



LEVEL CROSSING

Design & Risk Assessments

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SAICE Symposium 2005



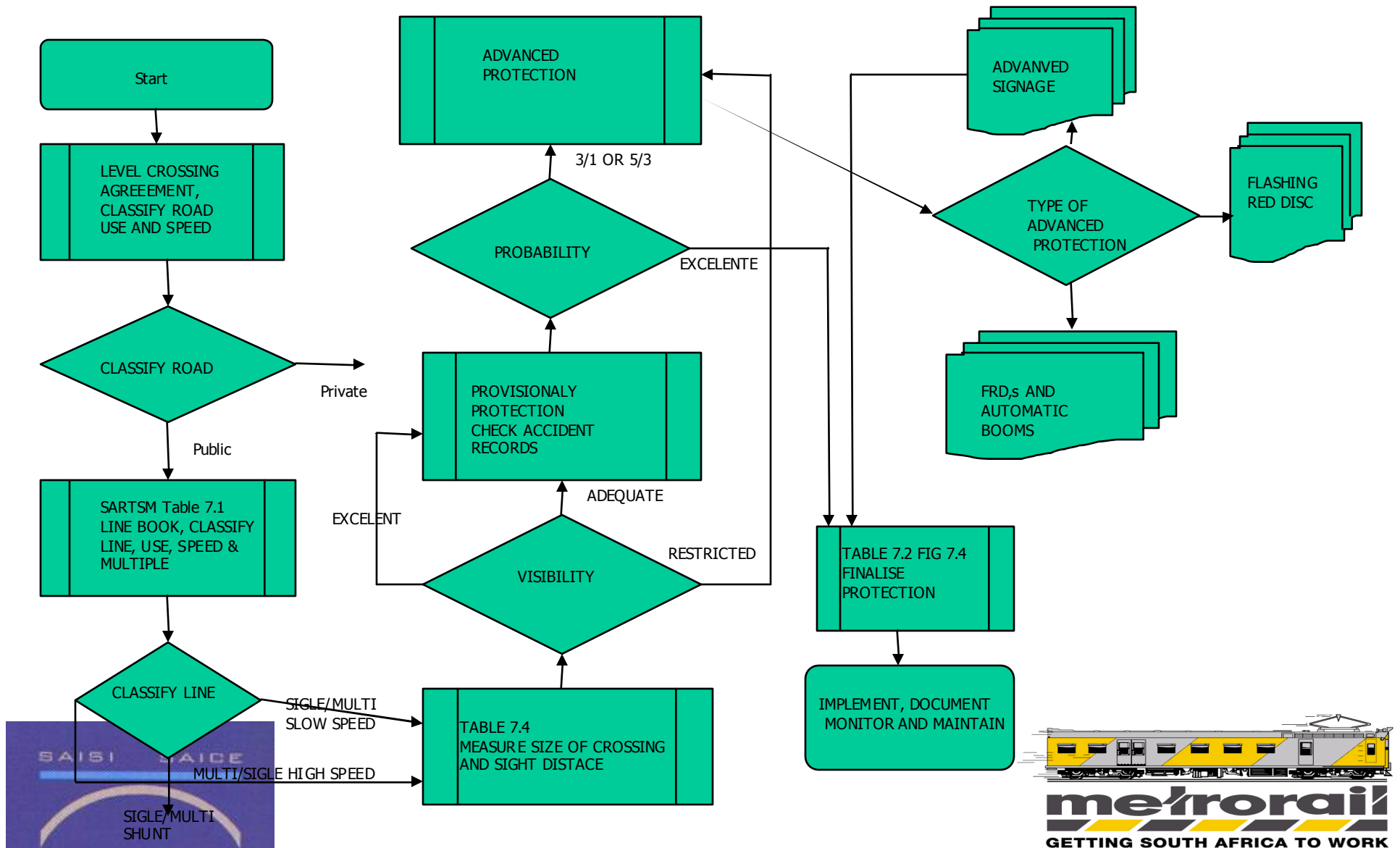


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- Introduction
- Protection design
- Risk Assessments
- Accident prediction models
- Conclusion
- Recommendations



