

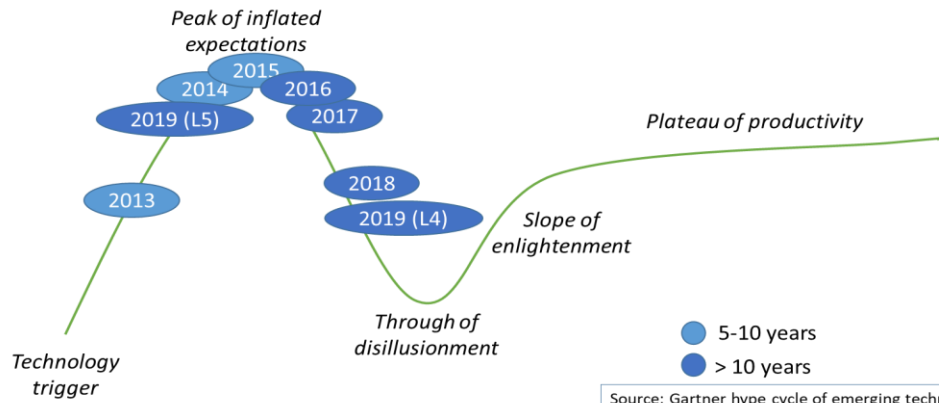
ADS safety projects timeline



- Adapt/extend functional safety practices for ADS
- AV system architecture
- Start understanding the new safety challenges

- ADS Safety argumentation Product lines, tools, safety contracts, HMI, risk acceptance criteria

- More work on continuous safety lifecycle
- Variability, machine learning, collaborative vehicles, off-road use cases



Source: Gartner hype cycle of emerging technologies

ISO 21448 | ISO TS 5083
ISO 3450x | UNECE NATM
EC Regulation 2022/1426
ISO 17757 | ISO 18498
TSFS 2021:4

Main topics

Safety Assurance

- Continuous safety cases and safety contracts
- HMI safety analysis

Safety of ML

- Safety requirements for ML
- ML Safety mechanisms



Safety Design

- Collaborative / cooperative vehicles
- Precautionary safety

Variational Safety

- Synthesis and analysis of safety variants and invariants

Minimal risk conditions

- Strategies for handling near ODD exit or failures
- How to argue that an MRC is safe
- MRC strategies for collaborative AVs to limit impact on productivity.



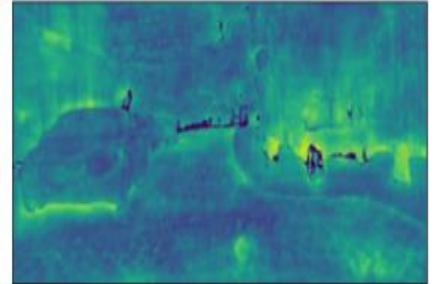
Snapshot from simulation of a scenario with a concerted minimal risk manoeuvre.

- *Minimal Risk Condition for Safety Assurance of Automated Driving Systems*, Magnus Gyllenhammar, Mattias Brännström, Rolf Johansson, Fredrik Sandblom, Stig Ursing, Fredrik Warg, 6th International Workshop on Critical Automotive Applications: Robustness & Safety (CARS) at EDCC 2021.
- *Minimal Risk Manoeuvre Strategies for Cooperative and Collaborative Automated Vehicles*, Victoria Vu, Fredrik Warg, Anders Thorsén, Stig Ursing, Fredrik Sunnerstam, Jimmy Holler, Carl Bergenheim, Irina Cosmin, 9th International Workshop on Safety and Security of Intelligent Vehicles (SSIV), held in conjunction with DSN 2023.

Example results

Out-of-distribution (OoD) detection

- Identifying data samples that deviate from the training data in machine learning.
- How OoD can be used for safety in both the development and operational phase of an ADS.



