak on the same dates of the delay data analysis at chapter three; 26.06.2014 and 27.06.2014. It was possible to get the platform occupation time and free time from the signal data bases through a manual data filtering (some calculations were needed to be performed). Morning peak service was segregated into one hour time slots and then the free and occupation time was mapped in relevance to each main platform at FOT. Platform No. 10 and 11 was exempted as they are more or less dedicated for KV line traffic. Platform No. 1 and 2 exempted as they don't have the through connectivity to the coastal line.





**Figure 20 : Platform occupation pattern at FOT in morning peak – 26.06.2014 (SLR CTC signal data base)**

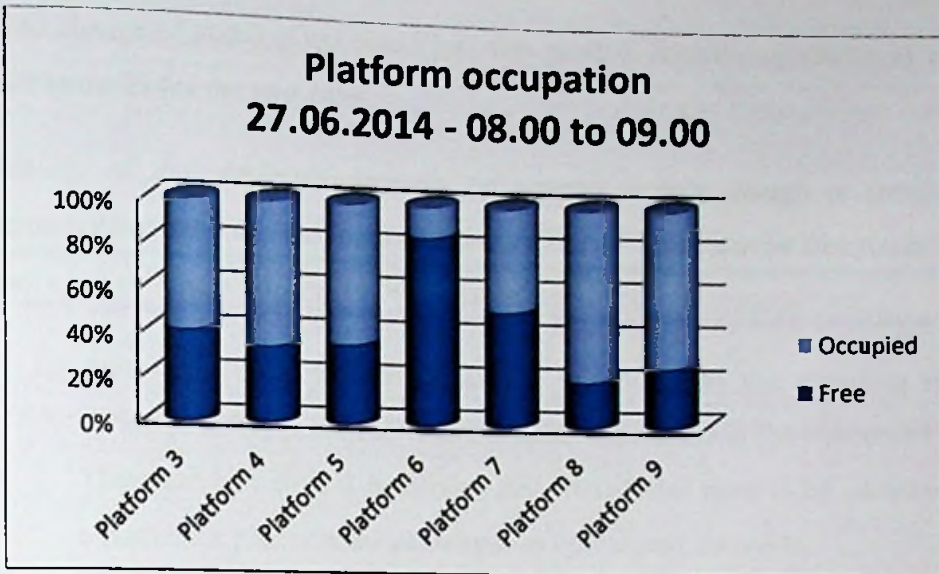


Figure 21 : Platform occupation pattern at FOT in morning peak – 27.06.2014 – 08.00 to 09.00 (SLR CTC signal data base)

When the platform occupation is observed it could be noted that the occupation level is high between 07.00 to 08.00 (school traffic) and at its highest between 08.00 to 09.00 (office traffic) inside the peak service and was common for both days. Still the fact remains that there are adequate free times even within the given period which counts to be 36% free time and 43% free time on 26<sup>th</sup> and 27<sup>th</sup> respectively. This fact again provides evidence for that the “**lack of platforms**” is not contributing for the delay. Then what really happens? . Platform occupation level is high between 08.00 to 09.00, but still there are sufficient free time at platforms to admit trains, still trains are queuing up at admission signals ?.

Then it requires explore the kind of occupancy these platforms are undergoing. Because the above charts only presents the occupation time but not by what means the occupation takes place. To sort out that, a more elaborative investigation is required to be carried out on platform occupation.

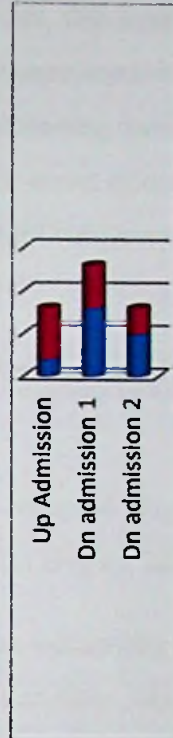
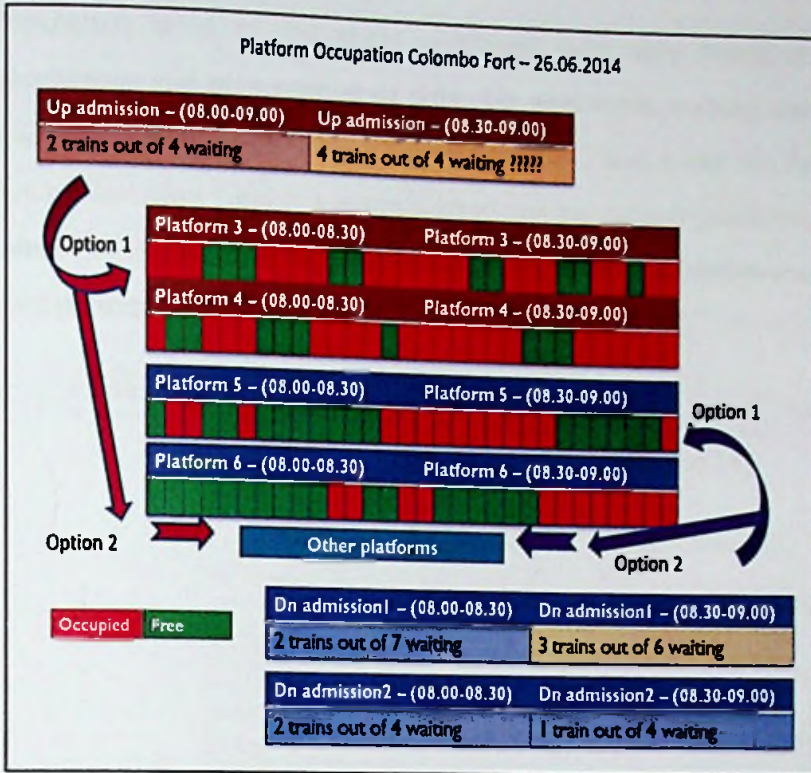
### Explore the target platform availability – Type of occupation

