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# Mobile Technological Evolution in Train Radio Communication

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## ABSTRACT

Presently, India has the dubious distinction of recording an exponential number of train accidents as compared to its other developed counterparts. Though, no accident is completely avoidable, what can be done is to develop a certain technologically advanced machinery which can scale down the prospects of such accidents and expedite Disaster Management in case of any mishap. This would help to curtail the damage to life and property. The "Mobile Train Radio Communication (MTRC) "system is a dynamic and technologically avant-garde system based on the "Global System for Mobile Communication-Railways (GSM-R)" technology and it can play an intrinsic role in abbreviating train accidents by aiding effective communication.With the passage of time, India has shown its technological capability to the world, be it through the successful launch of the "Mangalyaan" in the very first attempt, the invention of various machines and electronic gadgets by the Engineers and Scientists across the country, the development of India as a nuclear power and so on. As Dr. D. Swaminadhan said in his speech, "Science and technology have been an integral part of Indian civilization and culture over the past several millennia". India has the best of resources and technical minds

available, through which it can move ahead of its other developed counterparts. As life is very precious, a major requirement of the present is to switch over to the "MTRC" system at the earliest. The railway accidents over the past decade cannot be neglected and the unfortunate events cannot be entirely reasoned as an event occurring out of chance. Trains are merely machines running on railway tracks and they cannot think of how to avoid accidents on their own. As B.F. Skinner rightly said "The real problem is not whether machines think, but whether men do". It is up to the human beings to design and use an efficient system which can help the train driver and the station master to know about the possibility of any untoward hazard beforehand by developing effective communication between the concerned officials.

## INTRODUCTION

Since its inception in 1853, Indian Railways have progressed a long way. Presently, India has the third largest railway network in the world, covering a total length of around 65,000 Kilometers. [1] With the passage of time, Railways have become a commonly used medium for long distance transport in India. More and more passengers are using Railways as a means of travel. Millions of tones of goods are now being transported by trains. Indian Railways transport 7651 billion

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passengers and over 921 million tons of goods annually. As the world is getting technologically advanced, more complications have set in regarding safety and security of passengers. The report of the High Level Safety Review Committee of 2012 estimates that almost 15,000 number of persons gets killed every year in train accidents. Apart from this, security in trains is also a major concern. Considering all these necessities, the need of the hour is to develop an effective and a technologically advanced communication system in the Indian Railways.

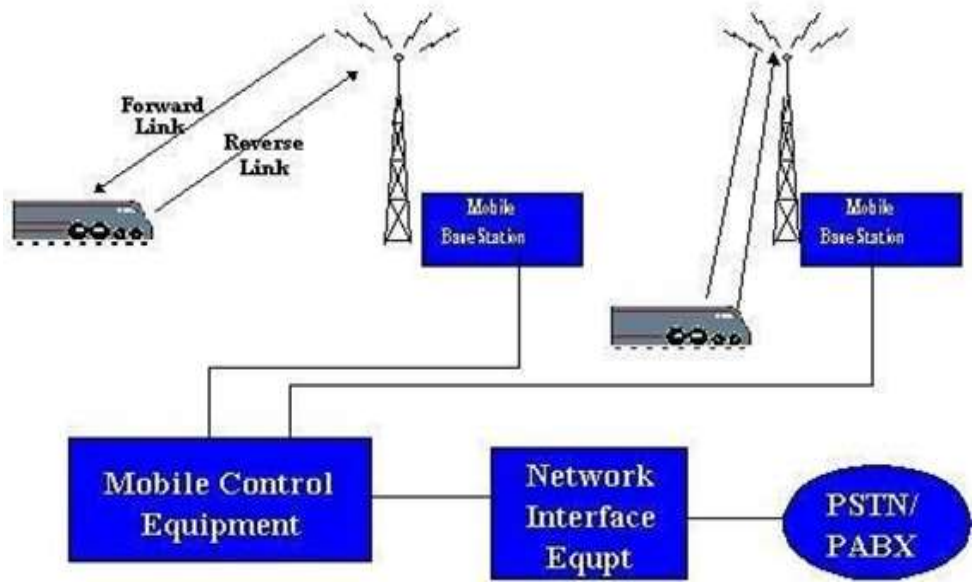


**Figure 1: Basic Mobile Telephone Service Network**

[1] The Mobile Train Radio Communication (MTRC) system.
[2] Seems to be the right answer to these concerns. MTRC uses the "Global System for Mobile Communications- Railway (GSM-R)" technology.
[3] To facilitate an instant and constant interaction with the train crew with the Control Centre and Station Master.

