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Enhance Safety Performance through Quantitative and Qualitative Analysis of Accidents in Egyptian National Railway

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Abstract

Rail transport plays an important role in creating a sustainable future for transport. Safety can be defined as qualitatively or quantitatively to prevent unacceptable risks. Improving safety is the main goal of each railway company as safe operation helps in increasing the level of service offered to the users. This paper deals with quantitative and qualitative analysis of accidents in Egyptian National Railway for annual accidents during the period of 2011 till 2017 for the six zones classified according to causes as absolute values and relative values to determine the worst zones and the most popular causes to improve the safety level and put the corrective plan to minimize the effective of accidents on both economic and safety of the society, to realize this goal a data collections were obtained and traffic fluction were calculated by the use of the official time table in train.km/year for the six zones. The study proposes effective solution for the decision maker to enface this very dangerous problem and improve the economic efficiency of the system, and preserve the environment surrounding the system.

Keywords: Egyptian National Railway(ENR); Safety; Risk; Quantitative; Qualitative; Accident; Derailment; Collision; Level crossing and Fire.

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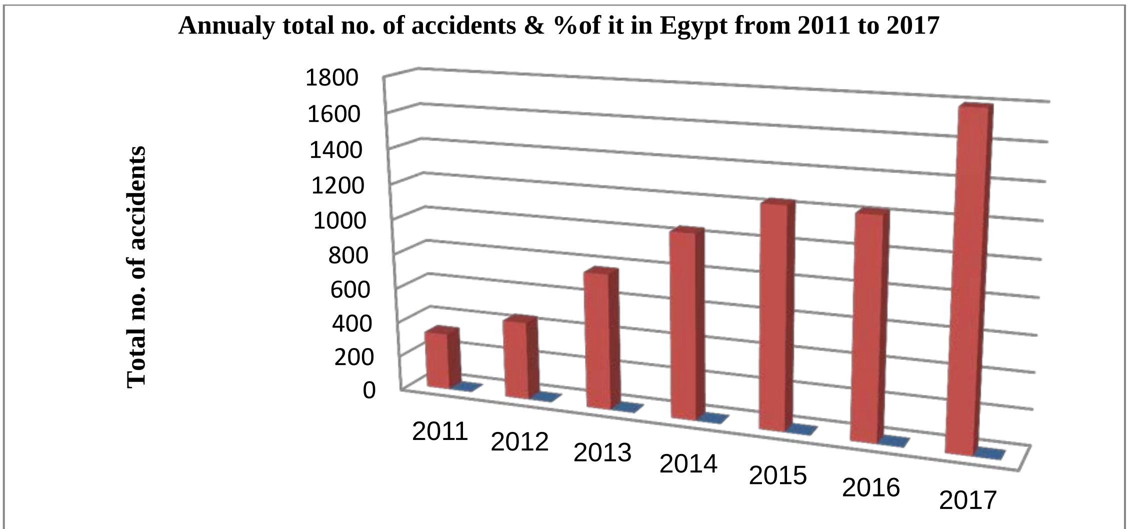
1. Introduction

Rail transport plays an important role in creating a sustainable future for transport. Safety can be defined as preventing unacceptable risks. Improving safety is the main goal of each railway company as safe operation helps in increasing the level of service offered to the users, improving the economic efficiency of the system, and preserving the environment surrounding the system. A significant rail accident is any undesired or unexpected incidents involving at least one rail vehicle in motion, resulting in at least one killed or seriously injured person or in significant damage for the railway system (railway infrastructure, rolling stock, and railway operation) and the environment [1]. According to Egyptian National Railway, the total number of railway accidents in Egypt from 2011 until 2017 was 6,843 that is high number of accidents, and the latest four years from 2014 to 2017 there have been more than 1,000 accidents yearly, specially in 2017 which have the largest number of accidents, figure (1) illustrate the rate of accidents during the seven years & % of it.



	2011	2012	2013	2014	2015	2016	2017
Total no. of accidents	327	447	774	1044	1235	1223	1793
% of total no. of accidents	5%	7%	11%	15%	18%	18%	26%

Figure 1: Number of annual total accidents in Egypt during the years 2011 till 2017and %of it.

The approach taken in this research is to conduct detailed analysis of the train accident data supplied by the railways authority; Analysis of the causes of train accidents helps to put the correction plans to reduce accident occurrence in the most cost-effective manner possible.

2. Definition

Safety of a railway system can be defined qualitatively or quantitatively [2]:

2.1. A qualitative assessment approach of safety is risk level

2.1.1. The correlation between the frequency and the severity of an event defines four risk levels [2]

2.1.1.1. Non-permissible

Accidents of this category must be eliminated.

