

# **Human Interface in Railway Safety**

## **– A New Dimension**

**From:**

**Amitabh Agarwal**

**Director (Safety), Ministry of Railways,**

**Government of India**

## 1.0 INTRODUCTION

Indian Railways operate on gigantic dimensions covering over 63,000 route kilometers, loading of 1.8 million tonnes of freight, carrying 15 million passengers, and logging more than 2 million train kilometers per day. Historically, Indian Railways have also played a vital role in the socio-economic development of the country. As Indian economy marches ahead Indian railways have also taken several technological and policy related initiatives to meet the emerging challenges. While technological initiatives are rightly directed towards better utilization of assets and reduce human dependence but this has in turn translated into a newer dimension of human interface. The human factor in railway safety has now become function of several additional factors making it more critical and complex than in the past. The paper aims to discuss this changed perspective of human interface in this technology driven scenario with the help of some typical case studies.

## 2.0 Safety on Indian Railways – An Overview

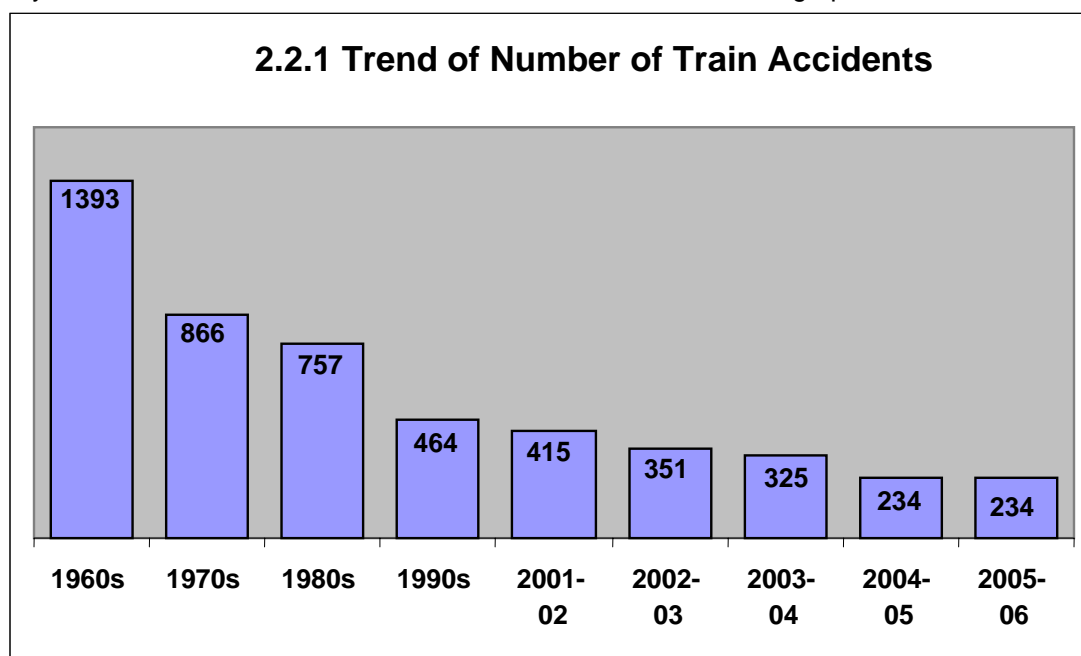
### 2.1 Corporate Safety Plan

With view to accelerating the pace of the safety drive Indian Railways formulated a 10-year Corporate Safety Plan for the period 2003-2013 entailing multi pronged strategy, laying emphasis on prevention by reducing human dependence and mitigation of consequential effect in case of an accident. This Plan was presented to the National Parliament in August, 2003.

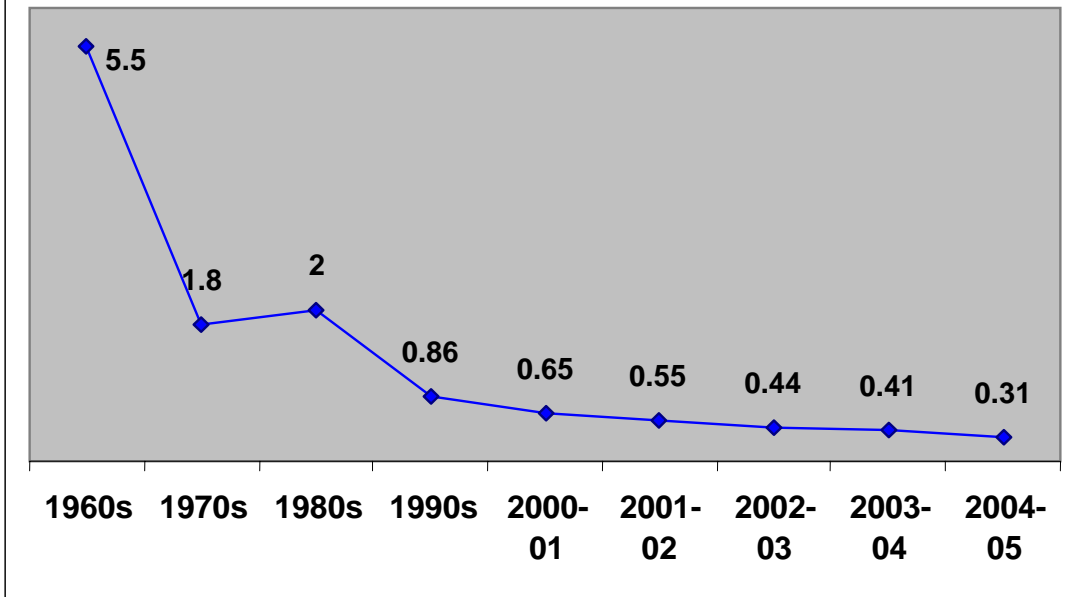
To ensure that financial constraints do not inhibit the implementation of the Plan, fund requirement for the Safety enhancement works, as outlined in the Plan, has been identified as Rs.318 billion including Rs.170 billion Special Railway Safety Fund already committed.