It ensures safety of passengers by providing effective communication between Driver and Control Room. The MTRC system can be used to warn the drivers beforehand of the running trains as well as the concerned officials. In case of any security problem, concerned staff can immediately intimate the concerned security establishment. If any accident takes place, the MTRC system will facilitate better post-disaster management. In the present day, Railways need not just effective voice transmission, but also have the capability to analyze all the technical data to arrive at the correct decision to be taken on the spot.

In India, as per Action Plan of Vision 2020 and safety concerns highlighted by the High Level Safety Review Committee report, a beginning has been made to put MTRC into use in the railways. The MTRC project is being implemented by the Indian Railways Project Management Unit (IRPMU), and it is expected that this technology will help to improve the

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Railway communication in India manifold and make Railways a safer and better mode of transport for the common man.

**Mobile Communication Evolution**

The very first generation of commercial cellular network was introduced in the late 70's with fully implied standards being established thought the 80'S.

**BLOCK DIAGRAM**

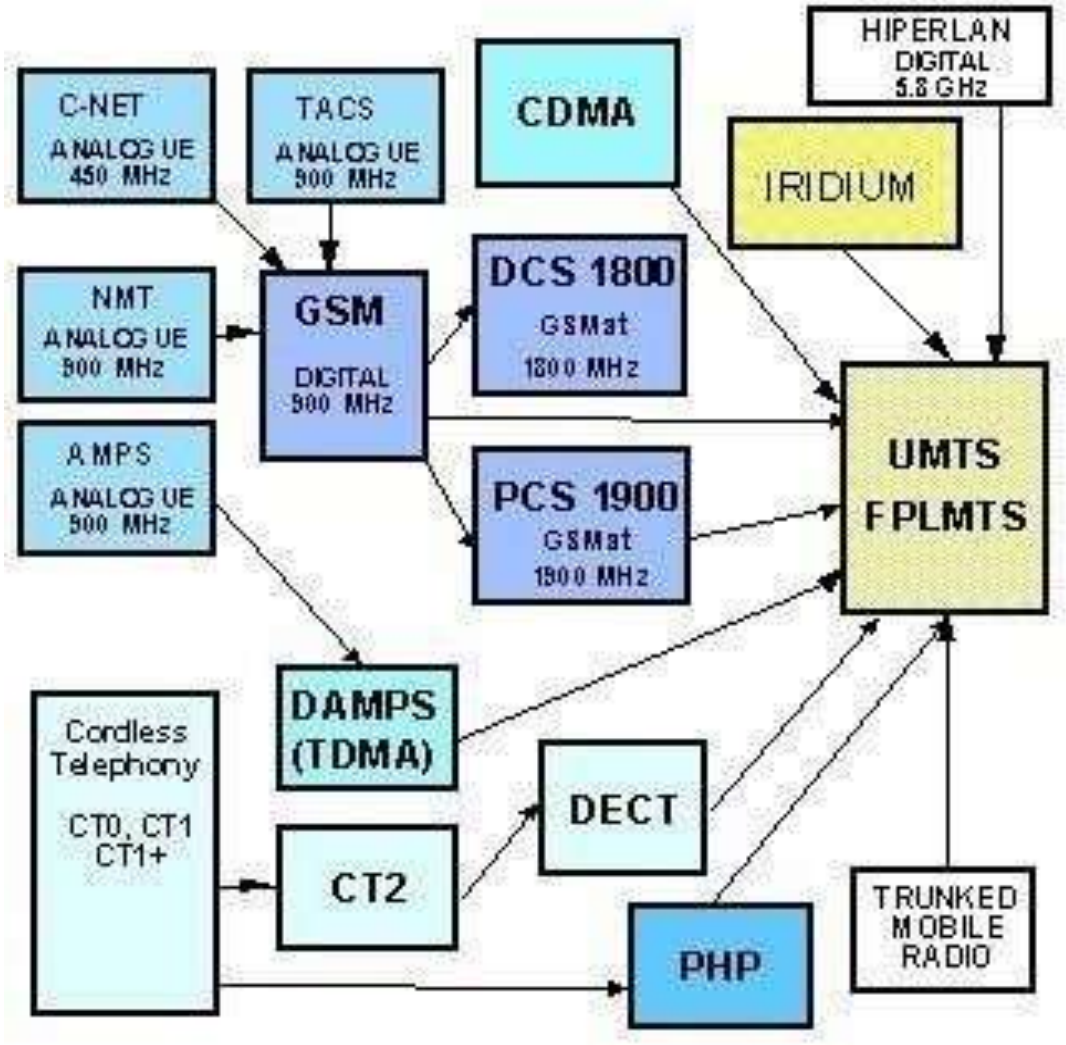


**Figure Mobile Technological Evolution**

**Evolution of 2-Way Radio Platform**

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The following diagram explains how the evolution of 2-Way radio platform has taken place.

The first truly mobile two-way radio was developed in Australia in 1923 by senior constable Frederick William Downnic of the Victorian police. Farly two-way sheam allowed only one station to transmit at a time.

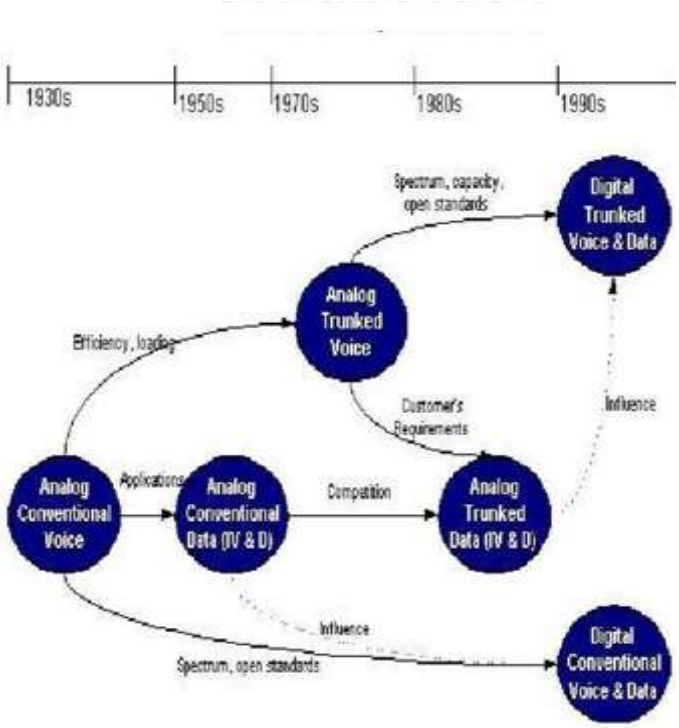


