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Analysis of Delay Causes in Mumbai Suburban Western Railway Network

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Abstract

Transportation development contributes greatly to the economic development of the country and also interconnects larger distances. Out of the modes of transport, railways are most effective and efficient land transport. Local trains help commute major amount of population. The Mumbai suburban section of Western Railway serves around forty lakh commuters per day, running at a commendable ideal frequency of 3 minutes during peak hours overlooking delays and cancellations, with the former generally leading to the latter. Delays affect both the commuter as well as the operator. Commuters plan their journey from one place to another according to the schedule of trains and frequent or irregular delays increase the degree of uncertainty. On the operational side, guaranteeing punctuality is a huge challenge, especially because of infrastructural, financial, social and political constraints. Delays goes on multiplying as one delay of train causes delay for the trains running behind. For these purposes, delay analysis is a powerful tool wherein the various causes of delays are examined, compared and categorized by studying historic data. This research aims to address delay causes in terms of occurrence frequency, progressive variation, resultant impact and other external unpredictable, at times unavoidable factors. The results of this study can be viewed from multiple perspectives to provide insights on the suggested subjects of focus. Trespassing, mail / express trains running late and Engineering issues are found to be major causes of delays and needs to be focused.

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Keywords: railway; delay causes; statistical analysis; western railway;

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1. Introduction

1.1 Overview

Transport system provides better access by interconnecting different regions. Transportation contributes greatly to the economy of the country. Land transport, water transport and air transport are different modes of transport system. Each system carries certain limitations on the basis of accessibility, cost, time and comfort. Water transport is not easily accessible to various regions, air transport proofs costly and limited in access but is time saving, road transport is easily accessible but proofs time and energy consuming, whereas railways provide less limitations comparatively as they are easy to access, less in cost and quite comfortable. Railways provide more effective and efficient transportation as they serve large amount of population. Rail transport system are 6 times more energy efficient and 4 4 times more cost efficient.

The Indian Railways is one of the major transport service providers that interconnects travelers from distant locations at a phenomenal rate. It has two of its zonal departments in Mumbai, namely the Western Railway and the Central Railway. These contribute to the suburban local trains along with freight and passenger trains. Mumbai is known for its life in local trains, and they hold a historical presence in witnessing the transformation of Mumbai as well as the drastic change in its population, the impact of which is conspicuous on social, economic, political and environmental levels. The first local train in India travelled from Bombay to Thane. Over a period of time, there have been innumerable changes, and as of today, the service is running at a very high efficiency. It takes great pride in resurrecting its services swiftly even after the occurrence of disastrous events such as bombings, politically threatening strikes or cases of excessive rainfall leading to floods. It is a known fact that being a public service, the Indian Railways are garnering huge losses, and to be in a functional state in spite of this is commendable.

Delays are the impunctuality occurred due to various unwanted factors. Delays causes huge disturbance in the time schedule and affects the efficiency of travel journey. Various factors responsible for delays are classified operational causes, passenger traffic causes and other causes (Nagy and Csiszar, 2015). Operational causes include infrastructural problems, vehicle problems, traffic control problems, staff problems, engineering problems. Whereas other causes include guaranteeing connections, delay caused by other rail companies, extraordinary event and other trains passing.

Delay goes on multiplying train by train. So, there is a need for these delay factors to be reduced as it may have impactful effects on the schedules. Hence the objective of this paper is to analyze various factors affecting or causing delays for railways in the Western Suburban of Mumbai.

1.2 Area of Study

The Western Railway is one of the fragments of the 17 zones of the Indian Railways, and is among the busiest railway networks in India. It constitutes 37 stations, terminating at Churchgate and Dahanu Road at either end. In this report, the terms ‘up’ and ‘down’ have been used to refer to directions towards and away from Churchgate terminus. The local train service is divided into fast, semi-fast and slow trains that halt at stations according to the priority assigned to the respective stations. The importance of stations is identified via surveys and feedback letters written by commuters. Also, services are mediated according to time and demand.

