FUNCTIONAL APPROACH ON VEHICLE INTEGRATED SAFETY ASSESSMENT

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Motivation

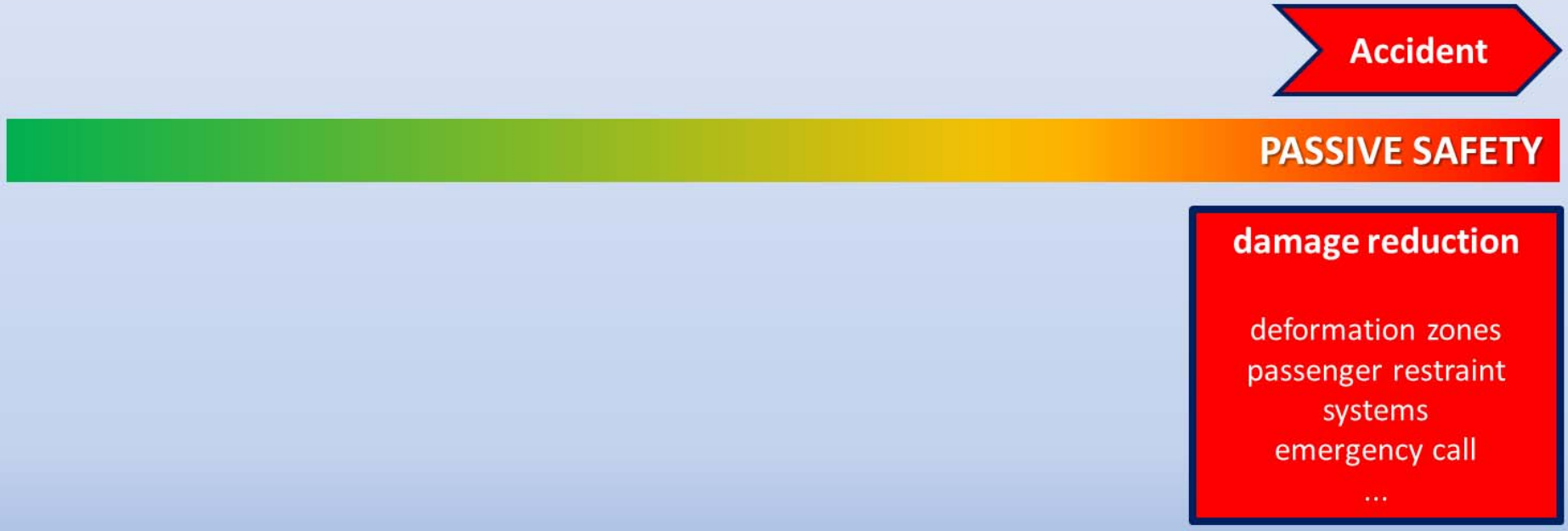
- evaluate false positives
- create method with fail/pass criteria definition
- provide system independent assessment method for any upcoming integrated safety system
- create system evaluation method in compliance with Vienna Convention on Road Traffic

- joint project
  - *Czech Technical University in Prague*
  - *TÜV SÜD Czech*

Definitions

- obstacle
  - *any object on road*
    - car, motorcycle, pedestrian...
  - *any object in the vehicle trajectory*
    - bicycle, tree, building...
  - *virtual obstacle*
    - road dead-end, road shoulder...
- integrated safety systems
  - *systems simultaneously active – cooperative systems*
  - *pre-crash systems*
- damage
  - *material damage and/or injury*