It represents the most significant category and necessitates urgent safety measures by the services responsible, regardless of the financial and operational cost.

2.1.1.2. Non-desirable

Accidents of this category can be accepted only in case of inability to contain their consequences and always upon the relevant approval of the authority in charge.

2.1.1.3. Permissible

It corresponds to a generally acceptable safety level, without excluding further improvements, if it is feasible.

2.1.1.4. Unimportant

The incidents of this category are acceptable, provided that there is approval of the competent authority.

Table 1: Shows risk levels as the combination of frequency and severity frequency and severity of accidents

	Risk levels	Accident severity			
		Catastrophic	Severe	Minor importance	Negligible
Accident frequency	Frequent	Non-permissible	Non-permissible	Non-permissible	Non-desirable
	Possible	Non-permissible	Non-permissible	Non-desirable	Permissible
	Occasional	Non-permissible	Non-desirable	Non-desirable	Permissible
	Unusual	Non-desirable	Non-desirable	Permissible	Unimportant
	Rare	Permissible	Permissible	Unimportant	Unimportant
	Unlikely	Unimportant	Unimportant	Unimportant	Unimportant

Source: Adapted from European Standard EN50126-1 2000, Railway Applications: Reliability, Availability, Maintainability and Safety (RAMS), Part 1, CENELEC European Standards (European Committee for Electromechanical Standardization).

2.1.2. Regarding the classification of accidents according to the severity of their consequences, the following definitions are suggested

2.1.2.1. Catastrophic

Fatalities and/or multiple severe injuries and/or severe environmental impact and/or extensive property damage.

2.1.2.2. Severe

One fatality and/or serious injury, and/or significant environmental impact, and/or limited severe property damage.

2.1.2.3. Low severity

Minor injury, and/or significant threat (or low impact) on the environment, and/or limited damage.

2.1.2.4. Negligible

Possible minor injury and/or minor property damage.

2.2. A quantitative assessment of safety is accident indicators. Countries use specific indicators related to accidents (per year) to evaluate their railway networks' safety [2&6]

1. Total number of serious accidents (number).
2. Relative number of serious accidents (number/train-kilometer).
3. Distribution of accidents per accident category.
4. Fatality risk indicator: death toll as a result of train accidents per million train-kilometers.

2.3. The railway accidents can be classified into five main categories

2.3.1. Collisions

It includes head-on collision, rear collision and side collision. It also includes accidents at Level Crossings.

2.3.2. Derailments

This refers to the offloading of wheel or wheels from the track causing detention or damage to rolling stock / permanent way. It includes Derailment on the main track and Derailment on sidings.

2.3.3. Fire in Trains

Accident related to fumes, fires of vehicles, tractors or cables in trains.

2.3.4. Opponents on lines

The incidents of opposition to the lines are accidents caused by external factors that affect the rail, such as the fluctuation of the atmosphere resulting in the occurrence of a tree or cable electricity on the track or leave things on the track.

2.3.5. Other Train Accidents

2.3.5.1. Signal abuse

It is an accident that exceeds the semaphores and the disks when the signal is red, even though it is red.

2.3.5.2. Traffic abuse

It is an accident that violates the work of railway passengers, which mean entering the train in a busy railway that is supposed to be empty.

2.3.5.3. Platform abuse

Is the occurrence of accidents exceeding the trains to the platforms of the stations, that is, the driver exceeds the Green Semaphore and away by the door of the vehicle from the platform of the station so that passengers can get off at the station .

2.3.5.4. Turnouts abuse

When crossing the turnouts; it is closed or open in another direction or needs maintenance.

2.3.5.5. Train separation

These are incidents of separation of the train cars from each other or the separation of the tractor from the vehicles

2.3.5.6. Door opening

Is the opening of the doors of the train, such as the opening of the doors of freight trains during the transfer of army vehicles and the transfer of guns over vehicles.

3. Methodology

Railway safety is a result of concerted dynamic and daily effort of all relevant actors who interact in the railway system.

The figure 2 summaries proposed methodology for the safety analyses for railway.

3.1. First step

Define current situation (rate, location, types of accidents, and causes of accidents).

3.1.1 ENR network divided into six zones

(Central zone, Middle delta zone, West delta zone, East delta zone, Middle zone, Southern zone).

3.1.2. Types of railway accidents

ENR accidents divided into five types:

1- Collisions (at level crossing - at illegal level crossing - gate collision - train collision – by fraction).
2- Derailments (on main lines - on branch lines - on refuge and yards).
3- Fire in Trains.
4- Opponents on lines.
5- Other Train Accidents (Signal abuse - Traffic abuse - Platform abuse - Turnout's abuse - Train separation - Door opening).