With a daily accounted ridership of 34.27 lakhs in the fiscal year 2015-2016 and 35.19 lakhs in the fiscal year 2016-2017, the trains in the Western Railway function with a gigantic capacity of 3,504 passengers, carrying 5,300 passengers per se for 12 car rakes and a capacity of 4100 passengers, carrying 6500 passengers per se in 15 car rakes. Nine coach trains were initially used but with demand, the number of coaches increased. Currently, the number of functioning trains are up to 1355 per day on weekdays, 1307 per day on Saturdays, 1334 per day on holidays and 1265 per day on Sundays. The system majorly consists of quadruple track pathways, with six to seven parallel tracks in certain regions. It includes electric engines running on alternating current, carrying the rolling stock. Major track maintenance works are carried out every Sunday, leading to phenomena commonly known as ‘Jumbo Blocks’. The per day ridership is directly impacted by the morning (8:30 hrs - 11:30 hrs) and evening (17:30 hrs - 20:30 hrs) peak hour rush. The gauge followed throughout is broad gauge (1676 mm wide) with the line

extending to a 123.78-kilometer-long stretch. The maximum speed of trains is 110 km/hr in some locations while the average functional speed is 60 km/hr. Apart from Electric Multiple Units (EMUs), we observe Mainline Electric Multiple Units (MEMUs) functioning between Virar and Dahanu Road, which is a 64 km stretch. There are three EMU carsheds namely Mumbai Central carshed, Kandivali carshed and Virar carshed (the largest carshed in Asia) and a repair shop at Mahalaxmi.

The Western Railway line consists of (major stations in bold):

1. **Churchgate**
2. Marine Lines
3. Charni Road
4. Grant Road
5. **Mumbai Central**
6. Mahalaxmi
7. Lower Parel
8. Prabhadevi
9. **Dadar**
10. Matunga Road
11. Mahim Jn.
12. **Bandra**
13. Khar Road
14. Santa Cruz
15. Vile Parle
16. **Andheri**
17. Jogeshwari
18. Ram Mandir
19. **Goregaon**
20. **Malad**
21. **Kandivali**
22. **Borivali**
23. Dahisar
24. Mira Road
25. **Bhayander**
26. Naigaon
27. Vasai Road
28. **Nalla Sopara**
29. **Virar**
30. Vaitarana
31. Saphale
32. Kelva Road
33. Palghar
34. Umroli Road
35. Boisar
36. Vangaon
37. **Dahanu Road**

Continuous surveillance is carried out by means of Control Rooms. A Control Room is a designated space which serves as a facility for the constant monitoring of stations and routes in its broad vicinity. The stretch from Churchgate to Virar falls under the scope of the Control Room located at Mumbai Central, whereas the stretch beyond Virar is invigilated by the Valsad division. Each station is represented in a separate quadrilateral, featuring a graphical representation of the routes on either side. Tracks available for transit are displayed in green, while those briefly out of transmission are illuminated in red.

2. Data collection and classification

2.1 Delay classification

As per the norms of the Western Railway and the Indian Railways in general, any setback that persists beyond a 5-minute threshold is classified as a delay. Further, punctuality rates are calculated taking into consideration delays that exist beyond this limit. A primary delay is caused when one train faces an independent setback. Secondary delays are those which are unavoidably created due to primary delays and these delays lead to further disruption in rail traffic. The railway operation management often targets and copes with failures and external disturbances that may cause primary delays. In heavy traffic areas of rail networks, primary delays can quickly propagate and lead to the so-called secondary or knock-on delays. Generally, the time lag is mitigated by making minor adjustments in following train velocities. But some cases present themselves in such a way that the only possible solution is to cancel one or more sets of train services in the opposite direction so as to avoid stock build-up on one end. Delays are a cause for lack of service reliability and customer satisfaction which in turn leaves a lasting footprint on road traffic and subsequent pollution levels.
Identification of delay events and their causes help plan services for the future and can be used for:

- Traffic forecast on operational side: Train schedules and connections are modified considering delay trends;
- Traffic forecast on passenger side: Factors like atmospheric conditions, service lines, service type, etc. drive the punctuality of vehicles (departure and arrival time).

Another considerable operational issue faced while establishing connections is the capacity of stations. Operations of 15 car trains are hindered by a lack of capacity of some station platforms to meet their length. This leads to inefficient passenger accommodation.
Travel time reliability and its variations in different traffic zones have been investigated as part of this study. Reliability varies not only inside a particular zone but between zones as well, since Central Railway trains join the Western Railway routes from Bandra to Borivali and these are generally inept with respect to punctuality due to infrastructural reasons. It has been noticed, however, that a train seldom reaches it destination before time and the optimal head start decreases with service reliability, but not necessarily with service frequency.
Service reliability can be based upon:

• The maximum amount of overhead amount over the basic fare that passengers are willing to pay in order to avoid uncertainty (meanwhile travel time does not change),
• The maximum additional travel time that passengers are willing to accept in order to avoid uncertainty.