For the ease of checking the nature of occupation, concerned hour from 08.00 to 09.00 is segregated into two minutes time slots and occupation of each main platform was monitored. Precision of two minutes was adequate to monitor the arrivals and departures. Platform occupation data was again taken through the SLR CTC data

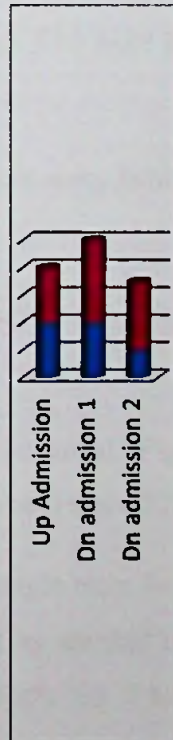
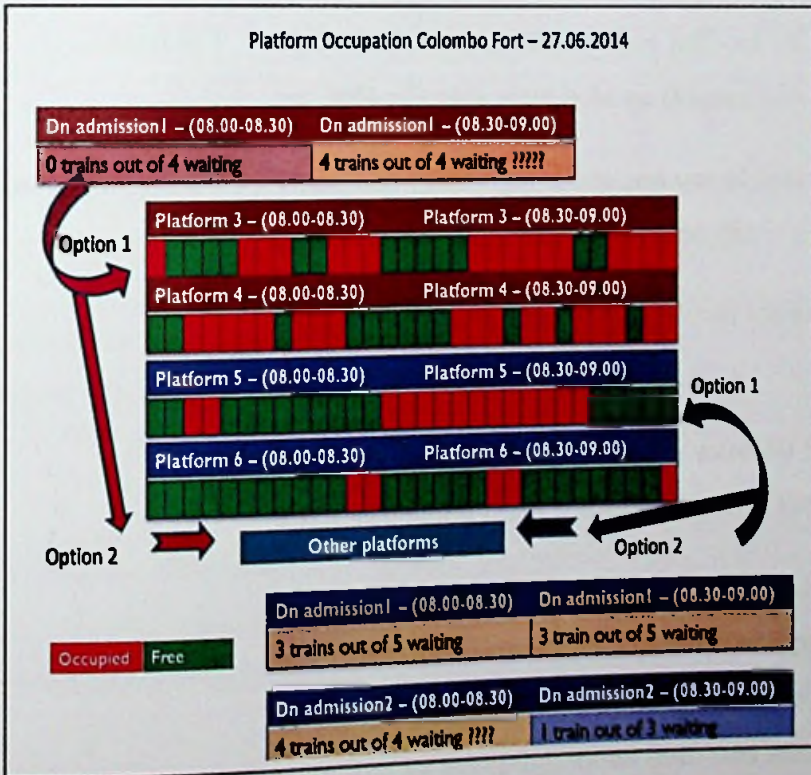
base and change of status (Occupied/Free) was plotted. Results are shown in Figure 22 and Figure 23 for the two days.

Availability of the platforms depends on several factors though it seems that platforms are not available due to occupation of trains. There can be free times in the platforms but still the platform is not available due to various reasons like;

1. Admitting to the particular platform is blocked by the signaling system owing to safety precautions due to other operations in the concerned area.
2. There can be habitual constrains that some trains need to be admitted into a particular platform for passenger or operational interests.
3. There can be failures or malfunctions in the signaling system blocking a particular platform.
4. There can be some trains occupying particular platforms for longer durations, which could be caused by various reasons.



**Figure 22 : Platform occupation types at FOT – 26.06.2014 (SLR CTC signal data base)**



**Figure 23 : Platform occupation types at FOT – 26.06.2014 (SLR CTC signal data base)**

Occupation level of the main platforms was only monitored for the ease of calculations and presentation of data. Up admission waiting trains were considered against the default platforms for up trains; No 3 and 4 and similarly waiting trains at Down admission 1 and 2 was considered against default platforms for down direction trains; No. 5 and 6. Comparison for 26.06.2014 is as follows and 27<sup>th</sup> follows the same pattern.

Up admission signal: There had been eight trains and out of that six were held up; 75% of trains were held up (Figure 18).

Relevant platforms; No. 3 and 4 were 80 % occupied (Figure 20). Occupation times are agreeing with the plot (Figure 22).

But there are several trains which have been occupying the two platforms under concern for fairly long durations like 06 mts. x 2, 08 mts. x 2, 12 mts.x2 and one train has occupied No. 4 platform for 14 mts.

Down admission 1 : There had been thirteen trains and out of that five were held up; 30% of trains were held up (Figure 18).

Down admission 2 : There had been eight trains and out of that three were held up; 37% of trains were held up (Figure 18).

Collectively more than 30% of down trains have been held up at two down admission signals.

Relevant platforms; No. 5 and 6 were 60 % occupied (Figure 20). Occupation times are agreeing with the plot (Figure 22).

But platform No. 5 has been occupied by a single train for 20 mts. while platform No. 6 has been occupied by another train for 16 mts. Apart from these two trains, platform No. 5 and 6 were free for accepting trains from two admission signals.

Among the various probabilities those can make a platform line unavailable, blocking by the signal system and habitual constraints remains same over a period of time. Long occupation by trains and failures in operation and signal gears could be varied. But still if a particular factor remains unchanged or repeating frequently, like the long occupation of trains, it suggests that the way of handling resources or the operational practices are inefficient. Long occupation of trains can be a result of an inefficient operational practice since it already seems a frequently occurred undue which is almost seen as a fixed issue.

Accordingly it is evident that track and platform utilization is suffered by lack of efficiency but the resources are at an adequate level. This conclusion is made based on the following facts;

- Trains queuing up at admission signals while the average occupation of platforms are at a lower level and 40 % of free time is still available at up and down platforms. Lack of platforms was not evident to be a contributory factor for the delay.
- Signal failures or operational failures have not been reported in the two days the analysis taken place.

