Future Role of Safety Testing Technology in Vehicle Design and Development and Highway Safety

Professor Cing-Dao Kan

Wednesday, October 28, 2015

GEORGE MASON UNIVERSITY

Center for Collision Safety and Analysis CCSA

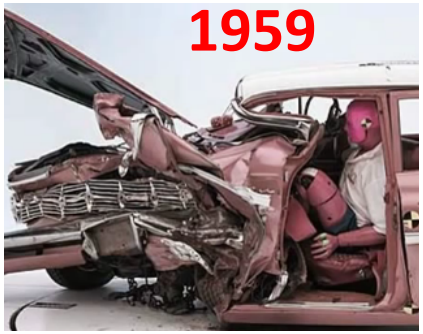
Overview

- Full scale vehicle crash testing
- Organizational aspects
- Sled testing
- Component testing
- Interior & pedestrian safety testing
- Anthropomorphic test devices (“dummies")
- Testing and simulation

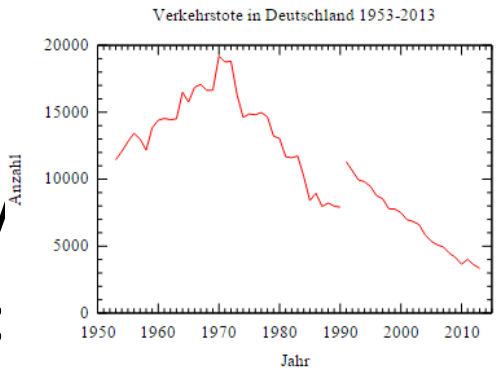
Crash test - history

- 1934: First barrier crash test by GM
- 1959: First crash test at Mercedes Benz
- 1979: NHTSA begins crash testing
- 1997: Euro NCAP's first results released
- 2006: China NCAP

Crashworthiness then and now



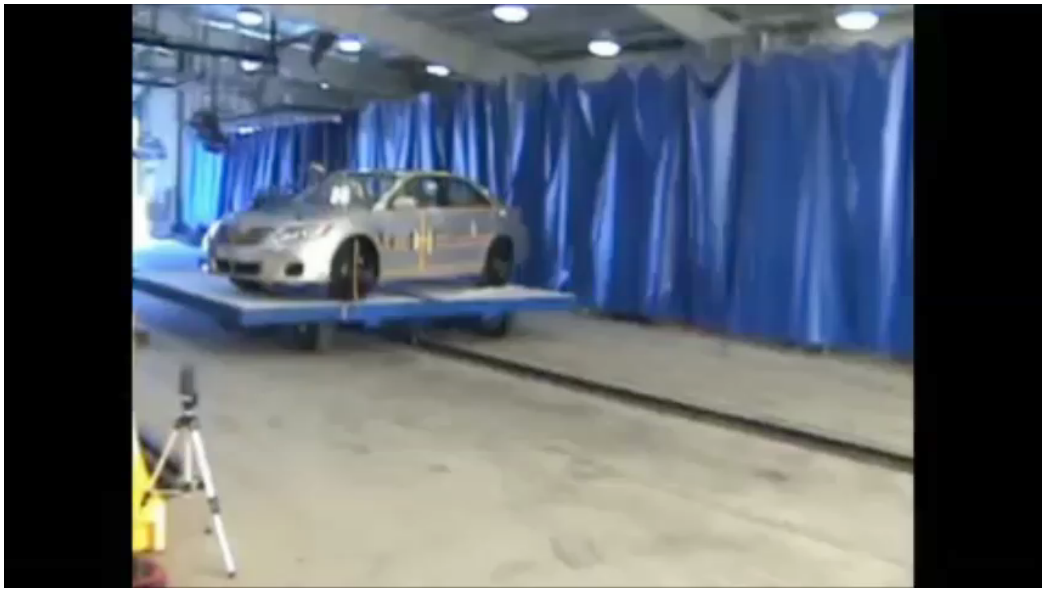
- Fatalities in Germany 1950-2010:



- 1950's: ~ 6 deaths per 100 million miles traveled in US
- 2009: ~ 1 death per 100 million miles traveled in US

Side Impact – e.g. Oblique Pole Test

- "Flying Floor"
- Pre-test preparations
- "Impact point pin"
- "Retaining bands"
- Camera positioning
- Sensor technique
- 50% male and 5% female front occupants