Corporate Safety Plan envisages reduction of accidents on Indian Railways by the year 2012-13 substantially. Collisions are targeted to be completely eliminated. Derailments will come down by 60% and Fire accidents by 80%. It has not been possible to project assured improvement in level crossing accidents as there is no control over the circumstances that lead to such accidents.

2.2 As result of regular review and initiatives undertaken Safety on IR has improved considerably by way of continuous reduction in train accidents as can be seen from graphs 2.2.1 & 2.2..2:

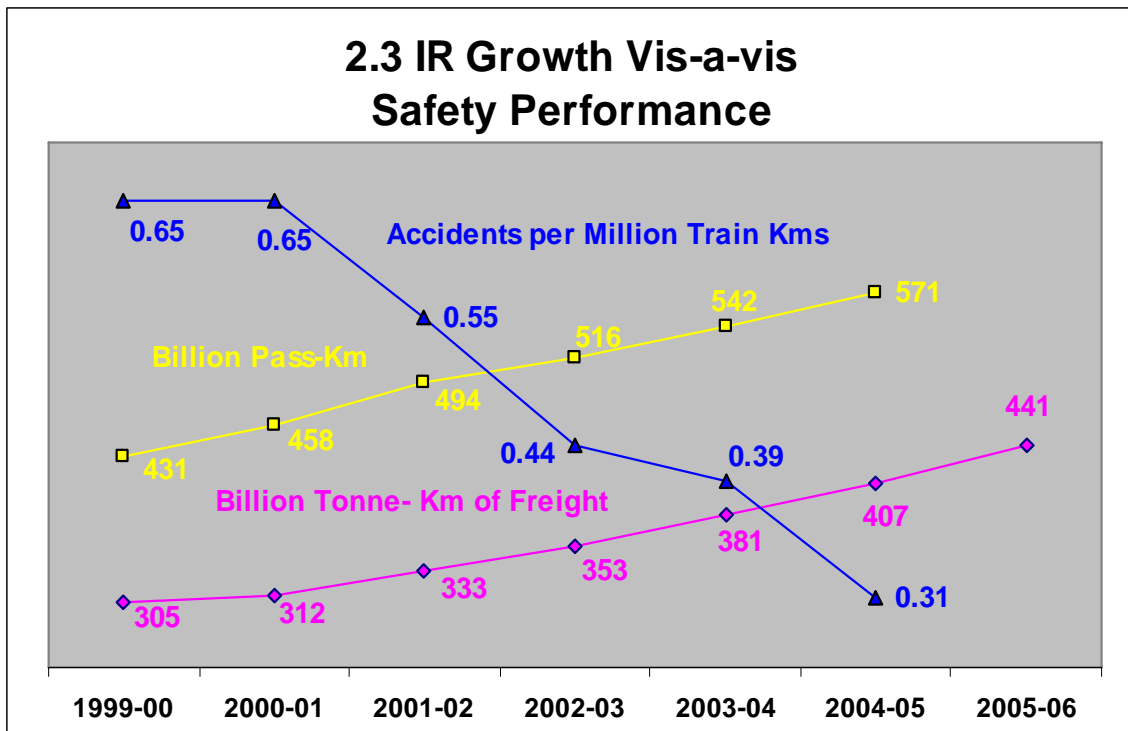


### 2.2.2 Trend of Accidents per million Train Kms



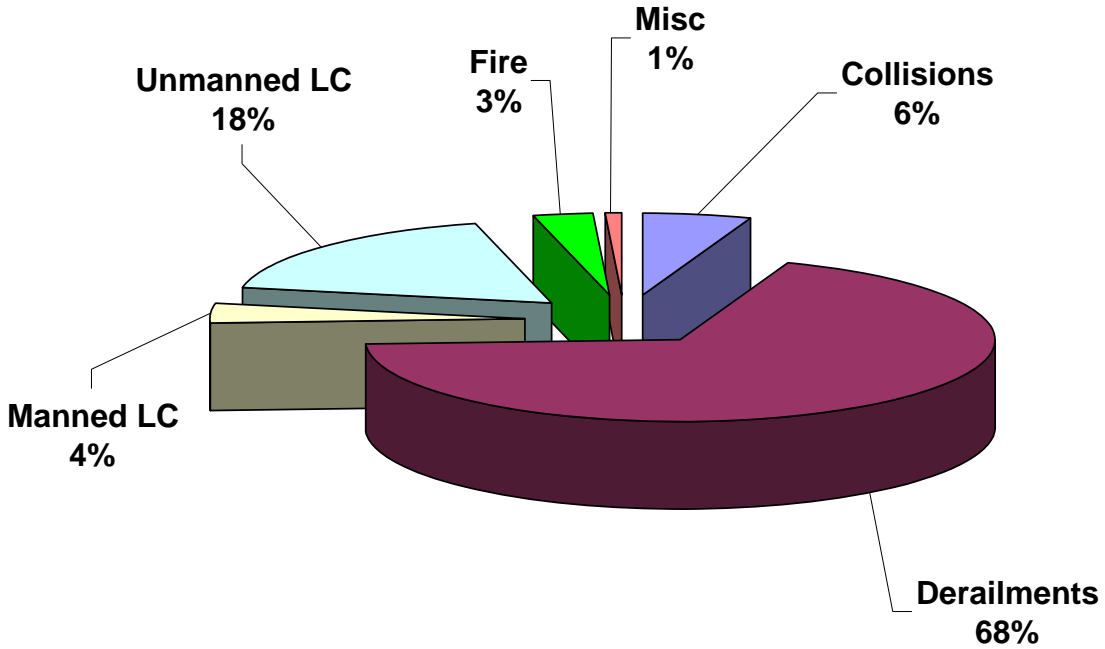
2.3 While there has been a gradual decline in number of accidents, what is creditable is the fact that the Indian railways have improved on all the productivity indices over the years as is evident from the graph 2.3.

