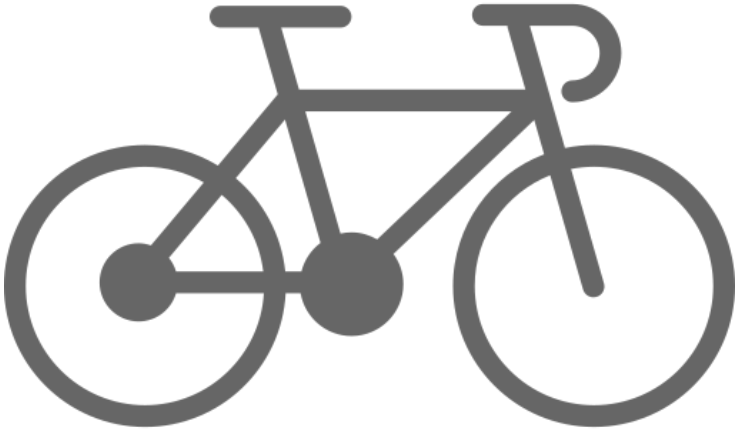

Bike Safety

Bram, Everhard & Seth

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Problem definition

Research question

‘How to systematically improve the safety of cyclists in Enschede by changing the infrastructural design of biking routes’.

▲ Een auto kwam in botsing met een scooter © Tubantia

Meteen twee ongelukken na opening ‘nieuwe’ Raiffeisenstraat in Enschede

System definition

Time periods:

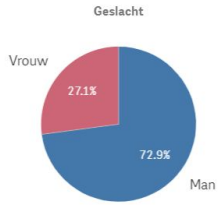
Past
Current
Future

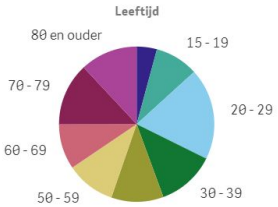
System boundary:

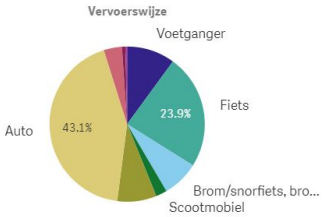
Super-system
System of Interest
Sub-system

