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- BSc in EE, Karlstad 1995
- MSc in Applied Math. LiU 1999
- PhD in Control, Chalmers 2004
- Volvo Technology 2004 – 2008
 - EPAS control at VCC
 - Friction estimation at VCC and Volvo Trucks
- VTI, vehicle technology 2008 –
 - Vehicle, active safety and tire test development
 - Friction estimation, vehicle modeling
- Chalmers, vehicle dynamics, 2011–
 - Modeling of vehicle disturbances (aerodynamics)
 - Vehicle state estimation
 - Driving simulator motion cueing, surface characterization

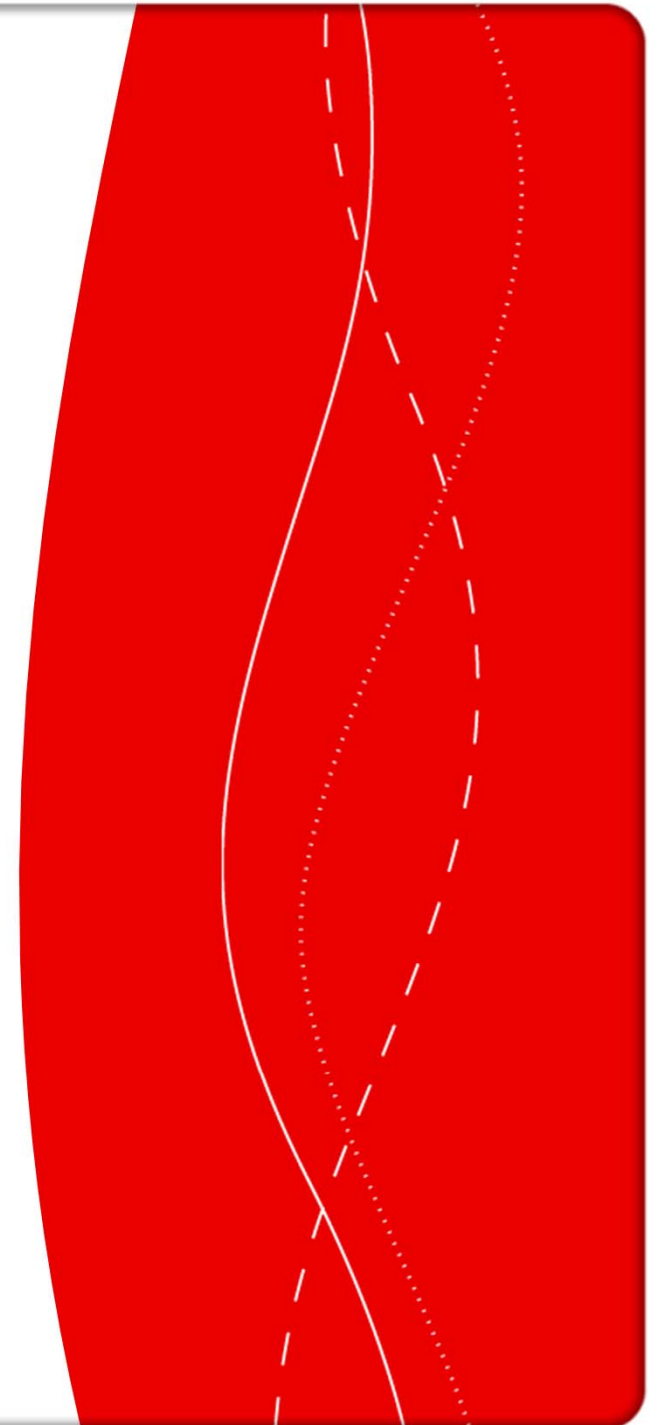




System performance testing in vehicle dynamics

-- with or without the driver?

Fredrik Bruzelius



Agenda

- What is *Performance Testing* in vehicle dynamics context, what is its usage and how does it relate to *Development Testing*?
- *How does the driver fit into performance testing?*
- *Some projects dealing with related topics*
- *Concluding remarks*

Performance testing

From Wikipedia:

“A performance test is an assessment that requires an examinee to actually perform a task or activity ...”

“The purpose is to ensure greater fidelity to what is being tested....”



Performance testing in vehicle dynamics

- Measuring the performance of a vehicle in a vehicle dynamics context have many stakeholders
- **Legislators** to base laws and legislations
- **End customer testing institutes and organizations** (e.g. NCAP) for consumer guidance
- **Product producers** (OEMs, suppliers etc.) for monitoring, awareness, follow legislations etc. etc.

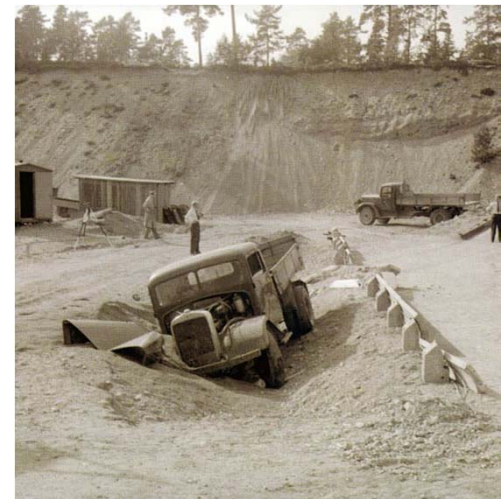


Development testing in vehicle dynamics

- Wikipedia (for software)

“Development Testing is a software development process that involves synchronized application of a broad spectrum of defect prevention and detection strategies in order to reduce software development risks, time, and costs.”

