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# Automated simulation of scenarios to guide the development of a crosswind stabilization function

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# Motivation

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Ever growing complexity
of automotive controllers

How to validate and test?

- do more road tests ?
- write more test scripts ?

This does not scale well
Code size grows faster
New processes needed

- After initial coding you can expect one bug per 20 lines of code
- After thorough unit testing you can expect 1 bug per 1000 lines of code in the final release
  - 1 line ~5 bytes, so 1 bug per ~5KB

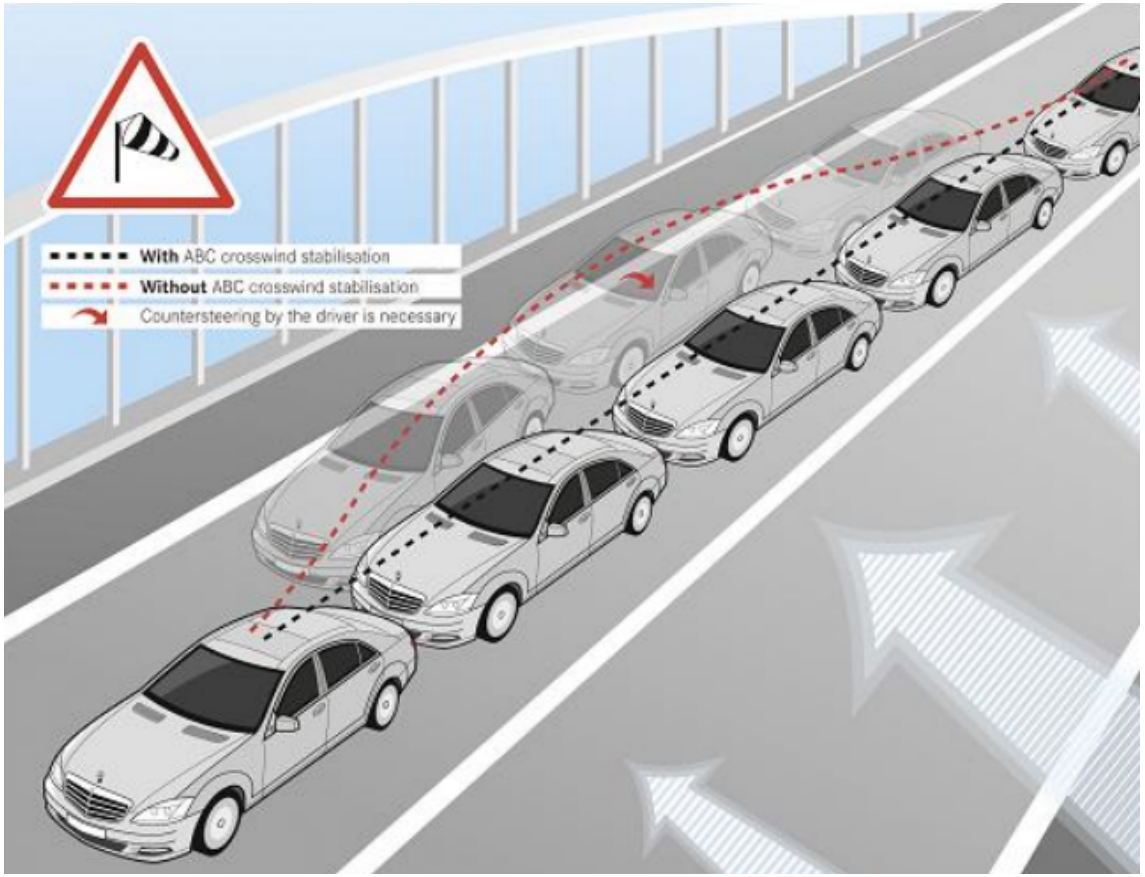
| Application | Code Size | Statistics |
|---|---|---|
| Steering Angle Sensor | 32KB | 7 Bugs |
| Low-end Sensor Cluster | 128KB | 26 Bugs |
| Airbag Controller | 256KB | 52 Bugs |
| EPS Controller | 512KB | 104 Bugs |
| Central Chassis Controller | 1.5MB | 308 Bugs |

source: presentation by Hans Adlkofer, Infineon, 2009

**Idea**

- increase degree of automation
- generate and evaluate useful test cases automatically

