The Elusive Fully Automated Vehicle
two years on, are we closer to deployment?

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Automated Vehicles

- There is great enthusiasm for high level automated vehicles (driverless)
- Easy to imagine and demonstrate
- The challenge is great and becoming more apparent
- The role of artificial intelligence is often overlooked
- This discussion examines the significance of artificial intelligence in driverless vehicle crash avoidance

Automated Driving Levels, (SAE J3016)

Level 0	No automation
Level 1	Driver Assist - adaptive cruise control, auto windshield wipers, automatic lights, anything that supports the driver (e.g. ESC, V2V)
Level 2	Partial Automation - hands off and feet off but eyes on. *Driver is responsible - Low speed congested traffic*
Level 3	Conditional Automation - hands off feet off eyes off – shared dual control but *driver is responsible*
Level 4	High Automation – Vehicle controls all aspects of the dynamic driving task but some modes may involve the driver
Level 5	Full Automation - complete machine control – Driver has no responsibility at all.

Levels 1 and 2 have been achieved and are being deployed.

Levels 3 and 4, the human is less involved in the driving task. High speed crash risk rises.

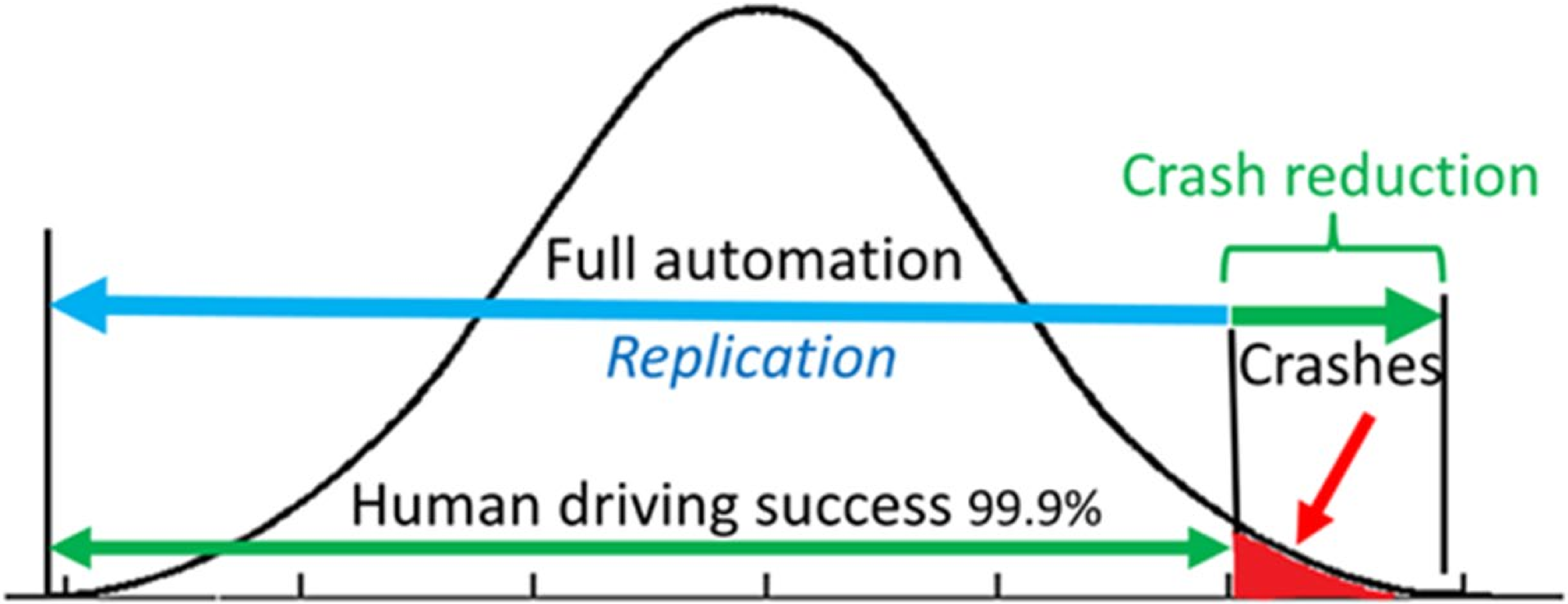
Levels 5 may be unattainable for all conditions

About crashes

- Public view – Since most crashes are the result of human error, automated vehicles should be able to sharply reduce crashes by removing the human from vehicle control
- But serious crashes are rare events – based on 0.73 fatalities per 100 million vehicle km traveled, it would take an average of about 7,210 years of vehicle travel for a fatal crash to occur.
- Chances are, a given human controlled vehicle will be 99.99 percent fatality free during a year.
- Automated vehicles will need to perform better.

