New Applications for Vehicle Dynamic Simulation

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Background

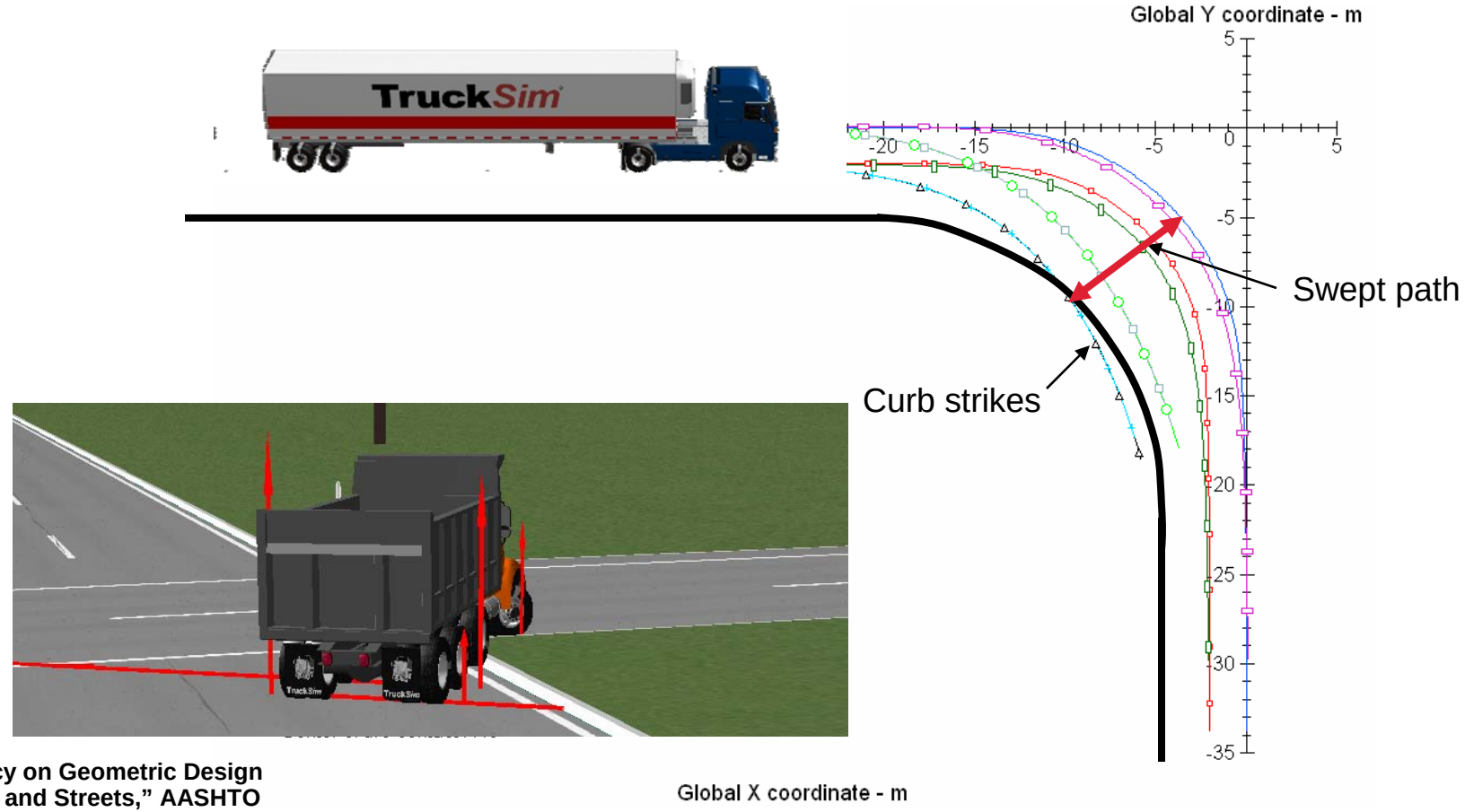
- Vehicle dynamics simulation tools are generally designed:
  - By automotive engineers
  - For automotive engineers
- Vehicle simulation has utility to other communities
  - Highway designers (geometry and pavement structures)
  - Regulators responsible for Road Use Laws and safety standards
  - Military equipment developers
  - Researchers
  - Accident reconstructionists
- Over the past years Car*Sim* and Truck*Sim* have been employed in many of these “outside the box” applications