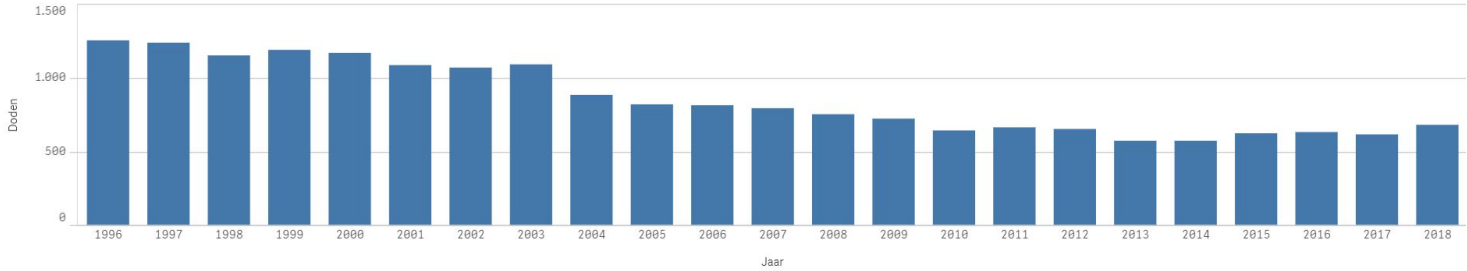
Define safety objectives

- History of accidents
- Legislation









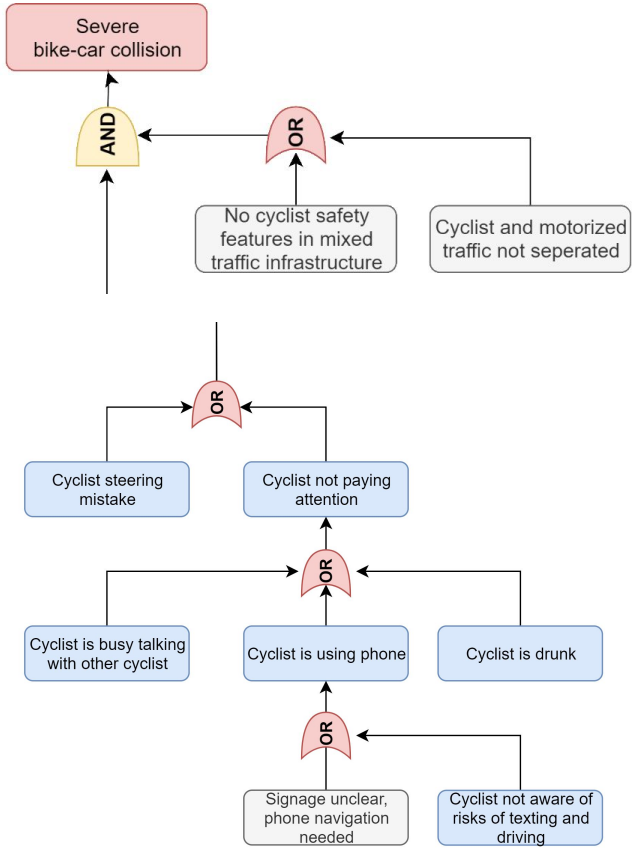
Identify hazards

Feature Tree analysis

- Single and bike-car collisions
- Caused by car-drivers, cyclists and **environment**

Failure Mode Effect Analysis

- Slippery road
- Mixed traffic



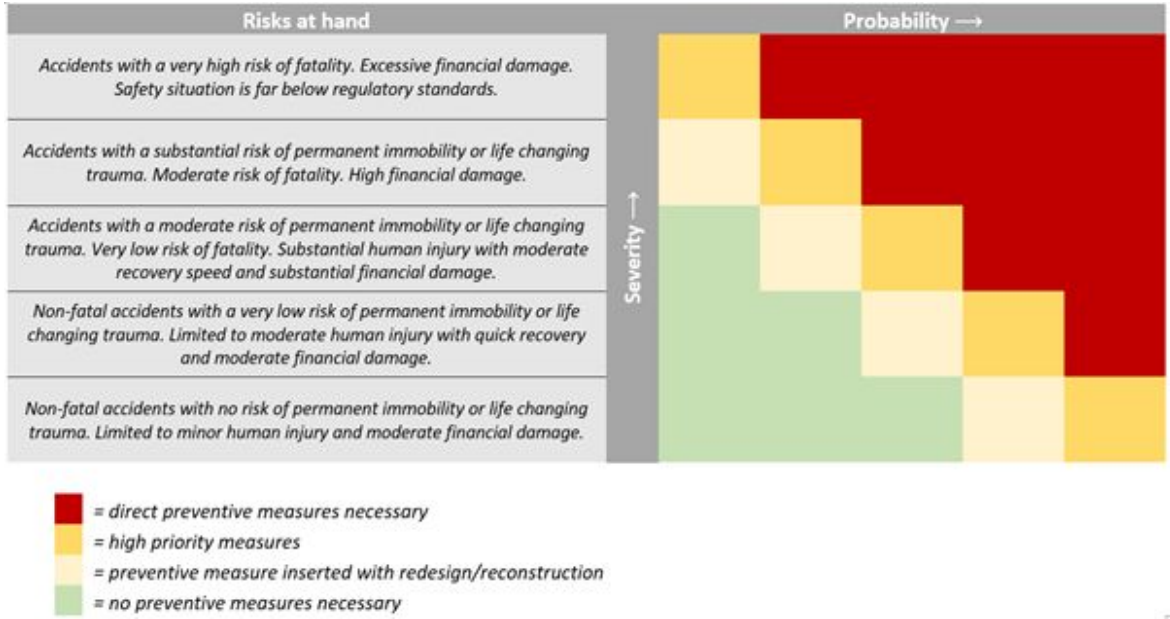
Control hazards

- Solutions based on safety, efficiency & cost

- **Separate traffic flows**
- **Add signage/line indication**
- **Reduce speeding at intersections**