Therefore the number of the platforms may be adequate over a developed and a planned practice and hence "lack of platforms" is not identified as a contributory factor for the delay.

### **Operational practices to overcome queuing**

When the trains are queued up at the admission signals due to various reasons, train controllers are compelled to push the trains into other platforms to avoid the further queuing up. But what really happens is although the queue gets eased slowly controllers are imposing restrictions to opposite side admissions. These restrictions normally come in the guise of signaling system. There are several platforms (ex: No.5 and No.6) which acts as a twin unit and restricts both side admission to twin platforms at the same time (simultaneous admission is blocked). Platforms No. 3 and 4 are also same. But this situation is not normally exercised as default admission lines do not require the trains to be admitted on to those twin units. Once the default

lines are blocked these restrictions come into play but since there are no other options available rather than pushing the trains to unpopular platforms. Unplanned and un-designed would be a better term for explaining.

Pushing the trains into other platforms are creating restrictions not only in the admitting but also when the trains are taken out at the other end. Cross movement in a one end always blocks the admission on the opposite end due to signaling restrictions designed for safety requirements; to avoiding trains coming head-on by accidentally overshooting. Therefore the delay at admission signals caused by the long occupation of the trains at platform lines give rise to further delays at to the opposite side trains. This scenario is referred to be as "Cascade Delays" ; A secondary delay occurs when the source of the delay is another train. The most common reason for this delay transfer is that several trains need for same resource at the same time and thus have to wait for it to get free. Such resources can be signal block sections, switches or platform tracks at stations. A source for secondary delay is not due to lack of resources is when a connecting train gets delayed because it awaits the late arrival of another train (Lindfeldt, 2012).

Common practice is to overcome these kinds of scenarios is giving a mercy time (Allowance) to the frequently delaying trains so that they can at least hide the delay. But at FOT this is not practical as such arrangement is already there causing long occupations and had apparently lead to secondary delays.

Allowance is extra time in the timetable that is added to the scheduled timetable of trains. It can both be used to extend the running time between stations, running time allowance, or to make longer stops, allowance at stations. In both cases, the allowance can be used by the train to recover from suffered delays (Lindfeldt, 2012).

### **Contributory factors for low utilization**

This concludes that there is a contribution caused by the inefficient utilization of tracks and platform lines but not necessarily implies that any of these infrastructure items are short to the requirement.

In addition to the above conclusion there were sufficient evidence to take up the low flexibility in the FOT yard resulted by signaling system and track layout. Signaling system has not been updated timely and track layout suffers due to space constrains. Contributory level for the delay is high in signaling perspective since the restrictions of the system results in slowing down the train admissions. At the same time the signaling system has not been even updated to cater the existing track layout with proper flexibility which makes the situation worse that the provisions made available by the track and platform layout is still restricted by the signaling system. For an example, signaling system is yet to be updated for taking the full use of the fourth line between MDA – FOT which can contribute immensely to ease up the congestion between the two stations (Figure 13). Therefore the inflexible signaling system considerably contributing towards the delay in morning traffic by restricting the line utilization.

### **4.3 Geographical Situation of Feeding Depots**

#### **Double movements in MDA – FOT section**

All the yards are situated in Maradana while S9 and S10 yard is having an additional access to Colombo Fort (Figure 1). Yards are situated at Maligawaththa, which falls at about 500 meters away from Maradana towards the main line direction. There are five yards and two maintenance facilities located at Maligawaththa as illustrated in Figure 1.

Location of yards is ideal for the coastal line operation as all the trains are started from Maradana and feeding depots are further away from Maradana which doesn't cause any additional mileage for the empty set that forming the train. Forming set from the feeding depot find the starting point of the train on the way in the same direction and hence doesn't engage any double travel of a particular distance (MDA – FOT). Whereas main line trains usually starts the journey at Colombo Fort and the empty set which forms the train is fed from Maradana depots, need to go passing Maradana to starting point Colombo Fort and again need to travel passing Maradana which causes a double travel across MDA – FOT section. Not only causing an additional distance and causing the double travel over the same span, forming sets



uses the same running lines to reach the starting point. This creates an additional movement in access lines between MDA – FOT. Same kind of additional travel takes place at the end of the journey and again causes an additional movement in access lines between MDA – FOT. Therefore one main line train results two unnecessary movements in the MDA – FOT access lines.

Above additional double travels are caused by the poor locating of feeding yards. Feeding depots for a particular service section need to be situated further away from the served section so that the feeding and leaving after the service doesn't result any double travels or doesn't cause any hindrance to running lines.

Apart from the additional travel, this situation leads to waste time and engage the crew for a longer time. Allowances for the train crew, operating staff and subsequent additional wastage of signaling and other maintainable gears which results additional allowances for the maintenance staff and hence the travel is ultimately uneconomical. Further need to be added the fuel wastage and the train set wastage too. Finally the situation of feeding yards leads the train service into an inefficient and unprofessional.

### **Poor locating of supporting services**

There are several additional services engage in a train service such as fueling, turn around the locomotives and special coaches and cleaning and preparation of coaches etc. These services need to be exercised in the feeding depots itself or need to be organized in such a way that they do not hinder the running lines. The case is not that in feeding depots in SLR. Having shed 5 (please refer Figure 1); the Electric loco shed 2 on the other side of the running lines to the location of coaches shed (shed 2), it always need to cut across the running lines to attach the locos to the passenger coaches, the most frequent activity a train could expect.

Apart from that some maintenance facilities are too located in a way that creates train /loco movements across the running lines. Location of "Turn Table" is an example. Turn table is a maintenance facility which is used in turn around the locos and direction sensitive special coaches like "observation saloons". Turn table and the coaches are located in either side of the running lines. Situation is the same for

Hydraulic locomotives against the turn table and Power sets against turn table. All these create cross movements across the running lines.