Quasi-static roof strength tests

- FMVSS 216
  (2 sides, 5 inch)
- IIHS test
  (1 side, 10inch)

Frontal – IIHS Small Overlap Impact

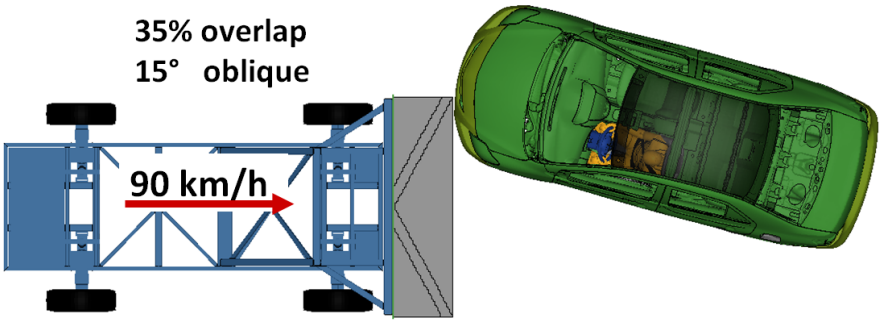
- 25 % overlap
- 40mph
- since 2012

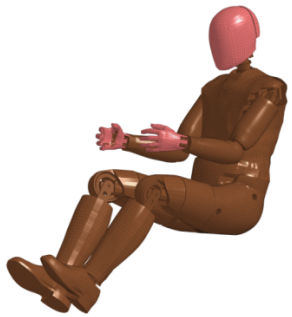
Additional test configurations

- Internal tests
- Real world safety
- Sensor tests
- Rear seat occupant
- Compatibility tests
- Future ratings
- Future regulation

Future test – Oblique Impact

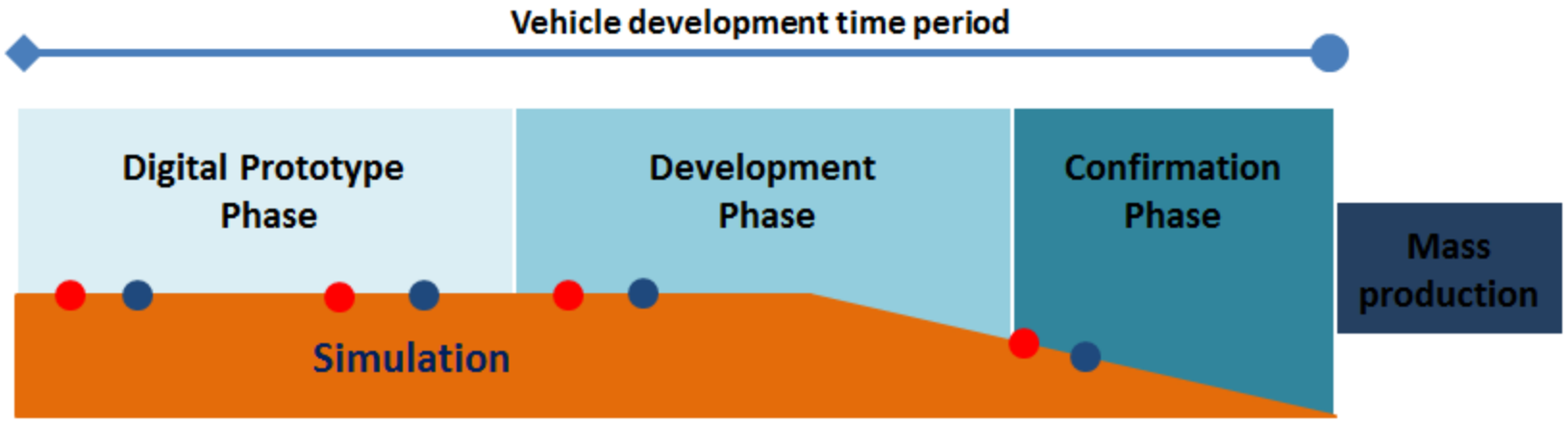
- Configuration not final
- Activities in Europe and US
- New barrier
- New load paths, kinematics
- New dummy