# Outline




- Motivation
- Principle of the scenario generator
- Validation of the crosswind stabilization function
  - the function
  - the validation setup
- Validation results and Conclusion

# TestWeaver: Scenario Generator

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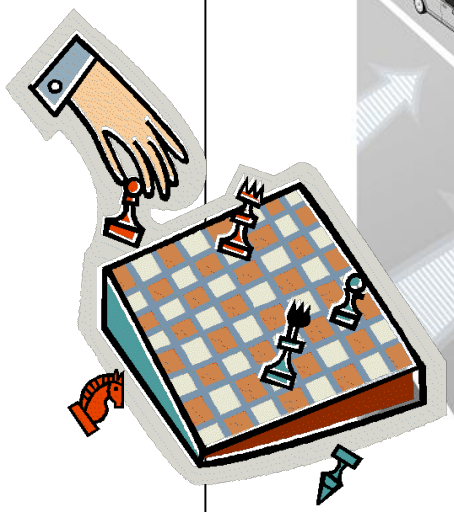
## Idea

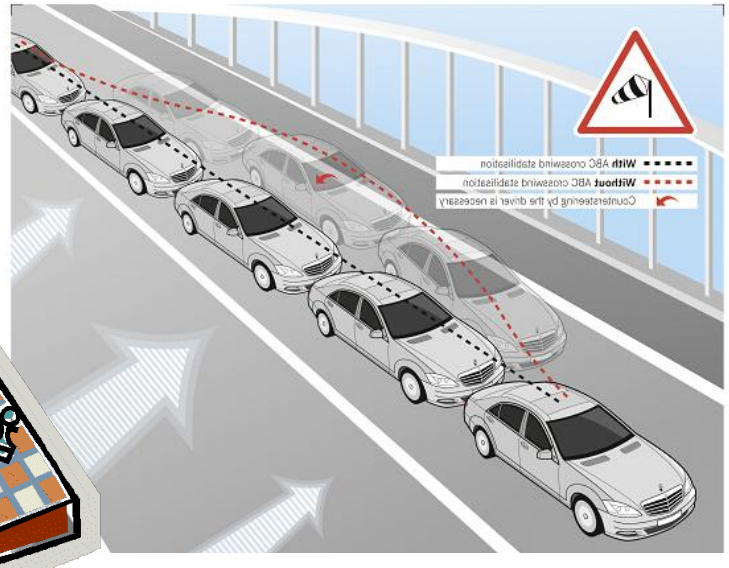
- intelligent generation of 1000s of differing test scenarios
- active attempt to:
  - maximize state coverage
  - drive the system in “difficult” situations

## Benefit

- high coverage
- low efforts for test specification

**Testing =**
**playing against (simulated) system**





# TestWeaver - Test Generation Strategy

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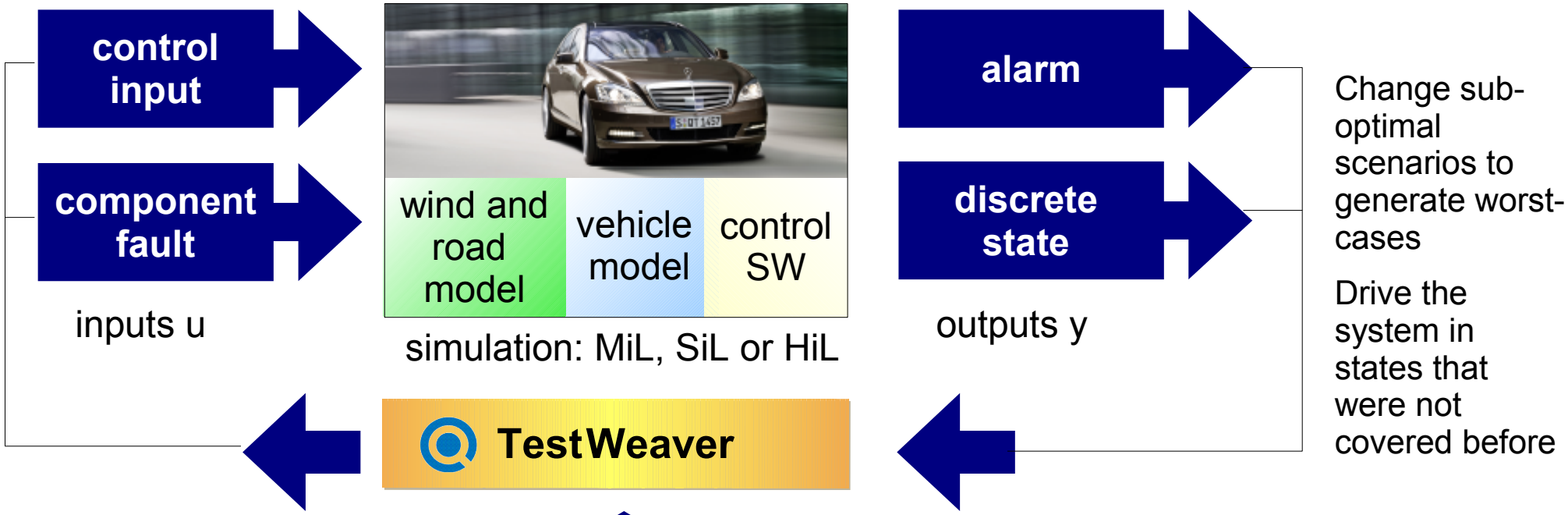
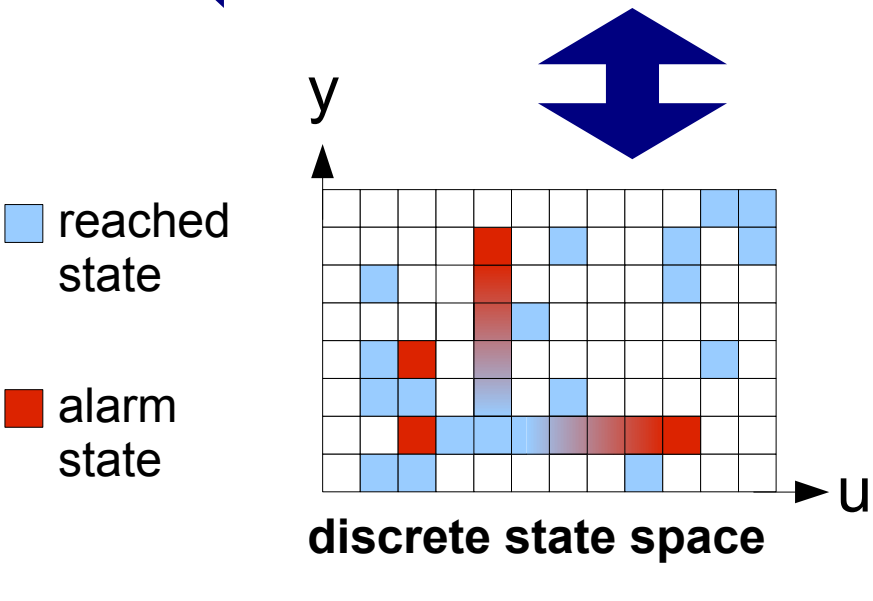
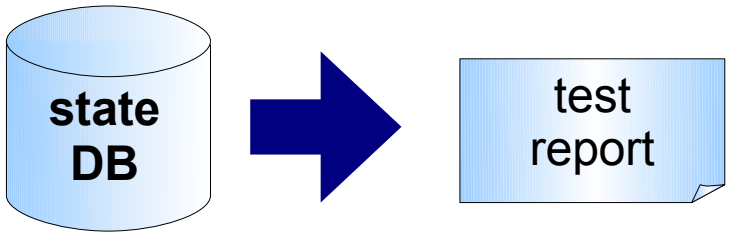



**Reactive scenario generation**
each scenario depends on history of generated scenarios

**All cases can be reproduced**



# TestWeaver - Test Generation Strategy

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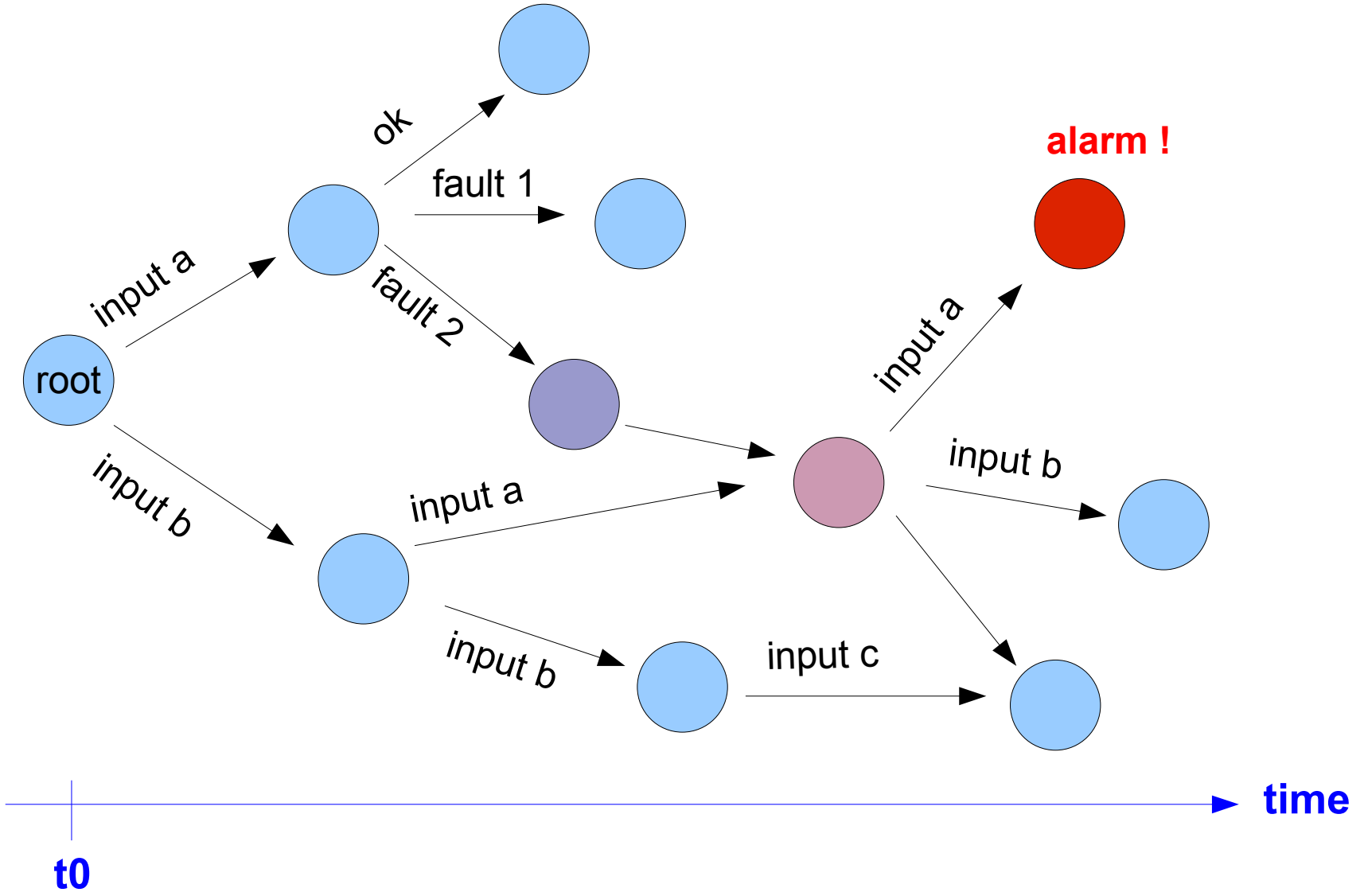

