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RAILWAY SAFETY REGULATOR
RAIL SAFETY ON THE RIGHT TRACK

IRSC 2025
Advancing Railway Safety through Innovations and Collaborations
Hong Kong, China 25th - 30th November 2025

Exploring Human Depth & Distance Perception at Level Crossings

Deepak Budhram Pr. Eng
Head – Safety Management
Railway Safety Regulator – South Africa

Human Depth & Distance Perception at Level Crossings

Depth perception plays a crucial role in ensuring safety at railway level crossings, as it affects a road user's ability to accurately judge the distance, speed, and movement of approaching trains.

- Context
- Problem Statement
- Research Approach and Research Design
- Potential Impact
- Conclusion

Context: Level Crossings in SA

Province / Type of Network	Eastern Cape	Free State	Gauteng	KwaZulu-Natal	Limpopo	Mpumalanga	North West	Northern Cape	Western Cape	Grand Total	% Split by Level crossing location
Running mainline	712	725	68	652	329	350	563	777	310	4486	**59%**
Branchline	303	23	15	38	58	170	137		870	1614	21%
Siding	41	129	138	285	55	168	162	82	50	1110	15%
Yard	14	8	14	98	4	65	27	9	24	263	3%
Main Line				70						70	1%
Branch Line				59						59	1%
Locomotive yard		1	17	10		3	6	13		50	1%
Loco Shed						1				1	0%
Grand Total	1070	886	252	1212	446	757	895	881	1254	**7653**	

Context: Level Crossings in SA

Physical Foot print
Rail Network of +/- 32 000 track km
Approximately 1 level crossing every 4.1km
Railways occupy approximately 456 km2 of land in SA ~ 0.04% of the total land area
Typical level crossing footprint ~ 900m2 , assuming effective carriage way and railway length including protection and signage
Level crossings occupy approximately 6.9 km2 of land in SA ~ 0.001% of the land in SA

Societal Characteristics
9 provinces
11 Official languages
+/- 9 Ethnocultural groups (Heritage & Tradition)

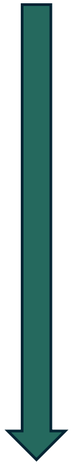
Hofstedes (2010) Cultural Dimensions
• Individualism (IDV) – 65
  • Balance group loyalty, norms & traditional relationships
• Uncertainty Avoidance (UA) – 49
  • Tolerates ambiguity and flexibility

Context: Level Crossings in SA

Operational characteristics
+/- 200 operators
Variation in train speeds across different level crossings (15km/hr – 80km/hr)
Freight and passenger train mix
Variations in road carriage way characteristics
Variation in road user mobility (HMV – Pedestrian)
Variation in utilisation of level crossings – Land use
Variation of rail traffic density
Variation in level of control (passive vs active traffic control)

Level of Protection (SANS 3000 2-2-1)	Eastern Cape	Free State	Gauteng	KwaZulu-Natal	Limpopo	Mpumalanga	North West	Northern Cape	Distribution
Level of Protection 1	3%	6%	3%	69%	4%	11%	0%	4%	**5%**
Level of Protection 2	29%	31%	1%	12%	0%	2%	20%	5%	**28%**
Level of Protection 3	16%	7%	4%	15%	14%	19%	15%	11%	**46%**
Level of Protection 4	9%	11%	9%	23%	2%	9%	7%	31%	**19%**
Level of Protection 5	0%	7%	0%	0%	0%	0%	86%	7%	**0%**
Level of Protection 6	0%	0%	0%	0%	0%	0%	0%	100%	**0%**
R1/W404 Combination	0%	0%	100%	0%	0%	0%	0%	0%	**0%**
Undefined	8%	0%	0%	14%	0%	17%	39%	22%	**1%**

Passive



Active

Problem Statement

Level crossings continue to be a strategic focus for the Railway Safety Regulator (RSR) due to their direct impact on human lives and the severity of their potential consequences of safety incidents. The complexity of managing these crossings is further compounded by evolving travel patterns, increased variability in vehicular and pedestrian traffic, and diverse operating conditions across South Africa's rail network.