Application Areas

- Trucking
  - Road compatibility (off-tracking, dynamic loads)
  - Performance Based Standards
  - Rollover
- Military vehicles
  - Tank model (Helmut Schmidt)
  - Stryker performance
  - Crusher development
- Research in Vehicle Control Systems
- Accident Reconstruction

Highway Design: Geometry

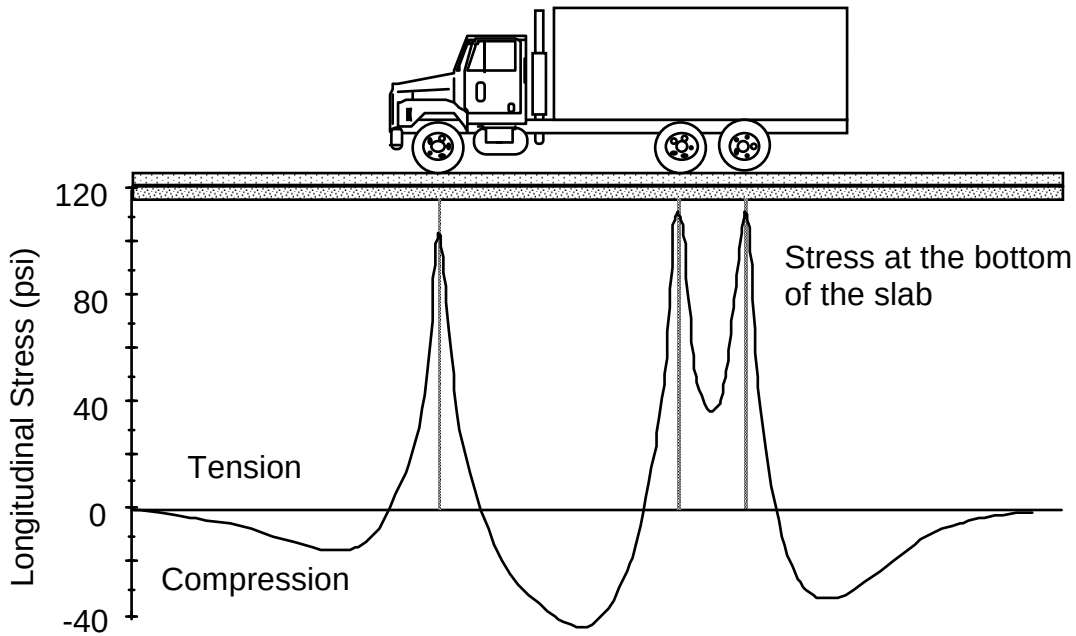
- Truck dimensions must be regulated for compatibility with road geometry
- Intersection right turn is typical example of a critical maneuver in U.S.
- Truck*Sim* provides an easy method for test



Ref: "A Policy on Geometric Design of Highways and Streets," AASHTO

Highway Design: Pavement Structures

- Stresses from truck wheels damage pavement, limiting life
- Which truck characteristics cause the most damage?
  - Number of axles
  - Axle loads
  - Suspensions type
  - Road roughness
  - Tires
  - Etc.