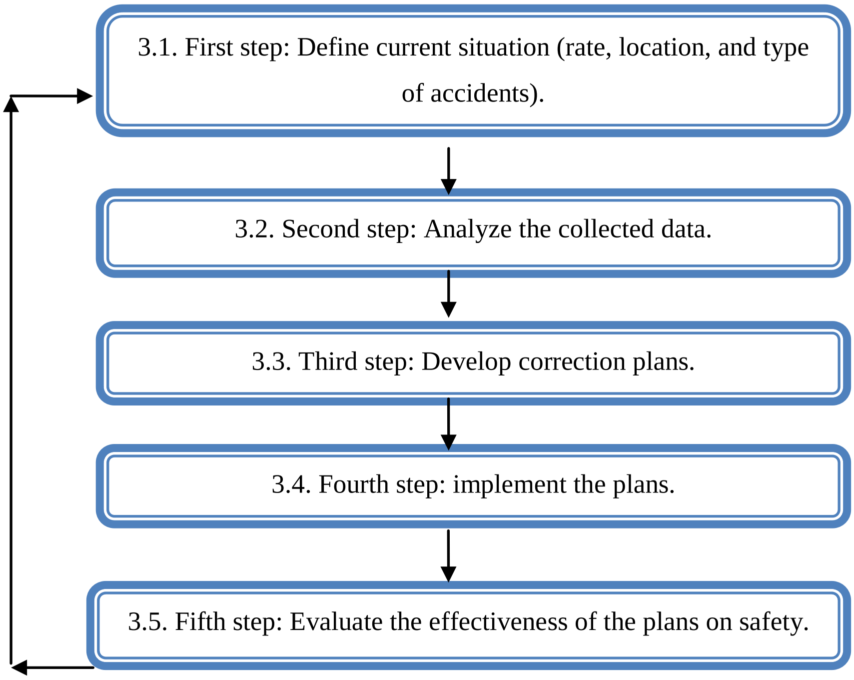


Figure 2: Represents flow chart of proposed methodolgy.

Case study: By applying this previous methodolgy on ENR.

3.1.3. Causes of railway accidents

Causes of railway accidents may be identified as follows:

- Defects in level crossings, (broken barriers, defect in the train announcement system, insufficient/lack of road signs, insufficient lighting).
- False switching, and don't fix the turnout in its correct location.
- Violation of instruction (Violation of/incorrect application of the regulations by the staff).
- Collision with buses, cars, trucks, motorcycle.
- Defects in the equipment of train control.
- Defective signals on semaphores or disks, or false information to the train driver.
- Inadequate maintenance of the track, which may lead to derailment.
- Mechanical failures of wheels and rails like that (rail erosion, rail cracks, rail defects, track geometry defects, sleeper cracks, error in the track alignment geometry (insufficient cant, insufficient length of transition curves, etc.).
- External factors like that (Earthquake while the train is moving, explosion on railway, Occupation of the track (by strikes, sand, rubbish, Pedestrian/animal drifts on track, waters/flooding of the facilities), vandalism, sabotage, terrorist actions, falling rocks, etc.).
- Collapsed bridge by structural failure.
- Improper loading or unloading of cargo.
- Technical failures in the railway infrastructure and/or in the rolling stock.
- Human errors like that (braking during moving the train, Speed not organized by train driver).
- Train staff which is either untrained or under the influence of drugs or alcohol. [1&3].

3.2. Second step: Analyze the collected data

Figurs 3,4,5,6 and tables 2,3,4,5,6,7,8,9,10,11 showes the distribution of the no.of accidents on the six zones .

Table 2: Represents the Total no. of accidentes &%of Total no. of accidentes from 2011 to 2017 for all types of accidentes .

Types of accidents	Total no. of acc. from 2011 to 2017		%of Total no. of acc. from 2011 to 2017	
	Absolute	Relative	absolute	Relative
Derailment	483	12.94	7	8
Total collision	5152	127.24	76	75
Fire in trains	161	4.2	2	3
Opponents on lines	536	14.21	8	8
Other train accidents	432	10.64	7	8