### 2.3 IR Growth Vis-a-vis Safety Performance



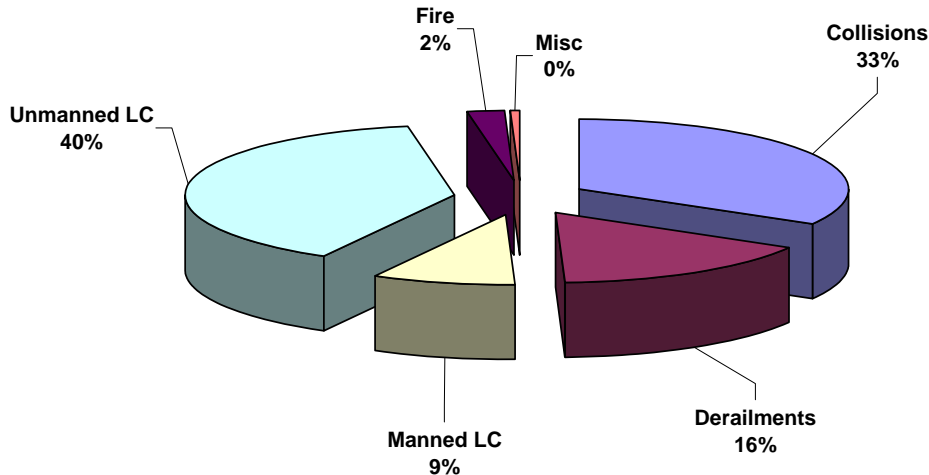
**2.4** During the last decade (1996-97 to 2005-06) derailments were a major contributor (68%) in the total tally. These were followed by level crossing accidents (22%). Collisions and 'fire in trains' accounted for 6% and 3% respectively as depicted in graph 2.4.

**2.4 Type wise Accidents per Year (1996-97 to 2005-06)**



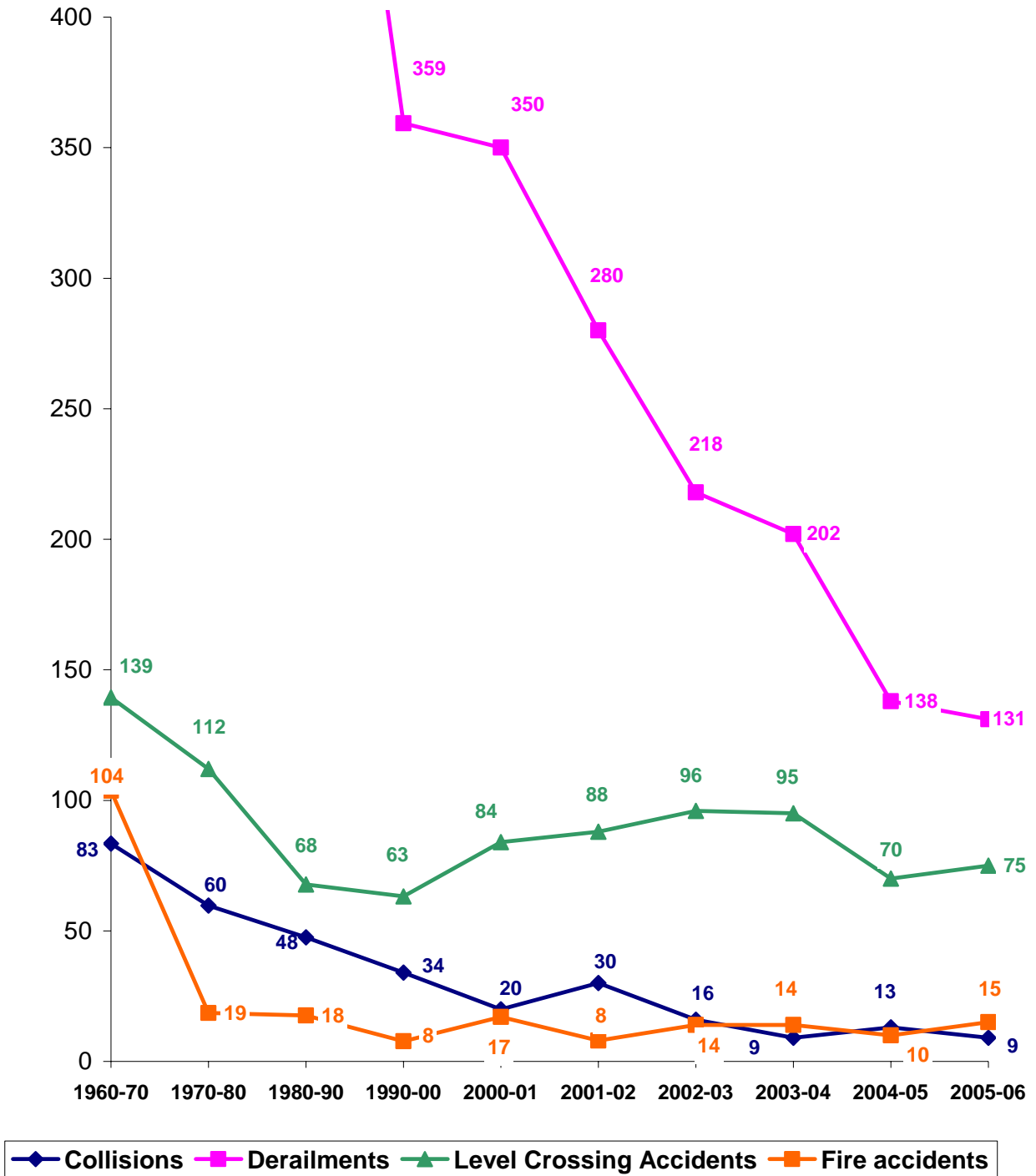
**2.5** Collisions are the most dreaded accidents for any railwayman. On Indian Railways collisions accounted for 6% of the accidents but these resulted in 33% of the total casualties. Accidents at level crossings accounting for 22% of the total accidents on IR were responsible for 49% deaths. Derailments though constituted bulk (68%) of the train accidents, these accounted for 16% of the casualties. (Graph 2.5)