Safety system intervention sequence



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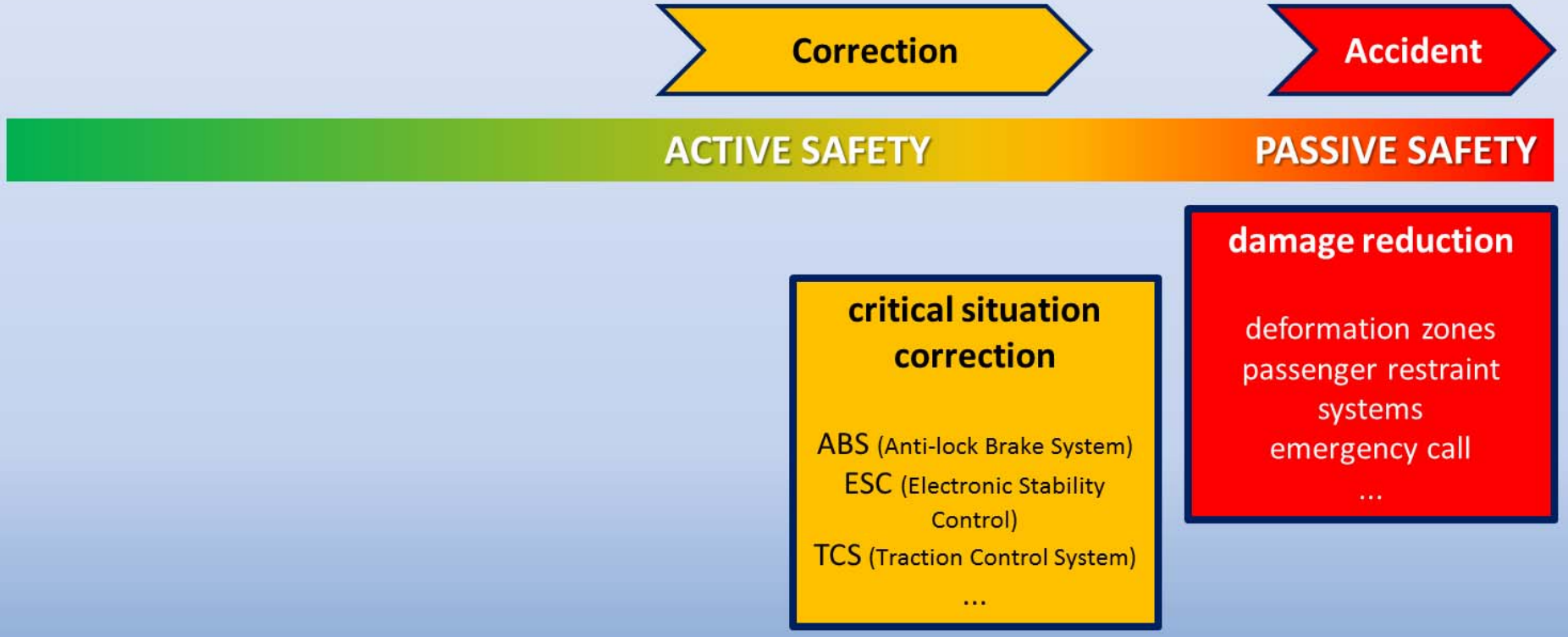

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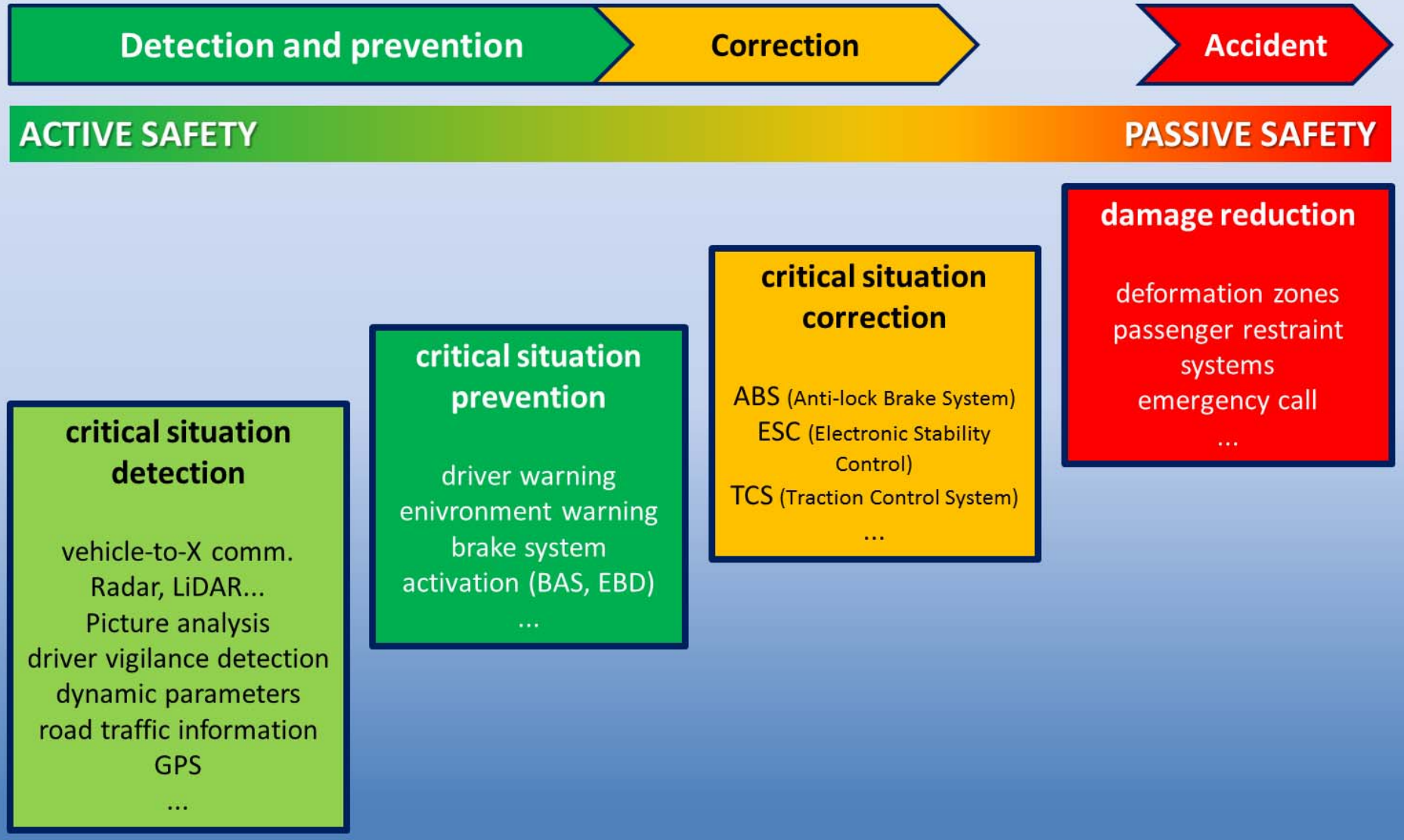