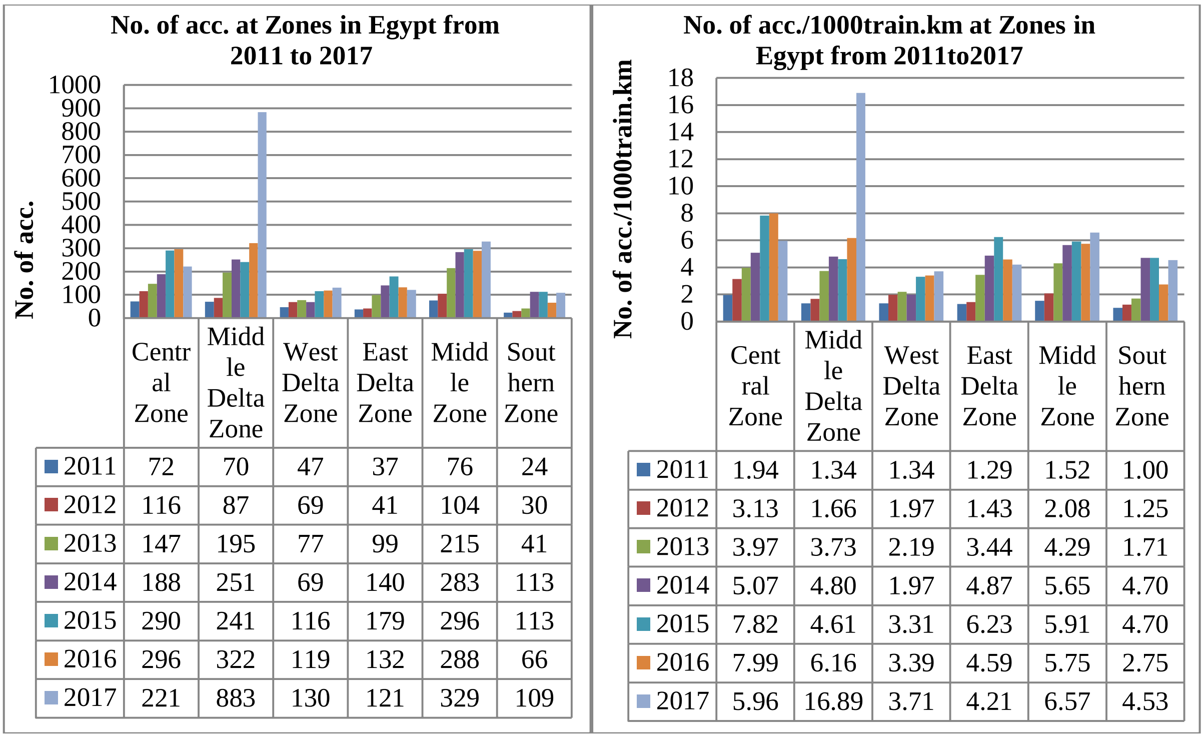


Figure 3&4: Absolute number of annual accidents on ENR networks during the years 2011 till 2017 for the sex railway zones in absolute accidents and in relative accidents per 1000 train.km.

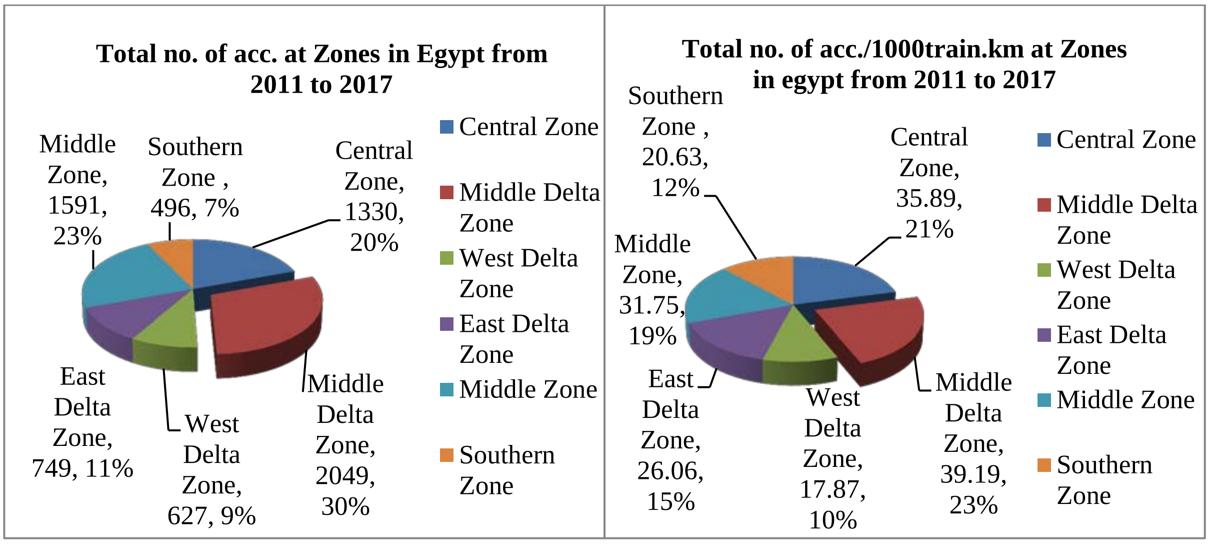


Figure 5&6: Persantage share of total accidentes on ENR networkes during the years 2011 till 2017` for each zones the sex Railway zones in abslute ccidentes and in relative accidente per 1000 train.km .