Monitor hazards

- Safety action table
- Influence safety culture



Prove sufficient safety

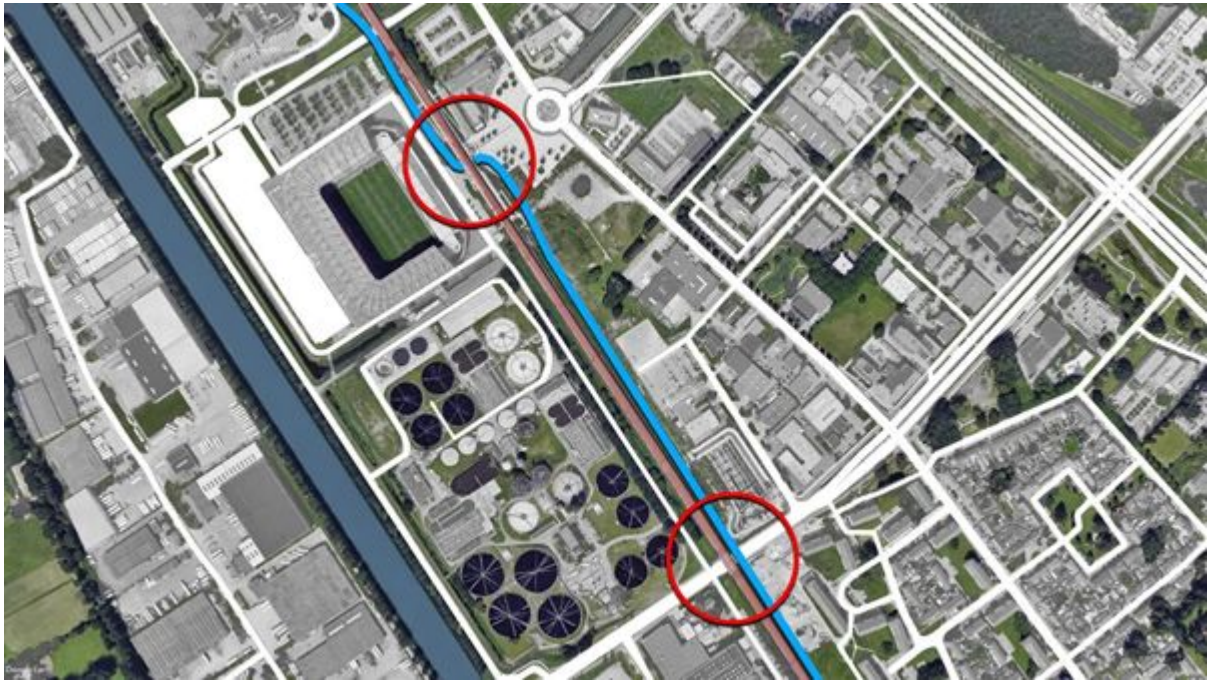
- Design philosophy
  - Based on the findings of the FTA, FMEA and other analyses performed during this assignment.

Design Philosophy

1. **Separate** vulnerable cycling traffic from other forms of traffic completely by using;
    a. Separate cycling roads
    b. Bridges over dangerous intersections
    c. Restricting car flow in densely cycled areas
2. **Influence** behaviour of traffic users by implementing safety features
    a. Only give open and wide roads when traffic volume is low and cyclist rare
    b. Use high curbs and narrow twisty roads to slow car traffic down at bike crossings
    c. Implement safety features that support conscious decision making, such as traffic islands, heightened cycling ways and distinct line indication.
3. **Monitor** infrastructure such that it is in optimal condition
    a. Make sure that potholes, loose surface or slippery roads are kept to a Minimum
    b. Invest time to evaluate whether traffic flows have changed and whether the infrastructure design still meets current demands
    c. Develop a safety culture where cyclists are aware of risks and car drivers respect the vulnerability of cyclists.