Nomenclature

A	Disruption Frequency
B	Cancellation Impact Index
C	Delay Impact Index

2.2 Data collection

Analysis has been performed on the following data sets:

- Annual Suburban train cancellations, classified by cause
- Annual Suburban train delays, classified by cause
- Daily Suburban train cancellations, classified by cause
- Daily Suburban train delays, classified by cause

The information contained within this report has been obtained from various sources including Government websites and documents as well as public domains. This has been done by obtaining reviews of both beneficiaries as well as stakeholders, studying transit patterns and railcar dynamics and processing usage data. Factual data corresponding to occurrence of irregular and unfavourable events is collected and stored with the respective station masters/ person locally appointed there. Eventually, this data is supplied to the Mumbai Central Suburban Department and stored for record keeping and claim settlement purposes. It is consolidated, segregated and tabulated with separate causations stated for major events and events with high occurrence frequency.

2.1.1 Consumer survey

A survey of regular travellers from Churchgate, Dadar, Andheri, Malad, Goregaon, Borivali, Dahisar and Mira Road has been conducted, obtaining their reviews on the current status of functioning of Western Railway as well as their opinions on scope for improvement in the near future.

2.1.2 Detailed list of delay events

Western Railways has made data available for each route in printed hardcopy. The manoeuvre of converting this data into usable digital documentation has been personally performed. With the focus distinctively being on yearly patterns, numerous observations have been made upon which, for detailed understanding of the principal object, daily data sets have been analysed.

2.2 Data processing

Detailed tables of instances of suburban trains losing punctuality in the last 30 months (April 2016 - September 2018) have been obtained from the DRM office - BCT. The cumulative figures as well as segregated 6 - month data points have been studied, attributing causes of delay to different departments and events. The various causes for train cancellation and delay have been categorised as shown in Figure 1, with some causes affecting punctuality at much higher rates than others. The punctuality percentages of trains over the course of time have been studied in order to comprehend progressive performance enhancement.
Two terms have been defined here and shall be used further in the study:

2.2.1 Cancellation Impact Index: It is the ratio of number of cancellations attributed to a particular cause to the total number of occurrences of the cause.
2.2.2 Delay Impact Index: It is the ratio of number of delays attributed to a particular cause to the number of occurrences of the cause.

The aforementioned indices have been applied only to major causes i.e. causes with the highest number of occurrences, so as to avoid any kind of data interference, distortion or inaccuracy in studying the results of the research. A cause is considered to be of satisfactory importance only if it is found to have an occurrence ratio greater than 5 percent of the total number of occurrences, failing which it is overlooked as negligible.

2.3. Classification of Causes of Disruptions in train services

- Security
- Signal
- Electric
    - Unit Def(Emu)
    - Unit Def (Ac- Emu)
    - Unit Def (Memu)
    - Unit Def (Siemens)
    - Ohe Failure
    - Engine Failure
    - Train Light/Rac
    - Elec. Power
- Others
- Mechanical
    - Loco
    - C & W
    - Others
- Construction
    - Electric
    - Signal
    - Engineering
- Traffic
- Accident
- Central Rly
- Engineering
- Commercial
    - Acp M/Exp
    - Acp Sub
    - Others
- Miscellaneous
    - Tp

- Lc Gate
- Bomb Scare
- Public Agitation
- Heavy Rain
- M/Exp. Running Late
- Night Soil/ Coach Dirty
- Grid
- C.R.O.
- M.R.V.C
- F/Weather
- Jumbo Block
- Two
- Bad Weather
- Bandh
- Aws
- Misc. Others

2.4 Data interpretation

Conclusions have been drawn based on results of statistical analysis that indicate:

- Frequency of occurrence of disrupting events
- Number of train cancellations due to an event
- Number of train delays due to an event
- Cancellation Impact Index of an event
- Delay Impact Index of an event
- Hazard Identification and Risk Assessment (HIRA)