**2.5 Average Casualties in Train Accidents (1995-96 to 2004-05)**



**2.6** Looking at different categories of accidents in the graph 2.6, derailments which form bulk of them, have come down from a large number in the sixties to 131 in 2005-06, collisions which are the most serious type have come down from 83 per year in the sixties to 9 in 2005-06. Fires in trains have also registered substantial decline from 104 to 15 per year in this period. Level crossing accidents have not shown much improvement. Railways have no control over the road users whose failures lead to almost all such accidents. Also, there has been phenomenal growth in the number of road vehicles in this period.

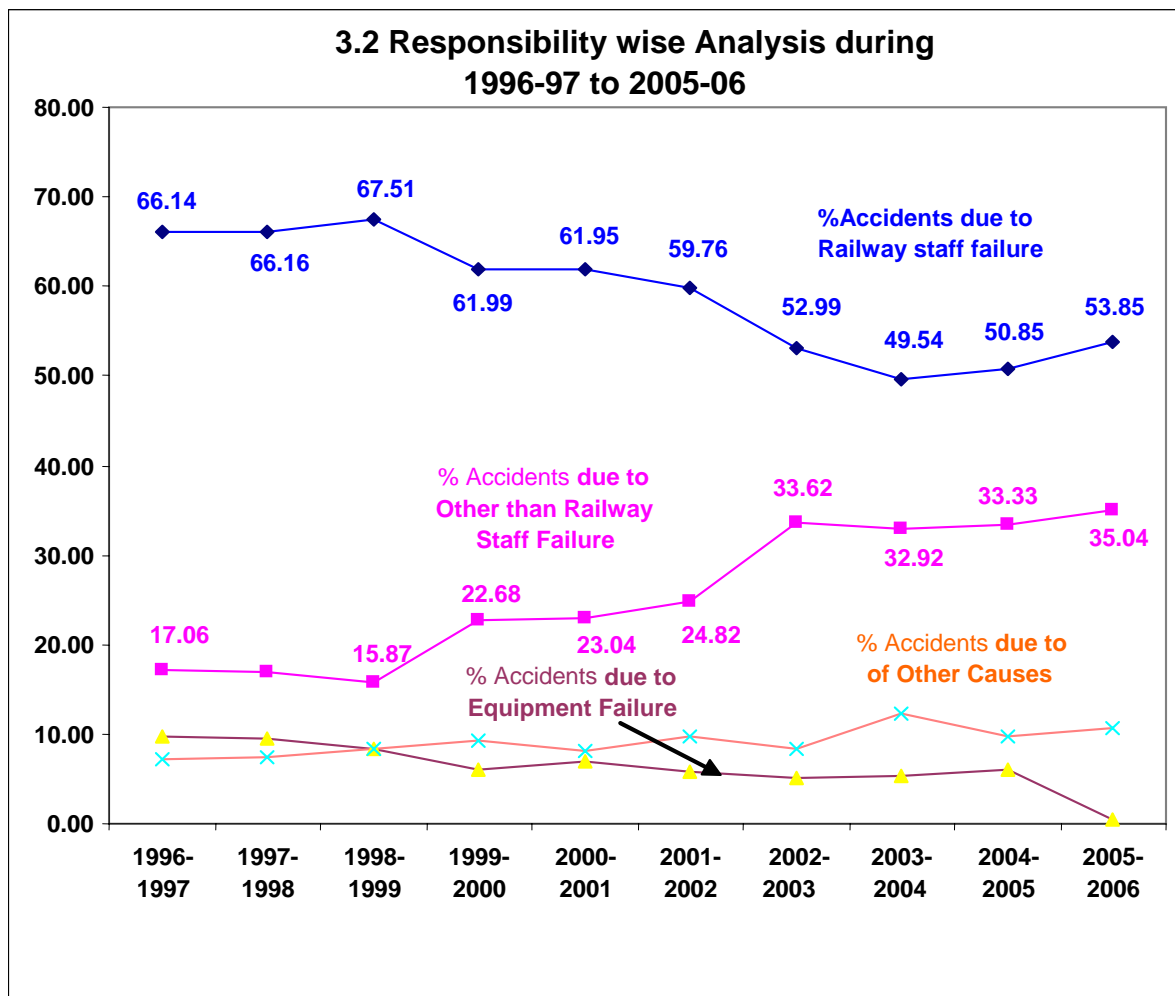
## 2.6 Type wise Accidents on IR since 1960 to 2006



