



# International Railway Safety Conference 2007 Goa, India

30th September - 6th October 2007



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Job Title: **Safety in Railways**

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Country: **India**

## **DEVELOPMENT OF THE CONTRIBUTION**

### **'Planning and Execution of Railway projects – Consideration for Safety Related Items '**

#### **1.0 Introduction:**

- 1.1 At the time of planning and execution of most of the Railway Projects, safety related items are not considered for inclusion, may be, in order to keep the cost of the project at the bare minimum so as to make the project financially viable, at least at the planning stage .
- 1.2 In many cases, safety related items of works are planned and executed , if at all , at later date in bits and pieces whenever necessity for the same is felt. Sometimes the realization of the necessity itself comes after accidents take place.
- 1.3 It implies that due importance is not given to the safety items at the time of planning and execution of the projects which may be resulting in unsafe working during the operational period . This not only hampers the operations but results in financial loss as well as loss to human life caused due to the accidents taking place because of the safety related items not provided along with the execution of the project.
- 1.4 In order to avoid such cases in future, now it is time to revise our planning process by giving due consideration to safety items in order to enhance the safety environment on the project during operations.
- 1.5 Objective of this paper is to identify the various items affecting the safety, in what way they affect the safety, the ways and means to take care of such items on the project to eliminate or at least minimize their effect on the safety during the period of operation of



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the project and also to devise system for their effective maintenance and utilization in the field.

## 2.0 Safety Hazard Items – How they affect the safety

The items which are normally affecting the safety on Railway working are listed out as under :

	Safety Hazard	How they affect safety
<b>Natural Causes</b>	Earthquake	<ul style="list-style-type: none"> <li>▪ Causes damage to the infrastructure like bridges , building, embankment etc.</li> <li>▪ If the damage / collapse of the infrastructure takes place while train passing over it , may cause disaster.</li> <li>▪ Collapse of building may cause casualty / injury to the passengers.</li> </ul>
	Flood	<ul style="list-style-type: none"> <li>▪ Heavy rains during monsoon may cause sudden flood which may wash away railway infrastructure like embankment, bridges etc.</li> <li>▪ If the washout / collapse occurs while train passing over it, may cause serious accident.</li> </ul>
	Cyclone	<ul style="list-style-type: none"> <li>▪ High velocity of wind and heavy rain during cyclone may critically hamper the train movement and may cause serious damage to infrastructure which may result in serious accident.</li> </ul>
	Landslides	<ul style="list-style-type: none"> <li>▪ Landslide in hilly area may cause blockade of track or damage to the running train causing accident.</li> </ul>
	Tsunami	<ul style="list-style-type: none"> <li>▪ In the coastal area there is likelihood of threat of tsunami causing serious damage to rail infrastructure.</li> <li>▪ Damage during running / passage of train may cause serious train accident.</li> </ul>
<b>P. Way Failure</b>	Rail / Weld failure	<ul style="list-style-type: none"> <li>▪ Any of these failure may cause derailment of train passing over it leading to accident.</li> </ul>
	Buckling of track	
	Shrinkage of formation	
	Embankment Failure	
	Signal Failure	<ul style="list-style-type: none"> <li>▪ May be leading to passing of the signal in wrong position which may result in collision with train in front.</li> </ul>
	Interlocking Failure	<ul style="list-style-type: none"> <li>▪ May result in train taking wrong route which may result in collision.</li> </ul>