Ensuring the safety of level crossings requires a coordinated, data-driven approach that aligns regulatory strategies with societal mobility trends and infrastructure realities, emphasizing preventive action to protect human life and optimize rail network safety performance.

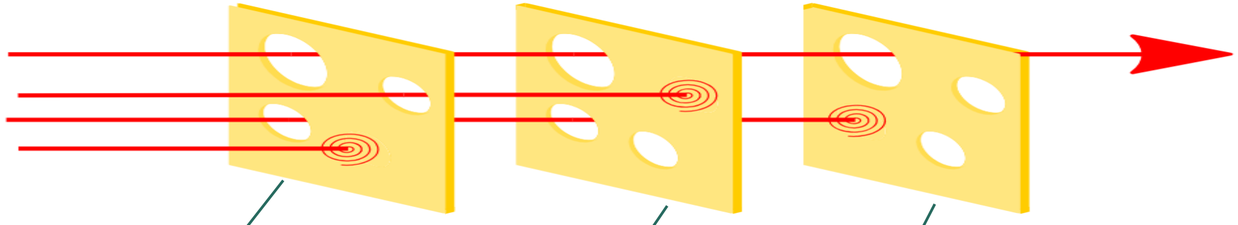
Literature Foundation

- “Level Crossing control design not typically based on human factors considerations” Green (2002)
- “…the most variable factor and most critical point… of Level Crossings is road user behaviour” Grippenkoven & Dressler (2018)
- “Level Crossings can be regarded as a Socio-technical system” Read *et. al*. (2013); Salmon *et. al*. (2016).
- Almost all literature and statistical analyses attribute the responsibility for accidents at level crossings to road traffic participants.

Information Processing

Perceiving the Level Crossing → Retrieve relevant knowledge from long term memory → Choosing and executing appropriate actions

Grippenkoven & Dressler (2018)



Error in perception

Error in retrieving knowledge from long term memory

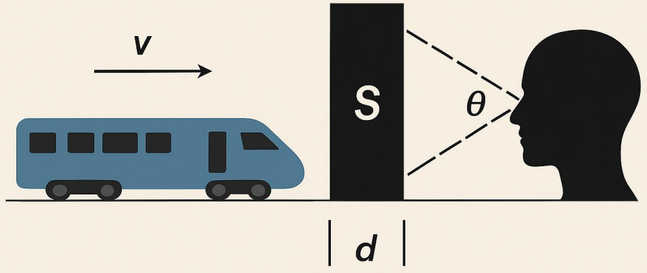
Error in executing appropriate actions

Errors in perception and mis-judgement

*This research focuses on perception at Level Crossings

Monocular vs Binocular Cues – Depth and Distance

Monocular Cues	Binocoluar Cues
Linear Perspective	Convergence
Relative size	Retinal disparity
Texture gradient	
Interposition	
Motion parallax	