2.3.1 Frequency of occurrence of disrupting events

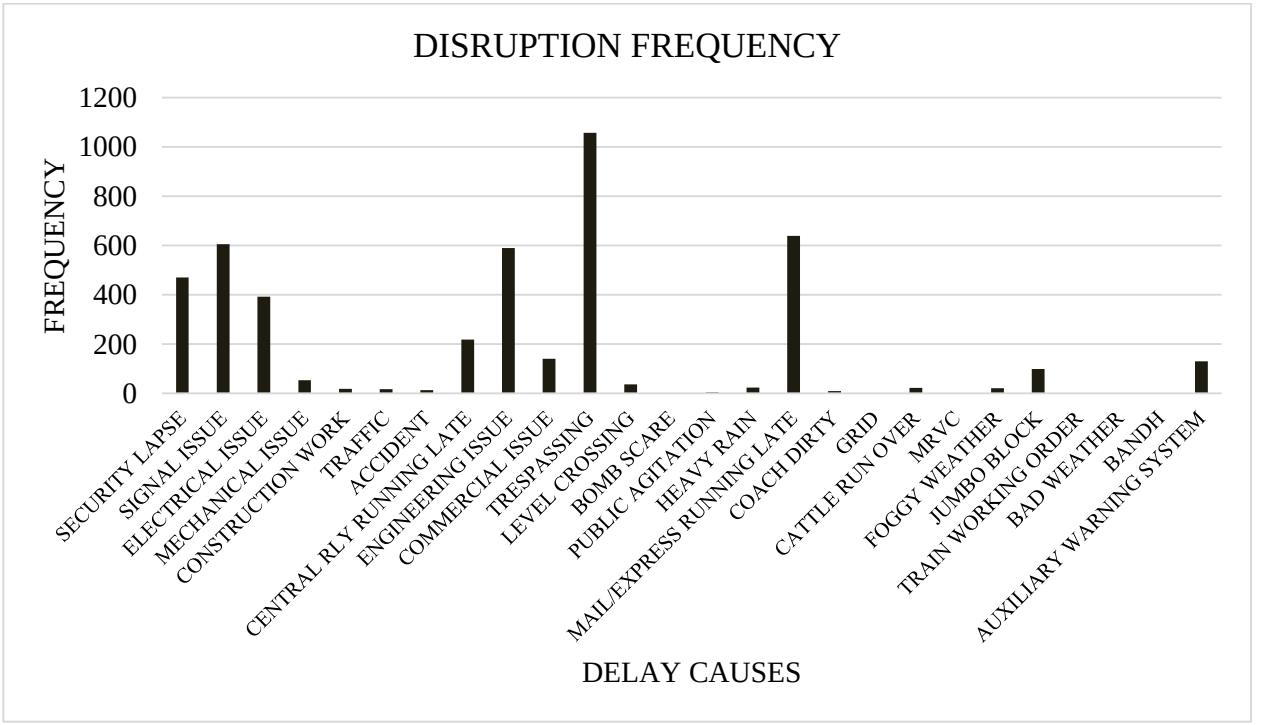

Fig 1. Graphical Representation of Disruption Frequency

Disruption Frequency takes into consideration the number of occurrences of a particular cause. Figure 2 is a graphical representation of distribution of total number of cases due to various causes of inconvenience presented to the Western Railway. The major contributors to this are trespassing, mail / express trains running late, signal issues, engineering issues, security lapses and electrical issues.