**Figure. Evolution of 2-Way Radio Platform**

## 3. NATIONAL AND INTERNATIONAL STATUS

### 3.1 Current Scenario: Signalling and Telecommunication in the Indian Railways network

Effective signaling is necessary for the proper functioning of railways. The Signaling and Telecommunication Department of the Indian Railways plays as integral role to ensure glitch-free signaling operations. The Corporate Safety Plan laid in 2003 opens up the avenues for the Signaling & Telecommunication body by striving for technological up- gradations and maintenance of the existing railways machinery.

In 2008, the Performance Audit conducted under the Special Railway Safety Fund reviewed the progress in meeting the aims which were raised in the Corporate Safety Plan initiated in 2003. The audit revealed that no zone, out of the 16 zones, was able to fulfill completely, all the objectives under the Corporate Safety Plan for the Signaling and Telecommunication plans like Mobile Train Radio Communication, Panel Interlocking, Solid State Interlocking, Track Circuiting etc. It indicated that the funds could be better utilized through effective planning and implementation of new technologies.

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It paved a way for the development of efficient machinery to curtail the incidence of train accidents in India.With the increase in rail traffic in India, the spate of Railway Accidents has also increased tremendously. Many reports, including the one given by the High Level Safety Committee reveal the rise in train accidents over the past decade. Most of these accidents have occurred due to failure, complete or partial, or malfunctioning of the railways Communications System. The graph give below makes it clear that most of the Train Accidents from 2009 to 2014 have occurred due to inefficient machinery and human failure. Many accidents have occurred at the unmanned railway crossings and these could have been avoided by the presence of effective Signaling and Communication machinery.

