Ko-HAF
KOOPERATIVES HOCHAUTOMATISIERTES FAHREN





Minimal Risk Maneuver

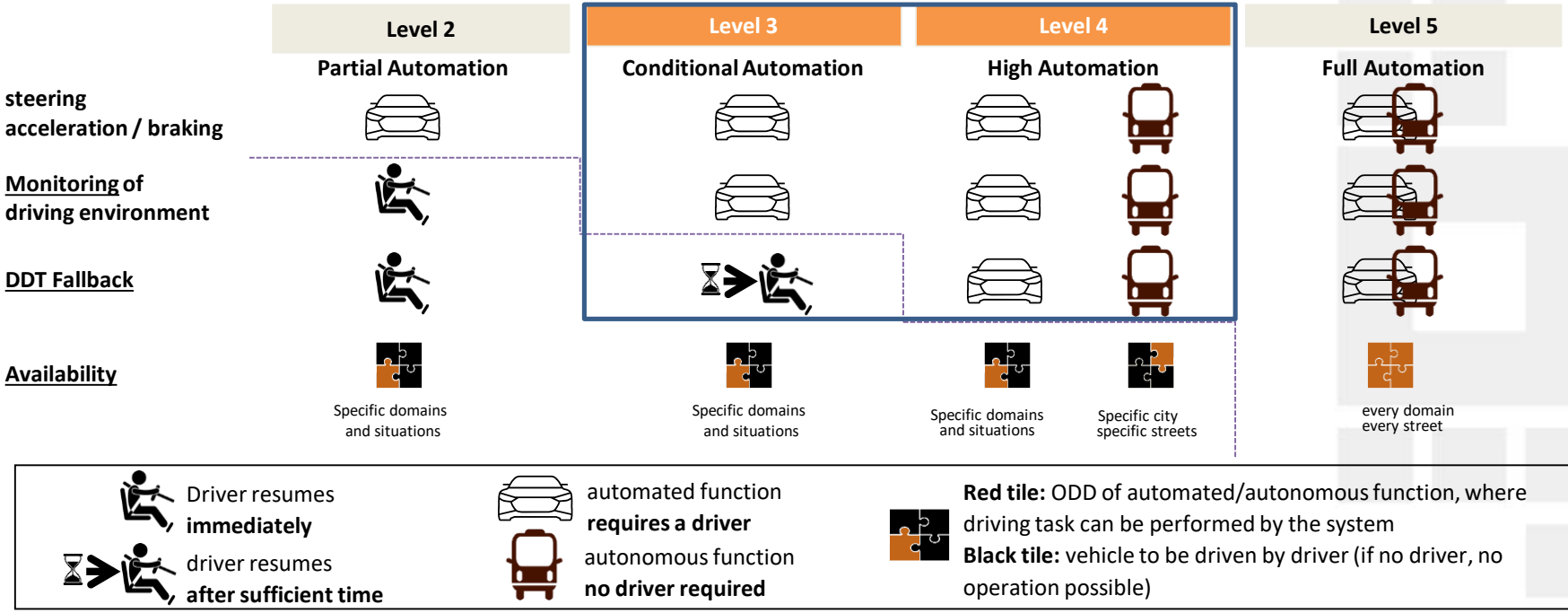
Dr. Thorsten Leonhardt, Audi AG

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Agenda

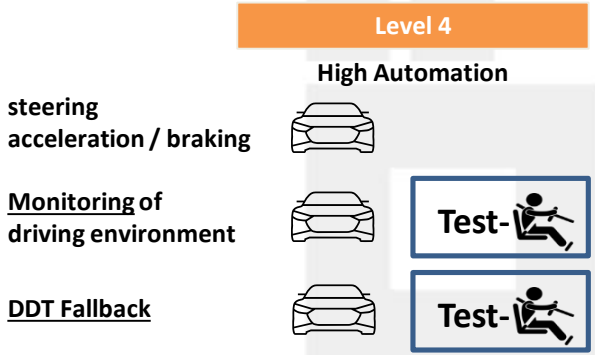
- Definitions and clarifications from SAE J3016
- Practical considerations
- Examples
- Viewpoint in UN-ECE
- Conclusions

Understading of driving automation (SAE J3016)