# The Crosswind Stabilization Function (CSF)

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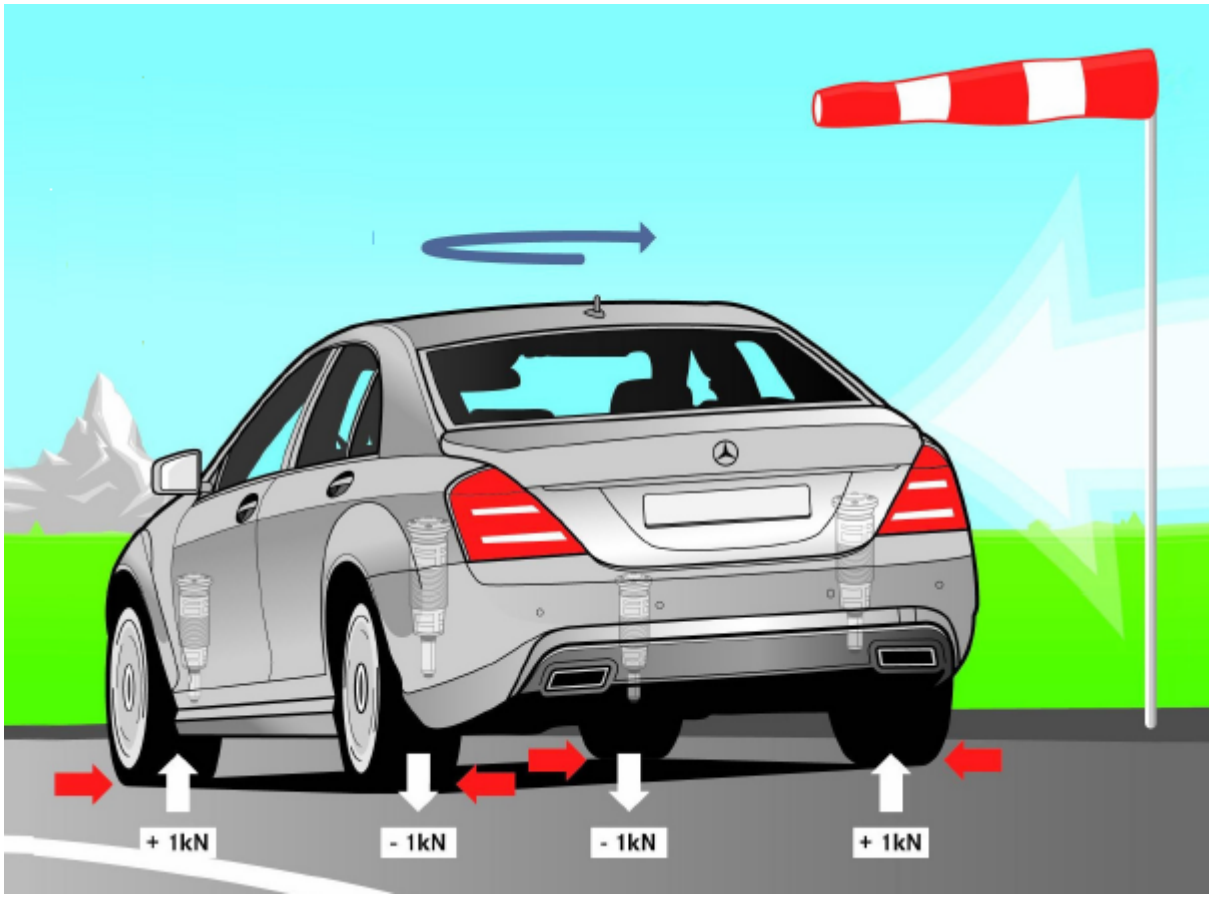


change of wheel load imposed by ABC (incl. CSF)