2.3.2 Number of train cancellations due to an event

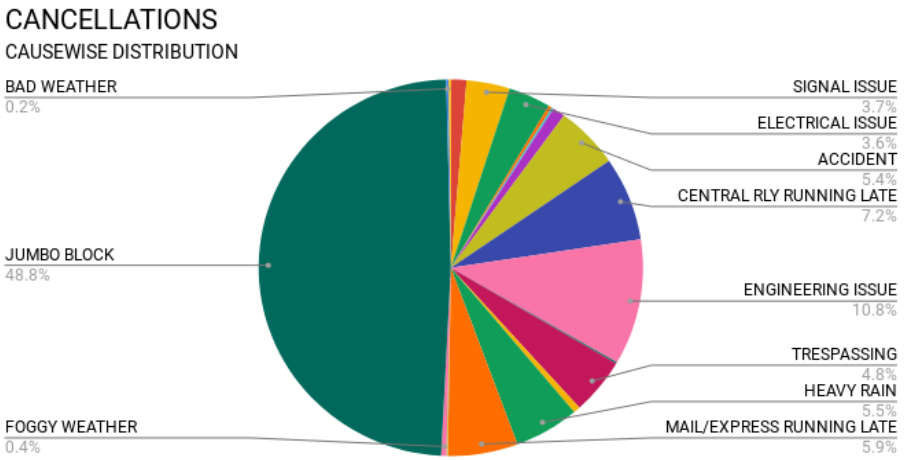

Fig 2. Graphical Representation of Cancellations

Cancellations represent trains initially scheduled to run but which, due to emergent circumstances, have to be eliminated from the running schedule for the day. Figure 3 represents graphically the cancellation data recorded for various cases which have been previously listed.

2.3.3 Number of train delays due to an event

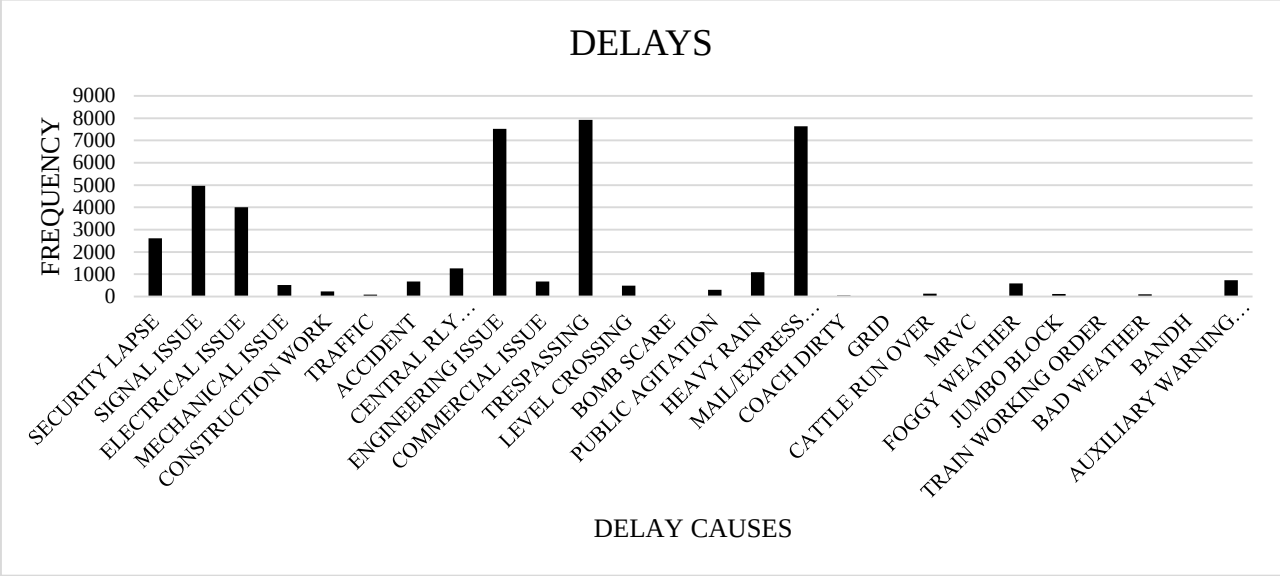

Fig 3. Graphical Representation of Delays

Delay is the term used to refer to situations where a train is forced to commute with a setback of a minimum of 5 minutes behind schedule. Figure 4 represents graphically the cancellation data recorded for the causes previously mentioned.