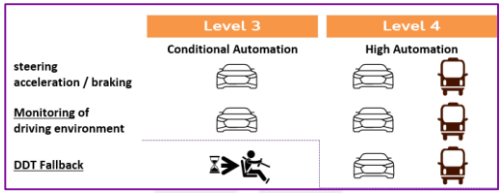


General remark on testing vehicles (source: SAE J3016 from June, 2018)

"The level of a *driving automation system feature* corresponds to the *feature's* production design intent. This applies regardless of whether the *vehicle* on which it is equipped is a production *vehicle* already deployed in commerce, or a test *vehicle* that has yet to be deployed. As such, it is incorrect to classify a level 4 design-intended *ADS feature* equipped on a test *vehicle* as level 2 simply because on-road testing requires a test *driver* to *supervise* the *feature* while engaged, and to intervene if necessary to maintain safe operation."



Definitions
(source: SAE J3016 from June, 2018)



DDT fallback

- “The response by the user to either perform the DDT or achieve a minimal risk condition after occurrence of a DDT performance-relevant system failure(s) or upon operational design domain (ODD) exit, or the response by an ADS to achieve minimal risk condition, given the same circumstances. “

MINIMAL RISK CONDITION

- “A condition to which a user or an ADS may bring a vehicle after performing the DDT fallback in order to reduce the risk of a crash when a given trip cannot or should not be completed.”

Examples for level 3 and level 4 (source: SAE J3016 from June, 2018)

Ko-HAF
KOOPERATIVES HOCHAUTOMATISIERTES FAHREN

Level 3

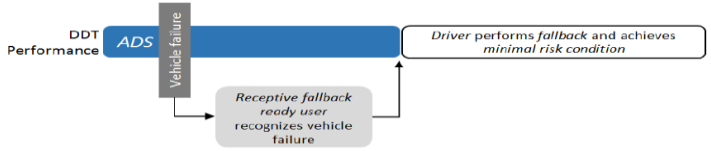


Figure 2 - Use case sequence at Level 3 showing ADS engaged, a vehicle failure and the user resuming control

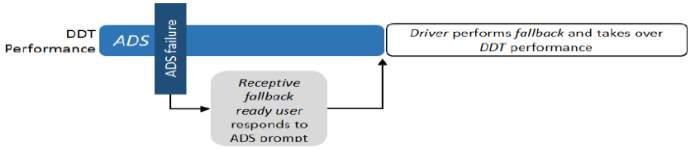


Figure 3 - Use case sequence at Level 3 showing ADS engaged, and ADS failure and the user resuming control

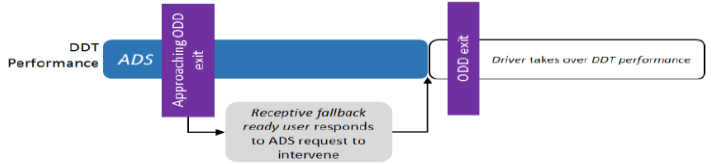
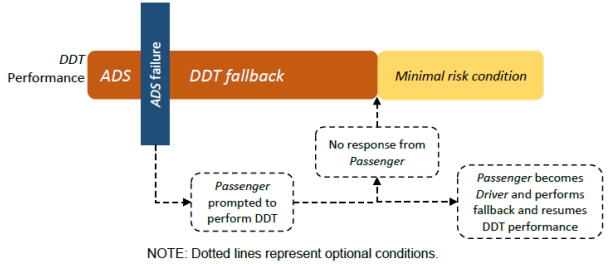


Figure 4 - Use case sequence at Level 3 showing ADS engaged, exiting the ODD and the user resuming control

Level 4



NOTE: Dotted lines represent optional conditions.

Figure 6

Sample use case sequence at Level 4 showing *ADS* engaged and occurrence of an *ADS* failure that does not prevent continued DDT performance by an available human *user*. The *ADS feature* may prompt a *passenger* seated in the driver's seat (if available) to resume DDT performance; if no driver's seat with *receptive passenger*, the *ADS* automatically achieves a *minimal risk condition*.