ASSESSMENT FLOWCHART





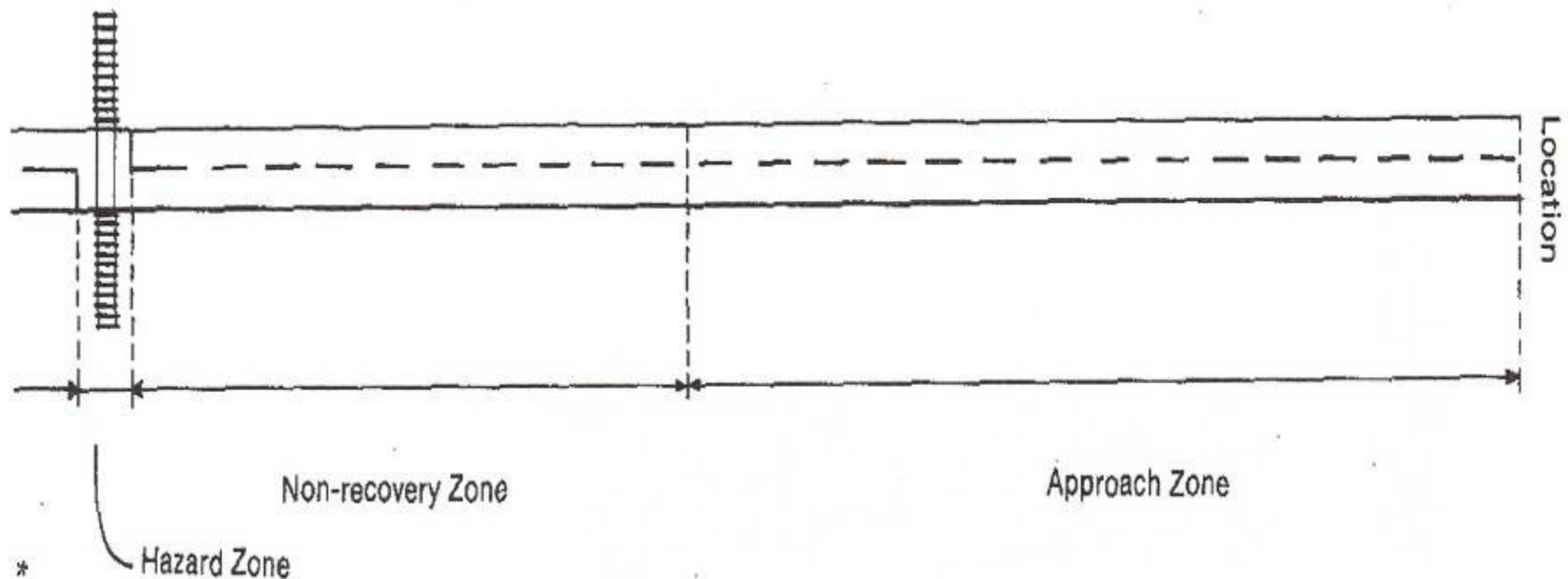
Introduction

- Site Operational Dynamics
- Driving requirements
 - Pre-trip planning
 - Vehicle control
 - Navigation
 - Guidance