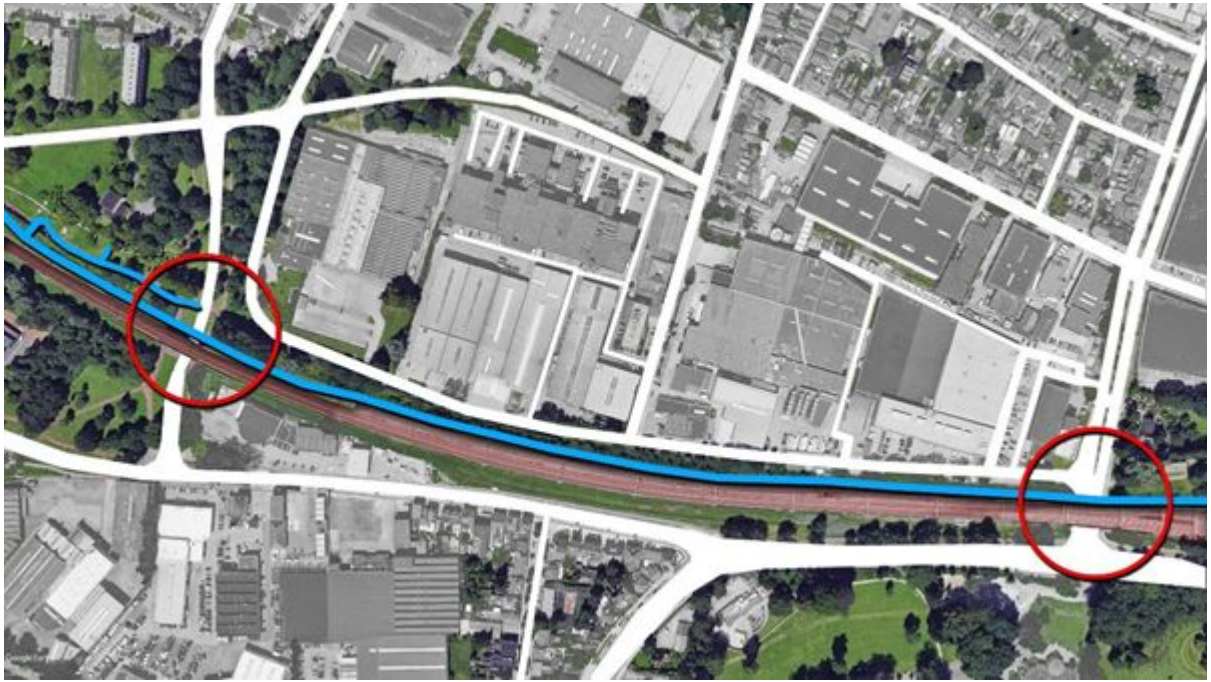
Case study I

Grolsch Veste –
Twekkelerzoom



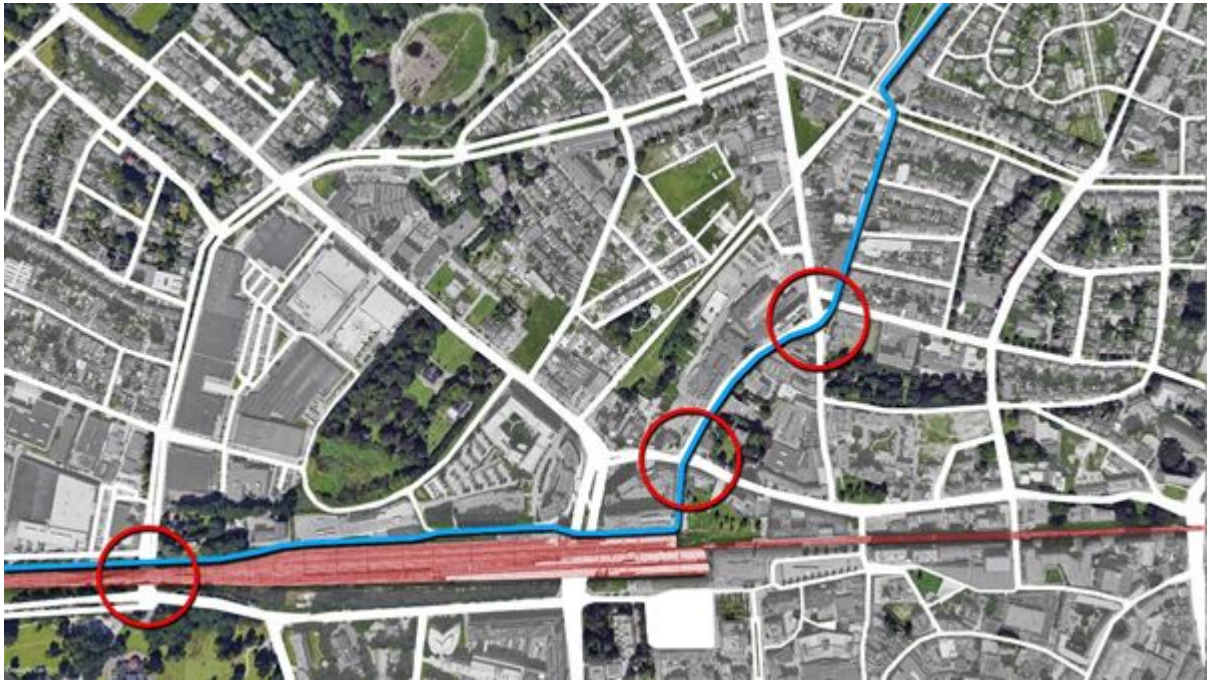
Case Study II

Lambertus Buddestraat - Central Station



Case Study III

Central Station –
Oldenzaal



Conclusion

Research question

‘How to systematically improve the safety of cyclists in Enschede by changing the infrastructural design of biking routes’.

We suggest using the design philosophy as **rules of thumb** during the design or redesign phase.


Thank you for your attention!

Physical hazard assessment

	Past	Present	Future
Super system	Small vehicles have to share the same road with vehicles like cars and trucks which do not match the same speed. Bad pavement creating broken roads. Bad line indication meaning that road users do not know where to/where to stop putting them in places where they should not be. Bad weather creating icy roads which causes road users to slip and don't have control over their vehicle.	Busy intersections so road users can not cross the road which can lead to the users making their own - dangerous- decisions Bad vision of what is coming from different sides which leads to road users making decisions which can be dangerous No room to stand still putting the road users on places where they should not stand. Needing to brake on a slope, if a cyclists has speed it might be difficult to brake on a slope	Busy roads that need to be shared with similar vehicles that go faster, this means that if a cyclists make swing it can crash into another cyclist. No room to overtake other cyclists so fast cyclist come very close to slower vehicles No room to step aside, if something's wrong with the bike you need a place to check/repair this, however standing still on a road with fast cyclists can be dangerous because their brake-path is slower.

Physical hazard assessment

	Past	Present	Future