THOR

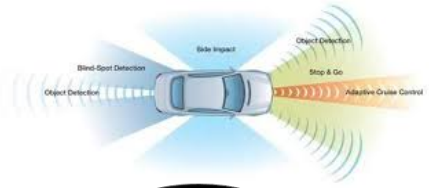
Vehicle development process

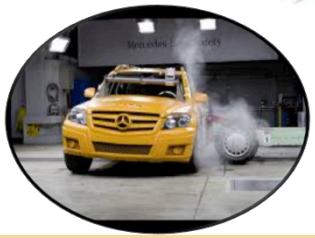


- Typically 3-4 years
- Can be shorter for derivatives
- Little or no testing in digital prototype phase

Vehicle functions

- Noise & Vibration Analysis
- Fatigue & Endurance strength
- Aerodynamics Analysis
- Fuel Consumption Analysis
- Vehicle Dynamics
- Active Safety
- …
- **Passive Safety**





OEM - internal interactions

Testing
(full scale, sled, subsystem, component)

Simulation
(vehicle structure, occupant, pedestrian)

Accident Research
(Onsite Investigations, Database Analyses)

Design/Project
(project management, styling packaging, cost, weight..)

Challenges for testing

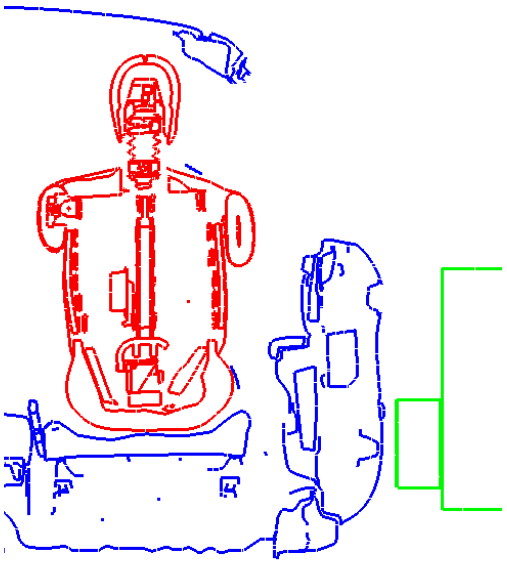
- Increasing number of vehicle platforms and derivatives
- Increasing number of requirements
- Stringent development plans
- Parallel setup and performance of tests
- Set priorities which test is necessary (which other tests are being covered, which can be skipped)
- Highly qualified personnel of different expertise: …
- Well organized processes (parts, setup, sensor, post-processing, pictures, filming …)

Necessity of sled testing

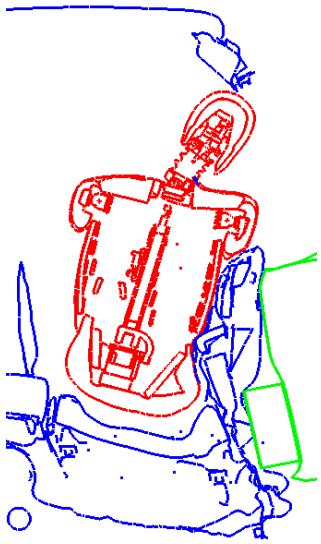
- Very realistic & efficient for load cases with little intrusion
- Complex load cases (e.g. side pole) require more validation & upfront sled setup
- Multiple use of sled with prototype/ predecessor interior
- Simulation (more realistic vehicle & intrusion behavior) and sled test (realistic restraint system hardware characteristics) complement each other
- Many tests with fast adaption (airbag folding ..) possible
- Very important (due to reduced & late full scale testing)

Sled test boundary conditions

- Vehicle pulse from testing
  (early prototype or predecessor)
- From simulation
- Intrusion profile
- Timing
- Tilting angle