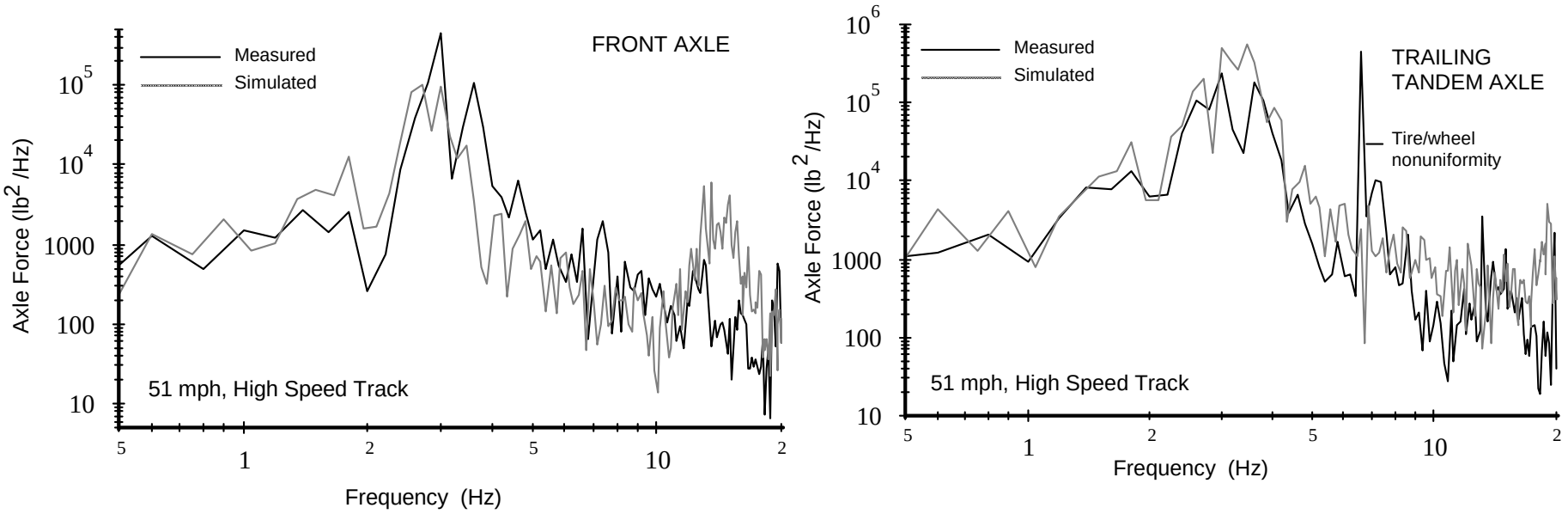


Stress in a concrete pavement from a 3-axle truck

Ref: NCHRP 353, "Effects of Heavy Vehicle Characteristics on Pavement Response and Performance"

Highway Design: Dynamic Loads

- Solution: Simulate trucks causing road damage
- Truck*Sim* models were validated for predicting wheel loads on roads with measured roughness profiles

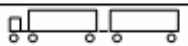
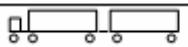
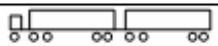


Power spectral densities of axle force at 51 mph on the PACCAR test track.

Ref: NCHRP 353, "Effects of Heavy Vehicle Characteristics on Pavement Response and Performance"