Definitions
(source: SAE J3016 from June, 2018)

- *Failure mitigation strategy*
  - *"Vehicles* equipped with level 2 and level 3 *driving automation features* may have an additional failure mitigation strategy designed to bring the *vehicle* to a controlled stop wherever the *vehicle* happens to be, if the *driver* fails to *supervise* the *feature's* performance (level 2), or if the *fallback-ready user* fails to perform the *fallback* when prompted (level 3)."

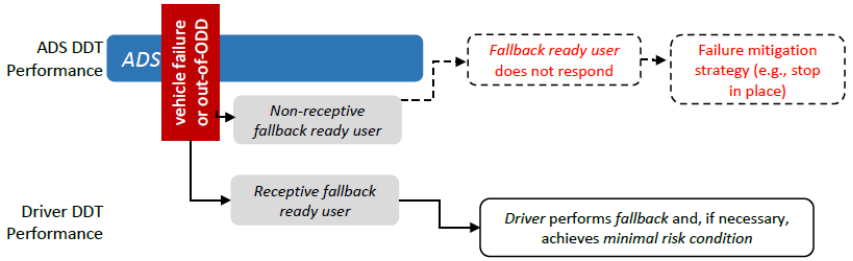


Figure 12 - Use case sequence for a level 3 feature showing ADS engaged, occurrence of a failure or out-of-ODD condition, and the fallback-ready user performing the fallback, or, if the fallback-ready user fails to do so, a failure mitigation strategy, such as stop-in-lane (Note: Dotted lines represent failure mitigation strategy.)

- Comment: Failure mitigation strategies in that sense are already deployed in Level 2 systems of current production vehicles (e.g. safe stop with Tesla Autopilot, active emergency stop assist at Mercedes, Emergency assist at VW group)

Practical considerations for the development

- How to find the minimal risk condition:
  - Not enough only to consider the minimal risk condition!
  - Moreover, the risks associated with the maneuver to achieve the MRC has to be taken into account.
  - Above that, road traffic regulations have to be taken into account

- Therefore:
  - Selection of the appropriate maneuver at the time of the start of the fallback depends on
    - the operational condition of the vehicle (e.g. failures, which might reduce the capability of the vehicle to perform the fallback)
    - the prevailung environmental conditions, which might restrict the available maneuvers to achieve the MRC
    - the allowed maneuvers to achieve the MRC

Example: environmental conditions

- Consider a Highway Pilot feature, where the fallback is triggered by a frontal sensor failure; the system is operational for a limited time.

  - For Level 3: Decision of MRC (if necessary) is done by the receptive user with sufficient time margin
  - For Level 4:
    - Removal of vehicle outside the active lane is the preferred option
    - However, due to dense traffic (e.g. congestion) the changing of lane entails additional risks, therefore a controlled stop in the current lane might be a better option

Example: operational conditions

- Consider a Highway Pilot feature, where the fallback is triggered by a propulsion failure or a flat tyre
  - For Level 3: Decision of MRC (if necessary) is done by the receptive user with sufficient time margin
  - For Level 4:
    - Removal of vehicle outside the active lane is the preferred option
    - However, due to the current motorway layout, a hard shoulder might not be available, so a controlled stop in an active traffic lane could be the only available option

Example: regulatory obstructions

- Consider a Highway Pilot feature, where the fallback is triggered by a collision with another traffic participant
  - For Level 3: Decision of MRC (if necessary) is done by the receptive user with sufficient time margin
  - For Level 4:
    - Removal of vehicle outside the active lane can be an option, if e.g. a hard shoulder near to the collision point is available
    - If not, proceeding with the journey to the next available spot outside the traffic could be interpreted as an infringement of road traffic regulation.

Viewpoint from UN-ECE

- "*Minimum risk maneuver*" means a procedure aimed at minimizing risks in traffic, which is automatically performed by the system, e.g. when the driver does not respond to a transition demand.

- Contents of these minimum risk manoeuvres are currently under discussion.

Conclusion

- Minimal risk maneuvers and minimum risk conditions are an essential role in the development of automated driving functions
- The selection of the appropriate maneuver is depending on
  - the operational condition of the vehicle
  - the prevailing environmental conditions
  - Regulatory boundary conditions
- Much progress for the clarification has already been achieved, especially on the standardisation side (SAE J3016).
- Different terminologies are in use.
- Further work is ongoing.





Thank you

for your attention!

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages