TUNNEL SAFETY AND VENTILATION – GRAZ 2020

TRUCK PLATOONING

A Quantitative Assessment of the Potential Consequences on Tunnel Safety

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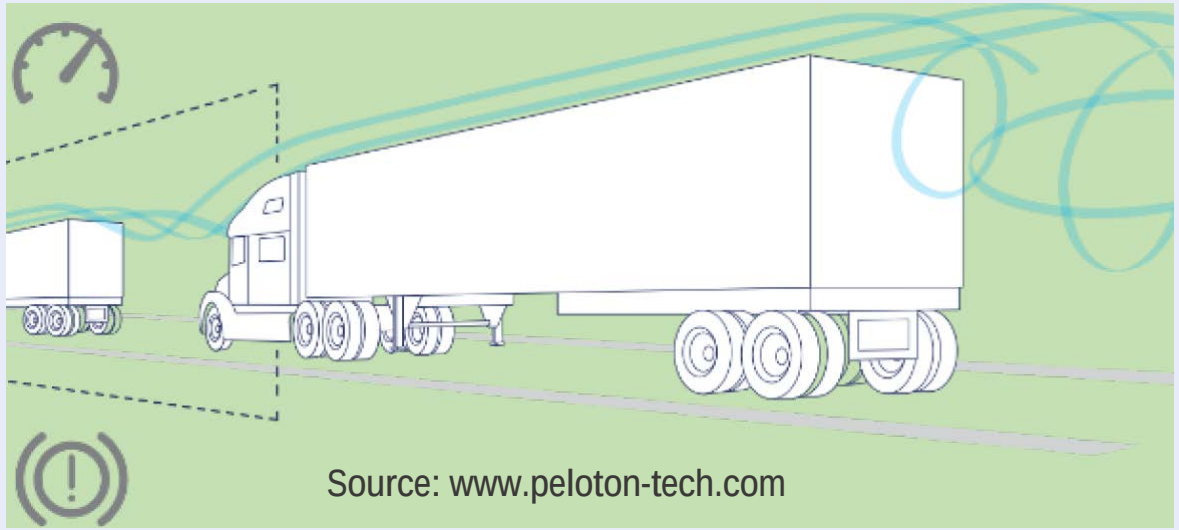
TECHNICAL BACKGROUND

TRUCK-PLATOONING TECHNOLOGY

„…in a truck platoon a variable number of large vehicles is driving in a convoy at short spatial distances, linked via wireless transmission tecnology.“

„Only the leading vehicle (LV) is actively controlled by a driver. The following vehicles (FV) are driven by automotive systems, only supervised by otherwise non-active drivers…”

Source: www.roadsandbridges.com



Source: www.peloton-tech.com

TECHNICAL BACKGROUND

MANDATORY SAFETY SYSTEMS

Adaptive Cruise Control (ACC)
Automatic adjustment of driving speed to maintain a safe distance from the vehicle ahead

Lane Centering Assistant (LCA)
Automatic centering on the driving lane which is chosen by the driver of the leading vehicle

Vehicle-to-Vehicle Communication (V2V)
Automatic vehicle-to-vehicle communication to instantaneously transmit driving actions of the leading vehicles

MOTIVATION / ADVANTAGES

- **Reduced air resistance** leads to less fuel consumption and emission of greenhouse gas
- **Compact large-vehicle convoys** increase the traffic capacity of existing road networks

ISSUES

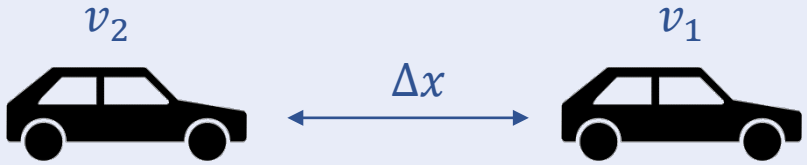
- **Effects on infrastructure** (i.e. bridges, access- and exit ramps and **tunnels**)
  - » Impact on collision likelihood
  - » Impact on incident severity

ANALYSIS OF LV DRIVING BEHAVIOUR

Measuring of driving behaviour:

- 7km tunnel with two driving lanes, an AADTV of 12'300 veh./day and a large-vehicle share of 12%
- 16% of large vehicles are driving in a platoon-like configuration (LV following another LV)
- 280'000 single vehicle datasets had been recorded in one driving direction and 5400 single LV datasets had been used in the analysis