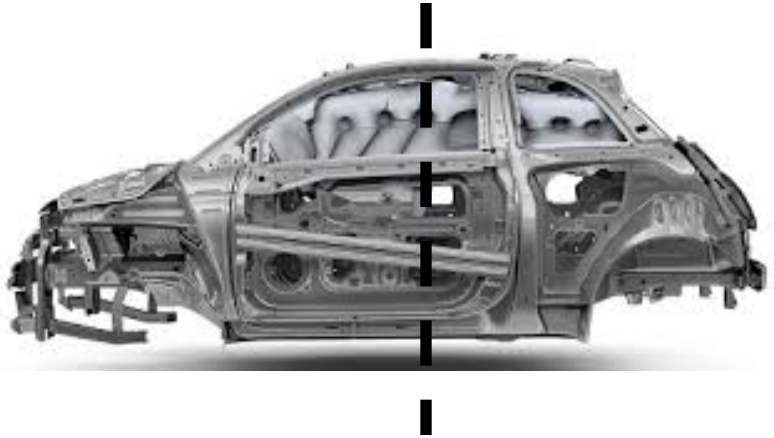
t=0ms



t=20, 40 ..ms

Sled test devices

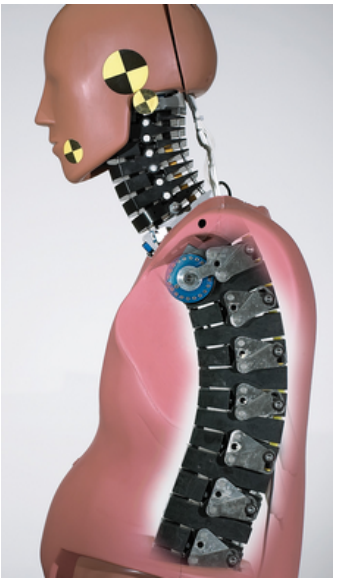
- Frontal impact sled
- Sled with pitching
- Side barrier sled on sled
- Side pole test:



1) full vehicle body in white structure on sled
2) sled with predefined hinges, pre-deformed structure (developed using simulation)

Rear impact - Whiplash

- BioRID
- EuroNCAP
- IIHS



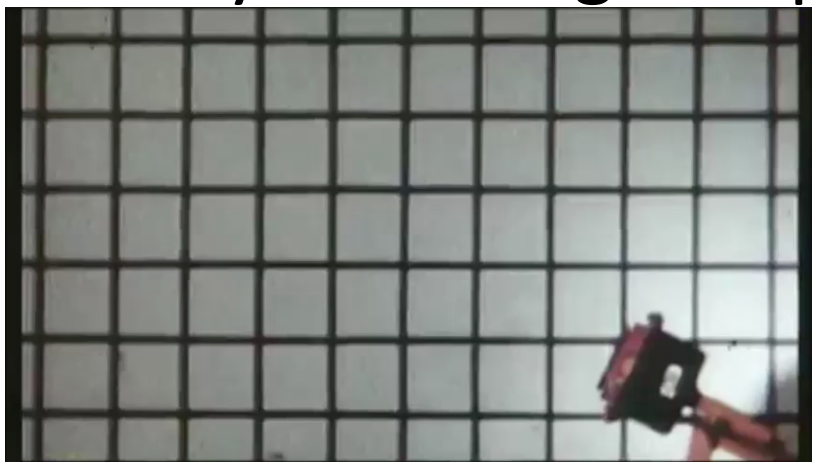
- Precise seating procedure
- Cooperation with seat manufacturer

Advanced sled testing system

- Multiple intrusion profiles/pulses
- Capture complex intrusions
- Principle testing
- Evaluate injury mechanisms

Restraint components then & now

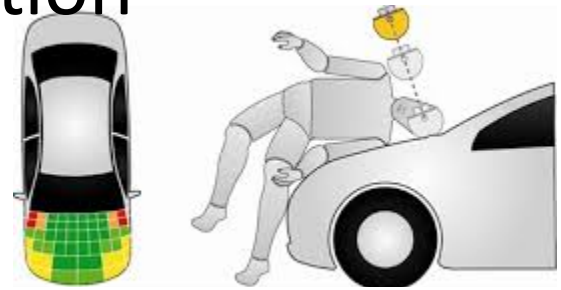
- 1958: Volvo invents 3-point seat belt
- 1971: Airbag patented by Mercedes
- 1980: Airbag in production (S-Class)
- Today: xx airbags & optimized restraints

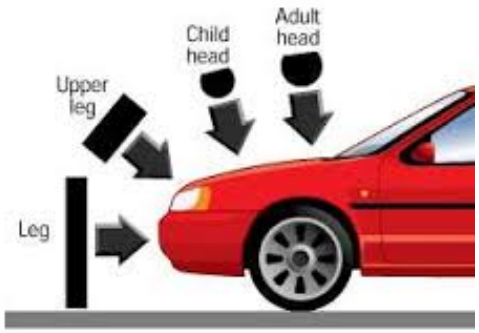


Pedestrian safety & Interior impact

- FMVSS 201u: upper interior head impact protection requirement since 1995 (US)