### **Contribution to MDA – FOT delay**

Yards are located outside of the section concerned for delays. But as per the description in the previous chapter (chapter 4.3 - Double movements in MDA – FOT section), situation of feeder yards are not in favor of main line operations and creating additional movements in the section concerned for delays causing further delays to the train service.

But the poor locating of supporting services do not pay a direct contribution to the delay occurrence at MDA – FOT section. As described in the previous chapter, there are a considerable amount of cross movements are created across the running lines due to poor location of such services. This causes the through service of main line to be obstructed frequently and results the trains departed from Maradana towards the main line is slow down. Then the expected headway is not effective and trains tend to stagnate at Maradana platforms or the section before that; the section under concern for the delay.

Following example describes the combination of delay contribution discussed in the preceding chapters; “Double movement in MDA – FOT section” and “Poor locating of supporting services”.

- “Podi Menike” train which departs from Colombo Fort to Badulla falls in the peak service under concern was used to be formed by a coaches set (this train is now replaced by a Diesel Multiple Unit – DMU; which no longer needs this operation). Train had an “Observation Saloon” in the rear and is a direction sensitive coach. On return from Badulla, the whole set is admitted to the coaches yard for cleaning and other services to be performed. This creates a cross movement across the FOT yard and access lines

**- cross movement no.1**

- After seeing the set to the coaches yard, the locomotive is detached and sent for running maintenance to the Electric Loco shed 2 at the opposite side of the running lines creating a cross movement. **- cross movement no.2**
- Then the set is being serviced and the “Observation Saloon” is sent to turn around through a shunting loco. Turn table is on the opposite side. **- cross movement no.3**
- “Observation Saloon” is sent back to coaches’ yard after turned around. **- cross movement no.4**
- Set is ready at the coaches’ yard and loco is to come from the electric loco shed to attach onto the set. **- cross movement no.5**
- Set is then ready for the journey and sent to Colombo Fort. Fortunately the practice is to start the train from No. 2 platform and therefore no cross movements but uses the access lines for a empty train movement. **- direct contribution to delay**
- Loco need to run around and need to occupy the access area for the shunting. Use of access line for a non passenger movement. **- direct contribution to delay**

Accordingly there are five (05) cross movements and two directly contributing movements to peak delay are involved to depart a single train. This implies how the poor location of feeding depots contribute for the morning peak delay in MDA – FOT section.

Therefore clear evident is found to conclude that the geographical location of feeding depots are directly and indirectly contributing the delay under concern.

In conclusion to end up the chapter it could be declared that the overlap operation and the geographical location of feeding depots is contributing to the delay but lack of platforms at Colombo Fort is not contributory. Still it need to be mentioned that the utilization level of the tracks and platforms are not satisfactory and leading to inefficiency. Signaling system needs to be updated at least to cater the existing track and platform capacity.

## CHAPTER 5

### 5.0 ALTERNATIVE APPROACHES AND IMPROVEMENTS

Sri Lanka Railways is not a profitable organization and seen more like a service maintained for the benefit for the passengers. As the nature of the organization there is an inborn reluctance within the organization for involving in mass scale projects due to several reasons such as lack of capital, service interruption and vast scale encroachments on to railway reservations which are required to be cleared in mass projects which is a tiring task and can result in a political intervention. Even though the some alternatives at mass scale are observed possible, they don't seem viable due to said reasons. Following the above facts, SLR is tend to practice short term plans rather than long term but nevertheless a long term plan is required for revamping, should come along with policy level decisions.

Opportunities and possibilities were therefore explored in the progress of the research to come up with short term solutions for the issue under discussion. Short term solutions can just be top level decisions or change of practices in the operating level or small scale rearrangements in the maintenance and infrastructure setup. These solutions mentioned above don't incur much of capital or enhancement of space hence can be experimented without much complications.

Therefore the research will be concluded with making suggestions and recommendations for possible alternatives within the same infrastructure and with an emphasis of short term implementation. Objective of the research was to find out the root causes for the delay and proposing alternatives for solving the said causes.

#### 5.1 Root Causes for the Delay in Morning Peak Service

Three probable causes were mentioned in chapter 1.5 under the project hypothesis;

1. Overlap operation
2. Lack of platforms
3. Geographical situation of feeding depots

There was sufficient evidence for proving that “overlap operation” is contributing for the delay in morning peak service (chapter 4.1). Lack of platforms was found not to be contributing but at the same time on the route of investigating the platform utilization, it was revealed that there is an issue on inefficient using of existing infrastructure. Then although the “lack of platforms” is not accepted to be contributing there is sufficient evidence for the existence of a new root cause; “Inefficient utilization of tracks and platforms due to inflexibility of track and signaling system” (chapter 4.2). Signaling combined with track layout can be crucial to capacity (Lindfeldt, 2012).

“Geographical situation of feeding depots” too was found to be contributing to the delay both directly and indirectly.

Considering the above facts, the root causes for the delay in morning peak service will be modified with sufficient proof to be;

1. Overlap operation
2. Inefficient utilization of tracks and platforms
  - Inflexible track and signaling system
3. Geographical situation of feeding depots

Contributory level of the above causes is already discussed in the preceding chapters and an opening to the discussion of finding the way out from same too is given. Above causes will be revisited in this chapter with the intention of finding the ways and means to overcome them.

## **5.2 Overcoming the Delay Contributing Factors**

Above three factors will be discussed in detail for suggesting alternative approaches.

### **5.2.1 Overlap operation**

Necessity of the overlap operation is discussed in detail in chapter 4.1.1 and it was established that the passenger demand for the overlap operation exists only for the main line. This conclusion was arrived using a passenger survey. And a passenger count gave evidence to establish that there is no adequate passenger demand for continuing the overlap operation for the coastal line.

Alternative approach for the SLR is to discontinue the overlap operation for the coastal line and terminate all the trains arriving in the morning traffic from coastal line at FOT.