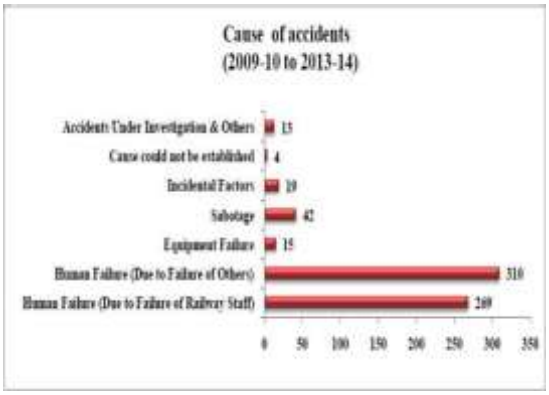


**Figure 3.1** Indian Train Accidents Statistics

As per an article in the Hindustan Times entitled “The killer trains of India”, the number of people who were killed in train accidents in the last ten years, is significantly higher than the combined number of Passenger Deaths in the UK, US and Canada. This article reveals the fact that though India has a vast railway network requiring more effort for effective management, the record of countries with similar large networks of railways is much better. There has been less number of casualties in these countries due to train accidents. This calls for implementation of better technology and up-gradation of existing Communication System at the earliest.

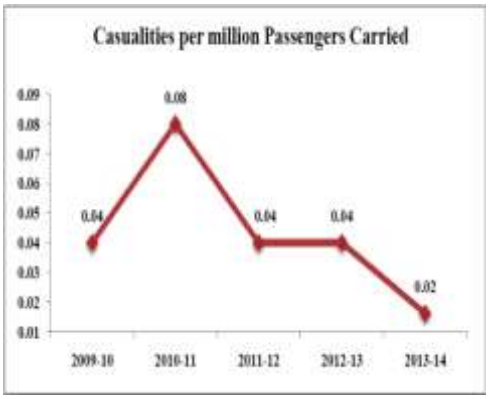


**Figure 3.2 Statistics of Indian Railways Accidents**

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To our respite, implementation of effective technology and action plans by the Indian Railways has lead to a dip in the Train Accidents over the years. The casualties per million passengers carried have fallen from 0.04 in 2009-10 to 0.02 in 2013-14. This is, in fact, an achievement for the Indian Railways.

The map given below illustrates the vast network of the Indian Railways, spreading its wings over the 16 zones. It shows the reason for a layman to believe that India has the third largest Railway Network of world. The zest of travelling in trains in India- with the hawkers selling some quick snacks in the local trains, the delicious food being served to the passengers in the trains, the beautiful and captivating landscape of the routes through which the trains pass, and the comfort provided to the tourists in the *Rajdhani* , *Shatabdi* and *Duronto* trains is worth appreciation. No doubt, Railways is the most preferred mode of long distance transport for the people travelling in India.

Though, these reasons are more than enough for us to feel great about travelling in Indian Trains, the displeasing statistics about the Train Accidents in India arise as a cause of concern for the Indian Railways. In India, there is a culture of **"Atithi Devo Bhava"** meaning Guest is like God. People who travel in trains are the guests and their safety is of utmost concern and importance to the Railway Authorities. To meet the expectations of millions of passengers who travel by trains daily, it is high time to implement newer plans etc. and make betterment in the present technology. It is time for a complete switchover from Analog Communication to Digital Communication. And what can be a better option in the present times than to switch to MTRC in all sectors and zones of the Indian Railways.
The "Indian Railways Project Management Unit (IRPMU)" is doing an excellent job in implementing the various strategies for this switchover and various other bodies of the Indian Railways, including the Telecom Directorate, Ministry Of Railways, Indian Railways have undertaken the tedious task of going digital through MTRC in the vast railways network of India.
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**Figure 3.3 Indian Railway Network**

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An effort was made in the 1980s to switch over to the MTRC system. Out of the 16 zones of the Indian Railways, South Eastern Railways and Central Railways incorporated the change. Though, the system was fine enough to fulfill the needs of that time, the bulky mobile handsets and machinery for charging made it unsuitable for use by the drivers and guards. The machinery was simply based on Radio Communication by propagation of Radio Waves, was prone to malfunctioning and not reliable.