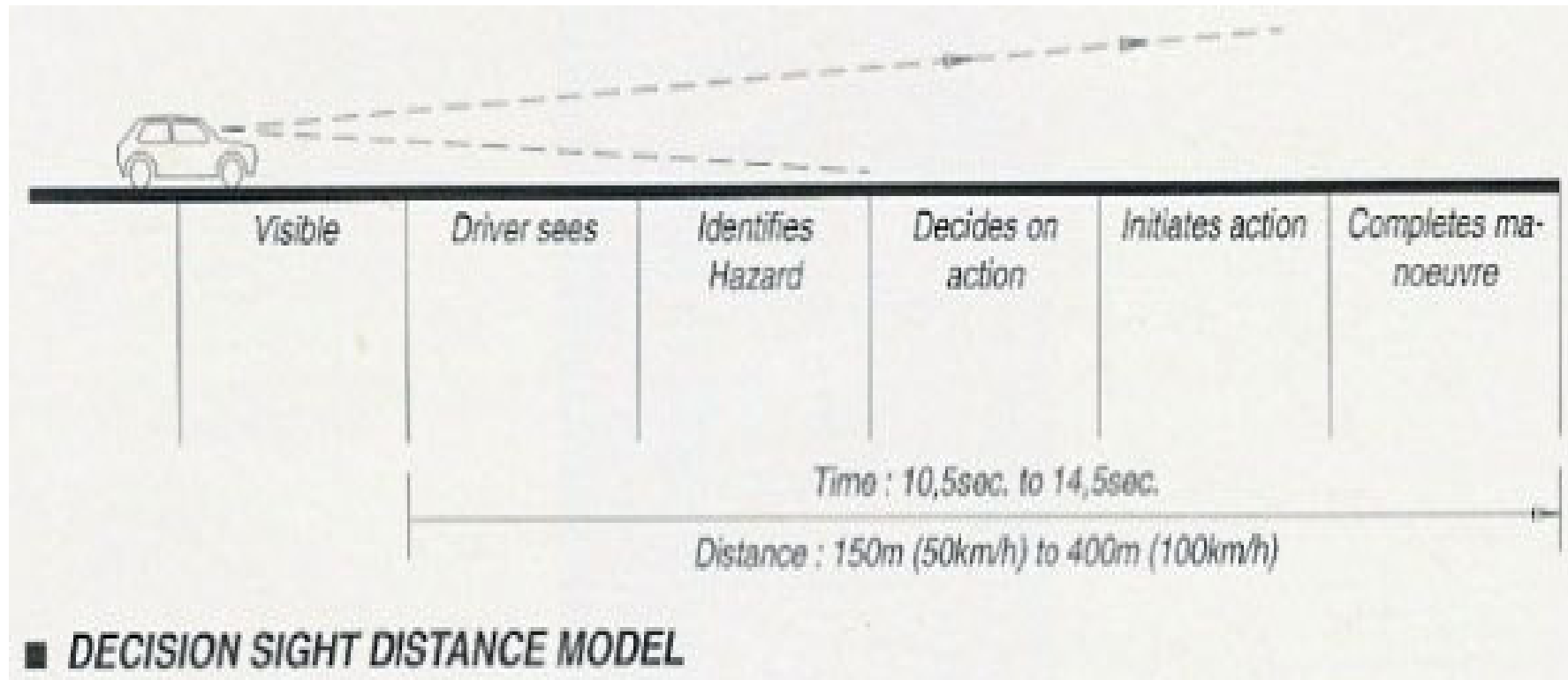
Protection Design

Road level crossing sight components



Protection Design

Road Sight Distance





Protection design

- Human factors
 - Sampling
 - Prior Knowledge
 - Processing limitations
 - Spreading
 - Vehicle control and guidance
 - Expectancy





Protection design

- Environmental factors
 - Unfamiliar Environments
 - Ambient light levels
 - Traffic volumes
 - Weather conditions
 - Street system complexity