Highway Design: Truck Configurations

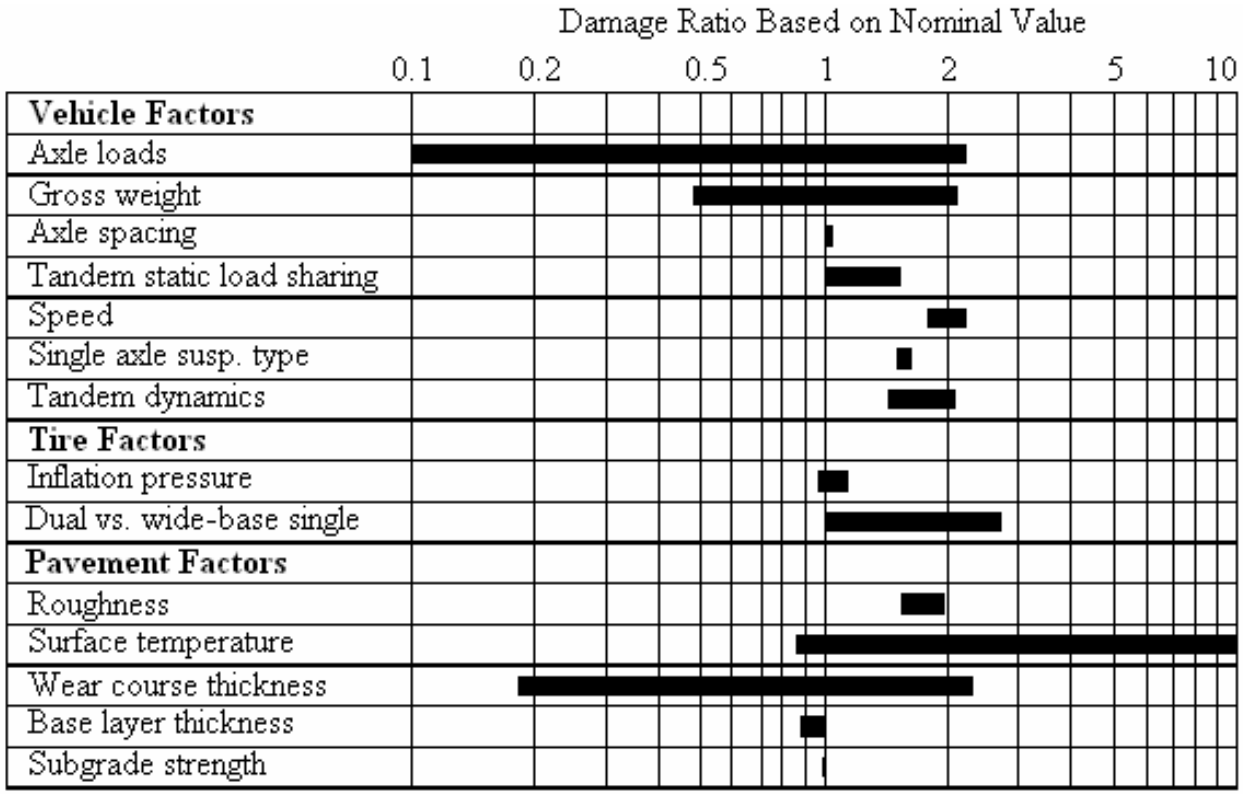
- 29 truck configurations
- Each truck tested in simulation to evaluate damage

Truck Num.	Truck Configuration	Configuration Name	GCVW (kips)	Axle Loads (kips)	Wheelbases* (feet)
1-2		2 Axle Straight Truck	32	12/20	15
3-4		3 Axle Straight Truck	46	12/34	18
5-8		3 Axle Refuse Hauler	64	20/44	17.5
9-12		4 Axle Concrete Mixer	68	18/38/12	20/12
13		3 Axle Tractor-Semitrailer	52	12/20/20	10/36
14-15		4 Axle Tractor-Semitrailer	66	12/20/34	12/36
16-20		5 Axle Tractor-Semitrailer	80	12/34/34	12/36
21		5 Axle Tractor-Semitrailer	80	14/33/33	10/36
22		5 Axle Tanker	80	12/34/34	12/36
23-24		6 Axle Tanker	85	12/34/39	12/38
25		5 Axle Doubles	80	10/18/17/18/17	10/22/22
26		5 Axle Doubles	80	10/20/15/20/15	10/22/22
27		7 Axle Doubles	120	12/34/34/20/20	12/38/22
28		9 Axle Doubles	140	12/32/32/32/32	12/38/38
29		Turner Doubles	114	10/26/26/26/26	12/22/22

Ref: NCHRP 353, "Effects of Heavy Vehicle Characteristics on Pavement Response and Performance"

Highway Design: Example Results

- Influence of each truck characteristic was quantified
- Result: guidance for highway designers and regulators



Factors influencing flexible pavement fatigue damage.