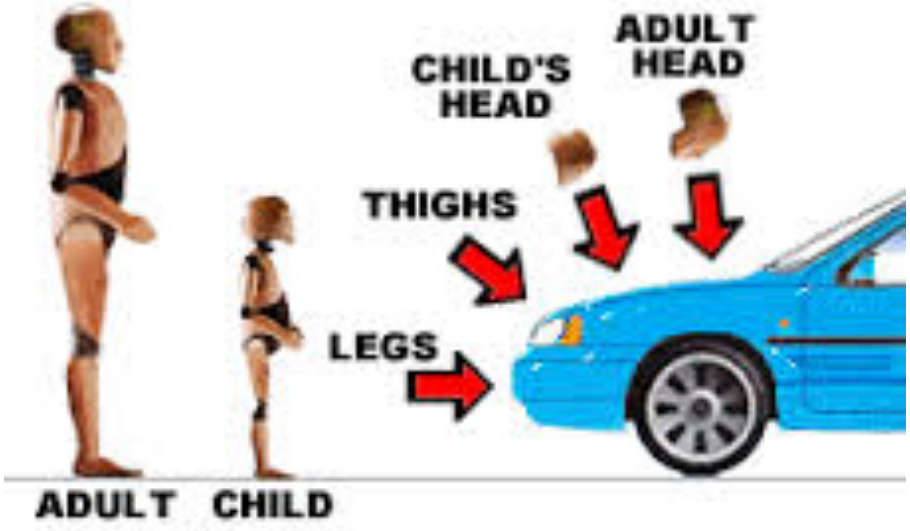
- Pedestrian protection requirements (Euro NCAP)





Pedestrian safety (Euro NCAP)

- Head impact
- Leg impact
- Adult
- Child
- Interdisciplinary teams
  (testing, simulation, packaging, styling)

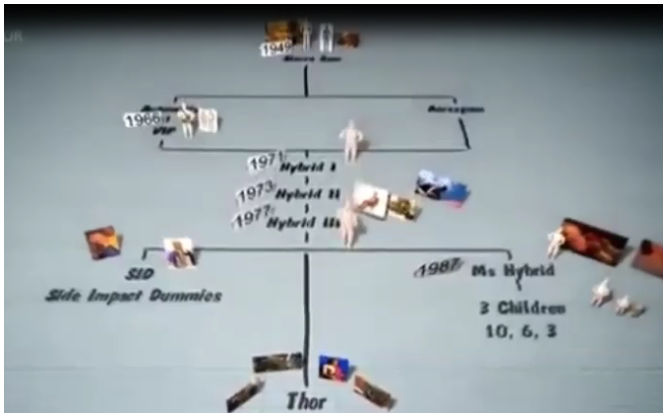


Pedestrian safety - Countermeasures

- Active systems
- Passive systems
- Affects styling
- Affects Packaging

Dummy historical

- 1947 - .. John P Stapp
- 1949: Sierra Sam
- 1966: VIP
- 1971: Hybrid I
- 1973: Hybrid II
- 1977: Hybrid III
- 1987: Hybrid III 5%
- ???: THOR?