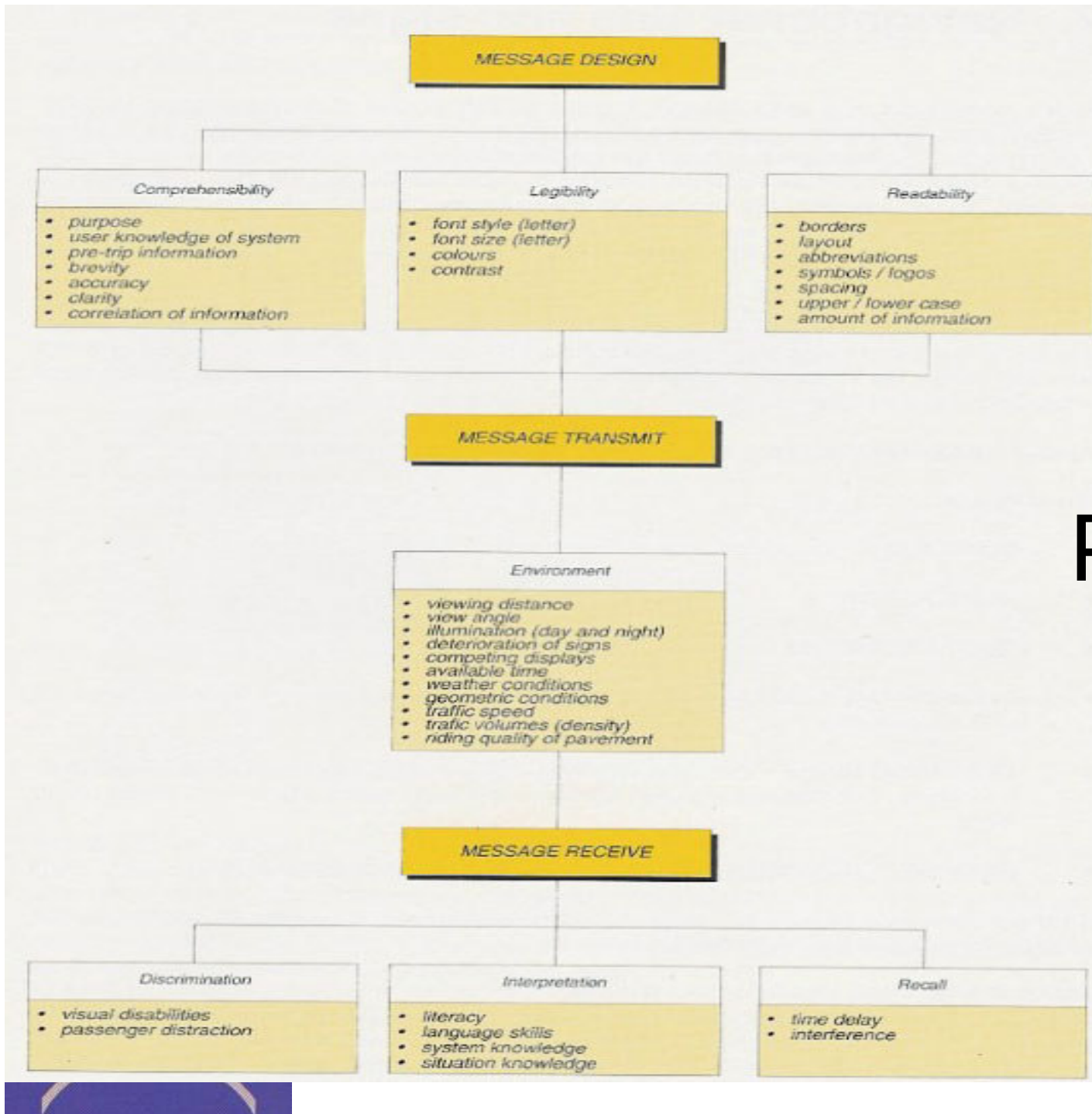




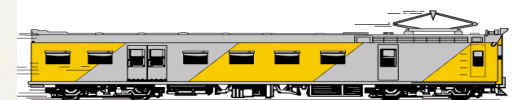
Protection design

- Effective signage installation
 - Comprehensive and relevant
 - Enable adequate response
 - Concise and simple but convincing
 - Conform to required standards
 - Continuity
 - Fulfill road users needs
 - Competitive with environment





Protection Design





Risk assessments

SANS 3000-1

Section 7

7.1 Operational risk assessment

7.1.1 The operator shall establish procedures to identify, evaluate and priorities risks by means of a risk assessment.





Risk assessments

Risk Rating

- S=Severity
- P=Probability
- E=Exposure
- RR=Risk Rating

$$S \times P \times E = RR$$



Risk assessments

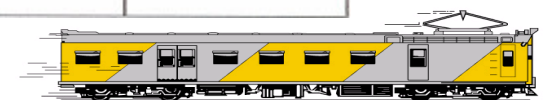
RISK ESTIMATION AND EVALUATION MATRIX

	EXPOSURE		PROBABILITY		P x E	RISK ESTIMATION AND EVALUATION MATRIX					
	Frequency	Duration	Description	Score		1	3	5	8	10	
High	Continuous	10	Likely to occur frequently	Frequent / Regular	10	80 - 100	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT	Unacceptable / TERMINATE	Unacceptable / TERMINATE	Unacceptable / TERMINATE
High	Frequent (Daily)	8	Will occur several times in the life cycle	Probable	8	40 - 79	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT	Unacceptable / TERMINATE	Unacceptable / TERMINATE
Medium	Occasional (Weekly)	5	Likely to occur sometime in the life cycle	Occasional / Can happen	5	20 - 39	Tolerable / TOLERATE	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT	Unacceptable / TERMINATE
Medium	Unusual (Monthly)	3	Unlikely but possible to occur in the life cycle	Remote/ Low Likelihood	3	10 - 19	Tolerable / TOLERATE	Tolerable / TOLERATE	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT OR TRANSFER	Tolerable with mitigation / TREAT OR TRANSFER
Low	Rare (Few Per Year)	1	So unlikely it can be assumed that an occurrence may not be experienced	Improbable/ Rare	1	1 - 9	Tolerable / TOLERATE	Tolerable / TOLERATE	Tolerable / TOLERATE	Tolerable with mitigation / TREAT OR TRANSFER	Tolerable with mitigation / TREAT OR TRANSFER
							1	3	5	8	10