Net time gap: $\Delta t = \Delta x / v_2$



Measuring device based on induction loops

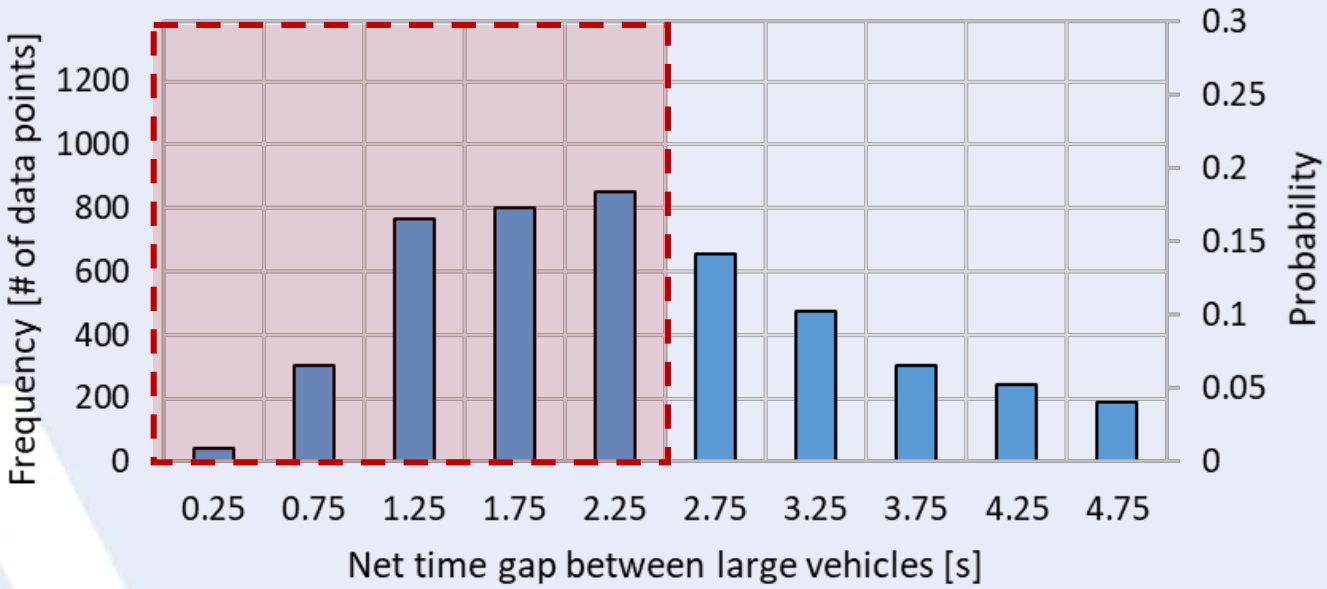
Tunnel in Austria

ANALYSIS OF LV DRIVING BEHAVIOUR

Driving behaviour results

- The average net time gap was found to be 2.4 s
- This corresponds to the minimum spacing according to Austrian law (50 m for 80 km/h)
- 60% of net time gaps where found to be lower and can be assumed to drive at too short distances