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	Safety Hazard	How they affect safety
<b>Steep Gradient</b>	Steep Down Gradient	<ul style="list-style-type: none"> <li>Steep downward gradient may sometimes lead to uncontrolled speed resulting in collision with moving / stabled train / rake ahead / in the yard.</li> </ul>
	Steep Up Gradient	<ul style="list-style-type: none"> <li>Steep upward gradient may lead to rolling down of rear portion of train formation backward in case of parting of train with poor brake power.</li> <li>The stabled train rake in the yard will have tendency of rolling away if not secured properly - in both the cases upward or downward steep gradient in yard .</li> </ul>
<b>Failure of Rolling Stock</b>	Entanglement of hanging part with track components	<ul style="list-style-type: none"> <li>May lead to derailment of the train resulting in accident.</li> </ul>
	Hot axle of rolling stock	<ul style="list-style-type: none"> <li>May lead to derailment of the train resulting in accident.</li> <li>May cause fire in the train resulting in damage to railway property and /or casualty / injury to travelling passenger.</li> </ul>
	Flat tyre of wheels of rolling stock	<ul style="list-style-type: none"> <li>May lead to derailment of train resulting in accident.</li> <li>May cause severe damage to rail / weld resulting in large scale failure of Rail / welds which may further lead to derailment and accident if left unattended.</li> </ul>
	Stalling of trains	<ul style="list-style-type: none"> <li>May lead to parting of train and rolling down of rear portion which may result in collision with any train / rake behind in yard leading to accident.</li> </ul>
	Parting of trains	<ul style="list-style-type: none"> <li>May cause rolling down of the rear portion in case of downward gradient which may result in collision in the yard behind.</li> </ul>
<b>Rail-Road Crossings</b>	Failure of road users	<ul style="list-style-type: none"> <li>In case of unmanned Level Crossing gates, failure of road user / road vehicle driver to take proper precautions while crossing may result in dashing the train with the road vehicle or road vehicle dashing the train causing accident in either way.</li> </ul>
	Failure of Railway staff	<ul style="list-style-type: none"> <li>In case of manned Level Crossings, failure on the part of gateman or the station master may lead to non-closure of the gate during passage of the train resulting in train dashing the road vehicle and causing accident.</li> </ul>



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	Safety Hazard	How they affect safety
<b>Human Failure</b>	Failure of Loco Pilots.	<ul style="list-style-type: none"> <li>▪ Loco Pilots passing signal at danger may cause collision with train ahead.</li> <li>▪ Failure to observe speed restrictions may cause derailment.</li> <li>▪ Failure apply emergency brake when needed may cause overshooting &amp; collision.</li> </ul>
	Failure of Station Staff	<ul style="list-style-type: none"> <li>▪ Resorting to shortcuts for shunting may cause collision</li> <li>▪ Not following correct procedure in train operation may lead to collision.</li> <li>▪ Lack of alertness or Lack of knowledge of rules may lead to wrong operations resulting in accidents.</li> </ul>
	Failure of Staff working on track	<ul style="list-style-type: none"> <li>▪ Failure to follow correct procedure while working on track may cause accident.</li> </ul>
<b>Miscellaneous</b>	Unauthorized Crossings	<ul style="list-style-type: none"> <li>▪ Unauthorized crossing by cattle may cause the train dashing with them leading to derailment causing accident.</li> <li>▪ Unauthorized crossing by light vehicles may cause dashing the train with them resulting in derailment and accident.</li> </ul>
	Fire	<ul style="list-style-type: none"> <li>▪ Fire due to hot axle or inflammable materials in the wagon / coaches of the train / careless on the part of the passengers / public may cause serious damage to the train and casualty / injury to passengers.</li> </ul>
	Terrorism	<ul style="list-style-type: none"> <li>▪ Terrorist attacks may damage track / bridges which may lead to derailment and serious accidents.</li> <li>▪ Explosion in the coaches of train due to explosives planted by terrorist may lead to serious accidents.</li> </ul>

### 3.0 Safety Related Items / Safety Related Action:

3.1 In order to eliminate the safety hazard posed by the above mentioned items or at least minimize their effect, various actions are required to be taken either at the stage of designing the various components of the project or by installing the various monitoring devices are required for timely pre-warning of the various failures so that the timely action can be taken to prevent any untoward incident. Of course, the various safety factors to be taken for designing of various components of the project as well as the various devices required to be installed will depend on the importance of the project. Actions required to be taken for various safety hazards are briefly given below which are only illustrative and not exhaustive:



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SN	Safety Hazard	Action to be Taken
1.	Earthquake	<ul style="list-style-type: none"><li>▪ Adequate safety factor is to be taken for design railway infrastructure like bridges , buildings etc..</li><li>▪ Installation of earthquake warning device.</li><li>▪ Co-ordination with earthquake monitoring centre / Agency.</li></ul>
2.	Flood	<ul style="list-style-type: none"><li>▪ Design of bridges with adequate waterway.</li><li>▪ Adequate depth of foundation against scour.</li><li>▪ Protection works on approach embankment.</li><li>▪ Adequate height of embankment against over topping.</li><li>▪ Slope protection in vulnerable area.</li><li>▪ Warning system to indicate the water level going over danger level in bridges.</li><li>▪ Co-ordination with weather forecasting department.</li><li>▪ Co-ordination with other agency for maintenance of works affecting railway infrastructure.</li><li>▪ System of manual / mechanical patrolling in vulnerable areas during monsoon.</li></ul>
3.	Cyclone	<ul style="list-style-type: none"><li>▪ Co-ordination with forecasting department.</li><li>▪ Pre-warning system to indicate the area of low atmospheric pressure.</li><li>▪ Device for measuring wind velocity in the area.</li><li>▪ System of manual / mechanical patrolling in vulnerable areas during monsoon.</li></ul>
4.	Landslides	<ul style="list-style-type: none"><li>▪ Geological investigation &amp; Slope-Stability Analysis.</li><li>▪ Easing out the slope in cutting as required for slope stability.</li><li>▪ Slope protection work.</li><li>▪ Protection against falling of boulders &amp; falling of the earth .</li></ul>
5.	Tsunami	<ul style="list-style-type: none"><li>▪ Installation of warning device.</li><li>▪ Co-ordination with other departments for prediction.</li><li>▪ Factor of safety in design of infrastructure.</li><li>▪ Protection works to be undertaken.</li><li>▪ System for quick restoration.</li></ul>
6.	Rail fracture	<ul style="list-style-type: none"><li>▪ Installation of device for detection of rail fractures.</li><li>▪ Periodical USFD testing of rails.</li><li>▪ Rectification / removal of defective rails quickly on priority.</li><li>▪ Anti-corrosion painting of rails in corrosion-prone area.</li><li>▪ Avoid running of trains with flat tyred wheels.</li><li>▪ Avoid over-loading in goods trains.</li><li>▪ Periodical screening of ballast to provide elastic bed.</li><li>▪ Greasing of track fittings to avoid corrosion of rail foot.</li></ul>