resulting lateral tire force

yaw to compensate the wind

# System model: vehicle with CSF

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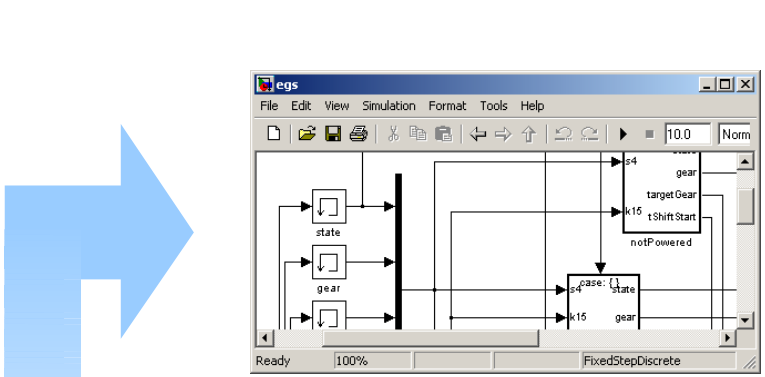
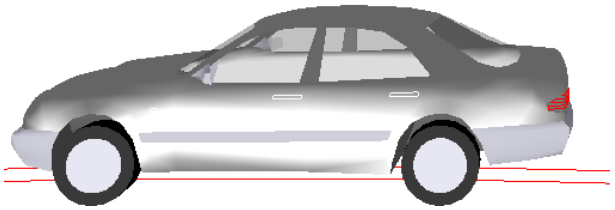



Matlab/Simulink



CASCaDE vehicle simulation

fast feedback

control SW

vehicle model

Silver

developer

virtual vehicle

# System model: Road and wind

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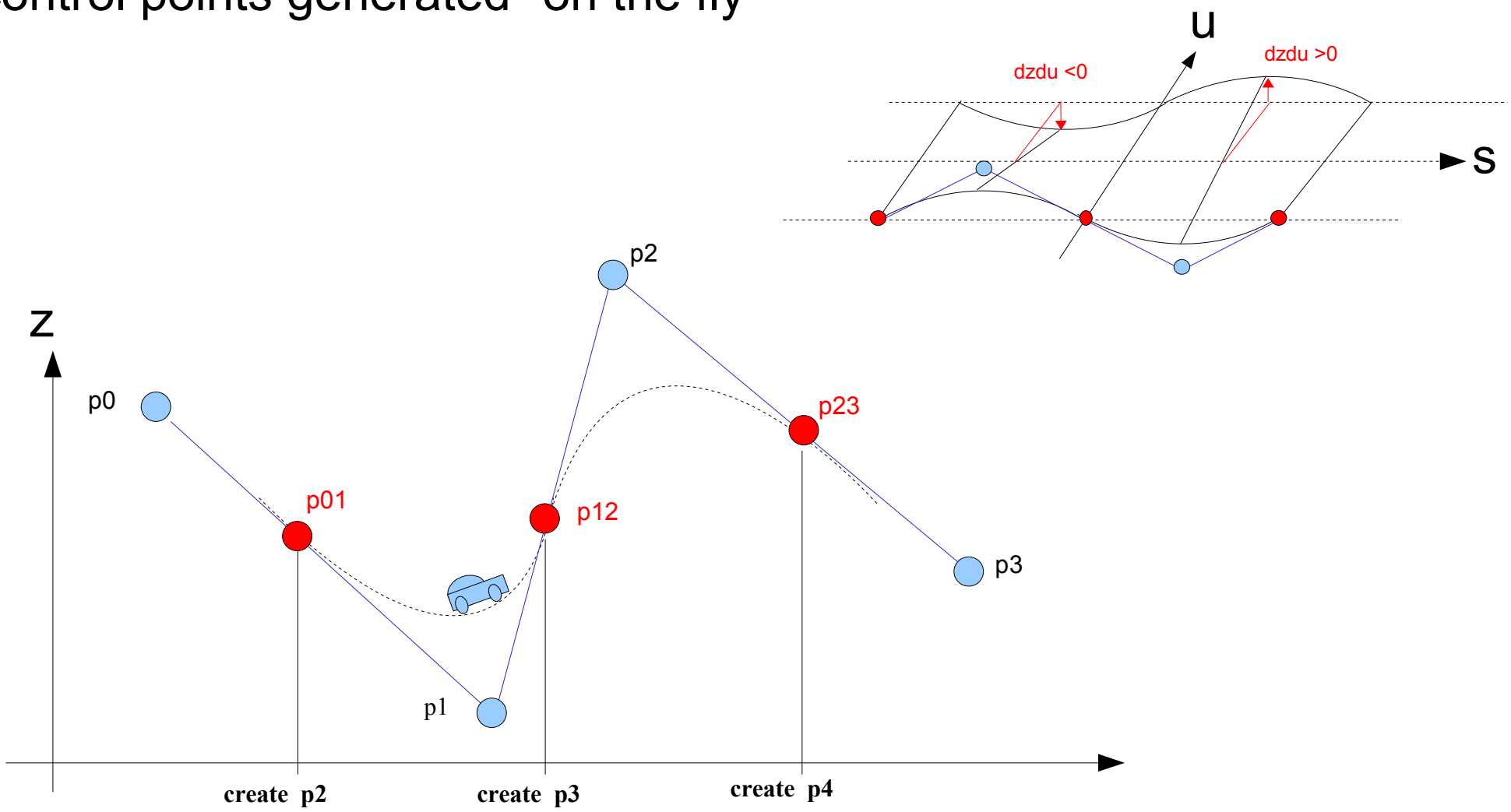
superposition of two bezier splines