- The main purpose is to understand rather than rating
- Understanding mechanisms in the design etc.
- Eliminating errors
- Find weak points
- etc



Requirements and properties

Performance testing

- High *repeatability*
- High *reproducibility*
- A *measure* (a real scalar value) is often used to quantify the performance
- Practical feasibility w.r.t.
 - Time consumption,
 - Spacing,
 - Cost
 - Required equipment
 - Required training
 - Etc. etc.

Development testing

- Ensure confident answers to a posed questions, e.g. “*is my design robust to ...?*” Or “*is there any bugs in my algorithm?*”
- Reconsiderations along the way, i.e. repeatability and reproducibility are typically not issues
- Practical feasibility considering the posed question w.r.t.
 - Time consumption,
 - Spacing,
 - Cost
 - Required equipment
 - Required training
 - Etc. etc.

How does the driver fit into this picture?

Performance testing

- Variations in human behavior *opposes* repeatability
- Variations between humans *opposes* reproducibility
- The need for large sets of test subjects to remedy repeatability and reproducibility *opposes* practical feasibility

Development testing

- Variations in human behavior and in between humans might be considered a prerequisite in some case (product xx should work for most people etc. ...)
- The need for large sets of test subjects *opposes* practical feasibility
- The underlying objective of generality (e.g. “*does it work for most drivers...?*”) *opposes* practical feasibility

Can we live without the driver in the context of Performance testing?

- We cannot ignore the fact that vehicles are driven by a physical non-perfect person.
- The function or feature of the vehicle most often depends on the drivers response (e.g. Tires, ABS, ESC, EBA, etc etc)
- The response of one driver might not be representative for another driver. We need to ensure e.g. safety to at least a majority.
- The increase of complexity makes it harder and harder to “separate the driver from the vehicle”
- The situation becomes even worse when put into a larger context with other drivers and vehicles in a traffic environment

⇒ **No, we cannot really exclude the driver here!**



Illustrating example: ABS

- The Anti-lock braking system (ABS) is nowadays widely accepted for its function
- A large variety of ABS tests have been developed, not considering the driver response (open loop tests)
- It is a commonly known reaction of many drivers to decrease the pedal pressure when ABS is intervening
- This affect the braking performance radically
- In the future, with more complex functions, the driver interaction will not be as simple as this one!



Outlook: some projects in the “neighborhood”

eVALUE Testing and Evaluation Methods for Active Vehicle Safety

- An EU framework 7 project, ended 2010
- Swedish partners: SP, AB Volvo and VTI
- The main objective was to define objective methods for the assessment of active safety systems (Performance testing)
- “Pioneer” project with the philosophy of system testing in a scenario setting (holistic perspective of the vehicle)
- Did not tackle the driver interaction issues



Outlook: some projects in the “neighborhood”

ASSESS Assessment of Integrated Vehicle Safety Systems for improved vehicle safety

- An ongoing EU project
- Swedish partners: Chalmers (SAFER)
- Project goal to develop harmonized and standardized assessment procedures and related tools for selected integrated safety systems
- An initial step towards incorporation of human response into performance testing is included in the project, no driver modeling though



Outlook: some projects in the “neighborhood”

ITERATE IT for Error Remediation And Trapping Emergencies

- An EU framework 7 project, ended in 2012
- Swedish partners: Chalmers and VTI (coordinator)
- The objective of ITERATE was to develop and validate a unified model of driver behavior (UMD) and driver interaction with innovation technologies in emergency situations.
- Parameterized driver models (driving skills etc) was developed, but not with a focus on the application of testing.



IT for Error Remediation And Trapping Emergencies



SEVENTH FRAMEWORK
PROGRAMME

vti

Outlook: some projects in the “neighborhood”

FFI Next Generation Test Method for Active Safety Systems

- An ongoing FFI project
- Partners: Volvo (coord), VCC, Autoliv, SP, VTI, Chalmers & Högskolan i Halmstad
- The aim is efficient active safety function verification and validation through consistent methods and tools.
- Focus on tools, methods and equipment development, but with a development testing scope in mind



Outlook: some projects in the “neighborhood”

FFI iCOMSA Correlation of Objective Measures and Subjective Assessments: efficient vehicle dynamics evaluation and new intelligent concepts

- A just started FFI project
- Partners: VCC & KTH
- Aims to find methods connect Objective Measures (from vehicle data) and Subjective Assessments (from driver rating) to support and make testing more efficient
- Focus on development testing, but with a driver model like approach

Outlook: some projects in the “neighborhood”

FFI Quadra QUANTITATIVE DRIVER BEHAVIOR MODELING FOR ACTIVE SAFETY ASSESSMENT

- An ongoing FFI project
- Partners: AB Volvo, Volvo Car Corporation, VTI, Chalmers
- The objective is to develop models of driver behavior with the purpose of evaluating, verifying and/or tuning active safety systems.
- The focus is not what we defined here as performance testing, but still “close” to answer the raised questions

Concluding remarks

- No project (in Sweden at least) is dealing with these issues explicitly
- To increase the fidelity of vehicle dynamics system performance testing we need to start incorporate the drivers response to a larger extent!
- Ideally we would like to have a driver model that
 - we can use to perform Performance Testing in an time and cost efficient manner using e.g. driving robots
 - ensures repeatability and reproducibility
 - is parameterized in different behaviors in a smart way to cover the variety of human responses
 - can handle the variety of technologies for one specific function or feature
- We need more research on driver models and specifically driver models in a performance testing context



Tank you for your attention!
Questions?