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SN	Safety Hazard	Action to be Taken
7.	Weld failure	<ul style="list-style-type: none"><li>▪ Installation of device for detection of weld failures.</li><li>▪ Periodical USFD testing of welds.</li><li>▪ Rectification / removal defective welds quickly on priority.</li><li>▪ Ensuring quality of weld with proper quality control.</li><li>▪ Going for mechanized / mobile flash butt welding.</li><li>▪ Use of longer rails to reduce the number of welds.</li><li>▪ Fish-plating of old thermit welds in use.</li><li>▪ Periodical anti-corrosive painting of weld collars.</li><li>▪ Avoid running of trains with flat tyred wheels.</li><li>▪ Avoid over-loading in goods trains.</li><li>▪ Periodical screening of ballast to provide elastic bed.</li></ul>
8.	Buckling of track	<ul style="list-style-type: none"><li>▪ Periodical stress measurement in rails &amp; periodical distressing of LWR / CWR as per requirement.</li><li>▪ Ensure adequacy of ballast on shoulders.</li><li>▪ Ensure proper longitudinal alignment of track.</li><li>▪ Avoid track maintenance works at higher temperature.</li></ul>
9.	Shinkage of formation	<ul style="list-style-type: none"><li>▪ Ensure quality of earth used for embankment.</li><li>▪ Blanketing of formation with good quality blanketing material.</li><li>▪ Proper compaction &amp; other quality control during execution.</li></ul>
10.	Failure of embankment	<ul style="list-style-type: none"><li>▪ Ensure quality of earth for embankment.</li><li>▪ Slope-stability analysis for getting stable slope.</li><li>▪ Adequate slope of the embankment with sub-bank ,if required.</li><li>▪ Protection works at vulnerable locations.</li></ul>
11.	Steep Gradient	<ul style="list-style-type: none"><li>▪ Catch siding and/or slip siding at station as per requirement.</li><li>▪ Flatter gradient, as far as possible, in the yard.</li><li>▪ Flatter gradient, as far as possible, in the loaded direction.</li></ul>
12.	Entanglement of hanging part with track components	<ul style="list-style-type: none"><li>▪ Installation of hanging part detection device along the track at certain interval.</li><li>▪ Proper securing of hanging parts with rolling stock.</li></ul>
13.	Hot axle of rolling stock	<ul style="list-style-type: none"><li>▪ Installation of 'Hot axle detection device' along the track at certain interval.</li></ul>
14.	Flat tyre of wheels of rolling stock	<ul style="list-style-type: none"><li>▪ Installation of 'Flat tyre detection device' along the track at certain interval.</li><li>▪ Detaching of flat tyred wagons / coaches after detection.</li></ul>
15.	Stalling of trains	<ul style="list-style-type: none"><li>▪ Ensure proper working of sanders.</li><li>▪ Use of banking loco for trains to upward gradient.</li><li>▪ Proper working instructions to loco pilots</li></ul>



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SN	Safety Hazard	Action to be Taken
16.	Parting of trains	<ul style="list-style-type: none"><li>▪ Ensure proper quality of coupling.</li><li>▪ Proper locking procedures for coupling.</li><li>▪ Proper working instructions to loco pilots.</li><li>▪ Provide flat gradient as far as possible.</li></ul>
17.	Signal Failure	<ul style="list-style-type: none"><li>▪ Advance signaling system</li></ul>
18.	Interlocking Failure	<ul style="list-style-type: none"><li>▪ Advanced interlocking system</li></ul>
19.	Failure of road users at unguarded rail-road crossings.	<ul style="list-style-type: none"><li>▪ Reduce No. of rail-road crossings as far as possible.</li><li>▪ Sub-ways to be provided for pedestrians and light vehicles.</li><li>▪ Road-over-bridges for major and important roads where heavy vehicles are plying.</li><li>▪ Provision of Train Actuated Warning Device.</li><li>▪ Organizing social awareness campaign in the nearby area, schools, bus depots, places of public gathering during festivals, fairs, etc.</li></ul>
20.	Failure of Railway staff at manned crossings.	<ul style="list-style-type: none"><li>▪ Providing interlocking of gate with signals.</li><li>▪ Ensure alertness of staff by frequent checks.</li><li>▪ Proper / timely advice by station staff to gateman for closure of the gate under exchange of private number(PN).</li></ul>
21.	Failure of Loco Pilots.	<ul style="list-style-type: none"><li>▪ Cab signaling with warning device to alert Loco Pilot against passing signal at danger.</li><li>▪ Installation of Anti-collision device in locos.</li><li>▪ Device for automatic braking at pre-set speed limit.</li></ul>
22.	Failure of Station staff	<ul style="list-style-type: none"><li>▪ Proper training to impart knowledge of train operations.</li><li>▪ More and more automation of decision making process.</li><li>▪ Periodical refresher courses for operating staff.</li></ul>
23.	Failure of staff working on track	<ul style="list-style-type: none"><li>▪ Proper training to impart knowledge of safety rules while working on track to infrastructure maintenance staff.</li><li>▪ Periodical refresher courses for refreshing their knowledge.</li></ul>
24.	Unauthorized crossings by- *Cattle *People *Light vehicles	<ul style="list-style-type: none"><li>▪ Provision of Sub-ways for cattle.</li><li>▪ Fencing on both sides of the track at the railway boundary to avoid trespassing by cattle and coming to the track.</li><li>▪ Trenching on both side of the embankment near the toe to make it in-accessible for the cattle to come on the track</li></ul>
25.	Fire	<ul style="list-style-type: none"><li>▪ Provision of Hot axle box detector along the track.</li><li>▪ Prevent carriage of inflammable materials in the coaches</li></ul>
26.	Terrorism	<ul style="list-style-type: none"><li>▪ Proper watch and alertness at all levels.</li><li>▪ Educate passengers to be alert.</li><li>▪ Effective Disaster Management Plan.</li></ul>