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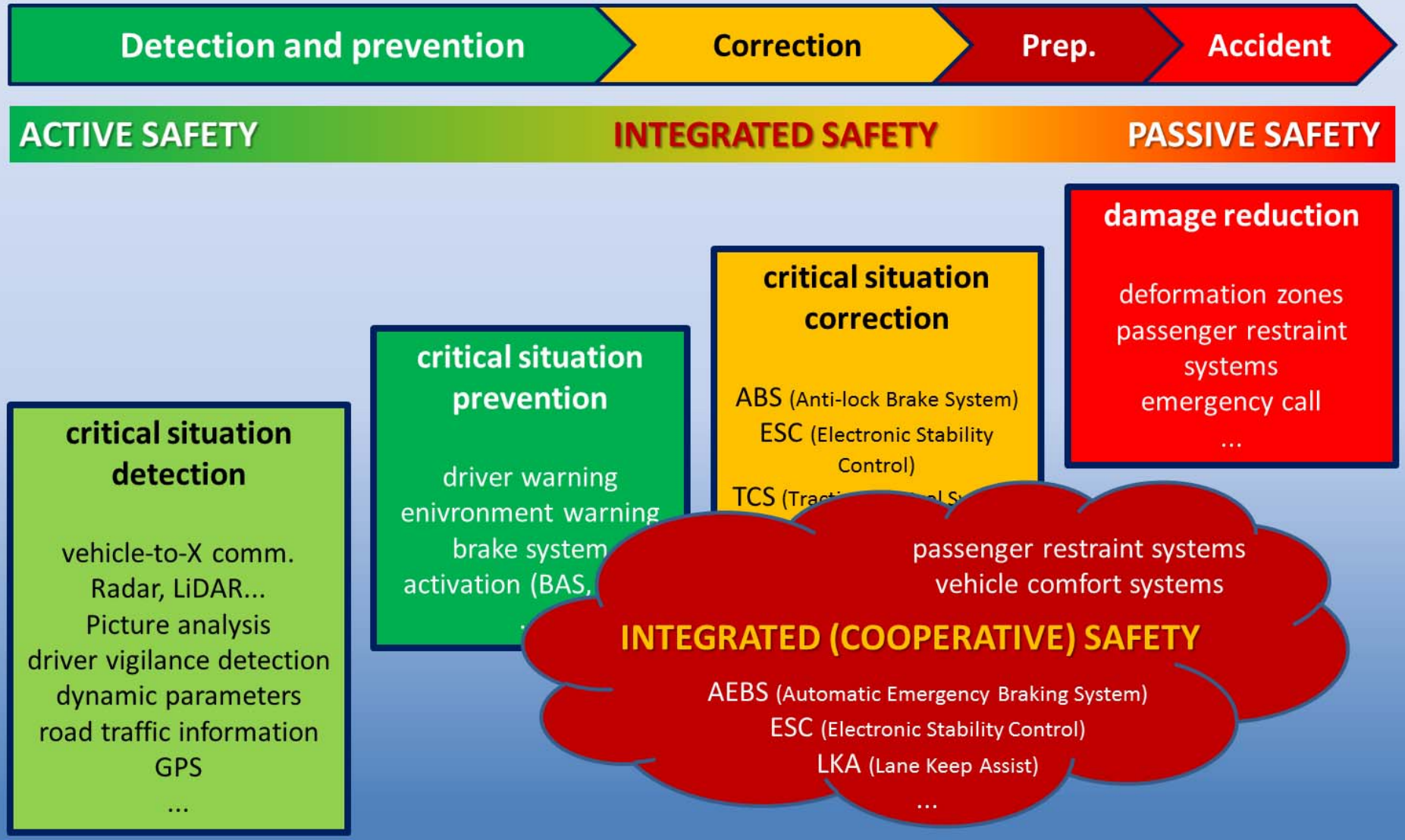
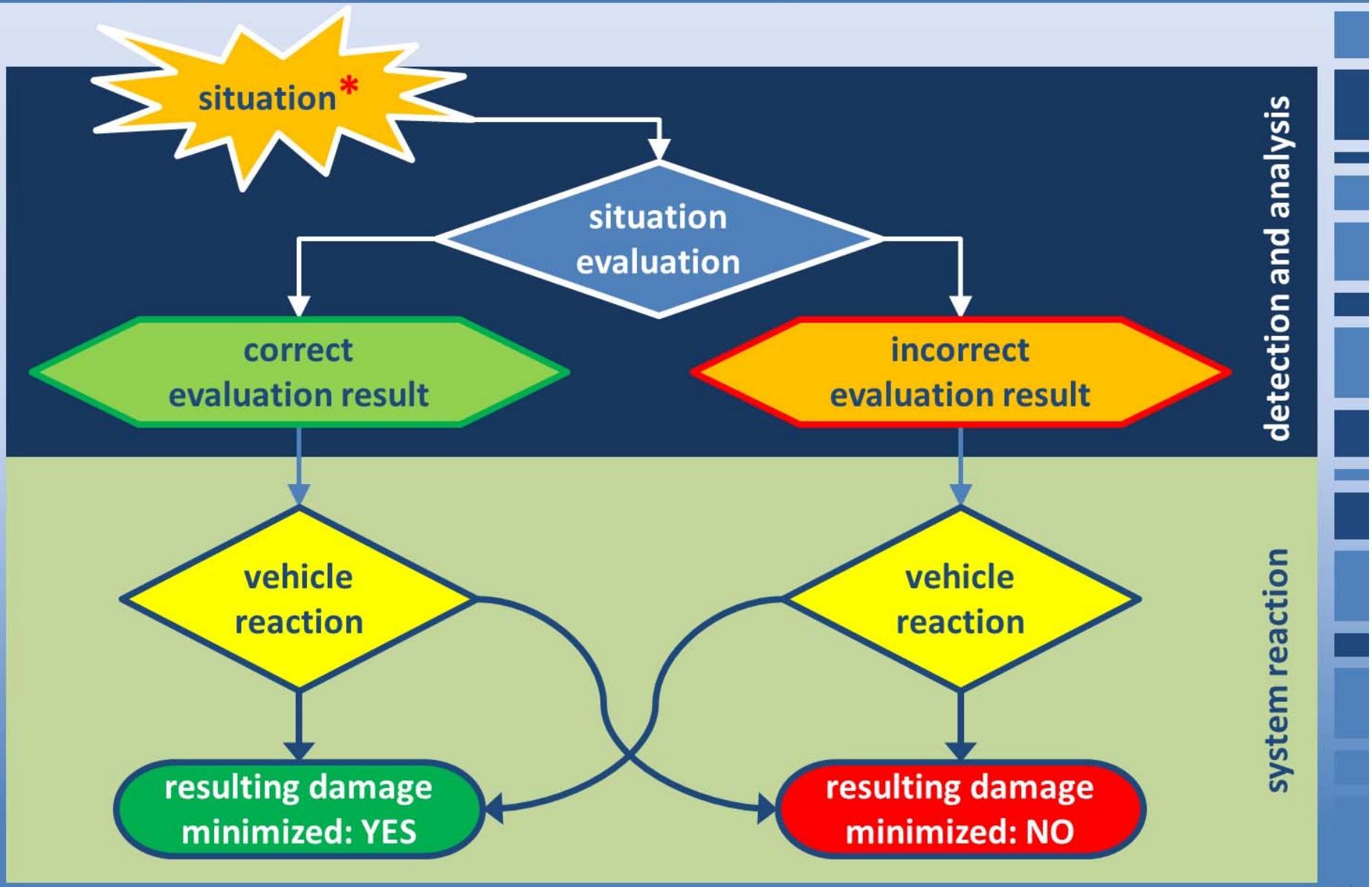