Ref: NCHRP 353, "Effects of Heavy Vehicle Characteristics on Pavement Response and Performance"

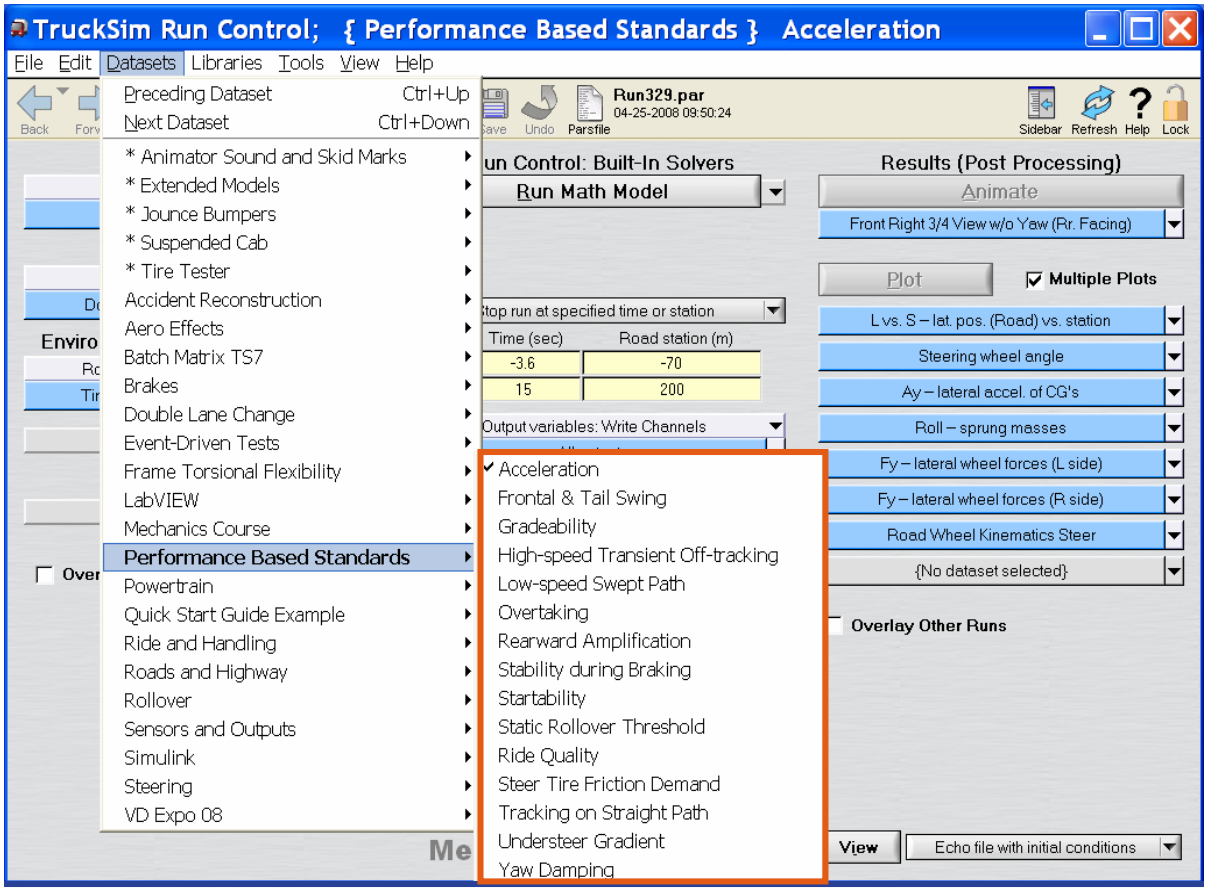
Regulators

- How do you specify and regulate truck properties?
  - Current truck regulations (Road Use Laws) are prescriptive
  - Sizes, weights and configurations
- New Approach
  - Focus on outcomes
  - Performance Based Standards (PBS)
  - National Transport Commission (Australia)
- Outcome objectives
  - Improve road safety
  - Protect road infrastructure
  - Promote innovation

http://www.ntc.gov.au/DocView.aspx?page=A023114044004500 20.