2.3.4 Cancellation Impact Index of an event

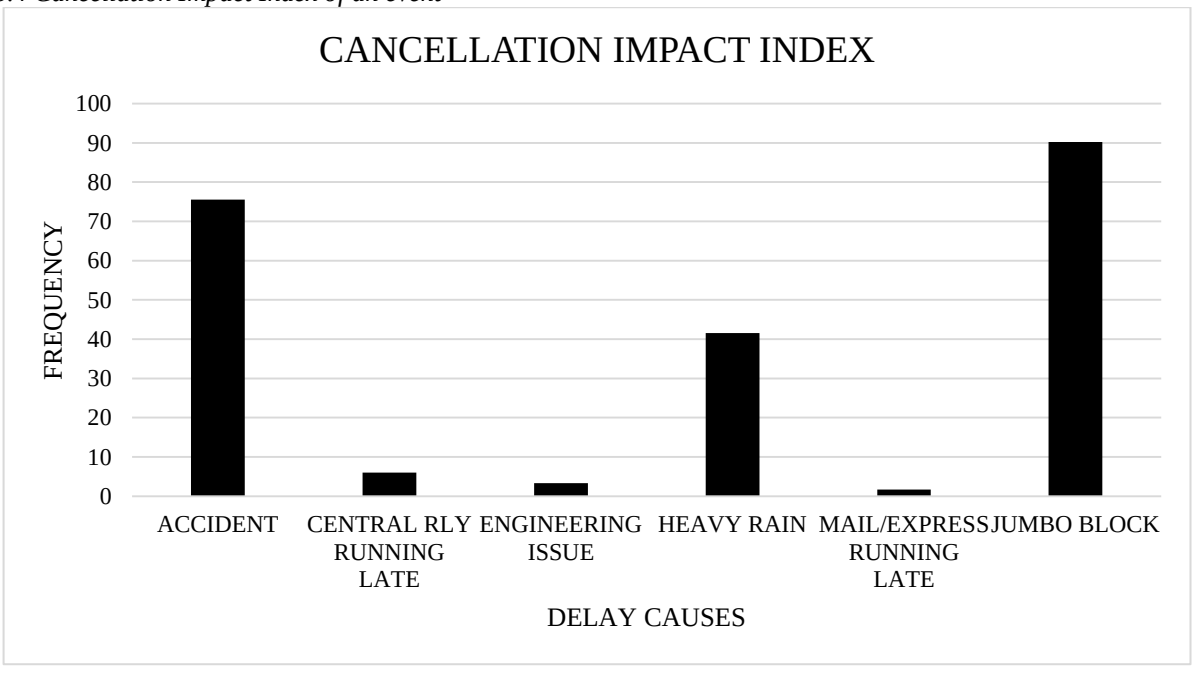

Fig 4. Graphical Representation of Cancellation Impact Index

Cancellation Impact Index has been defined in Section 2.2.1. Figure 5 represents graphically the major contributors with significantly high Cancellation Impact Indices. Other contributors have been neglected. The contributors garnering attention, in a decreasing order, are jumbo blocks, accidents and heavy rain.

2.3.5 Delay Impact Index of an event

Delay Impact Index has been defined in Section 2.2.2. Figure 6 represents graphically the major contributors with significantly high Delay Impact Indices. Other contributors have been neglected. The causes to focus on are engineering issues, mail / express trains running late, electrical issues, signal issues, trespassing and security lapses, in a decreasing order of importance.

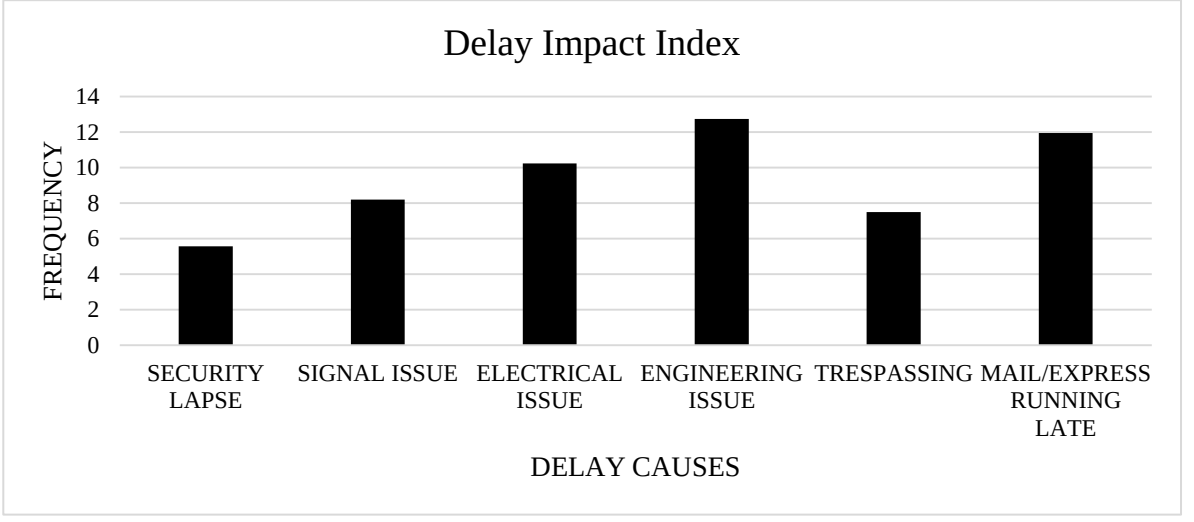

Fig 5. Graphical Representation of Delay Impact Index

2.3.6 Hazard Identification and Risk Assessment (HIRA)

The above graphical representations, along with the conceptualisation of HIRA - Hazard Identification and Risk Assessment, collate to give rise to an attribute that surfaces wherein some events seldom occur but have strikingly major impacts, whereas some events which occur much more frequently have almost negligible impacts.