System testing

- system approach
  - *functional safety laboratory testing*
  - *single system testing*
    - electronic stability control testing
    - lane keep assistant systems testing etc.
  - *correct behavior testing*
    - scenarios with system activity expected
- functional approach
  - *system cooperation testing*
  - *false positives testing*
    - scenarios when system should stay inactive
  - *system functional separation*

Safety system intervention process



* situation severity is determined by situation evaluation accuracy

System separation

- detection subsystem
  - *focused on obstacle detection reliability*
  - *can be tested by common functional safety testing methods*
  - *no need for full car testing*

- reaction subsystem
  - *based on message from detection subsystem information*
  - *provides dynamic corrections to vehicle movement*
  - *action based on existence of information not on its relevance*

vehicle reaction provides the only relevant result

System functional separation benefits

- simplification assumptions
  - *detection system behavior corresponds to manufacturer specification*
    - obstacle character detection
    - weather conditions
    - driver warning messages
  - *detection subsystem has passed functional safety tests*
  - *reaction system always gets relevant data*
- vehicle reaction corresponds to all available inputs
  - *independent of system sensor types*
  - *independent of system technology*
  - *inadequate dynamic reaction indicates system failure*

Vehicle reaction analysis

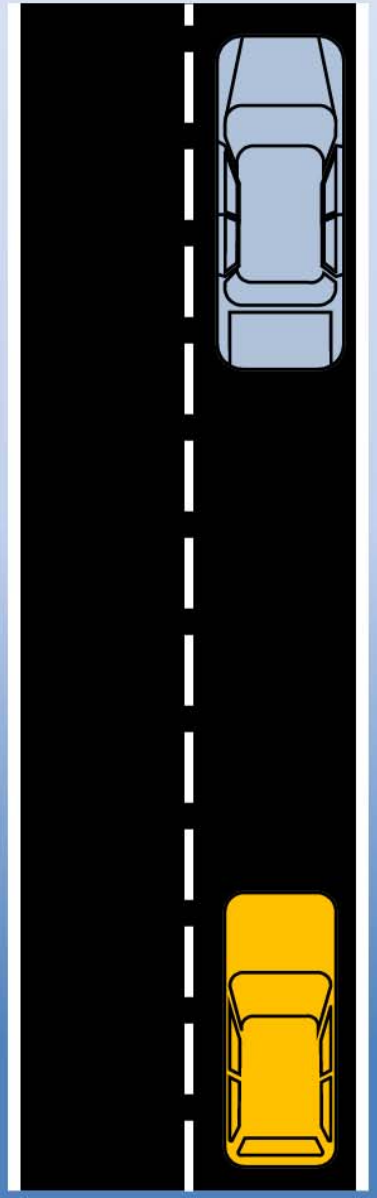
- cooperative safety is effective during near-crash situations
  - *should provide collision avoidance*
  - *should minimize accident damage*
- system **must** provide reaction to situation
  - *in case of driver unavoidable accident*
  - *in case of driver inattention*
- system **must not** provide reaction to situation
  - *non-critical situation during common driving conditions*
  - *near-hazardous situations*
  - *when the driver does not want to*

system intervention during non-critical situation is more dangerous than no intervention during critical situation

Testing conditions

- dynamic testing of cooperative system reaction
  - *partial system testing cannot provide real life data*
- obstacle type
  - *car or car-like target*
  - *virtual target (i.e. V2X)*
- test repetitions
  - *minimize the error of experimental data*
- weather conditions
  - *all tests during „optimal weather“ conditions*
  - *one selected test with low adhesion*

General test types



- non-destructive
  - *based on reaction space methodology*
    - possible existence more solutions to avoid collision
  - *near dynamic instability tests*
- test categories
  - *non-critical situations*
  - *near-hazardous situations*
  - *low-μ test*
- verification tests
  - *system robustness testing*
- destructive
  - *enhanced crash test with cooperative systems active*
  - *comparative testing method*

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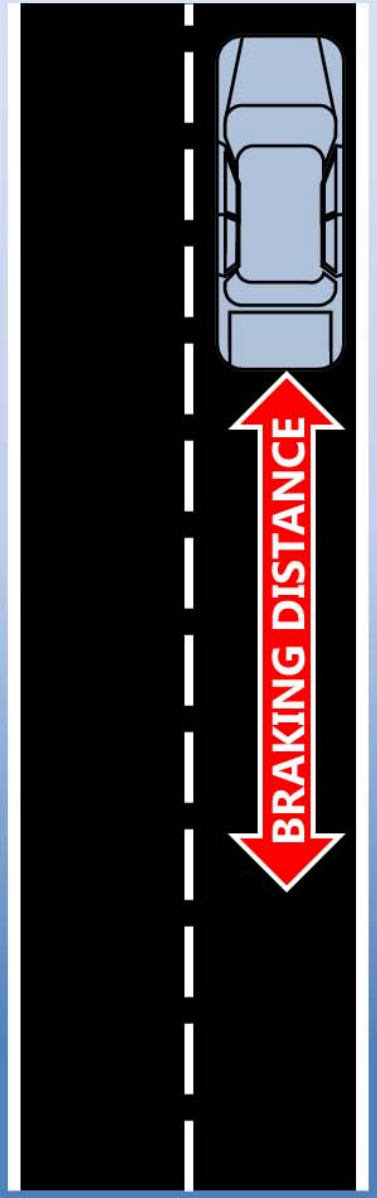

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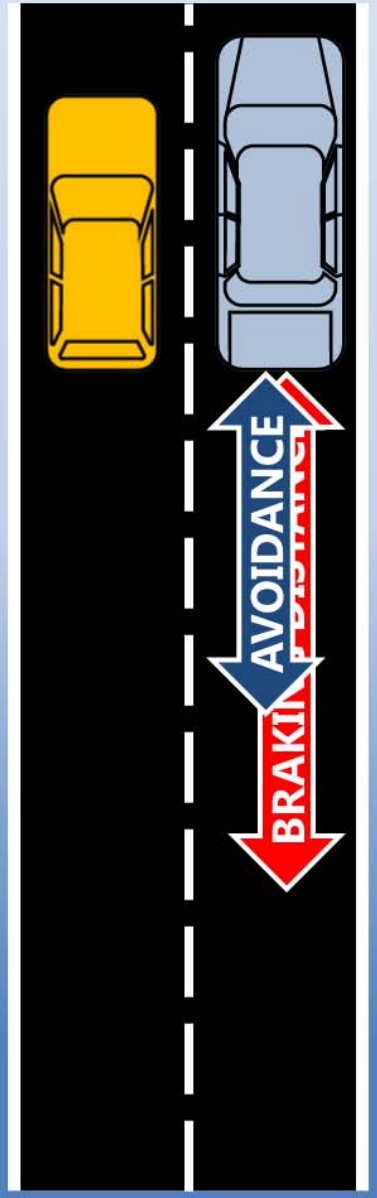