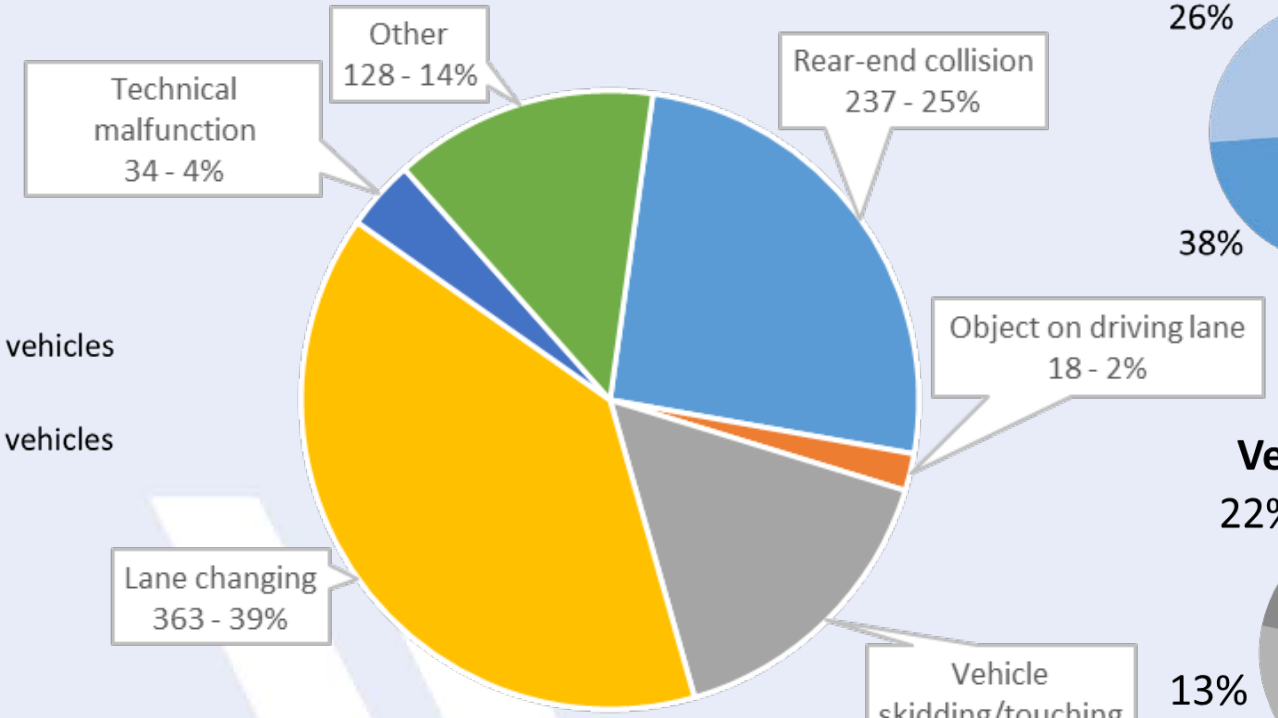
„…no dependency of the net time gap on the traffic state was found."

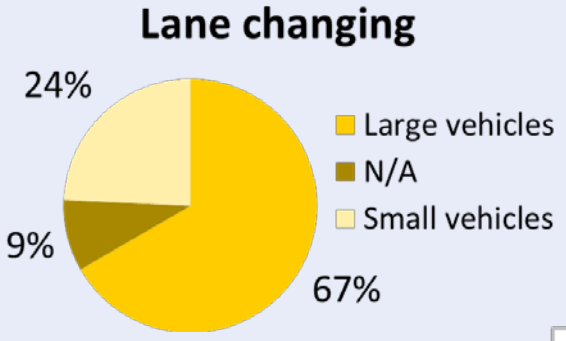


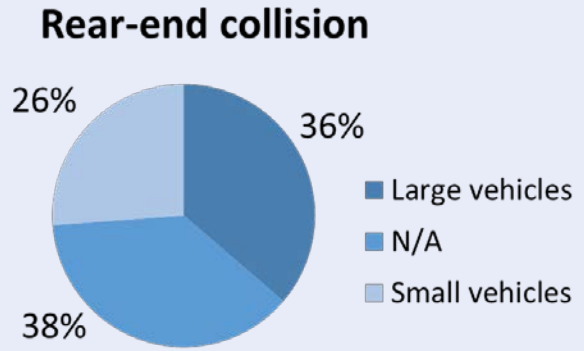
"The driver assistance systems (CACC), mandatory for the implementation of truck platooning, will therefore lead to a decreasing probability of rear-end collisions due to too short driving distances of large vehicles."

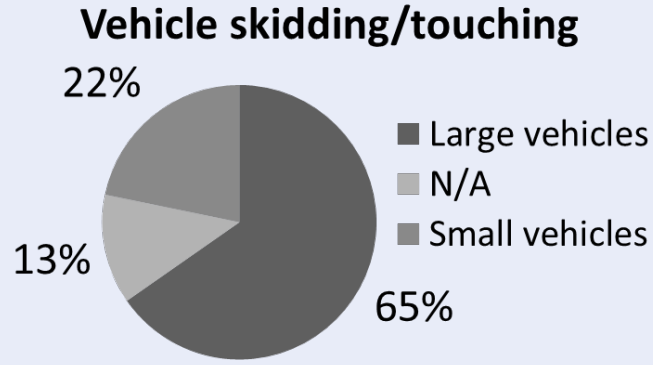
ANALYSIS OF TUNNEL INCIDENTS

"...historical tunnel incidents between the years 2007 and 2014, recorded in tunnels on the Austrian motorway network, have been studied"









From the 927 documented collisions involving large vehicles, 42% could have been avoided by the implementation of driving assistance systems mandatory for truck platoons!