### **Discontinuation of passengers**

There will be repercussions on the way the discontinued passengers would be handled. But as per the discussion on chapter 4.1.2, actual passenger count in way of demanding the overlap is as low as 5% of the total passengers reaching FOT. Therefore alternatives for discontinuing passengers may not require to be considered. Alternatively there will be main line trains starting from Colombo Fort and those passengers who are willing to continue up to Maradana could use this service. As per the table 2 in chapter 4 there are 17 trains arriving from the coastal line to Colombo Fort and 19 trains are there to start from Colombo Fort towards main line via Maradana. So there is sufficient connectivity for the discontinued passengers despite of the low number of 5 %. There will be a resulting discomfort for the passengers that they will have to changeover at Colombo Fort to reach Maradana but the benefit to the SLR will count to getting rid of 17 trains at the congested zone out of a total of 99 for the peak service three hours.

### **Dispatching of served trains to depots**

If the coastal line service is terminated at Colombo Fort, there will be 17 train sets getting stagnated at Colombo Fort after being reached from coastal line. Hence there should be a proper way of getting these trains away from the FOT platforms to avoid the recurrence of the delay issue in a different guise. At this point it is interesting to have a look on the train composition on the coastal line morning service. Table 6 below shows the train composition and from which depot they are fed into the service or which depot they should be dispatched to.

**Table 6 : Composition of coastal line trains**

<b>Train Number</b>	<b>Type of set/train</b>	<b>Feeding depot (Shed no. as per Figure 1)</b>	<b>Depot location</b>
8309	S10 set	S10 – Shed 8	MDA/FOT
8311	Coaches set	Coaches - Shed 2	Maligawaththa
8310	S8 set	Power sets - Shed 1	Maligawaththa
8317	Coaches set	Coaches – Shed 2	Maligawaththa
8316	Coaches set	Coaches – Shed 2	Maligawaththa
8320	S10 set	S10 – Shed 8	MDA/FOT
8363	S8 set	Power sets -Shed 1	Maligawaththa
8327	S11 set	S11 -Shed 4	Dematagoda
8328	S11 set	S11 – Shed 4	Dematagoda
8333	S11 set	S11 – Shed 4	Dematagoda
8059	S11 set	S11 – Shed 4	Dematagoda
8335	S10 set	S10 – Shed 8	MDA/FOT
8325	S10 set	S10 – Shed 8	MDA/FOT
8313	S10 set	S10 – Shed 8	MDA/FOT
8324	S9 set	S10 – Shed 8	MDA/FOT
8326	S11 set	S11 – Shed 4	Dematagoda
8097	S11 set	S11 – Shed 4	Dematagoda

(Suurvey data collection)

**Table 7 : Shed distribution of coastal line peak service**

<b>Shed No.</b>	<b>No. trains</b>
Shed 8 – MDA/FOT	6
Shed 4 - Dematagoda	6
Shed 1 &2 - Maligawatta	5

(Suurvey data collection)

Table 7 shows the shed distribution of the coastal line morning peak service and accordingly the distribution are among four sheds at three locations. Interestingly shed 8 is located in between Maradana and Colombo Fort and having access to both stations (Figure 13 and Figure 17). In addition to that a reasonable number of trains are fed from that depot. Therefore if the arrangements could be made to feed the entire coastal line peak service from that particular shed, the dispatching of above described trains getting stuck at Colombo Fort due to service termination could be done at a fastest time through a shortest path. Shed No.8 is connected to FOT just



before the point where the access lines starts and therefore assures the access lines are not getting disturbed due to this arrangement. Further to that the signaling system too supports this operation.

Benefits of feeding the coastal line morning peak service through Shed 8 – S9 yard between FOT – MDA are summarized below.

- Trains could be handled at a shortest path; shed 8 is less than 100 meters away from Colombo Fort. Trains are fed from depots situated at about 1.5 km away at present.
- Present way of feeding creates a lot of cross movements fouling the running lines similar to scenario described in chapter 4.3 under “contribution to MDA FOT delay”. Cross movements can be reduced to a great extent as 9 out of 17 trains are used to be fed from above remote yards.
- Seventeen (17) trains arriving from coastal line and thirteen(13) trains starting from Maradana towards coastal line can be removed from the congested FOT MDA access lines which results in reduction of 30 trains out of a lot of 99; nearly 30%. **Reducing of 30% of train movements itself will solve the delay.**

Actions to be taken by the SLR:

1. Take the decision to terminate the coastal line morning peak service at Colombo Fort.

This can be practiced over the morning peak service and then on success could be spread to total service too. SLR can implement this on trial basis and can revert back if unsuccessful. No any irreversible processes are involved.

2. Reshuffle the train feeding arrangements so that the peak service of coastal line is dealt with only S9 and S10 sets.

This too involves a decision act, no infrastructure to be changed.

Morning peak delay has been around for a considerable period and SLR has practiced some alternatives in mitigating the issue but yet to find a sustainable solution. Continuation of main line morning trains up to coastal line destinations is one of such measures that SLR has taken to solve the access line and platform congestion. This has mitigated the issue to a certain extent but not really solved. Alternative suggested in this chapter does not make any change on the above said step taken by the SLR, but making the step more productive.

### 5.2.2 Inflexible track and signaling system

Error! Reference source not found. below is an enhancement to Figure 13 in chapter 4.1 to illustrate the improvements required for the signaling system and track connectivity at FOT and MDA. Intention of having the improvements is to make the yard ready for the suggestions made under the research and bring the underutilized fourth access line to take more part in the FOT – MDA operations. Above suggestions made in the preceding chapter is possible up to some extent even without the suggested modifications.