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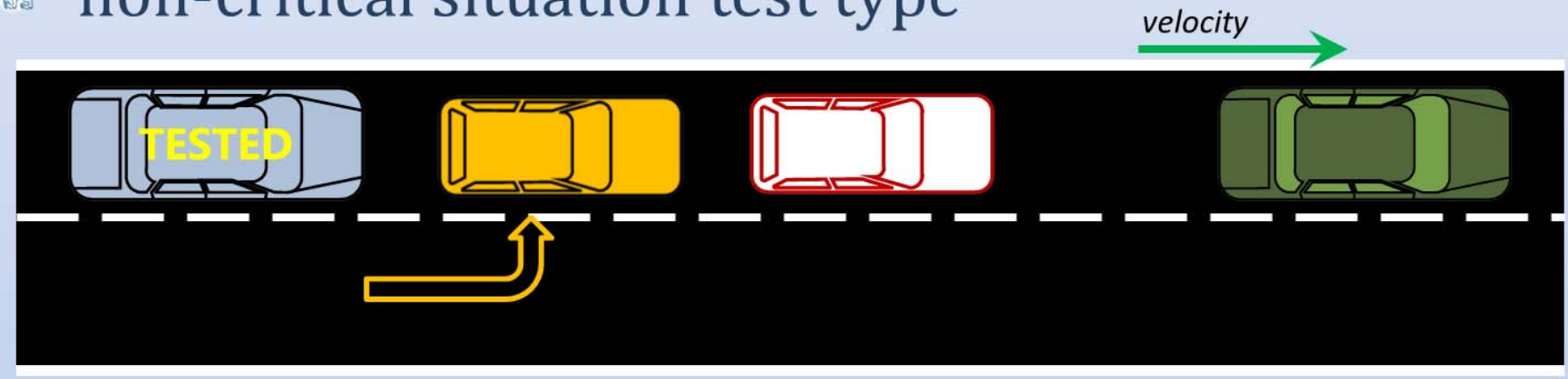
Non-destructive test examples

- non-critical situation test type

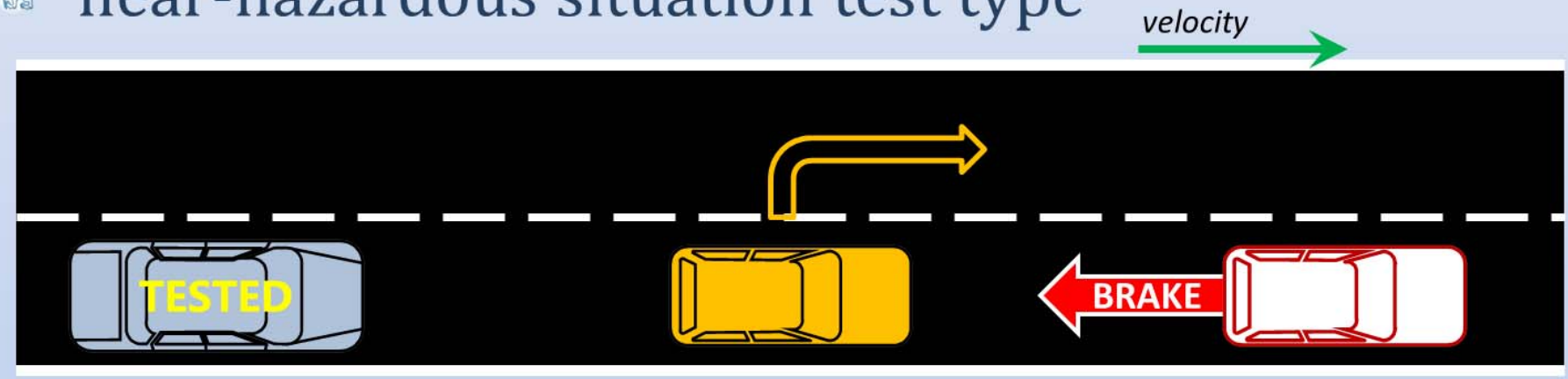


• fluently adjust new distance • do nothing	passed
• initiate emergency braking • activate alarm	failed

- proposed test conditions
  - *corresponding to common city traffic*
  - *convoy speed: 50 km/h*
  - *inter-vehicle distance: ca.10 m*

Non-destructive test examples (2)