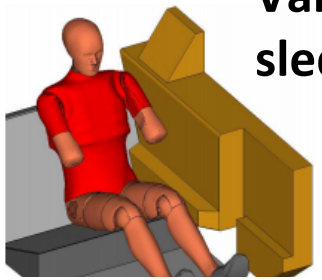


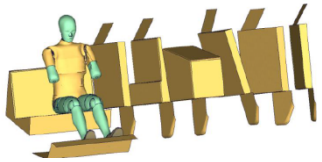
Examples of current & future dummies

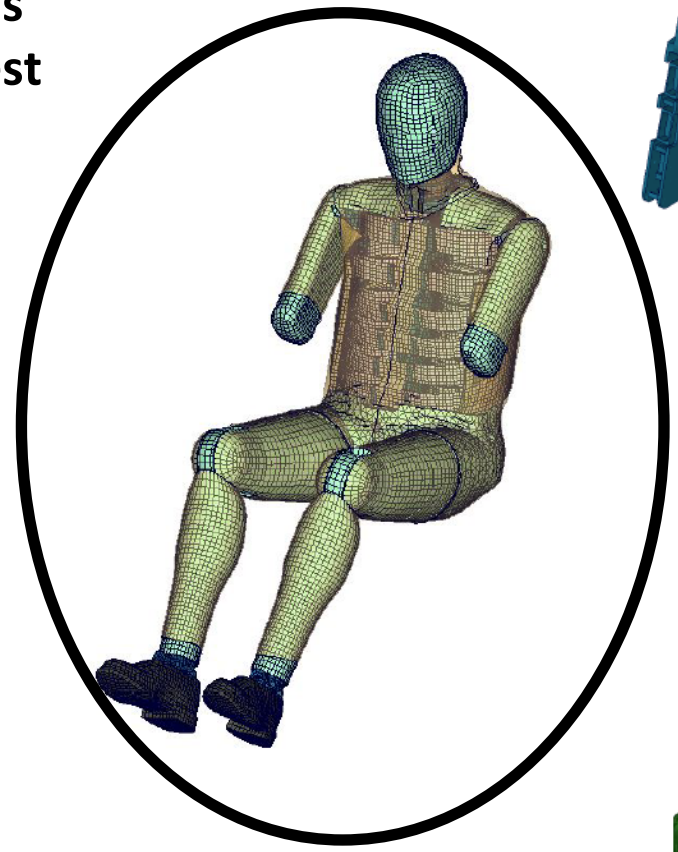
- SID2s: 5th percentile female
- BioRID: rear impact, whiplash
- WorldSID 50% (EuroNCAP 2015)
- WorldSID 5% under development
- Child dummies Q6 & Q10
  used by EuroNCAP (2015)
- THOR 50th & 5th percentile

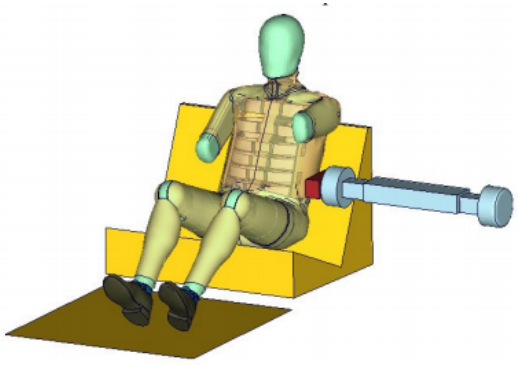
Example – Dummy model development

Various sled test

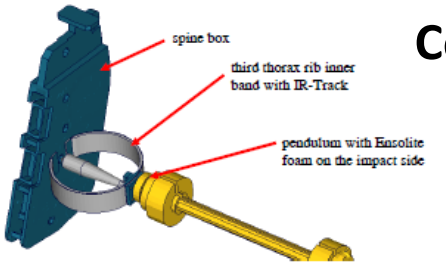








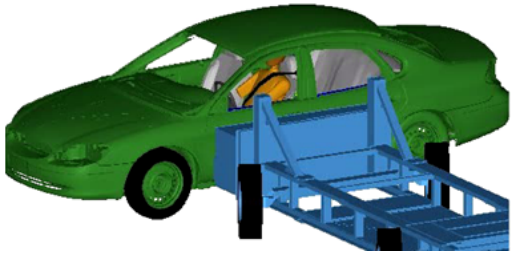
Full dummy tests



Component tests

Material tests

Full scale tests



FAT Dummy development process

Test results
Feedback from full vehicle test& simulation

Mercedes-Benz

Audi

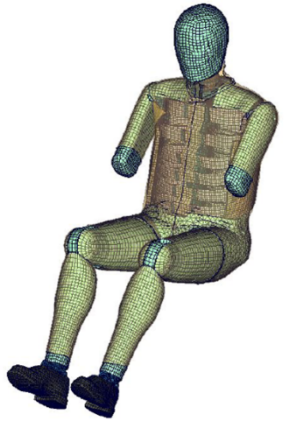
PORSCHE

German Association for Research on Automobile-Technique (FAT)/PDB

e.g.