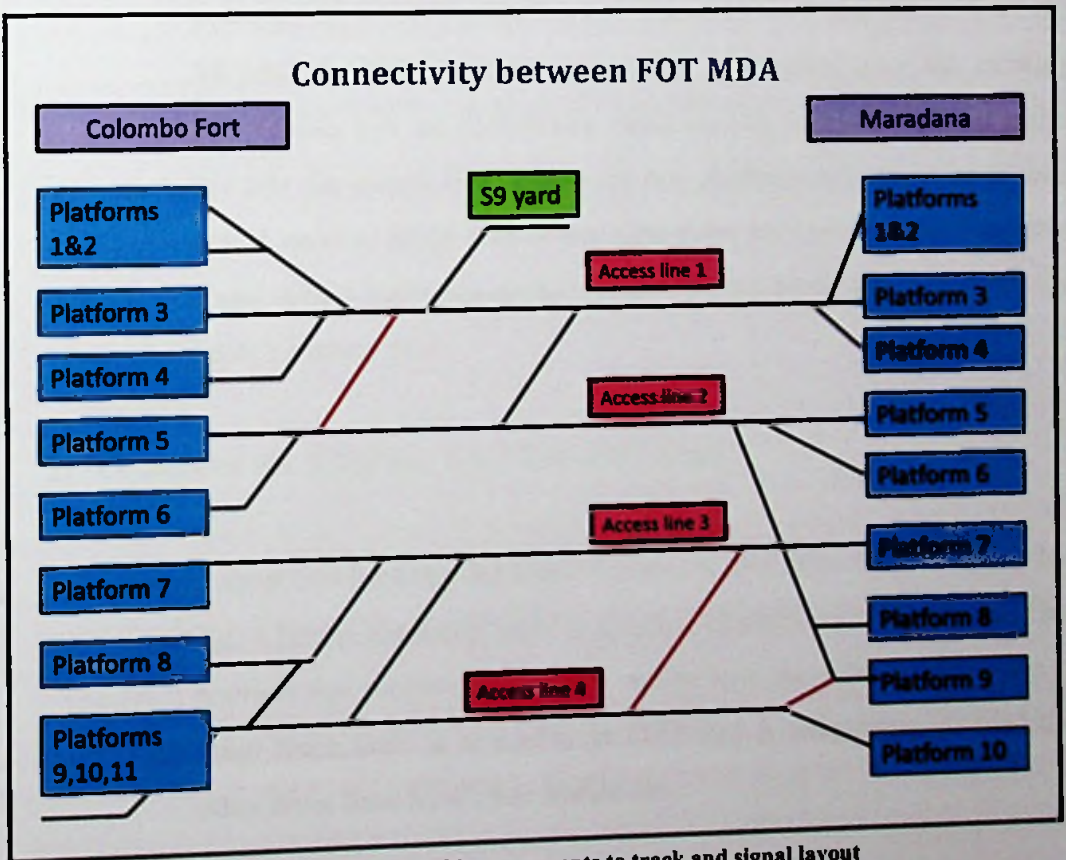


Figure 24 : Suggested improvements to track and signal layout

Three new connections are suggested for the existing layout as follows.

1. Additional connectivity to shed 8:

- Following the suggestions made in above chapter, if the service termination at Colombo Fort is implemented, there will be requirement to dispatch the arrived trains from coastal line which are mostly taken to No.3 and 4 platforms to the shed 8 – S9 yard. This connectivity is there at present in the track layout and signaling system facilitates the said movement. But since there need to be an alternative admission path to be used in case of an inability to use the default path (platform 3&4) and to add more flexibility, a new connection from the No. 5 and 6 platform lines towards the shed 8 is required.
- On the other hand according to the new suggested setup, the departing trains towards coastal line need to be fed from the shed 8. For this purpose too, a new connection is required to No 5 and 6 lines from the S9 yard; the shed 8. If the suggestion is accepted over the existing setup there will be difficulties experiencing in departing the trains towards the coastal line, since only two platform options are available. But it need to taken into count that there will not be any stagnated trains in said platforms as the release path (to shed 8) is very short and takes no much time.

2. Connecting No. 3 line and No. 4 line at Maradana:

- Connection between No.3 and 4 lines are available at the FOT end but No. 4 line is connected only to the No. 10 platform at Maradana. This restricts the performance of No. 4 line and since the connectivity to other three lines is available at FOT end it encourages to load the other three lines by 4<sup>th</sup> line traffic too.

- By providing the said connectivity, No . 7 to 9 platform will be connected to the 4<sup>th</sup> line and then the 4<sup>th</sup> line can better participate to ease the traffic between MDA FOT by taking a certain amount of the trains using the enhanced connectivity. A separate link between FOT MDA will be constructed over this to link the latter part of platforms (from No.7 onwards) on both ends. This connection is already provided in the track layout but signaling system need to be updated.

### 3. Connecting No.9 platform line to the 4<sup>th</sup> line at Maradana.

- No 9 and 10 platforms are more used to deal the KV line traffic at Maradana. Therefore by providing an additional connectivity, KV line operations will become easier. At the same time since the KV line movements are comparatively low than the other lines, this connectivity through the No.9 platform line could be used as an alternative path to access the Maligawaththa depots. There are five (5) sheds presently located in Maligawaththa area. All these shed movements are routed through the first 3 access lines at present, and the additional connection through the No 9 line provides a path to access the remote yards without obstructing the other access lines and avoids a considerable amount of cross movements.

Accordingly adding more connections will make the track layout more flexible and hence avails a lot of route options. Signalling track modifications can ease up the first three access lines which takes the total load at the moment will be eased up and result will be the increase in platform accessibility.

As concluded in the chapter 4.2 under “Track and Platform Utilization” evidence were there to arrive at the opinion that tracks and platform are available but the low flexibility of track layout and the signaling restricts them to be used. Therefore the above improvements shall be taken place to make the platforms usable to get rid of the common criticism that FOT station is “Lack of platforms”.



To conclude the chapter, 99 trains over 3 lines will become 99 trains over 4 lines converting 33 per line average to 25 per line. More to that if the coastal line is restricted to Colombo Fort this figure will come down as low as 69 trains over 4 lines ; 18 trains per line for three hours which seems quite feasible.