Performance Based Standards (PBS)

- Virtually all tests can be performed with Truck*Sim*
- Proposed new truck designs can be evaluated before build and test

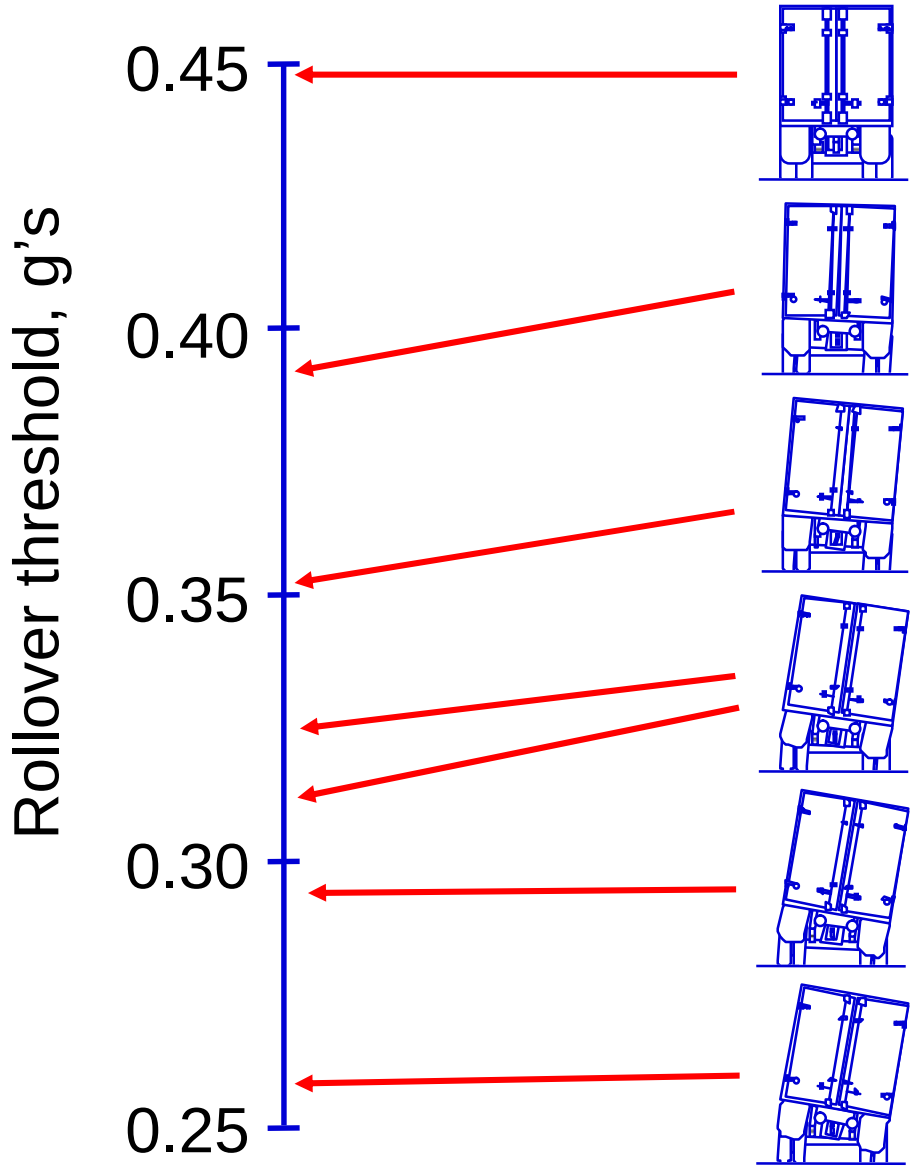


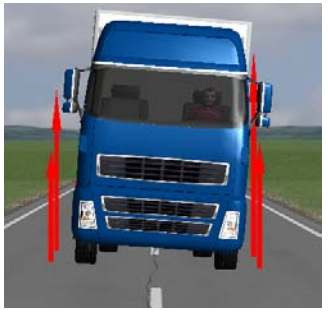
Ref: "Rules for Assessment of Potential PBS Vehicles,"
National Transport Commission (Australia)