System	Vehicle breaking unexpectedly in front of the cyclists which mean they need to brake quickly as well. Bicycles being relatively small which mean that they are not so good to be seen by larger vehicles such as trucks Vehicle unexpectedly turning left or right without using an indicator, which means cyclists cannot anticipate	Vehicle blocking the bike lane, it is easy to park a car there Being in the dead spot of a truck, since cyclists are relatively small he/she can be in the dead spot.	Slower vehicles are unexpectedly swinging on the road which means that they can bump into an overtaking cyclist Vehicles blocking the way out of the biking highway if they are standing still on an exit.

Physical hazard assessment

	Past	Present	Future
Sub-system	No proper lighting meaning that they are badly visible for other road users	No proper lighting meaning that they are badly visible for other road users. No proper brakes so they will not brake in time for an intersection Dead battery on e-bike so that they will suddenly stand still	Dead battery on e-bike so that they will suddenly stand still Failing cruise-control meaning that they will cycle faster than allowed on certain segments No prober lighting meaning that they are badly visible for other road users No prober brakes so they will not brake in time for an intersection

Functional hazard assessment

	Past	**Present**	**Future**
Super system	Bad weather creating failing parts such as frozen braking cables Failing stoplights meaning that it's unclear who goes first on an intersection	Bad weather creating failing parts such as frozen braking cables or batteries on an electric bike Failing stoplights meaning that it's unclear who goes first on an intersection	Bad weather creating failing parts such as frozen braking cables or batteries on an electric bike

Functional hazard assessment

	Past	**Present**	**Future**
System	Having too much weight on a bicycle meaning that it more difficult to brake in time	Vehicles don’t show where they’re going creating unclear situation if cyclist can overtake the vehicle or not	Vehicles don’t show where they’re going creating unclear situation if cyclist can overtake the vehicle

Functional hazard assessment

	Past	Present	Future
Sub system	No proper lighting meaning that they are badly visible for other road users No proper brakes so they will not brake in time for an intersection Worn out tires	No proper brakes so they will not brake in time for an intersection No proper lighting meaning that they are badly visible for other road users Brakes are not powerful enough Worn out tires Gears are stuck which means that the cyclist cannot accelerate quick enough from a full stop and thus will need longer to cross an intersection	Automatic braking failing Worn out tires

Operational hazard assessment

	Past	Present	Future
Super system	Bad weather blocks view for road users creating a dangerous situation where other road users are not seen Surrounding make it difficult for the driver to pay attention, this can be distracting street signs or other information No proper signs which can lead to road users making wrong decisions	Bad weather blocks view for road users creating a dangerous situation where other road users are not seen Surroundings make it difficult for the driver to pay attention, this can be distracting street signs or other information Unclear who is in the priority lane and has priority in the intersection Unclear if you're allowed to overtake, some streets are not made for that but can look like they are	Bad weather blocks view for road users creating a dangerous situation where other road users are not seen The road does not give a heads up for an intersection and thus cyclists are not expecting it, meaning that all of a sudden they have to decide quickly what to do Vehicles are not ringing meaning that they don't notify other users that they are overtaking them. Vehicles are not ringing meaning that they don't notify other users that they are overtaking them.

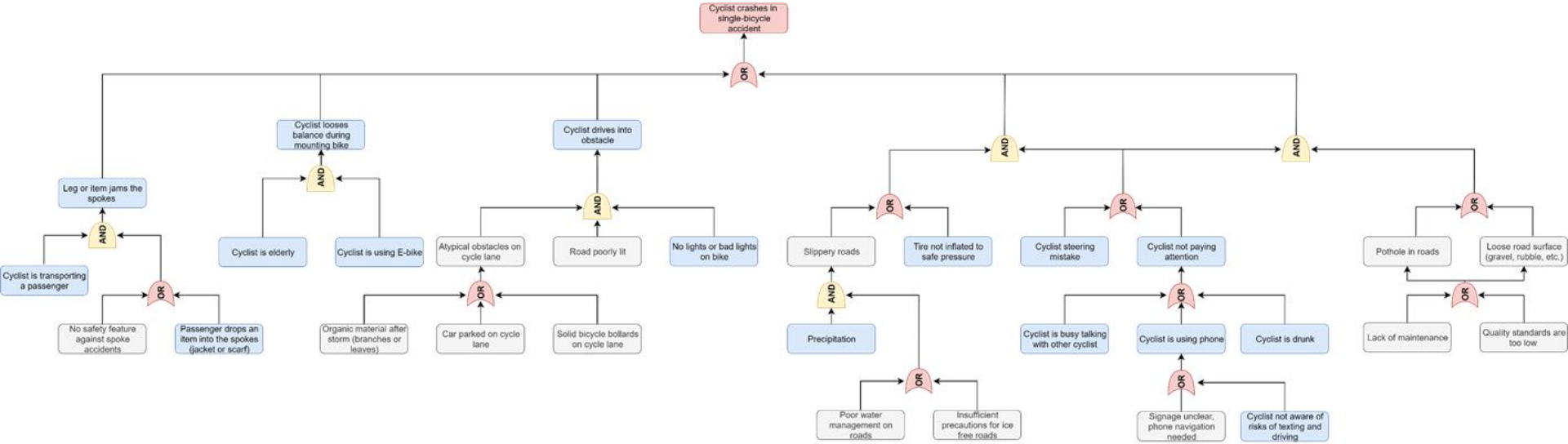
Operational hazard assessment

	Past	Present	Future
System	Cyclist is looking on his/her phone and getting distracted from the traffic Cyclist gets distracted by other road users and is not paying attention to anything else Cyclist going into a non-entry street creating a situation where they should not be	Cyclist gets distracted by other road users and is not paying attention to anything else Cyclist going into a non-entry street creating a situation where they should not be	Cyclist gets distracted by other road users and is not paying attention to anything else Cyclists gets distracted by bike computer and is not paying attention to anything else

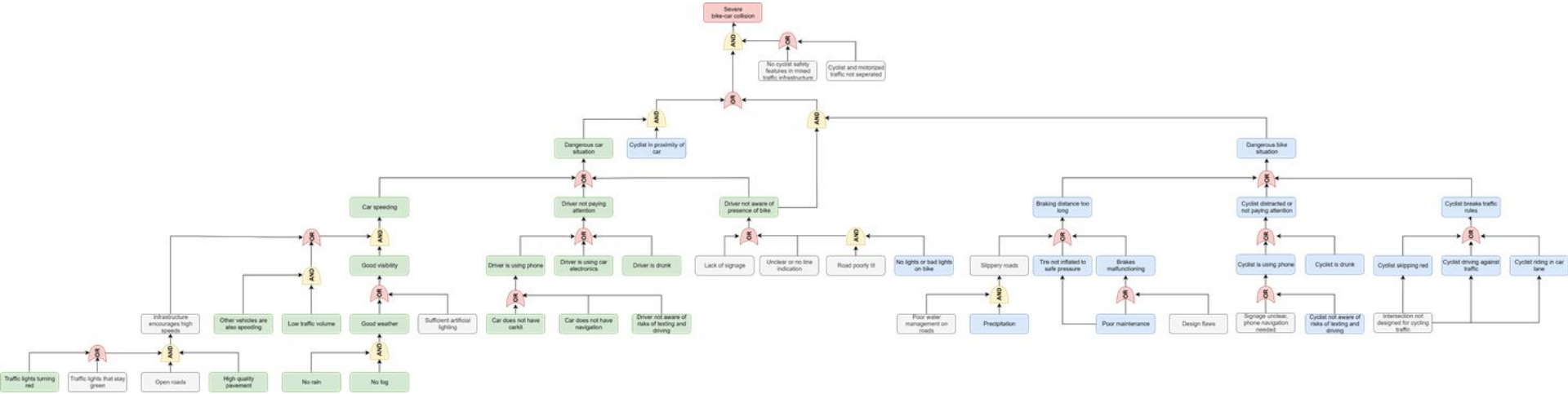
Operational hazard assessment

	Past	**Present**	**Future**
Sub system	Cyclists don’t break in time creating a possible collision between different road users Cyclists forgets to turn on lighting meaning that they are not visible for other road users	Cyclist forget to turn on lighting meaning that they are not visible for other road users	Cyclists don’t set the settings of the e-bike to the proper setting meaning that they go to hard on roads

FTA single bicycle accident



FTA bike-car collision



FMEA slippery roads

Hazard	Potential effects of hazard	Severity	Possible cause of hazard	Probability	Current control	Detectability	RPN
Slippery roads	*Falling and getting bruises and scratches*	5	*Slippery road because of poor maintenance*	4	*Rostered maintenance and inspection*	3	60
	Falling and getting severe damage to face	7	*Hit curb/sidewalk due to poor design*	6	*Rostered maintenance, inspection and citizen reports*	3	126
	Having to slow down or stop	1	*Slippery road because of poor maintenance*	8	*Rostered maintenance and inspection*	5	40
	Riding into tree and crashing	4	*Unsafe behaviour*	5	*Biking certificate during primary school*	6	120
	Collision with a car and getting broken bones or worse	8	*Slippery road because of poor maintenance and a speeding car*	6	*Rostered maintenance, inspection and police control*	1	48

FMEA lack of cyclist safety features

Hazard	Potential effects of hazard	Severity	Possible cause of hazard	Probability	Current control	Detectability	RPN
Lack of cyclist safety features in mixed traffic infrastructure	*Bike-car collision at intersection*	6	*Driver speeding and cyclist distracted due to a lack of line indication*	3	*Solid infrastructure design, police control and regulations.*	3	54
	Death of cyclist	10	*Driver not paying attention and speeding, cyclist without lights, poorly lit roads.*	3	*Solid infrastructure design, safety awareness under cyclists, police control and regulations.*	7	210
	Car has to brake hard because cyclist comes out of unexpected direction and causes chain collision	8	*Lack of signs, cyclist without lights, cyclist unaware of risks, road poorly lit*	2	*Solid infrastructure design, safety awareness under cyclists, police control and regulations.*	8	128