Anyway it need to be mentioned that alternatives discussed under this chapter incurs some capital and consumes time. In spite of said alterations are within the range of inherent technical capability, these suggestions shall be considered referring to medium term plans.

### 5.2.3 Geographical situation of feeding depots

Bad impacts under the poor location of feeding depots and service terminals are discussed in detail in chapter 4.3 with more emphasis of the negative impact of them. Here under this chapter the discussion will be more focused on rectifying the said shortcomings and hence the layout chart of feeding depots is referred back (Figure 1). Accordingly there are 8 feeding depots and two maintenance facilities deployed as follows.

**Table 8 : Description of feeding depots and maintenance facilities**

Feeding depot	Identity	Nature of activity	Location	Distance to FOT
Shed 1	PCS	Maintenance of Power sets (S8)	Maligawattta	1.5 Km
Shed 2	Coaches	Maintenance of coaches	Maligawattta	1.5 Km
Shed 3	HLS	Maintenance of Hydraulic locos	Maligawattta	1.5 Km
Shed 4	S 11	Maintenance of S11 Diesel multiple units (DMUs)	Dematagoda	2.0 km
Shed 5	Running shed	Maintenance of Electric locos	Maligawattta	1.5 Km
Shed 6	ELS	Maintenance of Electric locos	Maradana	0.75 km
Shed 7	Goods shed	Handling of freight	Maradana	0.5 km
Shed 8	S9 yard	Maintenance of S9 and S10 DMUs	FOT	0.1 km
Turn table	Turn table	Turn around locos and coaches	Maradana	1.0 km
Loading siding	CEW siding	Loading of track maintenance items (rails, sleepers , etc.)	Maradana	1.0 km

(Suurvey data collection)

All the trains started at Colombo Fort are fed through the above feeding depots. As described in the above Table 8 most of the feeding yards are situated away from FOT except for shed 8 from where it is suggested to take up the whole coastal line service (Chapter 5.2.1).

Composition of the coastal line trains are listed in Table 6 in chapter 5.2.1 and accordingly 6/17 trains are already fed from the closest yard ; shed 8 and 6/17 trains are fed from the far most yard. Additional recurrent cost of this arrangement counts to 2 x 2kms of six trains for feeding the morning traffic at the rate of 24 train kilometers x 365 days without earning a penny. Having suggested the all coastal line services to be handled through the shed 8, proposal will not be discussed over again at this chapter, but the avenues of re-arranging the feeding depots will be investigated to feed the service more efficiently.

#### **Efficient deployment of feeding depots**

Feeding depots for a particular train service shall be directional sensitive. Depots shall not encourage any cross movement or a double travel as described in chapter 4.3. Further the depots should be so arranged that the feeding the trains to platform lines and getting the service completed trains out of the platform lines as quickly as possible to avail the platform for the next train movement.

The achievement of above features is not a sole task of locating the depots but the track lay out and the signaling system need also to be supportive and flexible enough to accomplish. Modern designs of metro systems are keeping this kind of depot deployment and hence are capable of delivering the service at headway as low as 30 seconds. Track layout shall be flexible and modern signaling systems need to be installed with programmable train dispatching. More the deployment of modern systems delivers more is the lesser headway.

In case of SLR, modern systems are not affordable and hence the Colombo Fort issue is to be tackled with the existing lay out and the signaling system may be with small modifications. Therefore feeding depots arrangement is difficult due to flexibility constrains and space constrains.

## Ideal depots vs. practical depots

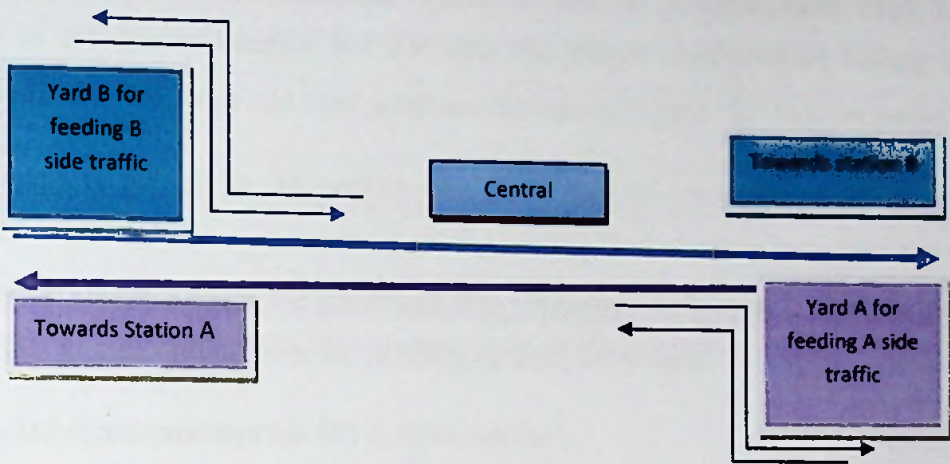


Figure 25 : Illustration of a model depot set up

Figure 25 sets an example for a model depot arrangement that does not involve any cross movement and designed to serve a direction sensitive feeding. But the station set up is too simple and this can be very much complicated in the actual scenario. Number of platform lines get increased unlike the two here and then the crossing arrangements come into play making the yard more flexible but slowing down and complicating the yard movements.

If this set up is expanded to suit the FOT MDA twin station set up in the central it would be seeing like below in the Figure 26 : Comparison of model depot set up with FOT MDA.