IMPACT ON CONSEQUENCES

EFFECT ON THE SEVERITY OF AN INCIDENT

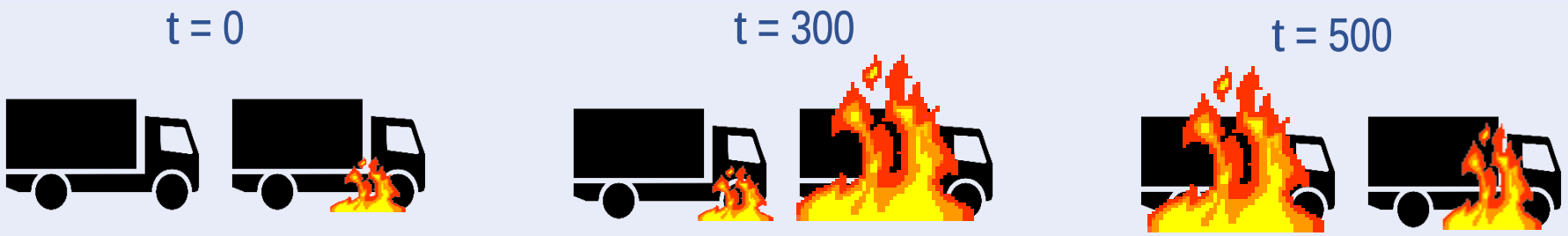
Impact on mechanical consequences

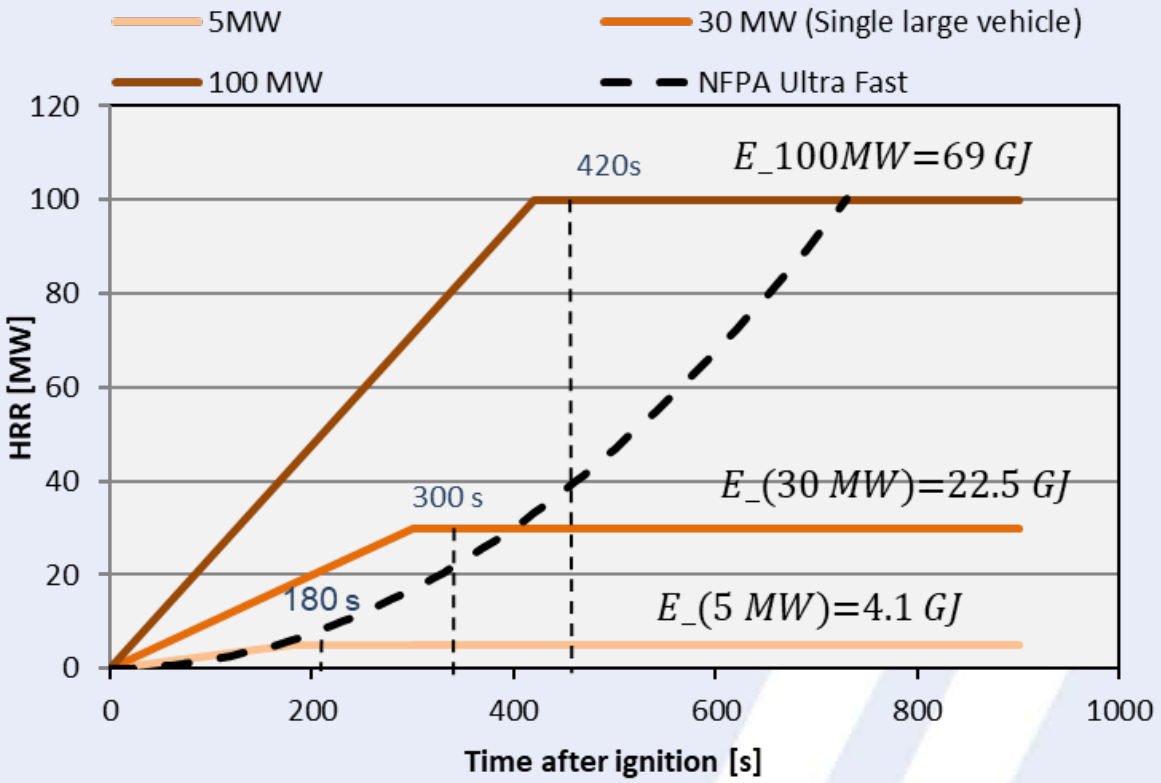
- The increase in collision mass is related to an increase of mechanical consequences
- As a result of mandatory driving assistance systems, the involvement of an additional platoon vehicle is very unlikely in case a member vehicle of a truck platoon is involved in a collision.
- Mechanical consequences for a 3-vehicle platoon: $1.0 \leq \Delta_{MC} \leq 3.0$