RATE OF ENLARGEMENT

Rate of angular enlargement

$$\frac{d\theta}{dt} = \frac{Sv}{d^2}$$

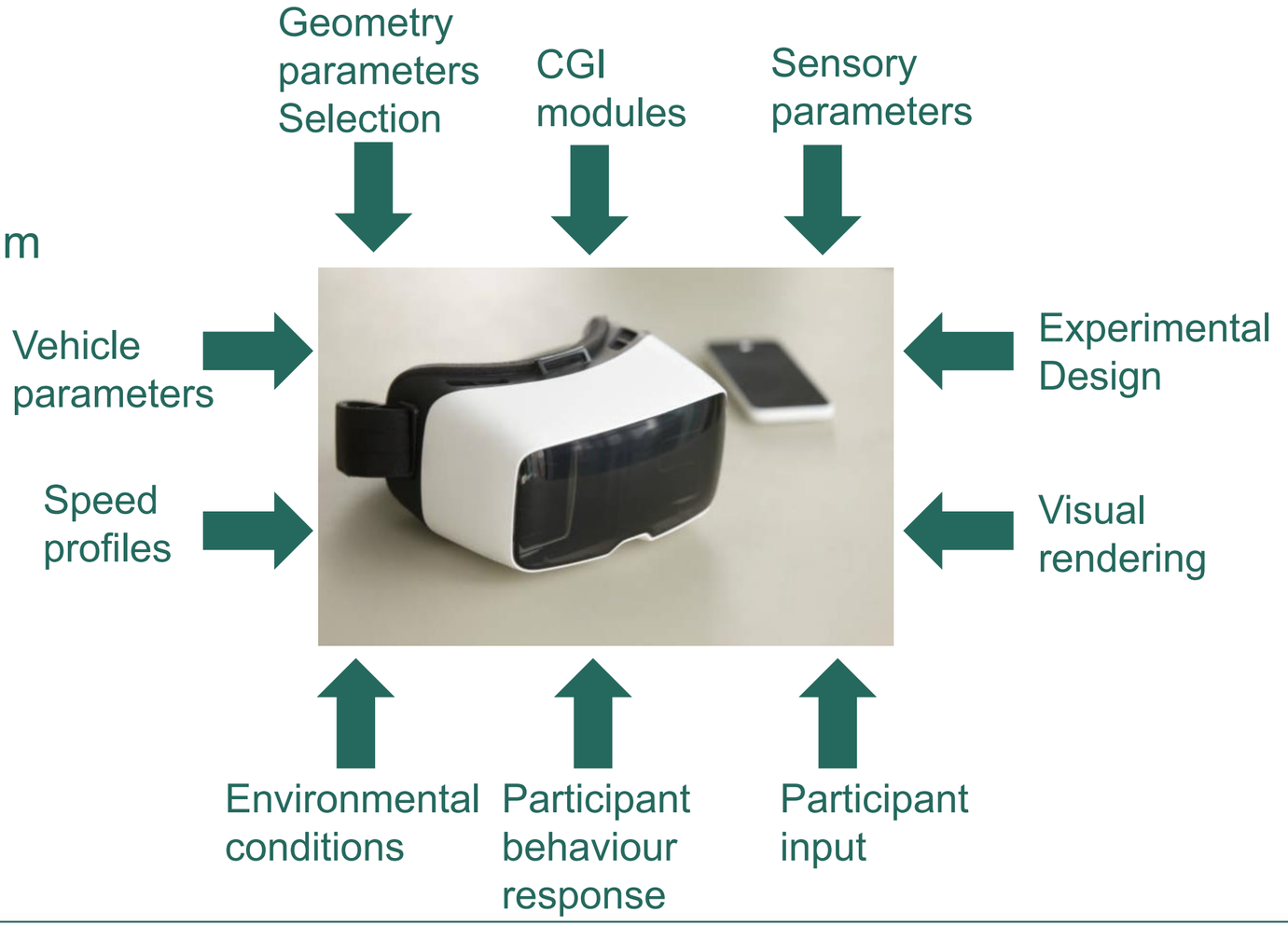
Research Approach

Approach to the contextual understanding of road users at level crossings:

- Accounts for geographical and cultural differences
- Focuses on fundamental physiological elements at level crossings
- Adopts a human centric approach to road users at level crossings
- Focus on Depth & Distance Perception at level crossings
- Factors affecting Depth & Distance perception at level crossings

Research Design

- Schools education and outreach program
- Road driver awareness campaigns
- Education and awareness
- Foundational level
- Human physiological + Technology
- Parameter testing



Potential Impact & Conclusion

- Quantified perceptual risk
  - Quantify parametric influence on ability to accurately judge speed and distance
  - Identify visual cue under which people misjudge danger
- Inform evidence based contextual design
  - Potential updates to level crossing design standards considering the Socio-technical system.
  - Geometry and line of sight optimisation in design parameters
  - Spatial alignment of level crossings relative to sun’s position
- Policy and regulatory optimisation
  - Empirical justification for design and regulatory updates
  - Regulatory decision support

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