Minimal Risk Maneuver

Dr. Thorsten Leonhardt, Audi AG
Agenda

- Definitions and clarifications from SAE J3016
- Practical considerations
- Examples
- Viewpoint in UN-ECE
- Conclusions
Understanding of driving automation (SAE J3016)

**Level 2**
Partial Automation
- steering
- acceleration / braking

**Level 3**
Conditional Automation
- Monitoring of driving environment
- DDT Fallback

**Level 4**
High Automation
- Specific domains and situations
- Specific city, specific streets

**Level 5**
Full Automation
- every domain, every street

**Availability**
- Driver resumes immediately
- driver resumes after sufficient time

- automated function requires a driver
- autonomous function no driver required

- **Red tile:** ODD of automated/autonomous function, where driving task can be performed by the system
- **Black tile:** vehicle to be driven by driver (if no driver, no operation possible)

September 19th & 20th, 2018

Ko-HAF – Minimal Risk Maneuver
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)
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).”

- 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 prevailing 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
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.
"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.
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!

The contents of this presentation (including but not limited to texts, images, photos, logos, etc.) and the presentation itself are protected by intellectual property rights. They were created by the project consortium Ko-HAF and/or licensed by the project consortium. Any disclosure, modification, publication, translation, multiplication of the presentation and/or its contents is only permitted with a prior written authorisation by the consortium.

© Copyright Project Ko-HAF, 2018, Contact: projektbuero@ko-haf.de