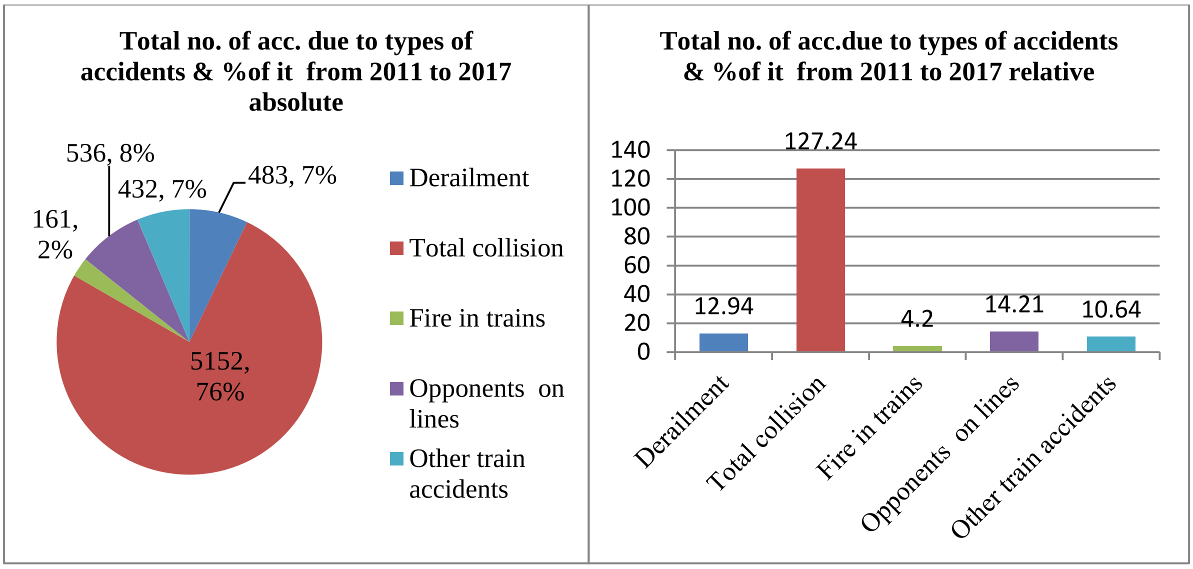


Figure 5&6: Total no. of acc. due to types of accidents & %of it on ENR networkes during the years 2011 till 2017 in abslute accidentes and in relative accidente per 1000 train.km .

Table 3: Persantage of share of accidentes for each zone on ENR networkes during the years 2011 till 2017

Year / Zone	2011		2012		2013		2014		2015		2016		2017		%Total (2011 till 2017)	
	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.
Central zone	22	23	26	27	19	21	18	19	23	24	24	26	12	14	20	21
Middle Delta zone	22	16	20	15	25	19	24	18	20	14	26	20	20	40	30	23
West Delta zone	15	16	15	17	10	11	7	7	9	10	10	11	7	9	9	10
East Delta zone	11	15	9	12	13	18	13	18	15	19	11	15	7	10	11	15
Middle zone	23	18	23	18	28	22	27	21	24	18	24	19	19	16	23	19
Southern zone	7	12	7	11	5	9	11	17	9	15	5	9	6	11	7	12
Total	100%		100%		100%		100%		100%		100%		100%		100%	

Table 4: The fluction absolute (no. of acc.) & relative (no .of acc./1000train.km) total annual derailment accidentes and % of it for the six zones on ENR networkes during the years 2011 till 2017.

Zone / Year	Central Zone		Middle Delta Zone		West Delta Zone		East Delta Zone		Middle Zone		Southern Zone		Total & % of it			
	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	%	rel.	%
2011	7	0.19	6	0.11	2	0.06	8	0.28	4	0.08	2	0.08	29	6	0.80	6
2012	20	0.54	4	0.08	5	0.14	6	0.21	8	0.16	1	0.04	44	9	1.17	9
2013	32	0.86	7	0.13	9	0.26	10	0.35	11	0.22	0	0.00	69	14	1.82	14
2014	14	0.38	11	0.21	4	0.11	6	0.21	6	0.12	1	0.04	42	9	1.07	8
2015	33	0.89	18	0.34	31	0.88	16	0.56	10	0.20	6	0.25	114	24	3.12	24
2016	37	1.00	21	0.40	25	0.71	9	0.31	15	0.30	4	0.17	111	23	2.89	23
2017	21	0.57	13	0.25	15	0.43	17	0.59	5	0.10	3	0.12	74	15	2.06	16

Table 5: The fluction absolute (no. of acc.) & relative (no .of acc./1000train.km) total annual total collision accidentes and % of it for the six zones on ENR networkes during the years 2011 till 2017.

Zone / Year	Central Zone		Middle Delta Zone		West Delta Zone		East Delta Zone		Middle Zone		Southern Zone		Total & % of it			
	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	%	rel.	%
2011	31	0.84	36	0.69	28	0.80	19	0.66	21	0.42	11	0.46	146	3	3.86	3
2012	68	1.83	70	1.34	40	1.14	23	0.80	58	1.16	21	0.87	280	5	7.15	5
2013	85	2.29	151	2.89	41	1.17	73	2.54	160	3.19	37	1.54	547	11	13.62	11
2014	129	3.48	205	3.92	46	1.31	110	3.83	243	4.85	96	3.99	829	16	21.38	17
2015	191	5.15	183	3.50	57	1.62	129	4.49	234	4.67	89	3.70	883	17	23.14	18
2016	212	5.72	266	5.09	64	1.82	108	3.76	224	4.47	47	1.96	921	18	22.82	18
2017	168	4.53	841	16.09	83	2.37	94	3.27	275	5.49	85	3.54	1546	30	35.28	28

Table 6: The fluction absolute (no. of acc.) & relative (no .of acc./1000train.km) total annual fire in trains accidentes and % of it for the six zones on ENR networkes during the years 2011 till 2017.

Zone / Year	Central Zone		Middle Delta Zone		West Delta Zone		East Delta Zone		Middle Zone		Southern Zone		Total & % of it			
	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	%	rel.	%
2011	0	0	0	0	0	0	1	0.03	1	0.02	0	0	2	1	0.055	1
2012	2	0.05	0	0	1	0.03	1	0.03	2	0.04	1	0.042	7	4	0.199	5
2013	1	0.03	1	0.02	3	0.09	1	0.03	1	0.02	0	0	7	4	0.186	5
2014	7	0.19	8	0.15	4	0.11	2	0.07	4	0.08	0	0	25	16	0.605	14
2015	9	0.24	7	0.13	7	0.2	6	0.21	8	0.16	5	0.208	42	26	1.153	27
2016	13	0.35	6	0.11	1	0.03	4	0.14	6	0.12	2	0.083	32	20	0.836	20
2017	10	0.27	3	0.06	7	0.2	1	0.03	20	0.4	5	0.208	46	29	1.169	28

Table 7: The fluction absolute (no. of acc.) & relative (no .of acc./1000train.km) total annual opponents on lines accidentes and % of it for the six zones on ENR networkes during the years 2011 till 2017.

Zone / Year	Central Zone		Middle Delta Zone		West Delta Zone		East Delta Zone		Middle Zone		Southern Zone		Total &%of it			
	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	%	rel.	%
2011	22	0.59	16	0.31	12	0.34	6	0.21	24	0.48	9	0.374	89	17	2.303	16
2012	13	0.35	3	0.06	11	0.31	7	0.24	13	0.26	4	0.166	51	10	1.391	10
2013	14	0.38	23	0.44	13	0.37	8	0.28	22	0.44	4	0.166	84	16	2.072	15
2014	28	0.76	16	0.31	6	0.17	18	0.63	18	0.36	12	0.499	98	18	2.717	19
2015	29	0.78	14	0.27	9	0.26	20	0.7	21	0.42	6	0.249	99	18	2.671	19
2016	9	0.24	10	0.19	13	0.37	6	0.21	16	0.32	7	0.291	61	11	1.624	11
2017	11	0.3	7	0.13	9	0.26	2	0.07	17	0.34	8	0.332	54	10	1.429	10

Table 8: The fluction absolute (no. of acc.) & relative (no .of acc./1000train.km) total annual other train accidentes and % of it for the six zones on ENR networkes during the years 2011 till 2017.

Zone / Year	Central Zone		Middle Delta Zone		West Delta Zone		East Delta Zone		Middle Zone		Southern Zone		Total & % of it			
	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	rel.	ab.	%	rel.	%
2011	12	0.32	13	0.25	5	0.14	3	0.1	26	0.52	2	0.08	61	14	1.421	14
2012	13	0.35	10	0.19	12	0.34	4	0.14	23	0.46	3	0.12	65	15	1.607	15
2013	15	0.41	13	0.25	11	0.31	7	0.24	21	0.42	0	0	67	16	1.63	15
2014	10	0.27	11	0.21	8	0.23	3	0.1	12	0.24	4	0.17	48	11	1.219	12
2015	22	0.59	15	0.29	9	0.26	2	0.07	15	0.30	3	0.12	66	15	1.631	15
2016	18	0.49	12	0.23	13	0.37	2	0.07	23	0.46	3	0.12	71	16	1.739	16
2017	9	0.24	15	0.29	12	0.34	5	0.17	9	0.18	4	0.17	54	13	1.392	13

Table 9: The largest (zone in (absolute & relative) no. of accidents & the largest year & %of total no.(absolute & relative)) in all types of accidents.