PBS Example: Rollover Threshold

PBS Example: Static Rollover Threshold

Factors Influencing Rollover Threshold

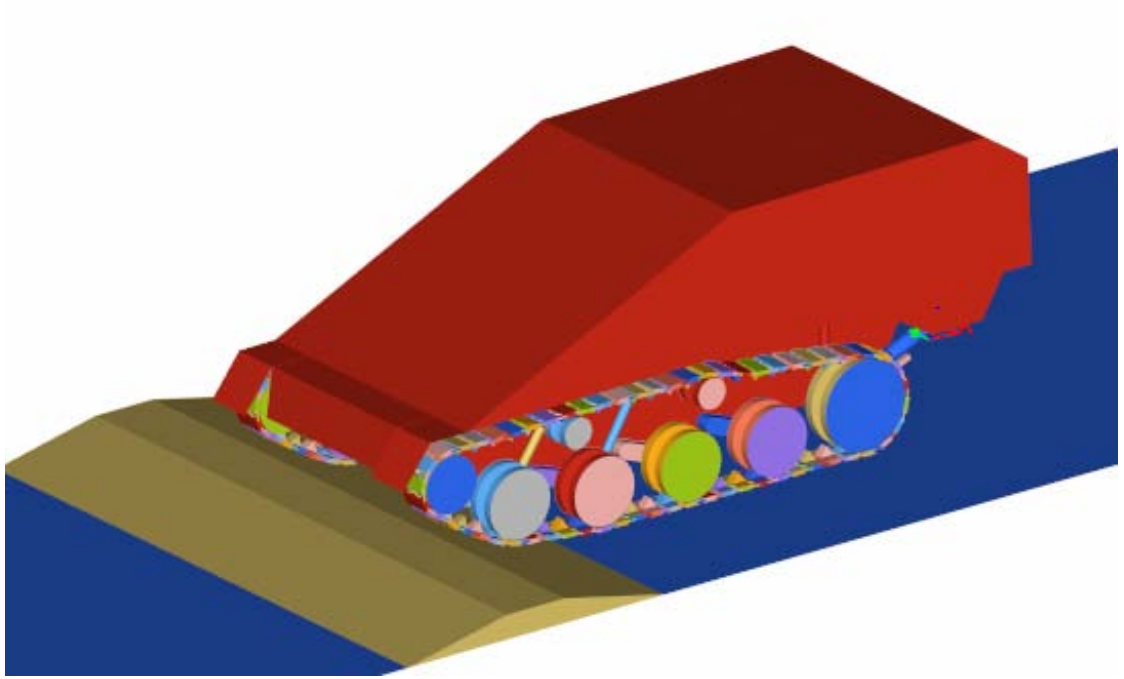




Ref: "Rollover of Heavy Commercial Vehicles," SAE RR 004

Military Vehicles: Tanks

- Tank chassis model developed with Vehicle*Sim*
  - Chassis, sprockets and idler wheels
- Track model added by Helmut Schmidt University
- Result: Tank mobility model