control points generated "on the fly"



# Automated validation

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## Objective: Validation of the CSF safeguard function

- activate CSF only in case of strong crosswind
- active for at most 4 seconds
- not activated by uneveness of road, steering actions or wheel slip

developer

test report

TestWeaver

drive the virtual vehicle
generate road and wind
search for bad scenarios

control SW

vehicle model

wind and road model

Silver

TestWeaver instruments

# Validation results and Conclusion

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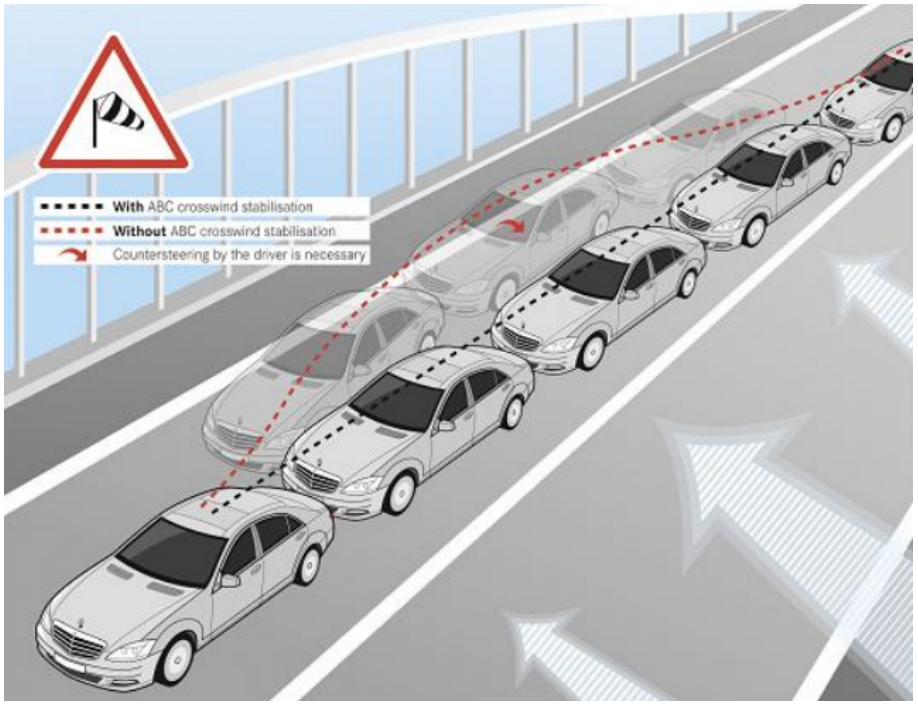
## Crosswind stabilisation

- generated and analyzed 100.000 different driving scenarios, each 45 sec. within 3 weeks
- Iterative improvement of the safeguarding function. See paper for details.
- Systematic fault injection, to validate fault tolerance




## Conclusion

- The presented approach seems extremely well suited for the validation of complex automotive controllers
- Main benefit:
  - high test coverage
  - with low work effort