The safety challenge

- Many belive that the primary achievemnt of self driving vehicles will be to reduce current crash numbers
- The hidden challange will be for self driving vehicles to achieve the current crash avoidance sucess of humans (fatality free 99.99% of distance travelled)



Crash avoidance distribution

Artificial intelligence

- Where systems are simple, and reasonably constant, current AI works well
- Much of the driving environment is steeped in nuance which is very challenging for AI to decipher
- *“people worry that computers will get too smart and take over the world, but the real problem is that they’re too stupid and they’ve already taken over the world”* Pedro Domingos

Defining artificial intelligence

Human intelligence is the intellectual prowess of humans, which is marked by complex cognitive feats and high levels of motivation and self-awareness. (Nuanced behavior)

Artificial intelligence is the acquisition of information and rules to reach approximate or definite conclusions with the capability of self-correction. (Predictable, robotic behavior)

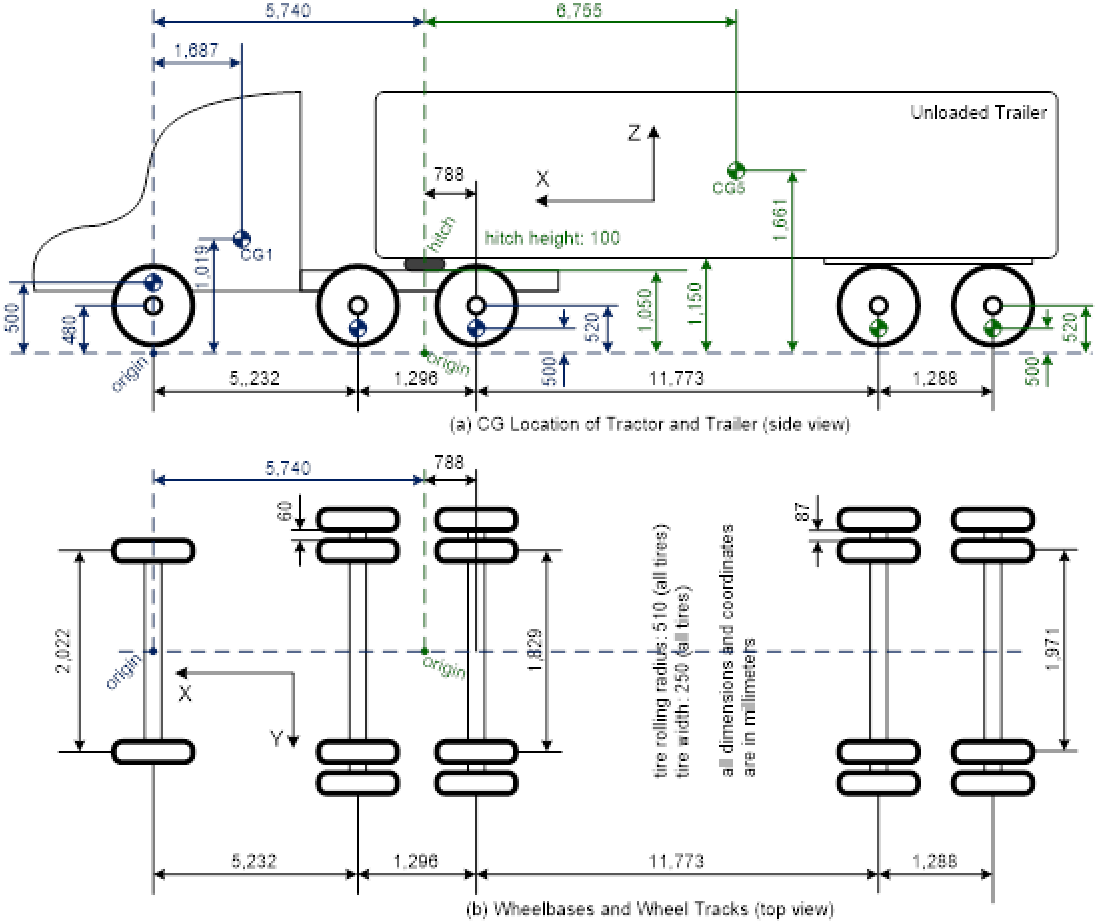
Exploring AI in crash avoidance

Two crash avoidance technologies for trucks are examined to illustrate the importance of AI in maximizing crash avoidance. (Using US crash data and crash avoidance estimates)

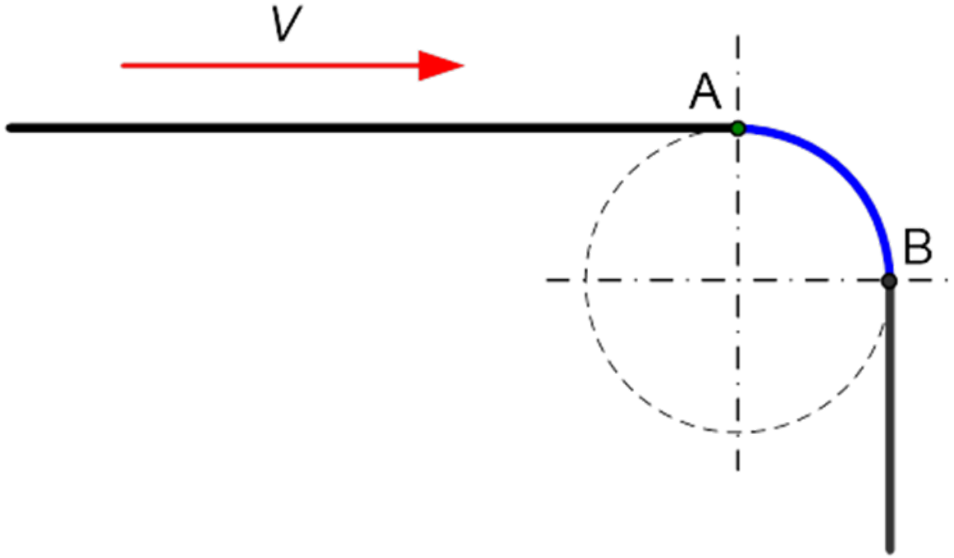
Electronic stability control

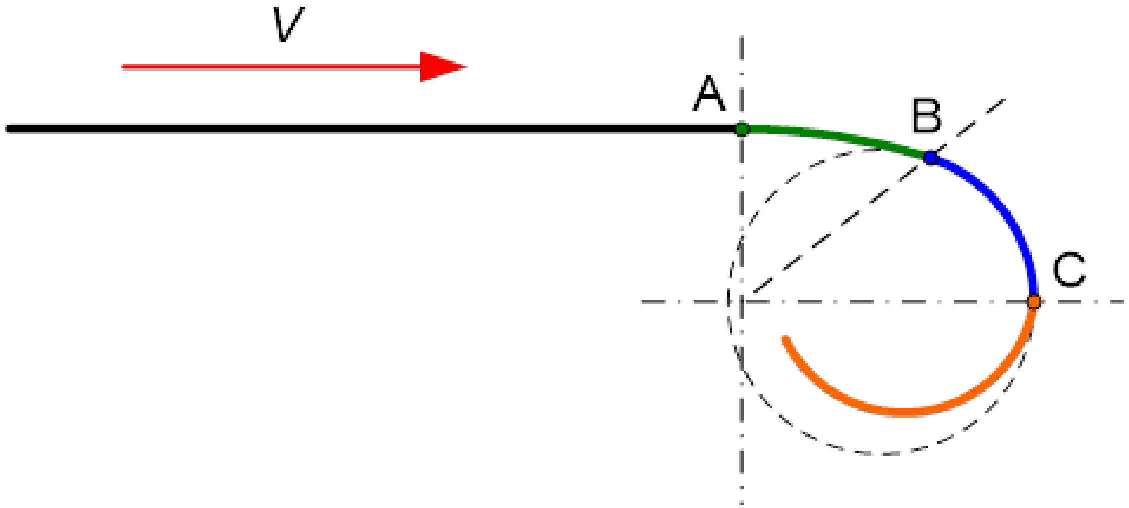
Forward Collision Avoidance and Mitigation systems

Hardware in the loop

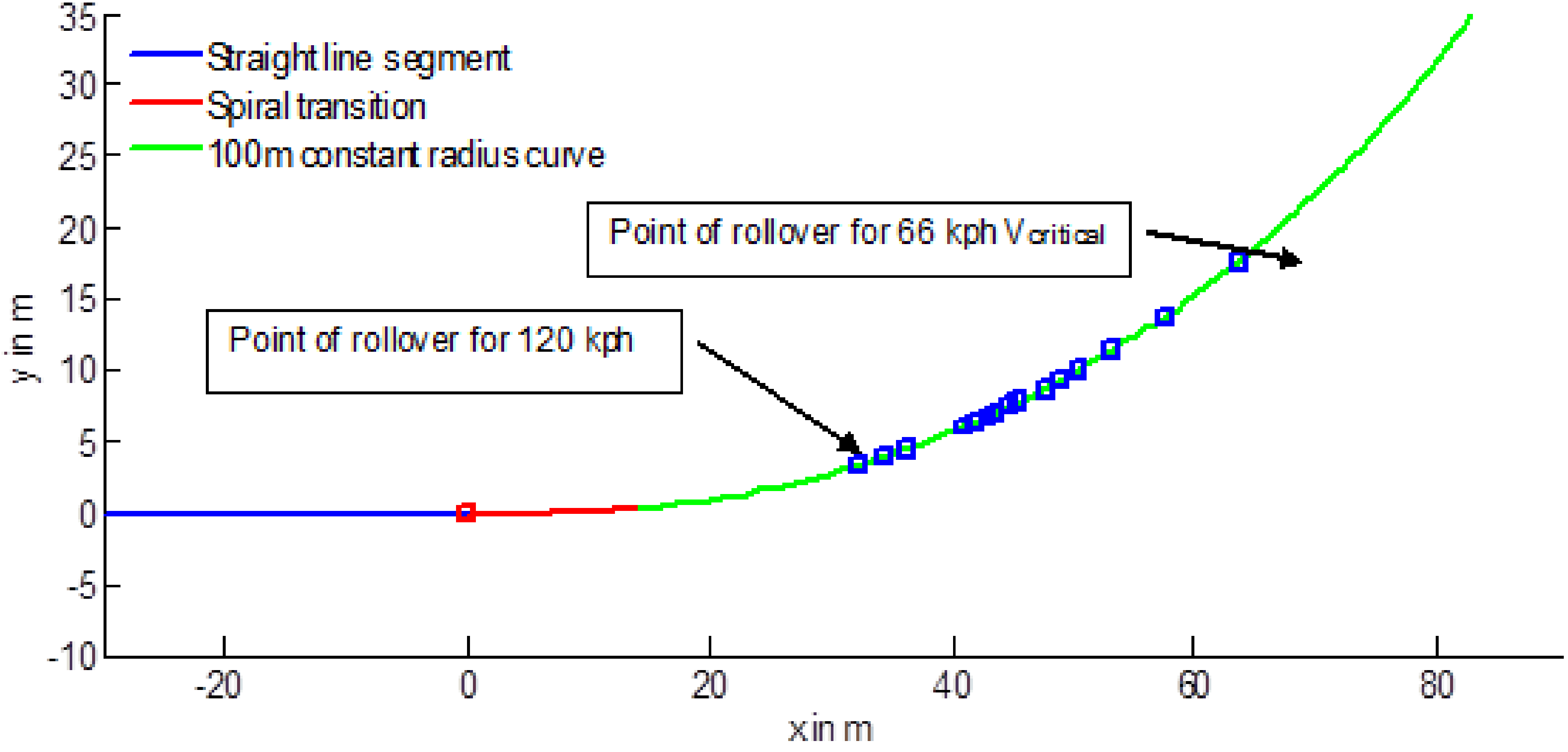


Examples of simulated maneuvers





Spiral to constant radius curve results



Electronic Stability Control system

Electronic Stability Control estimated reductions

Fatal	Injury
49%	29%

Potential crashes for AI to influence

Fatal	Injury
51%	71%

Forward collision mitigation system

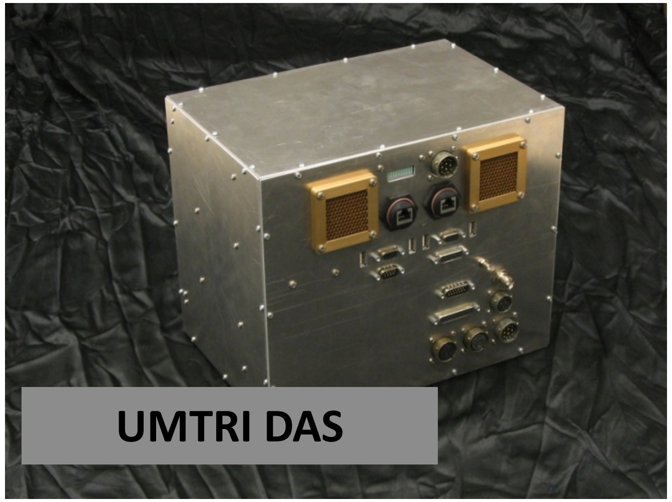
Annual counts USA

Crash type	Fatal	Injury	PDO	Total
	N	N	N	N
LV fixed	62	882	2,119	3,078
LV stopped	13	1,244	2,987	4,263
LV slower	90	1,199	1,794	3,082
LV decel.	18	1,502	3,152	4,750
LV cut-in	9	156	649	814
Total	**192**	**4,983**	**10,701**	**15,987***

* Total includes 111 crashes of unknown injury severity.

Subject Vehicle Highlights

SV Brush Guard



UMTRI DAS

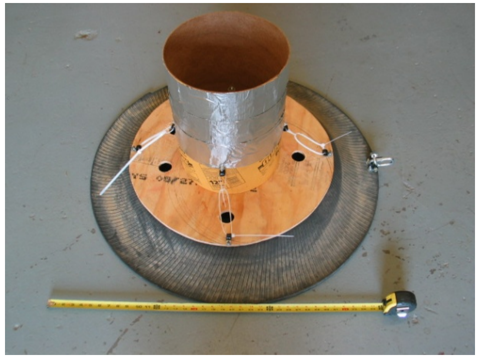
Forward Radar

Multiple DVI

DAS Interface

Towable Target Evolution

"Seed"



Initial UMTRI Radar only Target

Initial Vision Compatible Target

Vision Compatible Target

Final Vision Compatible Target

Forward collision mitigation system

Forward collision mitigation estimated severity reduction

Fatal	Injury
44%	47%

Potential crashes for AI to influence

Fatal	Injury
56%	53%

Potential for AI to influence crash outcome

	Potentially preventable using Artificial Intelligence	
	Electronic stability control	Forward collision mitigation
Deaths	51%	56%
Injuries	71%	53%

Arrogance of Engineering

737 Max – the failure of a system designed to prevent human error – *unintended consequences resulted in catastrophic events*

Contributing factors - Faulty sensors, complex disengagement procedure, **flawed artificial intelligence etc.**

There was a lack of human intelligence applied during the system design

Since artificial intelligence is the simulation of human intelligence, we have much to be concerned about.

Deployment

- Demonstration deployment of fully automated vehicles has occurred under ideal conditions
- There have been many crashes of automated vehicles, and crash scenarios map well to system weaknesses.
- Present automated vehicles have poor intelligence based primarily on sensor input and software situational analysis

Deployment

- Over time, it is likely that the power of human intellect in the task of driving will appreciated
- It is unlikely that <u>fully automated</u> vehicles will be deployed in significant numbers in the foreseeable future
- Climatic conditions, sensor performance, AI limitation, system reliability, represent formidable challenges.
- Partial automated vehicles are present now and they are very successful

Conclusions

- One of the greatest challenges for high level self driving vehicles will be to achieve the current level of human crash avoidance performance
- The two crash avoidance technologies examined, ESC and forward collision mitigation systems, were found to address less than 50 percent of fatalities and injuries from crashes relevant to the technology.
- It follows that artificial intelligence has the potential to address more than 50 percent of crashes relevant to these technologies.

Thank You

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