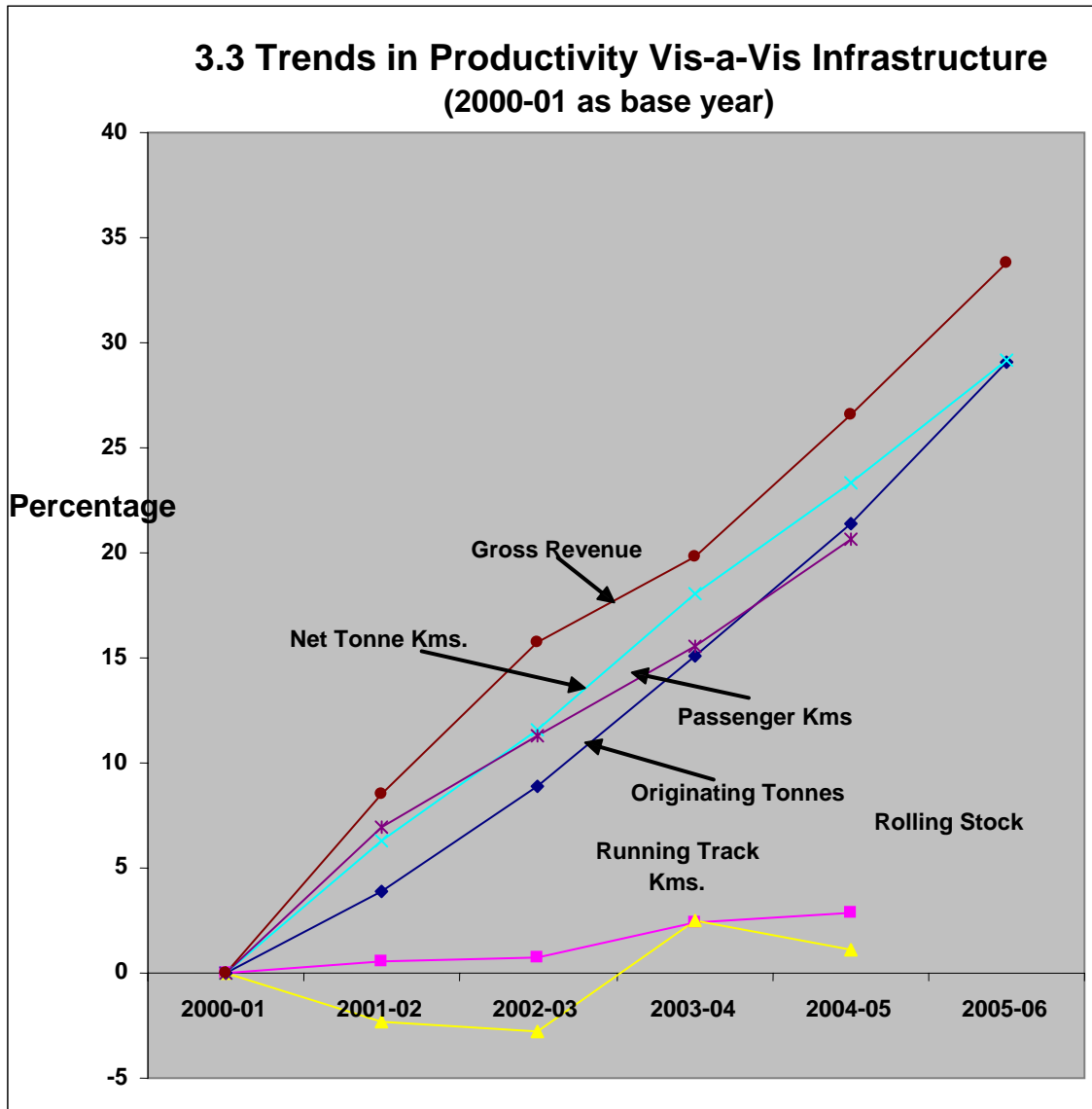
### 3.0 Human Element in Train Accidents

3.1 In the last 10 years (1996-2006) on Indian Railways, 59% of the accidents have been caused due to failure of Railway staff, 25.5% have been caused due to failure of other than Railway staff, failure of equipment has contributed 6.5%, and balance 9 % have been contributed by miscellaneous reasons. From the break-up, it is more than evident that human error from Railway Staff has been the major factor in causing the accidents on Indian Railways.