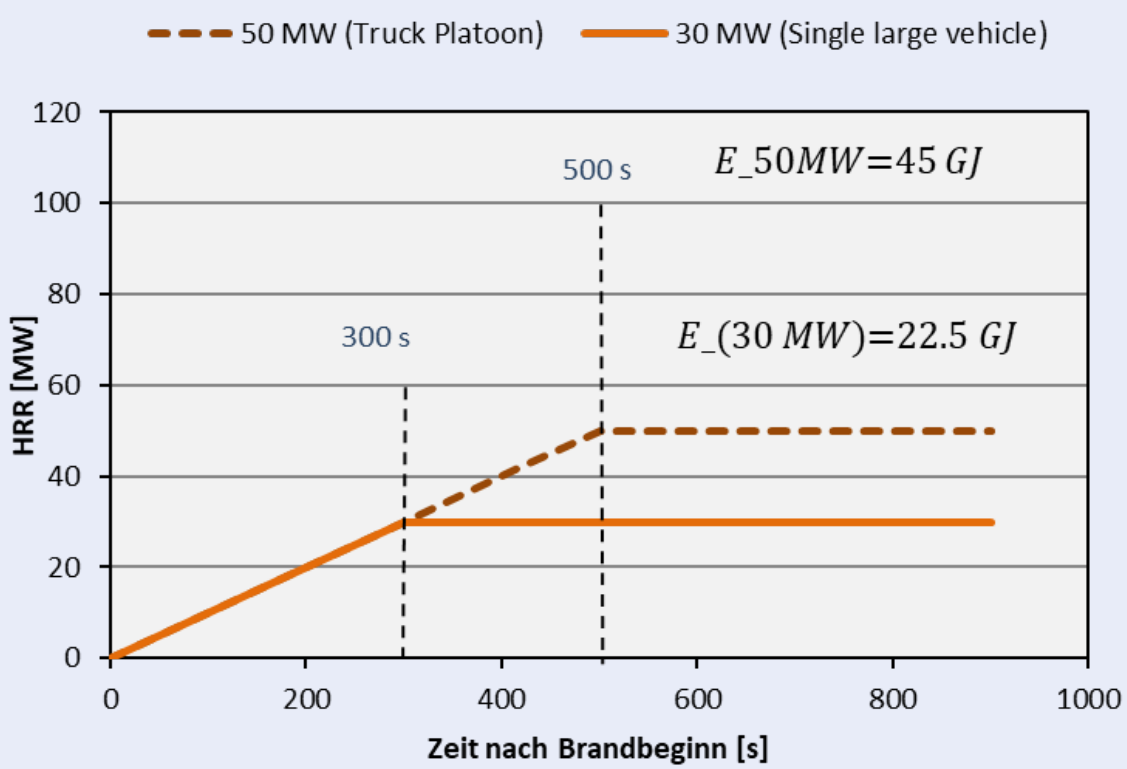
Impact on fire size

- Truck platoons do not increase the probability of a truck fire
- Truck platoons increase the probability of large vehicles stopping in line in case of an incident
- This increases the expectable fire size in case of a fire spreading from one vehicle to another

MODEL FIRE CURVES







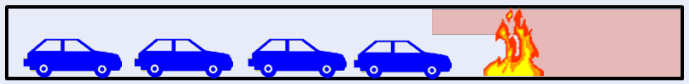
FIRE CONSEQUENCE ANALYSIS

MODEL TUNNEL DATA

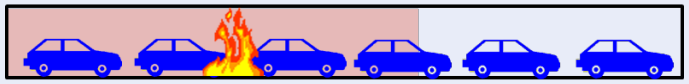
Tunnel parameter	Parameter value
Tunnel system	Unidirectional tunnel with 2 lanes
Tunnel length	$3'000\ m$
Emergency exits	9 (every $300\ m$)
Gradient	-1.5%
Tunnel cross-section	Vaulted, $46.6\ m^2$
Average traffic volume	$30'000$ vehicles per day in each direction
Ventilation system	Longitudinal ventilation 13 jet fans, thrust = $835 \pm 10\%$ N, diameter = $1.0\ m$