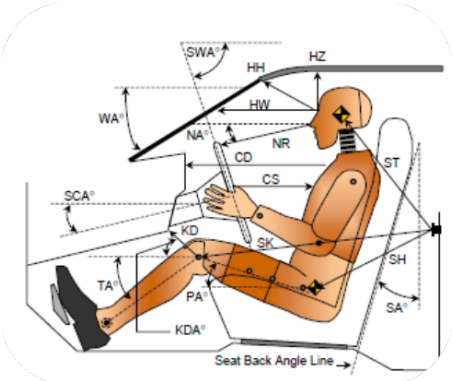
DYNA MORE

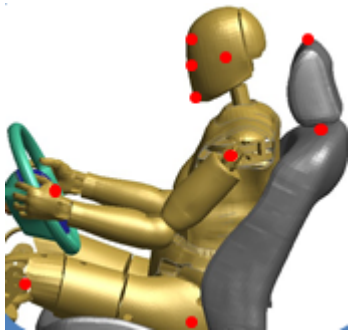
Simulation model
Different codes
Updates



Dummy positioning

- Seat position
- H-Point Manikin
- Defined distances
- xyz-coordinates





“Climate room”

- Ensure right temperature
- Injury criteria can be temperature dependent
- Some criteria more sensitive than others

Available Dummy Models

- Frontal dummies
- Side impact dummies
- Rear impact dummies
- Child dummies
- Different sizes
- Variations (US – Europe)

Future frontal dummy?

- THOR: Test device for Human Occupant Restraint
- Better biofidelity than Hybrid III
- 4 point thoracic injury evaluation
- Instrumented legs and face
- 5th percentile: under development
- Activities and plans to be used in Europe & US
- Development for 50th percentile is advanced

Simulation then and now

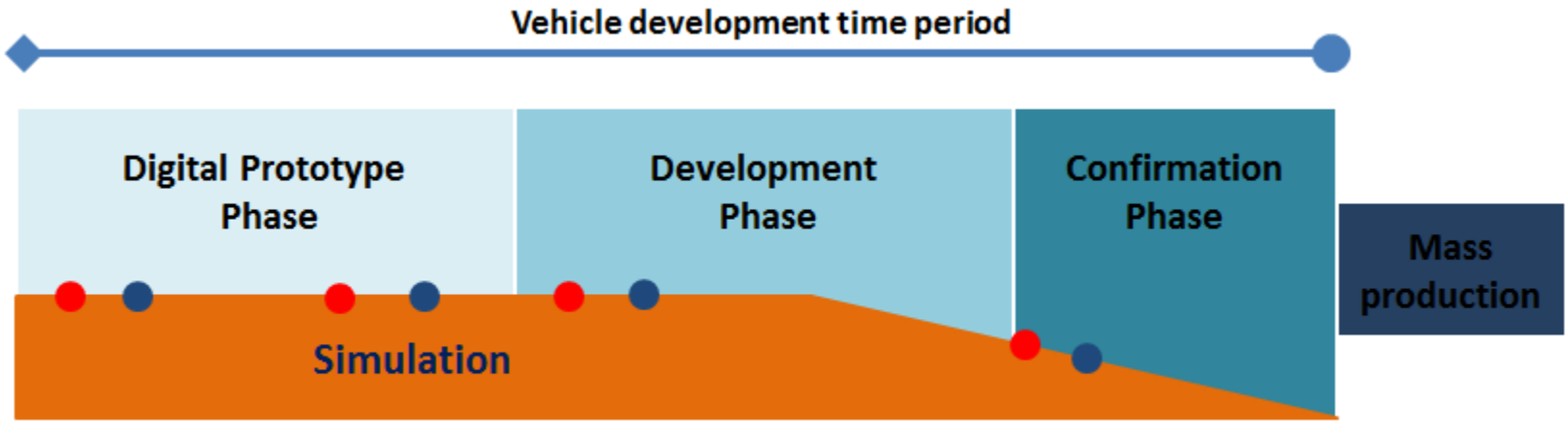
- **Simulation "yesterday":**
- Coarse meshes, structure only
- Separate rigid body models
- No component models from suppliers
- "Nice to have", development relied on testing

- **Simulation today:**
- Detailed models (~ 6 million finite elements for fully integrated model)
- "Not without" Major contribution in development

Simulation & testing organizational

- Testing & simulation work hand in hand
- Development engineers familiar with both areas
- Testing engineers can judge simulation results
- CAE-engineers are integrated in testing tasks
- Some areas “merged test & simulation”, e.g. FMVSS201, Pedestrian safety, occupant safety
- Full scale vehicle & occupant simulation at OEM
- Sled test & simulation at OEM and system supplier
- Component test & simulation (airbags, trim ..) at supplier