Types of accidents	Zone		Year	%of total no. of accidents	
	Absolute	Relative		Absolute	Relative
Derailment	central zone	central zone	2015	24%	24%
Total collision	middle delta zone	central zone	2017	30%	28%
Fire in trains	central zone	central zone	2017	29%	28%
Opponents on lines	central zone	central zone	2014&2015	18%	19%
Other train accidents	Middle Zone	central zone& Middle Zone	2016	16%	16%

Note: Analyze the accidents in Egypt on years and the same situation till now without taking safty improvement , this equations above in table 10 shows the relationship between absolute and relative no. of accidents at

Zones in Egypt within 2011 till 2017 and shows equation for curves and correlation numbers for them related to polynomial curves , we try to solve this problem and reduse no. of accidents on the next years .

Table 10: Absolute Total no. of accidents and relative Total no. of acc./1000train.Km on Zones in Egypt within 2011 till 2017 and shows equation for curves and correlation numbers for them related to polynomial curves.

Zone	Central Zone	Middle Delta Zone	West Delta Zone	East Delta Zone	Middle Zone	Southern Zone
R^2	0.8398	0.8425	0.8955	0.8394	0.9484	0.6564
Equ. for no. of acc.	$y = -7.119x^2 + 28709x - 3E+07$	$y = 29.202x^2 - 117522x + 1E+08$	$y = 0.3571x^2 - 1424.7x + 1E+06$	$y = -7.1905x^2 + 28982x - 3E+07$	$y = -7.619x^2 + 30733x - 3E+07$	$y = -2.9643x^2 + 11954x - 1E+07$
Equ. for no. of acc./1000train.km	$y = -0.1921x^2 + 774.65x – 780989$	$y = 0.5585x^2 - 2247.8x + 2E+06$	$y = 0.0102x^2 - 40.61x + 40499$	$y = -0.2501x^2 + 1008.2x - 1E+06$	$y = -0.1521x^2 + 613.4x – 618551$	$y = -0.1233x^2 + 497.27x – 501341$

Table 11: The risk permissible level in all types of accidents to evaluate it from risk level of each type of accidents according to table 1 & this equation In Egypt within 2011 till 2017 .

Types of accidents	Total no. of accidents from 2011 to 2017	Classification of risks			Risk permissible level
		Accident frequent	Accident severity	Risk level	
Derailment	483	4	4	16	Non-permissible
Total collision	5152	5	4	20	Non-permissible
Fire in trains	161	2	3	6	Permissible
Opponents on lines	336	3	3	9	Non-desirable
Other train accidents	432	3	3	9	Non-desirable

Risk level = Accident frequent Accident severity (R=F*S) [4]*

3.3. Third step: Develop correction plans

(as well shown in the conclossion).

3.4. Fourth step: implement the plans

(as recommendation).

3.5. Fifth step: Evaluate the effectiveness of the plans on safety

(as recommendation).