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## 4.0 Collection of data on Various Safety Items for the Project Area:

- 4.1 For taking decision regarding consideration of various factors while designing the various components of the project as well as inclusion of various safety related items in the project for execution, certain data are required to be collected pertaining to the project area. Some of the safety items and various data on them required to be collected from various sources are listed in the foregoing Para as example. It is made clear that neither the list of items nor the data mentioned against them are exhaustive or comprehensive, they are only illustrative, and therefore, for each project comprehensive list has to be prepared considering all the relevant factors pertaining to the project in view.
- 4.2 While taking the above decision, following considerations also play important role:
- Type of traffic – whether passenger, goods or mix of both - proposed to be carried on the project line.
  - Proposed speed potential of the project line – whether high speed line?
  - Expected traffic density on the project line.
  - Population density of the project area – densely populated or sparsely populated?
- 4.3 As stated above, some of the safety items and various data on them pertaining to the project area required to be collected from various sources are listed as under:-

SN	Safety Hazard	Data to be Collected
1.	Earthquake	<ul style="list-style-type: none"><li>▪ Earthquake zone in which project area lies.</li><li>▪ Past history of earthquake in the project area.</li><li>▪ Factor to be taken for design of components of infrastructure.</li></ul>
2.	Flood	<ul style="list-style-type: none"><li>▪ Data from Meteorological Department on the intensity of rains in the project area.</li><li>▪ Previous history of flooding in the area.</li><li>▪ Highest flood level &amp; vulnerable locations.</li><li>▪ Water bodies / water tanks likely to affect railways.</li></ul>
3.	Cyclone	<ul style="list-style-type: none"><li>▪ Past history of cyclone in the project area,</li><li>▪ Vulnerable locations &amp; protection works to be taken up.</li></ul>
4.	Landslides	<ul style="list-style-type: none"><li>▪ Geological data of the soil in slope of cuttings &amp; slope-stability analysis .</li></ul>
5.	Tsunami	<ul style="list-style-type: none"><li>▪ Data on vulnerability of the project area to Tsunami.</li><li>▪ Past history - type and extent of damage reported.</li></ul>



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SN	Safety Hazard	Data to be Collected
6.	Earthwork for formation	<ul style="list-style-type: none"><li>Geological investigation of the soil along alignment of the project.</li><li>Testing of quality of earth to be used for embankment.</li><li>Quality of blanketing material suiting to the formation.</li><li>Slope stability analysis - provision of sub-bank &amp; slope protection work required.</li></ul>
7.	Gradient	<ul style="list-style-type: none"><li>Topographical investigation.</li></ul>
8.	Rail-road crossing	<ul style="list-style-type: none"><li>Population density in the project area.</li><li>Type and density of road vehicles used in the project area.</li><li>Type of terrain of the area.</li><li>Type of road in the area &amp; road traffic density.</li></ul>
9.	Unauthorized crossings	<ul style="list-style-type: none"><li>Pattern of cattle grazing in the area.</li><li>Type and population of different type of cattle .</li><li>Type of light road vehicle &amp; habit of local people.</li></ul>
10.	Disaster Management	<ul style="list-style-type: none"><li>Approachability at different point of the alignment.</li><li>Facilities already available in the area which will be helpful during any accident.</li></ul>

## 5.0 Risk / Threat analysis for the Project Area:

5.1 After collecting the various data pertaining to project area, the same are required to be analyzed critically to assess the risk / threat they are likely to pose to the project during the operation period. Based on the assessed risk / threat, the decision has to be taken regarding the various safety related items required to be proposed in the project.