Risk assessments

		1	3	5	8	10
		SEVERITY				
		Minor	Marginal	Serious	Critical	Catastrophic
Fatalities / Injuries	Fatal Disabling Minor		Single minor injury	Single disabl. injury Multiple minor injuries	Single fatality Multiple disabl. injuries	Multiple fatality
Process / Service Disruption	Major Yard/Line Minor Yard/Line Station/Traffic Control Depot/Functional	< 1 hour 1-4 hours <20min < 1 hour	1-4 hours 4-8 hours 20-120min 1-4 hours	4-8 hours 8-24 hours 2-4 hours 4-8 hours	8-24 hours 24-48 hours 4-6 hours 8-24 hours	24-48 hours <48 hours <6 hours 24-48 hours
Incidents	Operating Operating Operating Operating Functional		Points run through Operational Irregularity Department Occurrence	SPAD Open Line Derailment Yard derailment Operational Irregularity Department Occurrence	SPAD Collision Open Line Derailment Yard Derailment	SPAD Collision Open Line Derailment Yard Derailment
Financial Loss	Damage Fraud Fare / Income Liability	0- R10k	R10K - R100K	R100k-R1m	R1m-R10m	>R10m
Environmental			Very Localised Isolated	Localised Depot Level	Local Off Site Effects	Sub Regional System Effect
Legal Exposure			Warning	Prohibition Order Government Directive	Formal Prosecution	Interdict Criminal Offense
Management Controls		Extreme Control	Comprehensive Control	Mgmt Potential high	Mgmt Potential Low	No Mgmt Potential



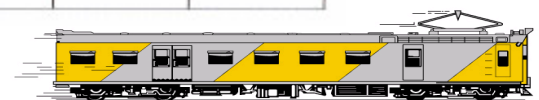
metrorail
GETTING SOUTH AFRICA TO WORK

Risk assessments

RISK ESTIMATION AND EVALUATION MATRIX

EXPOSURE	PROBABILITY				P x E	SEVERITY				
	10	5	3	1		1	2	3	4	5
Continuous	Likely to occur frequently	Frequent / Register	10	30 - 100	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT	Unacceptable / TERMINATE	Unacceptable / TERMINATE	Unacceptable / TERMINATE	
Frequent (Daily)	Will occur several times in the life cycle	Probable	5	40 - 79	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT	Unacceptable / TERMINATE	Unacceptable / TERMINATE	
Occasional (Weekly)	Likely to occur sometime in the life cycle	Occasional / Can happen	5	20 - 39	Tolerable / TOLERATE	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT	Unacceptable / TERMINATE	
Unusual (Monthly)	Unlikely but possible to occur in the life cycle	Remote/ Low Likelihood	3	10 - 19	Tolerable / TOLERATE	Tolerable / TOLERATE	Tolerable with mitigation / TREAT	Tolerable with mitigation / TREAT OR TRANSFER	Tolerable with mitigation / TREAT OR TRANSFER	
Rare (Few Per Year)	So unlikely it can be assumed that an occurrence may not be experienced	Improbable/ Rare	1	1 - 9	Tolerable / TOLERATE	Tolerable / TOLERATE	Tolerable / TOLERATE	Tolerable with mitigation / TREAT OR TRANSFER	Tolerable with mitigation / TREAT OR TRANSFER	

		SEVERITY				
		1	2	3	4	5
		Minor	Marginal	Serious	Critical	Catastrophic
Fatalities / Injuries	Fatal Critical Minor		Single minor injury	Single death, injury Multiple minor injuries	Multiple death, injuries	Multiple fatality
Process / Service Disruption	Major Shutdown Minor Shutdown Resource/Service Control Equipment/Control	1-1 hour 1-4 hours 30-100mins 1-1 hour	1-4 hours 4-8 hours 20-100mins 1-4 hours	8-24 hours 8-24 hours 8-24 hours 8-24 hours	24-48 hours 24-48 hours 48-72 hours 24-48 hours	24-48 hours 48-72 hours 72-100 hours 24-48 hours
Incidents	Operating Operating Operating Functional		Points not through Operational Irregularity	Signal Open Line Derailment Yard Derailment Operational Irregularity Derailment Occurrence	Signal Collision Open Line Derailment Yard Derailment	Signal Collision Open Line Derailment Yard Derailment
Financial Loss	Damage Fines / Income Liability	0- R10k	R10k - R100k	R100k-R1m	R1m-R10m	>R10m
Environmental			Very Localised Incident	Localised Major Incident	Local OR into Effects	Not Regional System Effect
Legal Exposure			Warning	Non-Compliance Order Government Directive	Formal Prosecution	Interdict Criminal Offence
Management Controls		Ad-hoc Control	Comprehensive Control	Major Potential High	Major Potential Low	Not Major Potential