3.2 Manpower is the most valuable asset on Indian Railways which is highly labour intensive with a work force of nearly 1.4 million. It is a challenge to create and maintain high motivation level and stress free environment for this large workforce encompassing several categories of staff. Skills of manpower suiting varied job requirements are suitably developed requiring adequate attention in training institutions. On Indian Railways, while frontline staff is properly trained and their working closely monitored, staff involved in maintenance activities has also been on sharp focus since they also have important role to play in preventing accidents. To enhance the quality of human resources multi prompt strategy has been adopted on Indian Railways impact of which can be gauged from the graph 3.2 indicating gradual declining trend in accidents due to failure of Railway staff from about 67% in 1998-99 to about 49% in 2003-04 which has again shown the uptrend to about 51% in 2004-05 to 53% in 2005-06. This uptrend is noteworthy and is the focus of deliberation in subsequent paras.



3.3 To appreciate the newer dimensions of human interface that has not only caused the proportion of accidents due to human interface high but have also resulted in the uptrend of such instances in the recent years, it is essential to study the trends of productivity parameters vis-à-vis growth in assets like running track and rolling stock.



From graph 3.3 which correlates improvement in productivity indices with year 2000-01 as base year with respect to the growth in infrastructure i.e. running track kilometer and rolling stock, it can be seen that productivity indices have gone up about 30% while there has been hardly any growth in infrastructure during these years. This level of growth in productivity has been possible by the virtue of initiatives directed towards better utilization of assets, mostly by introduction and proliferation of new technologies. Reduced human dependence was one of the major motives while embracing new technologies which were achieved with some success. But, human interface became more complex and function of several external factors, which generally do not surface as the direct cause of accidents and might be over looked during the accident inquiries.

3.4 Higher incidences of human failure surface as technical safeguards and backups do not always replace the human effort. Though an accident occurs only when both fail but it usually gets logged as 'human error' with a tendency of glossing over technical failure. Under optimum field conditions and with the best of intentions, a human being is likely to commit a mistake from time to time. This is the reason why operating procedures included many layers of checks and balances. More and more automation is resorted to prevent human errors.

3.5 It needs to be appreciated that crucial/vulnerable role of human interference comes into play at the time of abnormal working of Railways mostly due to asset failures. As reliability of assets improves, opportunities of the human intervention into vulnerable functioning of railways reduce. Accidents are mostly preceded by failure of asset and performance of operations from the frontline operating staff becomes key to the safe operation during such abnormal working conditions. To manage the abnormal working, the stipulated rules and regulations are mostly cumbersome and unfriendly to follow especially during long periods of abnormal working. Human intervention under the abnormal situation of assets failure for prolonged period is likely to falter as stipulated procedures may be practiced as routine by the staff. Moreover, there are several extraneous factors which cause the non adherence of such laid down rigid stipulations strictly in actual practice. Sometimes even the prescription of the procedure are vague or indifferent to the ground realities.

3.6 With enhanced competitiveness and demanding customers, management tends to always look for enhanced outturns. Under the normal operating conditions when all assets are functioning optimally, such aspirations of management are not only fulfilled but even bettered without risking safety. However, in case of asset failures leading to holdups in operation, productivity parameters are threatened due to delays caused by human intervention. With asset failures for prolonged period, such hold ups are considered as performance decelerator and are therefore not welcomed unduly stressing the staff resulting in short cut methods.

3.7 Following case studies<sup>@</sup> into the recent major accidents have been undertaken to study the human interference which led to major accidents in the recent past. The factors which led to such accidents have also been discussed in detail in the following case studies:

@ Analysis of the Cases is based on the personal views of the author.

### **3.7.1 Case 1**

#### **3.7.1.A Description of Accident**

Head-on collision of 9112 Dn Jammu Tawi Ahmedabad Express with 1 JMP Diesel Multiple Unit Passenger train between Bhangala and Mirthal stations of Northern Railway on 14.12.2004 at 11.53 hrs. As result of this accident, 38 persons lost their lives, 21 persons were grievously injured and 19 persons suffered simple injuries.

#### **3.7.1.B Cause of the Accident**

The two Station Masters did not exchange messages properly on VHF sets to repeat prior three train movements before seeking permission during failure of block working and dispatched trains in the same block section from opposite directions on a single line section.

#### **3.7.1.C Key Observations**

- (1) Quad cable supporting the block circuits was damaged due to construction activity in the section causing failure of Block instruments and block phones at both the stations about 24 hours prior to the accident.
- (2) Trains between Mirthal and Bhangala were being worked on paper line clear (PLC) since about 24 hours prior to the accident. PLC is one of the prescribed alternative means of train operation when block instruments fail which is the authority to proceed.
- (3) PLC cannot be issued to the driver unless line clear has been obtained through section controller in accordance with Northern Railway Block Working Manual. However, even though communication with controller was working in this case, line clear was being

obtained through VHF sets, which is the last permitted option in order of priority in case of failure of communication.