4. Results

- From figure3&4 we observe that the largest zone in total no. of accidents is middle zone & the largest zone in total no. of accidents/1000train.km is central zone within 2011 till 2017 but middle delta zone in 2017 has large increasing in absolute and relative no. of accidents because of increasing of gate collision in this zone .
- From figure5&6 we observe that the largest zone in total no. of accidents is middle delta zone with persentage of 30% & the largest zone in total no. of accidents/1000train.km is middle delta zone with persentage of 23% within 2011 till 2017.
- From table 2 & two figures6&7 we observe that the largest total no. of accidentes (absolute&Relative) at total collision with persentage 76% of the total no. of accidentes this represents more than half of total no. of accidentes from 2011 to 2017 because of large no. of accidents at level crossing specially at gate collision with cars .
- From table3 we observe that the largest no. of % of share of accidentes(absolute&relative) at 2011 is (23% in middle zone &23% in central zone) , at 2012 is (26%&27) in central zone , at 2013 is (28%&22%) in middle zone , at 2014 is (27%&21%) in middle zone , at 2015 is (24% in middle zone&24% in central zone) , at 2016 is (26% in middle delta zone&26% in central zone) , at 2017 is (20%&40%) in middle delta zone , Total absolute (2011 till 2017) is 30% in middle delta zone and Total relative (2011 till 2017) is 23% in middle delta zone .
- From table4 we observe that the largest zone in.(absolute & relative) no. of accidents is central zone at the most of zones & the largest persantage of total no.(absolute & relative) of derailment is 24% in 2015 .
- From table5 we observe that the largest zone in absolute no. of accidents is middle delta zone at the most of zones & the largest zone in relative no. of accidents is central zone at the most of zones & the largest persantage of total no.(absolute & relative) of total collision is (30% & 28%) in 2017 .
- From table6 we observe that the largest zone in .(absolute & relative) no. of accidents is central zone at the most of zones & the largest persantage of total no.(absolute & relative) of fire in trains is (29% & 28%) in 2017 .
- From table7 we observe that the largest zone in .(absolute & relative) no. of accidents is central zone at the most of zones & the largest persantage of total no.(absolute & relative) of Opposials on lines is (18% & 19%) in 2014&2015 .
- From table8 we observe that the largest zone in (absolute & relative) no. of accidents is Middle Zone at the most of zones & the largest persantage of total no.(absolute & relative) of Opposials on lines is (16%) in 2016 .
- From table9 we observe that central zone is the largest no. of accidents in the most of types of accidents.
- From table10 we observe that the largest correlation no. is 0.9484 in middle zone and the lowest no. is 0.6564 in southern zone.
- From table11 we observe that the largest risk level is 20 in total collision which have non-permissible risk level then derailment is 16 which have non-permissible risk level too.

5. Conclusions and Recommendations

- This analysis applied to all accidents on the six zones in Egypt from 2011 to 2017 to see which of them needs to be developed priority to reduce no. of accidents in it.
- We observe that central zone is the largest no. of accidents in the most of types of accidents.
- The largest total no. of accidents (absolute & relative) at total collision with percentage 76% of the total no. of accidents this represents more than half of total no. of accidents from 2011 to 2017 because of large no. of accidents at level crossing specially at gate collision with cars.

- The largest risk level is 20 in total collision which have non-permissible risk level then derailment is 16 which have non-permissible risk level too.

Correctin actions for maintanance:

- Closing of illegal level crossing on railway lines.
- Making reminder courses for workers in maintenance on lines.
- Distributing of workers in maintenance sites according to priority work and size.
- Examining the turnouts of stations and ensure the integrity of their tasks and change the damaged ones.
- Following-up the maintenance of the daily and periodic railways of welded and non-welded railways as well as diversions and level crossings in accordance with technical regulations to ensure the safety of the train tracks at the limited speeds.
- Paying attention to quality system in all works to rationalize the expenses and ensure that the implementation is not repeated again.
- Install the appropriate protection systems in level crossings.
- Detecting welds and securing defective welds.
- Put up warning signs, regulatory and the ground planning for vehicles movement when approaching the legal or illegal level crossing area.
- Install monitoring systems which identify any defective material or operation.
- For separated railways, ensure the maximum level of cooperation between infrastructure and operation.

Correctin actions for human power:

- Train drivers must comply with the speed limits for maneuvering and during heating (8 km /h).
- The drivers of the trains, locomotives or moving units should not exceed any of the semaphore or disks, which will only show the danger signal in the authorized cases and provided that the driver receives the appropriate movement order as the case may be.
- Ensure that employees are aware of the critical functions of safety instructions and the seriousness of their training programs.
- Improve the working environment for the train workers.
- Improve the education of all railway staff.

Correctin actions for safety regulations:

- Increasing the number of A.T.C control devices for trains with blocks and towers and activating their work.
- Determine the technical authorities who responsible for the accidents with the Railway Authority.
- Improve operational safety systems, such as the automatic train control system.
- Inform the clients and more generally the public on the dangers related to the railway system (though smaller compared to other transport modes).
- Implement the correction plane and reevaluate safety.

References

[1] V.A. Profillidis. Railway Management and Engineering, USA: Ash gate Publishing Limited, 2014, pp. 626-627-628.

[2] Sunil .K. Agarawal. “Accident manual 2012” India, 2012.

[3] Christos N. Pyrgidgis. Railway Transportation Systems, New York: Taylor & Francis Group, 2016, pp. 377-378- 382-383-384.

[4] Egyptian National Railway, Risk management, Egypt: General Administration of Control on the Operating, march 2017.

[5] Egyptian National Railway, Schedules of distance of trains - Lower and Upper Egypt, Egypt: General Administration of Control on the Operating, July 2013 &2016.

[6] Commission Directive2014/88/EU. “Directives.” Official Journal of the European Union, pp. 3-4, 9 July 2014.