As a consequence of these drawbacks, the Indian Railways decided to move ahead and introduced Mobile Train Radio Communication based on GSM-R technology. It all started with the introduction of the full duplex communication based system in the Nagpur- Itarsi section, Mughalsarai- Howrah , and the Delhi-Mughalsarai section. It marked the beginning of the MTRC revolution in India. The system lacked the essence of the MTRC in real sense as it could facilitate communication only between the driver and the control room or the guard and the control room, lacking the ability to aid direct communication between the concerned staff.

The "Gaisal Train Disaster", which occurred on 2nd August, 1999 due to the collision between the Avadh Assam Express from Dibrugarh and the Bramhaputra Mail from New Delhi, leading to more than 280 deaths and leaving over 320 people injured forced the Indian Railways to expedite the changeover to MTRC system. Finally in 2005, the MTRC project was sanctioned and Nokia Siemens Network given the work of implementing MTRC based on GSM-R technology in India. The Nokia Siemens Network implemented the country's first GSM-R based MTRC system in May,2008 for the North Central Zone of the Indian Railways.
As on 31st March,2013, only around 2,200 Route Kilometers (RKM's) of the
64,980 RKM's of the railway network have been covered by the GSM-R based MTRC system. Around Rs 205.94 Crores of expenditure has been incurred and over Rs 1000 Crores is required to cover the whole of Indian Railways' 20,000 RKMs of A, B and C railway routes.
It is the need of the hour to switch to MTRC at the earliest to curtail Train Accidents and safe journey for the passengers. As of now, the work is going on, and it is expected that if plans are properly implemented and funds fully utilized, in a few years from now, the vast network of Indian Railways will be fully equipped with the modern day GSM- R based MTRC system for Railway Communications.

Mobile Train Radio Communication to facilitate Railway passengers

■ Our Correspondent

BILASPUR, Apr 3

IN order to ensure safety of the passengers, Railways have taken the initiative of implementing Mobile Train Radio Communication which would provide better communication between the driver and the control room. The work is already in progress and is expected to bring a sea change in the history of communication technology in the Indian Railways.

According to information received from Railway sources, Mobile Train Radio Communication System would use GSM-R technology which is proposed to be provided on Rajdhani routes. This will facilitate instant communication of train crew with control centre and station master, thus enhancing safety and confidence in the train operating staff.

This will also enable maintenance of staff and officers deputed at different locations to communicate instantly with each other, thereby enhancing the system efficiency manifold.

Besides this Bharat Sanchar Nigam Limited (BSNL) has launched BSNL 3G Branded Rajdhani Express in association with the Indian Railways through the vendor who has direct agreement with the Indian Railways. BSNL has done advertisement with the objective of branding and promotion of 3G products and value Added Services including 3G themes. BSNL has allocated Rs1.95 crore for this purpose.

**Figure 3.4 MTRC to facilitate Railway passengers**

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Following the footsteps of the Indian Railways, the other railway bodies have also begun to implement the MTRC system for rail transport in India. The Metro Railway is also being covered by the GSM-R based MTRC system. The "Delhi Metro Rail Corporation (DMRC)" has also moved ahead to implement the GSM-R based MTRC system.

**Figure 3.5 MTRC systems across the world**

## 4. MTRC SYSTEM IN SINGAPORE

In 2003, the world's first Radio Communication Based Train Control system was implemented in Singapore by "Alstom", a French MNC which has implemented MTRC system in various developed counties. The project was implemented across 2 Metro Lines, the first being the 16 station North-East line and the other being the 29 station circle line.The North East line in Singapore a highly advanced and fully automatic underground driverless train line, a first of its kind in the world. The completion of this project in 2003 made Singapore the first country in the world to have a fully automatic metro based on the MTRC model for communication in the world's longest and highest capacity metro trains.

The MTRC system supplied is very advanced and fulfills the high standards laid down by the Singapore's "Land Transit Authority (LTA)" for passenger safety and quality of service.

The Map given below shows the metro railway network of Singapore. The network is very well planned and consists of an efficient MTRC system.

**Figure 4.1 MTRC system in Singapore**

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## 5. MTRC SYSTEM IN SAN FRANCISCO'S AIR TRAIN

Bombardier Transportation implemented a fully automatic train at the San Francisco Airport in 2003. Better known as the Air Train, the driverless train connects all of the San Francisco Airport's parking areas, terminals and the Bay Area Rapid Transit (BART) station. The map given below illustrates the network across which the Air Train operates.