- (4) Northern Railway Block Working Manual pertaining to obtaining the line clear through the controller indirectly or on inter-wire stipulates for obtaining train numbers with their description and private numbers of previous 3 trains passed over the block section, from the person competent to grant line clear to ensure that the reply to the line clear inquiry is emanated from the authorized person only.
- (5) As a measure of abundant precaution, the Station Masters while using the VHF sets for paper line clear working, should have followed the system of taking the train numbers with their description and Private Numbers of three previous trains passing over the block section, to ensure that reply to line clear enquiry was emanated from an authorized persons competent to grant line clear, as in the case of obtaining line clear though the controller indirectly or on inter-wire.
- (6) This is a saturated section handling both passenger and freight traffic to full capacity. It is quite strenuous to operate even under normal circumstances.
- (7) Both the Station Masters dispatched trains from their respective stations towards each other in the same block section by granting line clear on VHF sets exchanging private numbers and issuing PLC.
- (8) Poor supervisory and managerial intervention was continuing in this most unsafe and accident prone condition. The control was well aware that VHF sets were being used for line clear despite control phones were in working condition.
- (9) Work of locating and rectifying the fault was not undertaken on an emergency basis and was postponed for the next day to avoid night working. The rectification work could not take off even before this accident on the next day.

#### **3.7.1.D Human Element**

- (1) Human element came into vulnerable functioning after the technical failure i.e. the cutting of quad cable supporting control circuits during excavation of earth.
- (2) Both the Station Masters adopted the least cumbersome process of granting line clear after the failure of Block instruments and block phones i.e. VHF communication over controller communication being easy to use. Despite VHF communication being more vulnerable to outside interference, the prescribed safeguard for ensuring that reply to the line clear inquiry is emanating from the authorized person competent to grant line clear was not adopted by Station Masters.
- (3) Though the practice of granting line clear using VHF communication had been going on for about 24 hours for several trains in both the directions, by which time this abnormal working had lost its alert value in the minds of individuals involved and a lapse was bound to take place at the level of Station Masters.

#### **3.7.1.E Discussion**

All the above lapses manifested in the form of dreaded head-on collision with the last string of frontline action coming from the two Station Masters. Role of maintenance agencies can not be overlooked in causing the vulnerable situation of train operation for prolonged period which ultimately manifested into this accident. Certain prescriptions like imposing speed restriction under vulnerable situations like PLC working could have offered favorable opportunities under this unusual operating situation.

Table 3.7.1 depicts the multilayer failures resulting in accident.

**Table 3.7.1**

Cause	Description	Possible Preventive Action
<b>Direct cause</b>	Station Masters did not follow proper procedure of exchange of messages on VHF sets and dispatched both the trains in the same block section towards each other on paper line clear tickets.	<ul style="list-style-type: none"> <li>• Better training of station masters.</li> <li>• More tolerant management attitude in case of hold ups in operations in case of failures</li> <li>• Counseling to staff to follow</li> </ul>

<b>Contributory Causes</b>	<ul style="list-style-type: none"> <li>• Failure of regular mode of communication for about 24 hours forcing the station masters the continued use of alternative mode of communication which was unsafe to use unless cumbersome precautions were taken.</li> <li>• Prescribed procedure to use the preferred alternate modes of communication was too cumbersome.</li> <li>• Loose ends in stipulating procedure to be used as alternative mode of communication (VHF sets).</li> <li>• Heavy traffic was being handled on the Section hence more severe impact of consequent operational delays built into the manual procedures may have caused the short cuts.</li> <li>• Efforts needed for proper manual procedures were too demanding and tiring for 12 hour duty of station masters.</li> <li>• Improper management intervention</li> <li>• Successful past experience of short cuts without any penalty.</li> </ul>	<p>procedures regardless of delays.</p> <ul style="list-style-type: none"> <li>• Co-coordinated working at the construction site.</li> <li>• Emergent action to set right failed asset involved in train operation.</li> <li>• Strengthening of staff availability to undertake and supervise operations under such conditions.</li> <li>• Safe and simple prescription of alternatives needing human intervention.</li> <li>• Slow down operations in view of vulnerability.</li> </ul>
----------------------------	---	--

### **3.7.2 Case II**

#### **3.7.2.A Description**

Collision of 9168 Up Sabarmati Express with stabled goods Train at Samlaya Junction Station of Western Railway on 21.4.05 at 03.10 hrs.

As a result of this accident 16 persons lost their lives, 38 persons were grievously injured and 98 persons suffered simple injuries.

#### **3.7.2.B Cause of the Accident**

Signaling and Operating staff at Samlaya station failed to follow the procedure prescribed for failure of signal as result of which 9168 Up Sabarmati Express, which was planned to pass through main line, entered loop line and collided with the stable goods train.

#### **3.7.2.C Key Observations**

1. The linkage for the operation of the culprit point had been attended on the previous evening and proper fixing of the linkage was not ensured thereafter which resulted in failure of the signal..
2. Signal lever for clearing home signal for the mainline was in pulled position.
3. Both normal and reverse indication lights of the culprit point were in unlit condition.
4. Signal failure register had an entry of failure of indication of the culprit point with failure time of 2.35 hrs. which is 35 minutes prior to the accident. Control chart also had an entry to this effect.
5. Station Master had prepared a memo addressed to Electric Signal Maintainer (ESM). Both original and carbon copies were available in the memo book. Original copy was in detached condition.