5.2 Considering the gravity of the risk / threat perception of the various safety items, their priority list can be prepared which should include the following items:

- Various safety factors to be taken into account while designing the various components of the project.
- Standard of construction for various components to be adopted.
- Safety items to be executed to minimize the safety hazard.
- Monitoring devices to be installed to monitor the safety hazard items.
- System of working to be introduced.
- Infrastructure to be developed for tackling the accidents / disasters in case of their occurrence.
- System of inspection and monitoring required to be introduced.
- System of maintenance of various assets required to be introduced.
- Feedback system for continuous improvement to the various systems.
- System of Independent safety audit to be introduced.



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## **6.0 Gravity of the Risk / threat perception viz-a-viz cost analysis :**

- 6.1 Cost estimate of the various items listed out above for the project has to be made to decide which items need to be taken up along with the execution of the project and which items may be postponed for future execution in course of time during the operation when sufficient funds get generated in course of operation of the project itself over a period of time.
- 6.2 The risk perception of the various items coupled with the their cost analysis will be governing factor for finalizing the various aspects of the project.

## **7.0 Critical Examination of Project Proposal by Independent Safety Agency:**

- 7.1 In order to take an objective view on the safety related items proposed in the project, it is essential that the entire proposal is critically examined by an independent safety agency. This is necessary because in most of the time in-house / internal examination does not lay adequate emphasis on the importance of various safety items due to cost considerations.
- 7.2 Though financial viability and profitability are the guiding factors for taking a decision on any commercial venture, but the same should not be planned to be achieved at the cost of the safety related items. This aspect can be safeguarded in better way if evaluation of the project proposal is undertaken by an independent safety agency.

## **8.0 System for Maintenance of Safety Items:**

- 8.1 Merely execution of safety related items or installation of various monitoring system is not adequate in itself unless proper system of maintenance is developed for proper functioning of the system. Therefore, it is imperative to lay down the maintenance schedule for each item and ensure the compliance of the same scrupulously. In addition to the schedule of maintenance, agency for carrying out the maintenance, system for procurement of spare parts, quantum of stores inventory etc. are also to be laid down clearly for better results.

## **9.0 Inspection and Monitoring:**

- 9.1 Once the various safety items are executed and the project is commissioned, it is necessary that the system is developed for proper inspection and monitoring of the working of the various items in order to keep them effective. This system is supposed to ensure not only the proper working of the various installed devices, but also provides feed back on their working for further improvement for better results . This process of regular monitoring and feed back will be resulting in improvement of the existing items as well as development of some other improved new items which may be more effective compared to the earlier items.