The Air Train operates 24 hours a day across 2 lines- the Red Line and the Blue Line, and makes it very convenient for the passengers to move across various terminals and avenues of the San Francisco International Airport. The train covers 9 stations and has a daily passenger movement of around 2,30,000 people. The total track length is around 9.8 Km. the Air Train is an excellent example to show that the MTRC system facilitates the transportation of passengers through the "Automatic People Mover (APM)" based on the technically advanced concept of fully automatic and driverless trains. Presently, there are a total of 39
APM's which carry people across the Air Train network and the train makes effective use of MTRC system to facilitate effective communication between the driverless train and the control room. Moreover, this is needed to ensure minimum glitch and passenger safety. While in GSM, one needs to see the two dimensional aspect of communication, trains move in effectively one dimensional manner. As the technology involves a network of linear GSM, Directional Antennas can be used to improve the propagation characteristics. For Indian Railways, the Telecom Directorate has recommended 900 MHz frequency band for downlink and uplink signals respectively. They are essentially 935-960 MHz and 890- 915 MHz.

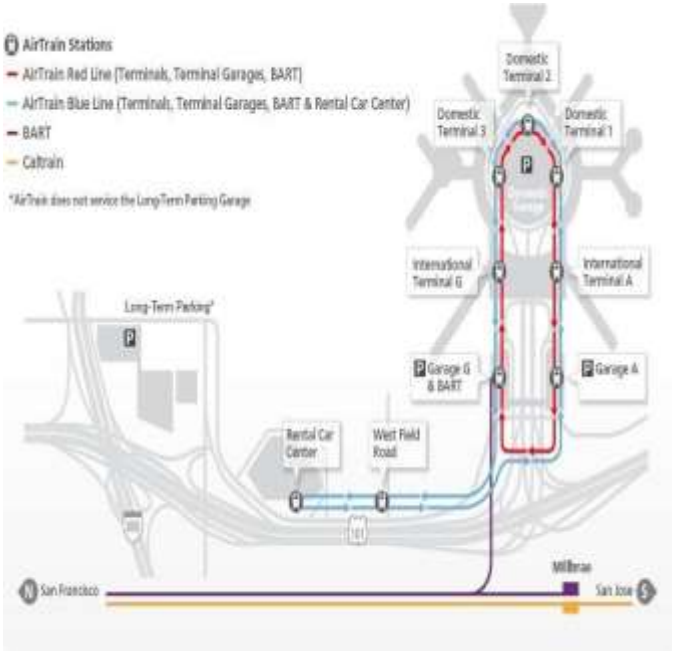


**Figure 5.1 Air Train Stations**

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## 6. APPLICATION

- CBTC System allow optimal use of the railway infrastructure as well as achieving maximum capacity minimum headway between operating train, while maintaining the safety requirements.
- Good average across entire railway track.
- Secure communication with no interference.
- Integration with track management System.
- Integrated GPS for location tracking.
- The evolution of the technology and the experience gained in operation over the last 30 years means that modern CBTC system are more reliable and less prone to failure then older train control system**.**

## 7. ADVANTAGES AND DISADVANTAGES

**Advantages:**

- Each cellphone uses a separate, temporary radio channel to talk to the cell site. The cell site speaks to many mobiles at the same time, using a cellular channel. The channels use a pair of frequencies for communication. One to transmit from the cell site, the direct link, and a frequency for the cell site to receive calls from the users, the reverse link.
- The communication between mobile units can be half-duplex or full-duplex. In case of half-duplex, the transmission and reception communications between the mobile units are not at the same time, that is, you can not speak and listen at the same time. In the case of full duplex communication, the transmission and reception communication is at the same time, that is, you can speak and listen at the same time.
- When the communications between mobile units are inside a cell, and if the cell is half-duplex, then it will only require a pair of frequencies. If it is full duplex, then the frequency pair requirement will be two.
- When a mobile unit is communicating with a mobile unit outside the cell, then the frequency pair requirement must be one per cell for half-duplex and full-duplex communications. Therefore, system resources are used more if mobile units communicate with each other in full duplex mode.