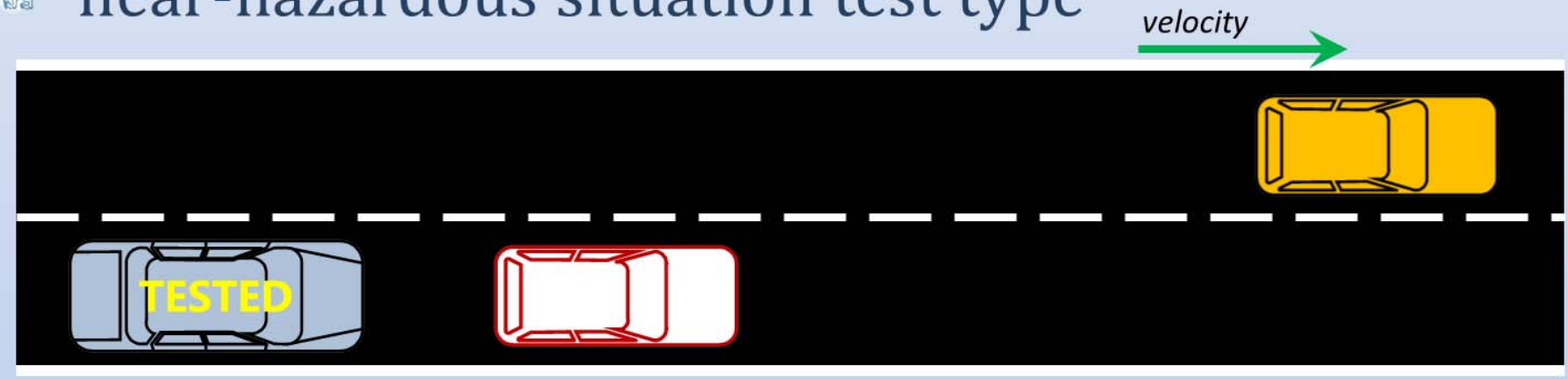
- near-hazardous situation test type



- proposed test conditions
  - *corresponding to common rural area traffic*
  - *convoy speed: 70 km/h*
  - *inter-vehicle distance: ca. 15 m*

Non-destructive test examples (2)

- near-hazardous situation test type



• avoid collision • do nothing	passed
• vehicle accelerates • vehicle decelerates faster than required	failed

- proposed test conditions
  - *corresponding to common rural area traffic*
  - *convoy speed: 70 km/h*
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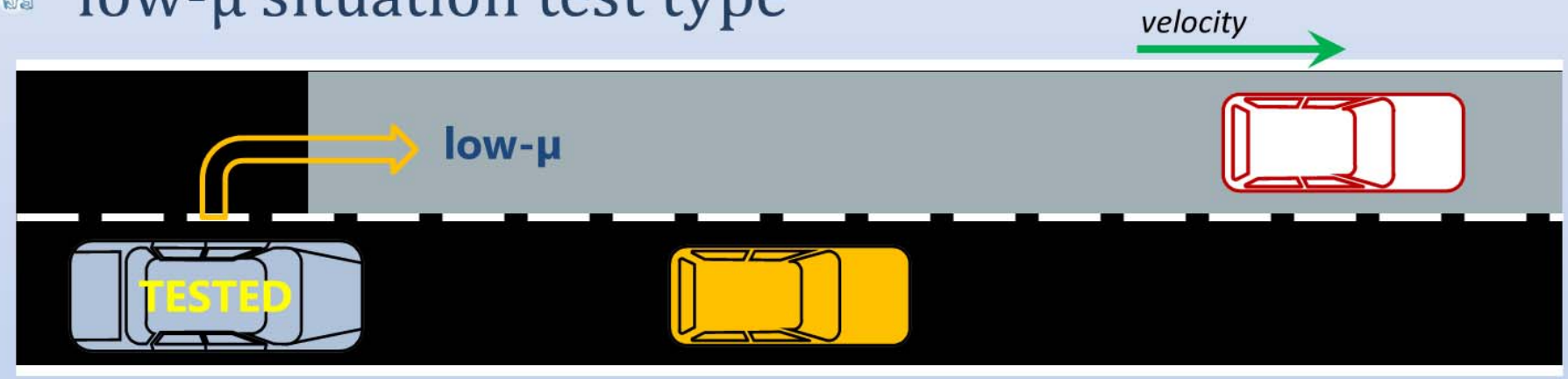
Non-destructive test examples (3)