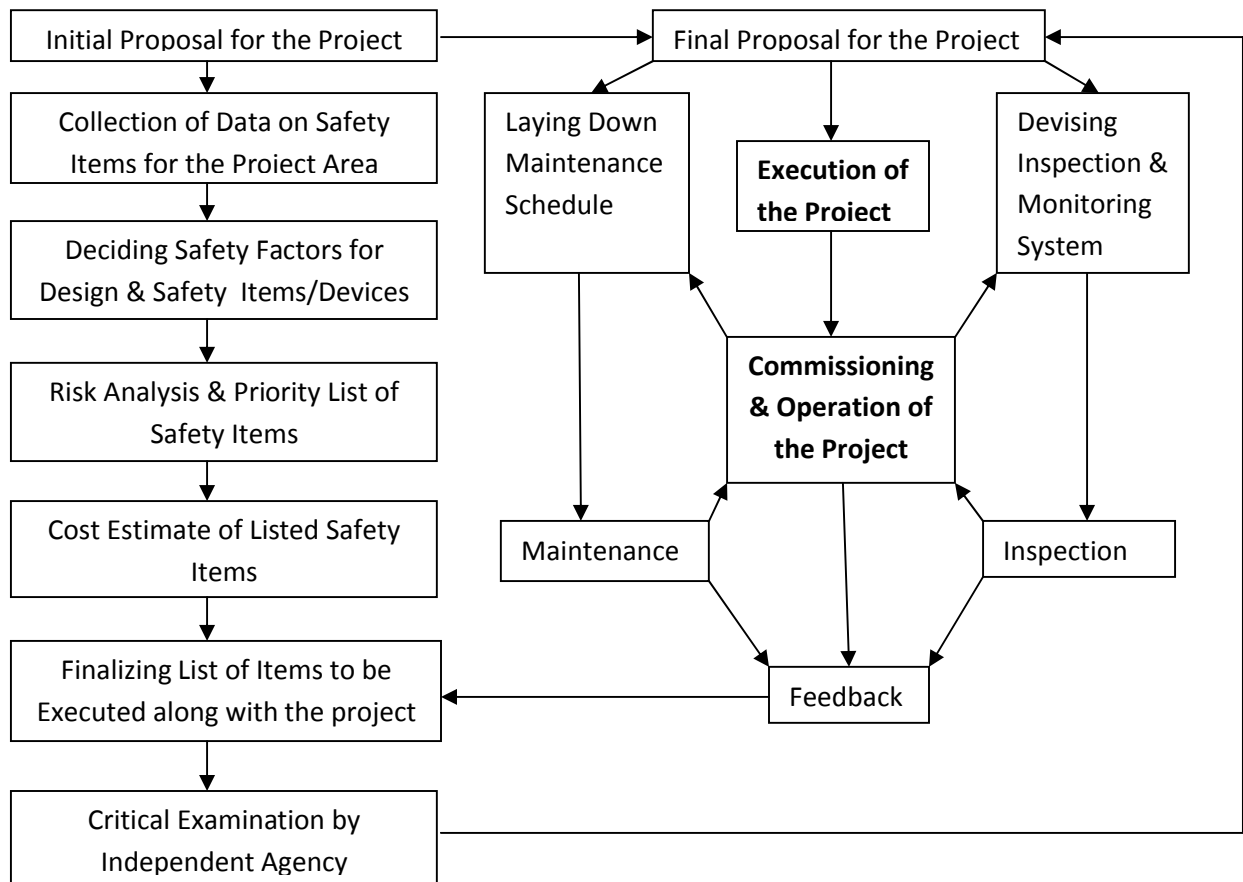
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## 10.0 Flow-chart of various Activities:

10.1 The flow-chart for the various activities as described in earlier Para is given below for easy understanding of the various steps and their inter-relationship with each other:-



## 11.0 Summary:

11.1 While initiating proposal for any Railway Project, due consideration for safety related item should be given in order to ensure the operations after completion of the project more safe with point of view of travelling public as well as goods carried. Not only this, but the safe operations also ensure more efficient operation with less down time on account of untoward incidents. The loss of revenue due to accidents also can be minimised with safe operations resulting in better profitability.



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- 11.2 Once the initial proposal of the project is made out, the list of probable safety hazard items with respect to the project area and the type of traffic planned to be carried, should be made out and relevant data for the same should be collected from various sources.
- 11.3 Based on the collected data, the safety factors to be taken for the design of various components of the project as well as the various safety items / devices required to be executed / installed may be finalized duly carrying out the cost-benefits analysis.
- 11.4 The proposal with the list of safety items proposed to be included in the project may be got critically examined by an independent safety agency for unbiased appraisal of the risk perception and the ways & means planned for mitigation. Thereafter, the proposal may be finalized and execution of the project may be taken up.
- 11.5 For efficient working of the created safety assets, maintenance and inspection should be laid down so that regular inspection and timely maintenance are carried out to ensure the proper working of the assets / system created.
- 11.6 The regular feed back from the working of the system needs to be taken and corrective measures for further improvement should be taken for further development of the system to ensure the safety in still better way.
- 11.7 Thus the safety planning is a dynamic process by which system can be made better and better which will ensure the operations safer and safer. There is no end, there is always scope for improvement .

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