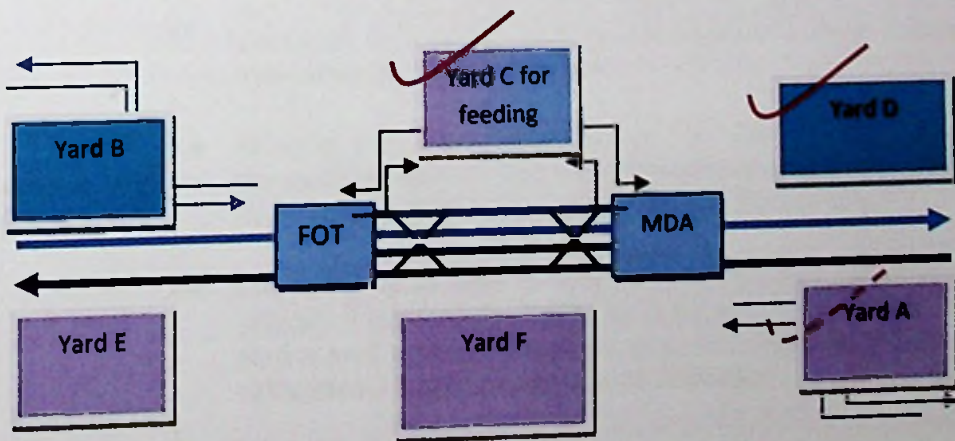


Figure 26 : Comparison of model depot set up with FOT MDA

As per the above model setup, neither FOT nor MDA is properly connected with yards for catering its directional traffic. Yards "C" and "D" are acceptable while Yard "A" is in the proper location but not with the proper configuration having only the facilitation for locos and need cross movements with yard "D" to form trains.

Therefore out of the six options only three options are available among FOT and MDA and only two are in proper configuration. This situation has given rise to all the above long discussed complications and ultimately causing delays. A reshuffling of yards or a reconfiguration for existing yards is the needful.

### Feasible alternatives for FOT MDA setup

There is no space available for yard locations "B" and "E" which are already restricted by the road set up and lake. There is some space available at location "F" but of course not sufficient for a yard setup.

Alternative arrangements viable with the existing space and other consequences are appended below.

**Table 9 : Alternatives suggested for FOT MDA depots and yards**

<b>Model Location</b>	<b>Alternatives suggested</b>
Location "A"	<ul style="list-style-type: none"> <li>• Needs re configuration to facilitate DMU sets or power sets so that the yard will become an independent depot. There is enough space and connectivity is possible. Already shed 4 – S11 yard is connected through this area but the location is about further 1 km away from the connecting point.</li> <li>• Bringing S 11 yard to the Location "A" which is now occupied by the shed 5 – Electric loco shed 2 and loading siding would lift the depot set up at MDA more closely to the expected model.</li> <li>• Interchanging of shed 4 (S11 yard) with CEW siding or shed 5 (Electric loco shed 2) is also possible with a low capital. Loading yard is need not to be this closer to a main yard and could be shifted to the shed 5 location without much difficulty.</li> </ul>
Location "B"	<ul style="list-style-type: none"> <li>• No space</li> </ul>
Location "C"	<ul style="list-style-type: none"> <li>• Already properly placed</li> </ul>



Location "D"	<ul style="list-style-type: none"> <li>• Properly placed for the shed 1 (Power sets).</li> <li>• Properly placed for the shed 2 (Coaches) and 3 (hydraulic locos) in combination.</li> <li>• Improper placement when shed 5 (Electric loco shed 2) is taken in combination. Interchanging shed 1 with shed 5 would make both sets in proper placement so that the Electric locos will serve in better combination with coaches' yard (shed 2).</li> <li>• Turn table presently at location "A" shall also be shifted to Location "D" where all the service need vehicles then will be available.</li> </ul>
Location "E"	<ul style="list-style-type: none"> <li>• No space</li> </ul>
Location "F"	<ul style="list-style-type: none"> <li>• There is some space to buffer the trains in prior to be admitted to a depot. Can be making use of with arranging a yard setup with signaling. In this case, the trains completing the service of main line can be pushed into the buffer area to get rid from the platforms and access area quickly. Then they can be sent to depots after the morning peak.</li> </ul>

Above suggestions of alternatives are not much complicated but a policy level decision is required. Some decisions are halfway done. When the "turn table" is concerned, a new turn table is already constructed in par with the above proposal but has not been commissioned for years due to some space issues and awaits signaling connectivity.

Shifting of facilities too is not a big issue and could be considered under a railway up gradation project.

## **CHAPTER 6**

### **6.0 RECOMMENDATIONS AND CONCLUSIONS**

#### **6.1 Conclusions**

Problem taken up at the research is a real existence and is not solved even to date despite of the various actions the Sri Lanka Railways has experimented on solving the issue. Existence of the problem is established under the chapter 3 and problem and the impact is quantified. As per the objectives, hypothetical causes were investigated in detail and contributory evidence over all hypotheses was adequately found and contribution towards the problem is proven. One hypothesis "Lack of platforms" was not accepted in raw but there were evidence to appearance of the same with some variation and hence modified to be "Inefficient utilization of track and platforms" within the course of progress.

Following root causes were found to be contributing for the problem.

1. Overlap train operation of coastal line.
2. Inefficient way of utilization of tracks and platforms due to lack of flexibility in track layout and the signaling system.
3. Improper positioning of feeding depots and maintenance facilities.

#### **6.2 Recommendations**

Alternatives for the root causes were discussed in detail in the chapter 5 and justifications for the recommendations were established. Therefore it could be recommended that the following suggestions could solve the problem in a short or medium term basis.

- Discontinuation of overlap operation of bringing the coastal line trains up to Maradana and terminating and starting the coastal line service from Colombo Fort.
- Reshuffle the fleet arrangement and coastal line service to be solely handled by shed 8; the S9 & 10 yard.

- Provide additional crossover connectivity for Maradana and Colombo Fort with improved connections to shed 8 and the fourth access line. Required connections are described under chapter 5.2.2.
- Reshuffling of feeding depots and maintenance nodes as described in chapter 5.2.3.
- Avoid long occupation at Colombo Fort platform lines. Retime the trains continuing through Colombo Fort to main and coastal lines accordingly.

Above recommendations are valid for a interim period as medium term plans but need a quick step at the beginning of the next era; the electric traction.

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