6. Prescribed form for authorizing the driver of 9168 Sabarmati Express to pass the Signal in Red condition was found prepared by Station Master with both the copies of the authority available in the book.
7. Cabin Relay rooms are double locked with each of the keys remaining in the safe custody of Station Master and Electrical Signal Maintainer. Key of Station Master's lock of the cabin relay room (wherefrom the culprit point/signal are operated) was in Station Master's key box and there was no entry for issue of this key on the date of accident.
8. It was the time of grouping of important trains in Up direction and failure of signal could cause detention as the prescribed procedure for dealing with a failed signal consumes extra time.

### **3.7.2.D Human Element**

- (i) Human element came into vulnerable functioning after the technical failure i.e. malfunctioning of Up main line home signal.
- (ii) The Station Master prepared the prescribed documents for advising the signal failure to the Electrical Signal Maintainer. However, the station master preferred to advise ESM on VHF set regarding the malfunctioning of Up home signal instead of sending the written advice. Electric Signal Maintainer alongwith his Assistant proceeded to the Cabin Relay Room and opened both the locks without having taken the key of Station Master's Lock and without making an entry into the signal failure register to this effect. Without checking the condition of the point causing failure of signal, Electric Signal Maintainer bypassed the relay interlocking the point with the signal so that the signal could be turned on without setting of the culprit point. The rectification of signal was communicated on VHF set to the Station Master by the ESM. 9168 Up Sabarmati Express was thus given pass through signal for the main line whereas the culprit point was still set for the loopline and thus the train entered the loopline and collided with stabled train.

### **3.7.2.E Discussion**

The lapse from operating and signaling staff occurred due to non observance of prescribed procedure to deal with the signal failure as per which a written advise is to be sent to the ESM by the Station Master regarding signal failure and signal is considered fit only after the receipt of written advise back from the ESM to this effect. During the intervening period, written advice is issued to the drivers of the trains for overlooking the aspect of the failed signal which costumes extra detention to trains. From observation 5 & 6, it is evident that the Station Master had the intention of following the prescribed procedure for dealing with a failed signal. However, the urgency of running trains without causing extra detention took the front seat of thought and short cut of verbal communication was resorted to by the station Master which was further compounded by the negligent working by ESM and his assistant who bypassed the interlocking relay instead of fixing the defective point which would have taken lesser time. From the report of the railway administration after the accident, it was observed from the readings of the counters fitted on the relay rooms at other stations that several other relay rooms had been opened without the opening the station Master's lock. This unsafe practice seems to have been persisting to prevent detentions. It is suspected that concerned officials were perhaps shy of reporting such failures and owning the detentions.

Table 3.7.2 depicts the multilayer failures resulting in accident.

**Table 3.7.2**

Cause	Description	Possible Preventive Action
<b>Direct cause</b>	Signaling and Operating staff failed to follow the procedure prescribed for failure of signal.	<ul style="list-style-type: none"> <li>• Better training.</li> <li>• More tolerant management attitude in case of hold ups in operations in case of failures</li> <li>• Counseling to staff to follow procedures regardless of delays.</li> </ul>
<b>Contributory Causes</b>	<ul style="list-style-type: none"> <li>• Poor attention to the associated linkages of involved point.</li> <li>• Heavy flow of traffic consisting of</li> </ul>	<ul style="list-style-type: none"> <li>• Better maintenance practices.</li> <li>• Intense super checks for non compliance of laid down</li> </ul>

	<p>prestigious super fast trains which were likely to be detained.</p> <ul style="list-style-type: none"> <li>• Pressure from section controller to hurry up.</li> <li>• Expectedly intolerant management of the associated delay affecting punctuality of many trains.</li> <li>• Successful past experience of adopting short cuts without any penalty.</li> </ul>	<p>procedures and Penal action in case of non compliance not resulting in accidents.</p>
--	--	--

**4.0 Conclusion**

In the interest of generating more revenue out of the existing infrastructure by introduction of newer technologies and policies, system become vulnerable to unsafe practices in the events of asset failure, especially for the prolonged periods due to complex features built into the system. All possible equipment failures scenarios have been covered by the manual procedures to ease immediate hold ups in traffic due to failures. No human error leading to an accident is caused for the sake of it but is prompted by factors such as psychological factors based on the past experience on dealing with the similar situation. With this in mind, Indian railways have also made conscious efforts to improve the reliability of assets to cut down the vulnerability of human element. Accident investigations are directed to look for all possible causes, whether directly associated or not, to device strategy to curb such trends. With innovative initiatives being taken by Indian railways to address these complex issues, proportion of accidents due to human error are surely to decline in the coming years with corresponding increase in productivity.

\*\*\*\*\*

## References

1. Indian Railways Corporate Safety Plan (2003-13), August 2003, Govt. of India, Ministry of Railways.
2. Indian Railways Year Books of relevant years, Govt. of India, Ministry of Railways.
3. Indian Railways Annual Report & Accounts of relevant years, Govt. of India, Ministry of Railways.
4. Indian Railways - Safety Performance of relevant years, published by Safety Directorate of Ministry of Railways, Govt. of India.
5. "Rail Accidents due to Human Errors – Indian Railways Experience", Amitabh, International Railway Safety Conference, 2005, Cape Town, South Africa.