Vehicle development process

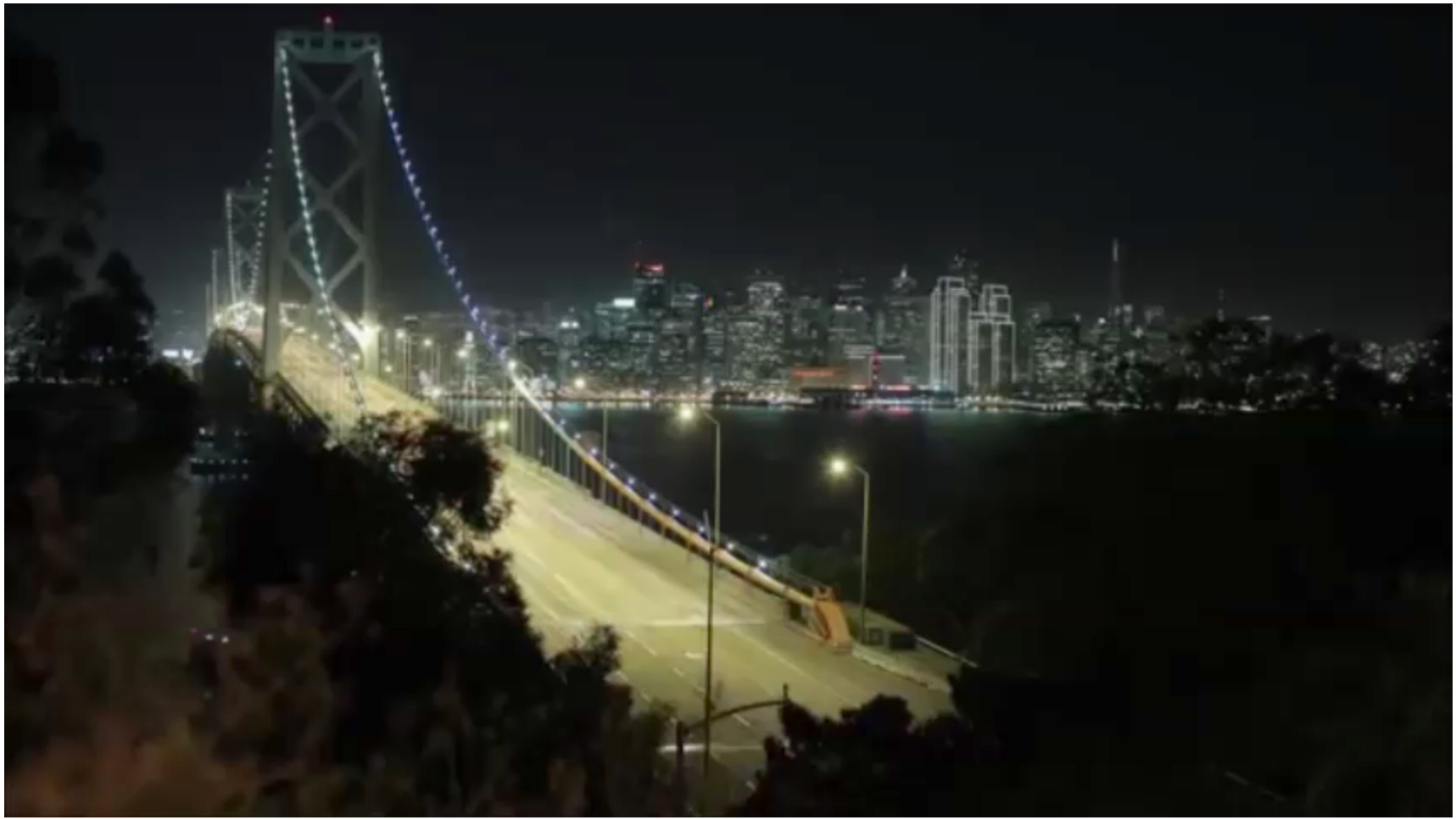


- Typically 3-4 years
- Can be shorter for derivatives
- Little or no testing in digital prototype phase
- Early phase more simulation dominated, later phase more test dominated

Future test & simulation

- **Test & Simulation work "hand in hand"**
- **Complementary use of test & simulation results**
- **Test of standard load case, Simulation of variations**
- **Passing of certain regulations through virtual testing (simulation)**
- **Simulation will not replace testing but gives additional answers**

Will we still need all this in the future?



Thank you

for

your attention!