**Disadvantages:**

- A disadvantage of two way radios is that when Increasing the height of the base station antenna, the chance of incoming interference increases.
- However, a base station antenna can be directed only towards the area where the signal is required.
- A disadvantage of two way radios is that in some areas they have to share a channel with several other users.
- Particularly in dense urban areas, radio channels can become congested with multiple users and exclusivity can become difficult to obtain.
- However at Wall to Wall Communications we can obtain an Ofcom license which can minimise interference between surrounding license systems.

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- A disadvantages of two way radio communications is that the connection between two way radios across multiple sites can become disrupted.
- This is a possibility, particularly if they are far apart and the large area network (LAN) connection is lost.

## FUTURESCOPE

- It enables single touch dialing to call any of the two section train controllers, Dy Train Controller and EMU Controller.
- MTRC system would also be beneficial in getting real time information of train operation during monsoon period.
- Auto Call Answer for taxis, cab radios for Motorman and Guards to receive the audio message is enabled in this device.
- Three controller's contact numbers are fed into the phonebook for easy access while dialling.
- Motormen are allowed to directly communicate the defect of EMU to EMU Controllers reducing detention of other trains.

- Motormen and guards of trains can be simultaneously informed through broadcast calls in case of any mishappening.
- In case the MTRC phone is busy then on making an emergency call goes to DY.TNL.
- It is a technically advanced communication system. It provides for instant interaction between the train crew, the station master and the control centre.
- The calls can be connected within 300 milliseconds once dialled.
- MTRC acts in a similar way as Air Traffic Control (ARC) does for an aircraft.
- The system monitors and tracks and aids in communication to ensure smooth movements of rakes.
- This is for the first time something like this has been commissioned by the Indian Railways.
- It has been installed in 90 out of 100 rakes between Church gate and Virar.

## CONCLUSION

Mobile Communication today is a fast growing field. No one can deny its role in Modern Railway Operations. However there is a need of proper choice of technology looking into Railways' Operational needs. It is beyond doubt that incorporation of Mobile Communication into Railways will open new operational avenues, there by reducing operational costs and increasing customer satisfaction by providing better services. This shall not only help in increasing productivity, but also help in increasing safety of operations. This is an age of communication. Indian Railways, which is a lifeline of the nation, is also geared up to take the requirements of the new millennium, which is knocking the door of this century.

It would not be wrong to conclude that the MTRC system will have an important role to play in the field of rail transport in the near future as India is entering into a phase where Bullet Trains are shortly to be introduced starting from small sectors which will have high speed of more than over 600 Km/Hr. Such high speed trains have a high risk of derailment and other hazards like failure of signals, communication system, and human failure. To successfully launch the

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system of Bullet Trains and to ensure its safe operation, the MTRC system, undoubtedly, is not just essential, but a must.

## REFERENCES

1.“Railways in India”, Wikipedia the Free Encyclopedia;https://en.wikipedia.org/?title=Indian_Railways
2.“MTRC system”, International Union of Railways ; www.uic.org
3.“GSM-R technology”,Wikipedia; (https://en.wikipedia.org/wiki/GSM-R)
4.Avishek Banerjee, IIT Kharagpur, “Railway Accidents in India: By chance or by design? “;http://cse.iitkgp.ac.in/resgrp/cnerg/Files/avishek_baner jee.pdf
5.“Indian Train Accidents statistics”; www.factly.in
6.Srinad Jha, Hindustan Times “Killer Trains of India”; (Jul 30,2012)
7.“Indian Railway network” ; Wikipedia the Free Encyclopedia (en.wikipedia.org)
8.“Mobile Train Radio Communication to facilitate Railway passengers” ; TOI, 04/03/13
9.“MTRC system across the world” ; en.wikipedia.org
10.“MTRC system in Singapore”; http://bernardteozy.blogspot.in/
11.“San Francisco’s Air Train” ;http://www.flysfo.com/maps/ground- transport
12.“EIRAINE SRS Specifications”; www.uic.org
13.“Communication Based Train Control” ; Wikipedia the free encyclopedia
14.(http://en.wikipedia.org/wiki/Communications- based_train_control )
15.”Automatic Train Supervision”; Wikipedia the Free Encyclopedia(en.wikipedia.org)
16.“Bullet out of Delhi”; Hindustan Times.