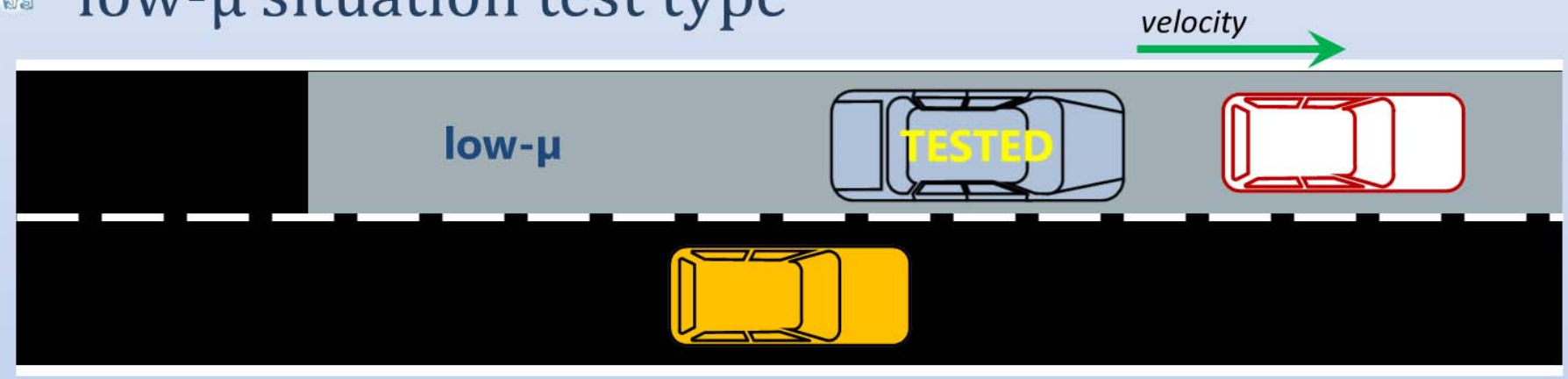
- low-μ situation test type



- proposed test conditions
  - *corresponding to common rural area traffic*
  - *vehicle speed difference: 20 km/h*
  - *initial inter-vehicle distance: 80 m*

Non-destructive test examples (3)

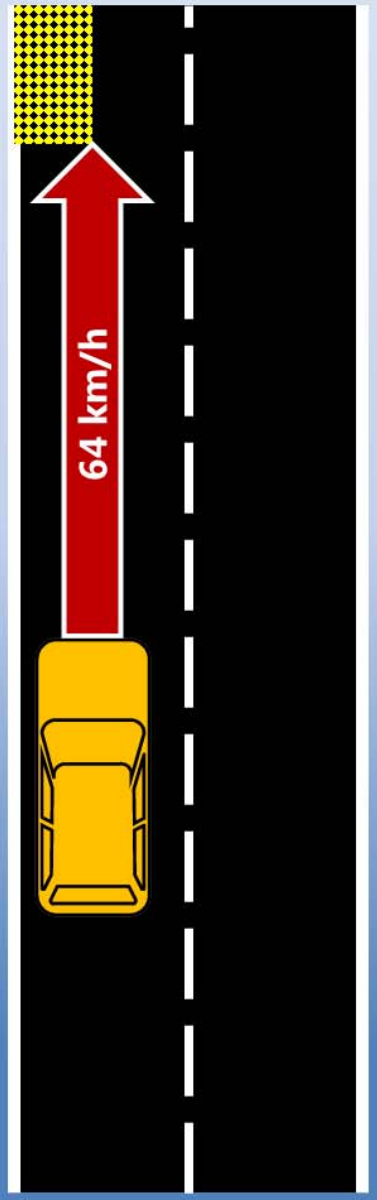
- low-μ situation test type



• adapt to low-μ conditions • avoid collision • do nothing	passed
• late reaction • late warning	failed

- proposed test conditions
  - *corresponding to common rural area traffic*
  - *vehicle speed difference: 20 km/h*
  - *initial inter-vehicle distance: 80 m*

Destructive test example



- *motivation:* passive safety systems can safe lives up to ca. 64 km/h, integrated safety should help at higher speeds
- comparative test
- frontal offset crash-test according to EuroNCAP
  - *integrated systems turned off*
    - starting speed 64 km/h
    - crash speed 64 km/h
  - *integrated systems turned on*
    - starting speed according to automatic emergency braking system specification
    - system set to "avoid by braking only" state
    - crash speed 64 km/h

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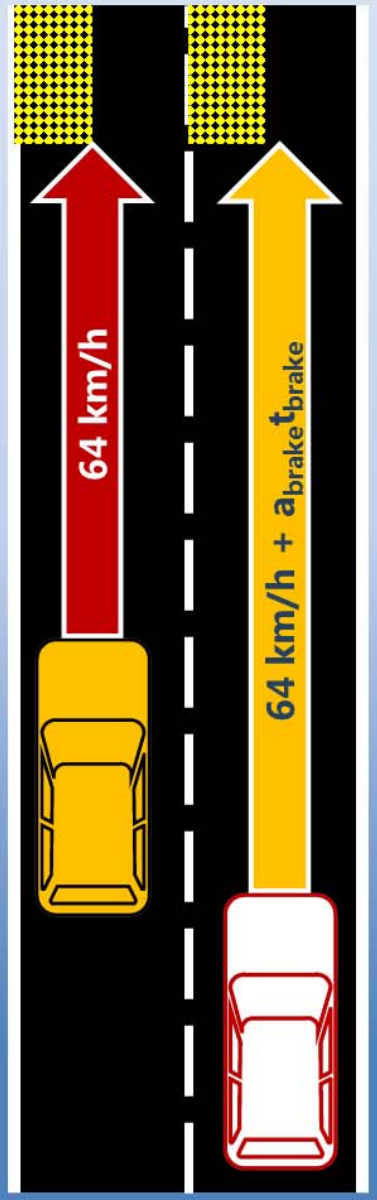

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Conclusion

- system functional separation provides less expensive testing with better results than system type separation
- functional approach allows to easily test false positives
- new approach does not require full car “infinite” test loops
- functional approach allows to define fail/pass criteria

Is investing into integrated safety systems more effective than periodical driver training?

contact

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