Risk assessments

Assumptions

- Severity is constant at its highest

Most level crossing accident result in Fatalities

- Exposure is constant

Most level crossing are exposed daily

Thus $S=10$ $E=8$

$$S \times P \times E = RR = 80P$$





Risk assessments

SARTSM Chapter 7

Clause 7.2.4 section 2(a)

The use of FRD signal should,... be used to control vehicles... when warranted by one or more of the following conditions.

When a crossing has an accident history involving at least three vehicle/train accidents in one year, or five vehicle/train accidents in three years



Risk assessments

Probability		1 year cycle	3 year cycle
Frequent	10	3	5
Probable	8	3	4
Occasionally	5	2	3
Remote	3	1	2
Improbable	1	0	1





Risk assessments

Short Comings

- Relies on hindsight
- Assumes available accident records
- Reactive rather than proactive
- Guide line are not clear





Risk assessments

Risk assessment & accident prediction models

- Peabo Dimmick formula APM
- NCHRP 50 APM
- US DoT APM
- Florida DoT APM
- New Hampshire Index APM





Risk assessments

New Hampshire Index APM

$$HI = V \times T \times Pf$$

$$HI = V \times T \times (Pf + TT + TTR + SD + AN + AL + L + G + VSD + W + LT) / 100$$

$$HI = (.01)(V)(T) + (.1)(HS)(TS) + (SD)(AN)(TR)(NTR)(AL) + (A2+1)(RF)(LP)(PF) + \dots + (SB)(SBP) + (10)(HM)$$





Risk assessments

PLCC Priority Rating

- V=Number of vehicles
- T=Rail traffic
- n=Sight distance 1to5

$$P = V \times T \times n$$





Risk assessments

Priority Rating

$$P = V \times T \times n$$

Priority Rating	Protection Device
$P \geq 2000$	Signs only
$2000 > P \leq 10000$	Flash lights and signs
$10000 > P \leq 30000$	Automatic barrier flash lights and signs
$P > 30000$	Grade separation structure





Risk assessments

SARTSM Chapter 7

Clause 7.2.3 Section 5

Whether or not railway crossing is controlled by a yield sign R2 or a Stop sign R1 the sight distance available at the sign must comply with the requirements of table 7.4



Risk assessments

TABLE 7.4 VISIBILITY DISTANCE ALONG RAIL LINE FOR STOP CONTROL TABLE 7.4

Train Speed (km/h)	X(m)	S(m)	
		7,5m	15m
120	5	460	500
100	5	385	420
80	5	310	335
60	5	230	250

NOTE:

- (1) Distance X(m) is the distance from the near side of the crossing from which drivers must be able to see distance S(m) along the rail line (see Figures 7.5 to 7.8 and 7.15 and 7.16).
- (2) S(m) is the sight distance for drivers of single unit trucks and trailers for 7,5 m and 15 m wide crossings.
- (3) These conditions also apply for drivers who have stopped at a YIELD sign R2.



Risk assessments

η Factor

Speed	η =Site distance factor				
120	1	2	3	4	5
100		1	2	3	4
80			1	2	3
60				1	2
≤60					1
Site dist.	420	385	310	230	≤230





Risk assessments

Probability Rating

- V=Number of vehicles
- T=Rail traffic
- η =Sight distance 1to5

$$P = V \times T \times \eta$$



Risk assessments

P Factor

Priority Rating	Probability	
$P \geq 2000$	Improbable	1
$2000 > P \leq 10000$	Remote	3
$10000 > P \leq 30000$	Occasionally	5
$30000 > P \leq 45000$	Probable	8
$P > 45000$	Frequently	10





Risk assessments

Risk Rating

- S=Severity
- P=Probability
- E=Exposure
- RR=Risk Rating

$$S \times P \times E = RR$$

$$S \times (V \times T \times \eta) \times E = RR$$





Conclusion

- Lack of data
- Insufficient accident statistics
- Lack of accurate traffic studies
- Inconsistencies in legislation
- Collection and collation of data
- Simulations and Modeling
- Review of standards





Recommendations

- Funding
- Crossing redesigns
- Communication and awareness plan
- Crossing elimination plan