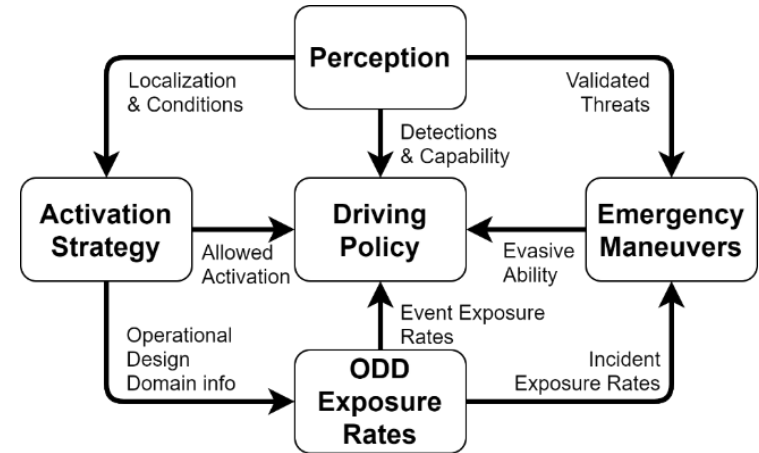
A Visualization of the Mahalanobis Distance, applied to a front looking camera. Brighter colours refer to higher uncertainty of the predicted pixel.

- *Out-of-Distribution Detection as Support for Autonomous Driving Safety Lifecycle*, Jens Henriksson, Stig Ursing, Murat Erdogan, Fredrik Warg, Anders Thorsen, Johan Jaxing, Ola Örsmark, and Mathias Örtenberg Toftås, 29th Intl. Working Conference on Requirement Engineering: Foundation for Software Quality (REFSQ 2023).
- *Evaluation of Out-of-Distribution Detection Performance on Autonomous Driving Datasets*, Jens Henriksson, Christian Berger, Stig Ursing and Markus Borg, The 5th IEEE International Conference on Artificial Intelligence Testing (AITest 2023).

Example results

Precautionary safety

- Safe planning methodology
- Use of current capabilities, external conditions, knowledge on human mistakes
- Use of field data for continuous improvement
- Adjust driving policy to meet quantitative risk norm



Precautionary Safety Driving Policy for Autonomous Driving, adapting the trajectory planning to the ability to perform evasive manoeuvres.

- *Precautionary Safety for Autonomous Driving Systems: Adapting Driving Policies to Satisfy Quantitative Risk Norms, Gabriel Rodrigues de Campos, Roozbeh Kianfar, Mattias Brännström, 24th IEEE International Conference on Intelligent Transportation (ITSC 2021).*
- *Uncertainty Aware Data Driven Precautionary Safety for Automated Driving Systems Considering Perception Failures and Event Exposure , Magnus Gyllenhammar, Gabriel Rodrigues de Campos, Fredrik Sandblom, Martin Törngren and Håkan Sivencrona, 33rd IEEE Intelligent Vehicles Symposium (IV 2022).*

Example results

More information

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Project papers

- Understanding the Impact of Edge Cases from Occluded Pedestrians for ML Systems
- Precautionary Safety for Autonomous Driving Systems: Adapting Driving Policies to Satisfy Quantitative Risk Norms
- Minimal Risk Condition for Safety Assurance of Automated Driving Systems
- ADS Safety Assurance Methods - Future Directions
- Human Interaction Safety Analysis Method for Agreements with Connected Automated Vehicles
- Developing SEoC - Original Concepts and Implications when Extending to ADS
- Uncertainty Aware Data Driven Precautionary Safety for Automated Driving Systems Considering Perception Failures and Event Exposure
- Holistic Perspectives on Safety of Automated Driving Systems - Methods for Provision of Evidence
- Out-of-Distribution Detection as Support for Autonomous Driving Safety Lifecycle
- Minimal Risk Manoeuvre Strategies for Cooperative and Collaborative Automated Vehicles
- Evaluation of Out-of-Distribution Detection Performance on Autonomous Driving Datasets
- A Simulation-Aided Approach to Safety Analysis of Learning-Enabled Components in Automated Driving Systems
- Managing continuous assurance of complex dependable systems
- A Unified Taxonomy for Automated Vehicles: Individual, Cooperative, Collaborative, On-Road, and Off-Road
- Choosing Risk Acceptance Criteria for an Automated Driving System