FIRE CONSEQUENCE ANALYSIS

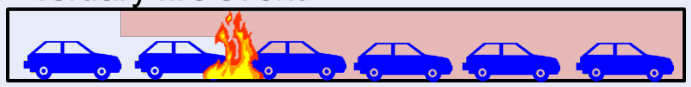
Primary fire event

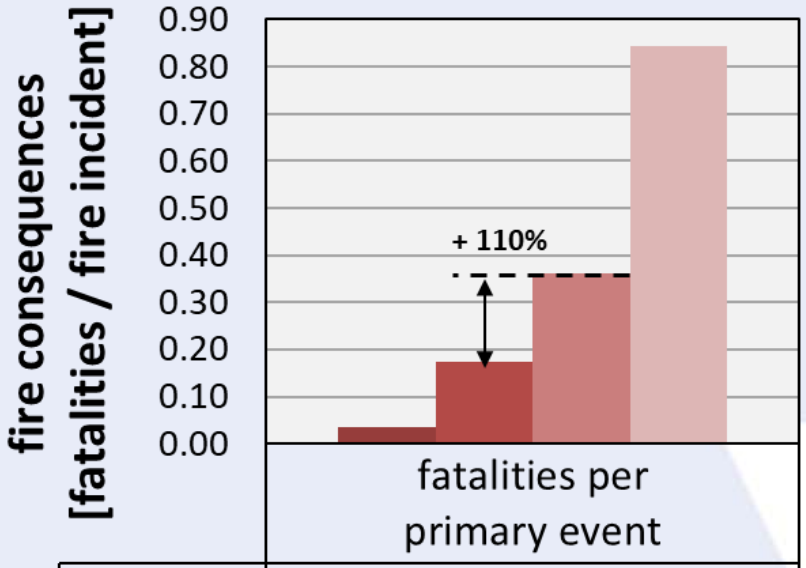


Secondary fire event

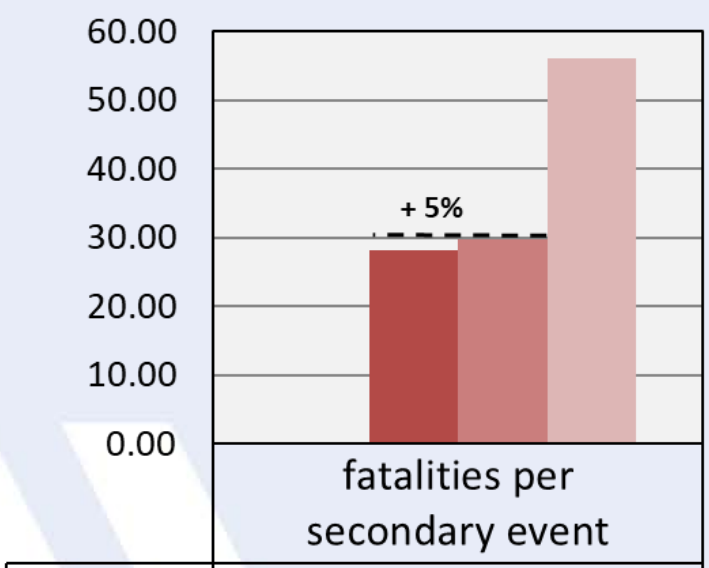


Tertiary fire event

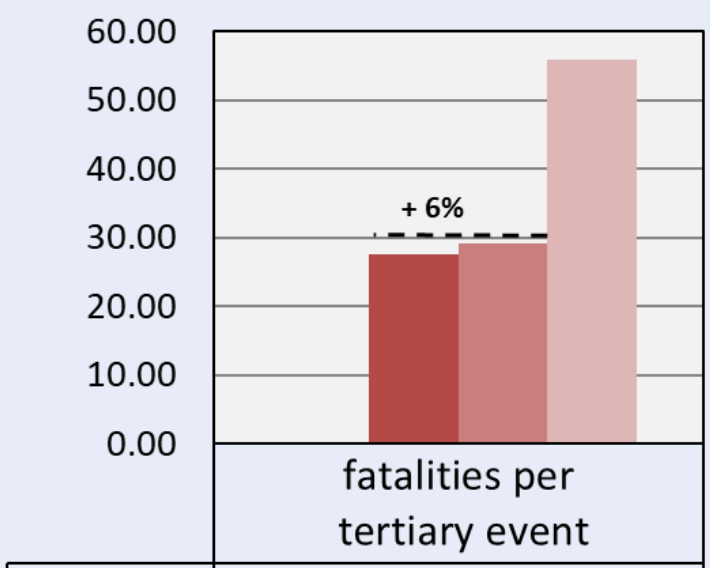




5MW	0.03
30MW	0.17
50MW	0.36
100MW	0.84

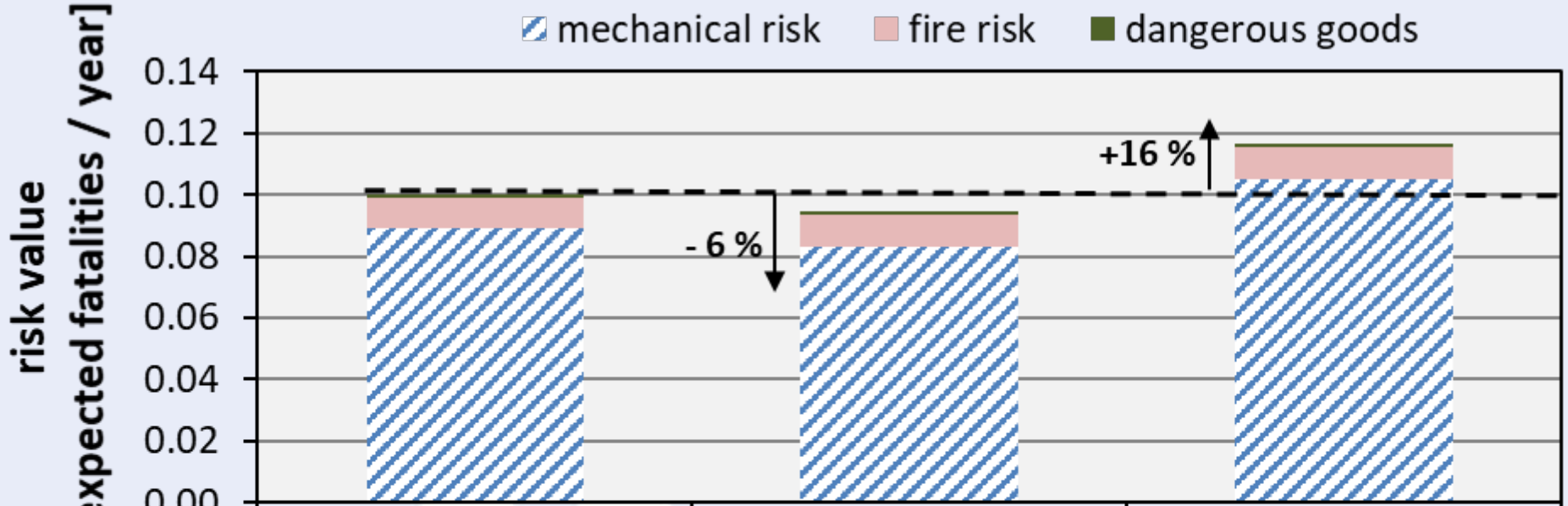


5MW	0.19
30MW	28.25
50MW	29.76
100MW	56.16



5MW	0.19
30MW	27.54
50MW	29.20
100MW	55.82

EXEMPLARY RISK ASSESSMENT



	S_Platoon =0	S_Platoon =0.5 Δmech.cons.=1	S_Platoon =0.5 Δmech.cons.=3
dangerous goods	0.001	0.001	0.001
fire risk	0.010	0.010	0.011
mechanical risk	0.089	0.083	0.105

CONCLUSIONS

Current Driving Behaviour

- Current driving distances are significantly shorter than legally allowed

Incident Likelihood

- A significant part (up to 40%) of historic tunnel collisions of LV could have been avoided by driving assistance systems

Incident Severity

- An increase of mechanical consequences is unlikely but cannot be excluded
- Fire consequences are going to increase because of larger fire sizes in particular for primary events
- The decrease in collision probability slightly exceeds the impact of an increased fire load

"With respect to the accuracy of the applied model, no major impact on the safety of tunnel users has to be expected."

There is no reason not do it from a tunnel-safety point of view

THANK YOU FOR YOUR ATTENTION!

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