Table 1: Reference Table - Hazard Identification and Risk Assessment (HIRA)

		DISRUPTION FREQUENCY (%)				
		<5	5-10	10-15	15-20	>20
DELAY IMPACT INDEX (%)	<5	LOW	LOW	LOW	LOW	MEDIUM
	5-10	LOW	LOW	LOW	MEDIUM	MEDIUM
	10-15	LOW	LOW	MEDIUM	MEDIUM	HIGH
	15-20	LOW	MEDIUM	MEDIUM	HIGH	HIGH
	>20	LOW	MEDIUM	HIGH	HIGH	HIGH

3. Conclusions

On the basis of statistical analysis, conclusions have been drawn based on different factors. Numerous bases have been identified and major causes of delay and cancellation of trains in the Mumbai Suburban Western Railway Network have been inferred towards the end.

3.1 Conclusion on the basis of disruption frequency

On the basis of frequency of disruption, the major contributors have been identified as trespassing, mail / express trains running late, signal issues, engineering issues, security lapses and electrical issues.

3.2 Conclusion on the basis of number of cancellations

The major contributors in this respect are jumbo blocks, engineering issues, central railway trains running late, mail / express trains running late, heavy rain and accidents.

3.3 Conclusion on the basis of number of delays

The major contributors in this respect are trespassing, mail / express trains running late, engineering issues, signal issues, electrical issues and security lapses.

3.4 Conclusion on the basis of Cancellation Impact Index

The major contributors according to the Cancellation Impact Index are jumbo blocks, accidents and heavy rain.

3.5 Conclusion on the basis of Delay Impact Index

The major contributors according to the Delay Impact Index are engineering issues, mail / express trains running late, electrical issues, signal issues, trespassing and security lapses.

3.6 Overall conclusion on the basis of Hazard Identification and Risk Assessment (HIRA)

The major causes of delay and cancellation of trains in the Mumbai Suburban Western Railway Network are:

- Trespassing, with a disruption frequency of 23.2 percent and a Delay Impact Index of 13.3 percent;
- Mail / express trains running late, with a disruption frequency of 14.0 percent and a Delay Impact Index of 21.3 percent;
- Engineering issues, with a disruption frequency of 12.9 percent and a Delay Impact Index of 22.7 percent.

4. Recommendations

The current scenario of western railway suburban train delays can be reduced by employing one or more of the following methods:

- Enforcement of stringent rules against trespassing: Even upon the existence of Laws prohibiting crossing of railway tracks and trespassing, such cases lead to a significant amount of delays that affects the day-to-day functioning of trains. If the Laws are reinforced through strict action rather than adhering to the current passive approach, significant progress can be made in this subject. The beneficiaries are also advised not to approach railway lines casually as this can prove to be fatal. As a part of returning courtesy to the Railways, the users of the system must follow a certain code of conduct at the very least.
- Currently, there are:

- Dahanu Road – Virar : 2 Lines
- Virar – Borivali : 4 Lines
- Borivali – Andheri : 5 Lines
- Andheri – Mahim : 6 Lines
- Mahim – Mumbai Central : 5 Lines
- Mumbai Central – Churchgate : 4 Lines

- There is no direct route for passenger trains. A dedicated corridor for express and freight traffic wherever possible will encourage them to not interfere with the functioning of the suburban trains. The fifth line that currently exists is discontinuous in sections between Santacruz and Mahim. So, the extension of the lines or the concept of dedicated elevated corridors could be possible solutions.
- As far as engineering issues are concerned, infrastructural failures like fault in track exist with such an urgency that proper functioning of trains is hampered. Efficient repairs and usage of wear resistant materials needs to be done.

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HIRA - Hazard Identification and Risk Assessment

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