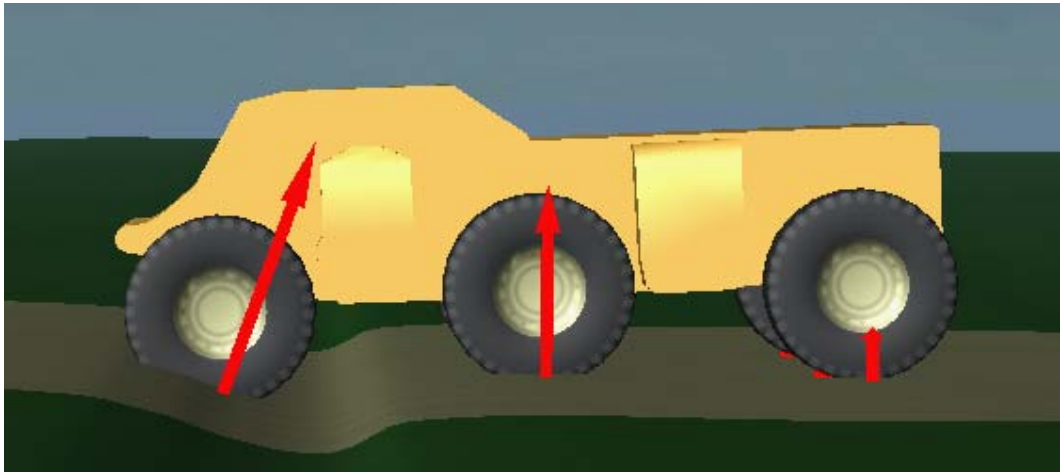
Ref: Prof. Dr.–Ing. Martin-Meywerk
Helmut Schmidt Universitat

Military Vehicles: Stryker

- Stryker has limited turning radius because of its size and front wheel steer angles (8x8 with 4-wheel steer)
- Could differential braking could improve performance?
- Easily demonstrated with Truck*Sim* model

Military Vehicles: Crusher

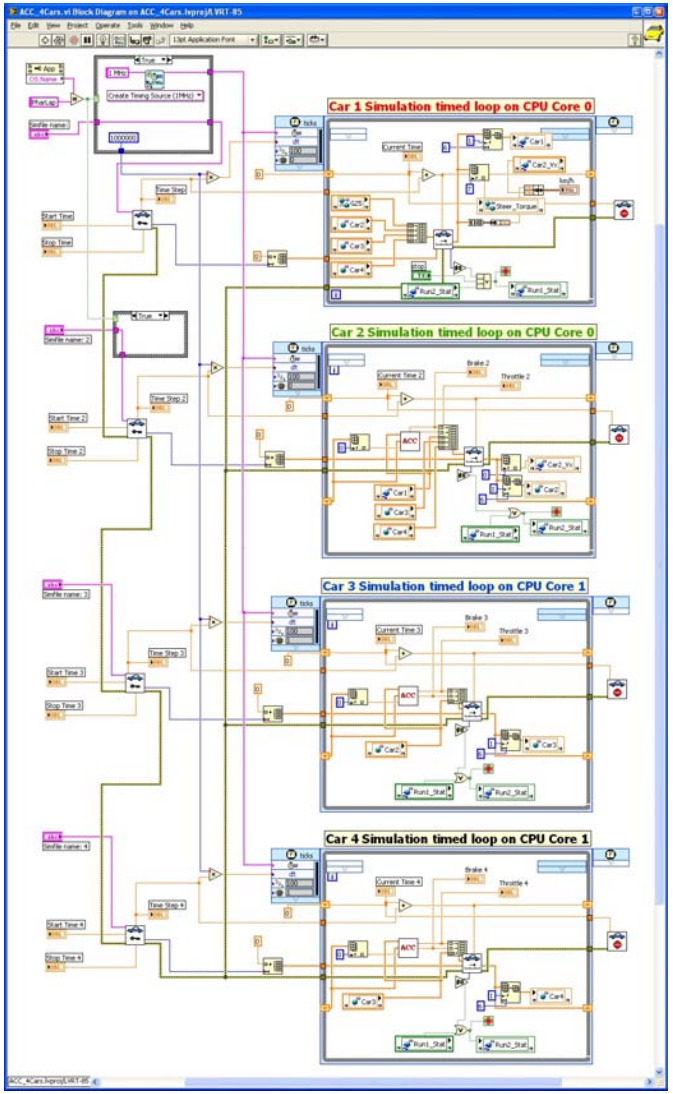
- Crusher is a high-mobility autonomous vehicle
- Can design changes be evaluated using simulation?
- Crusher is modeled in Truck*Sim*



Ref: DARPA Project, Carnegie Mellon University
National Robotics Engineering Center

Research: Adaptive Cruise Control

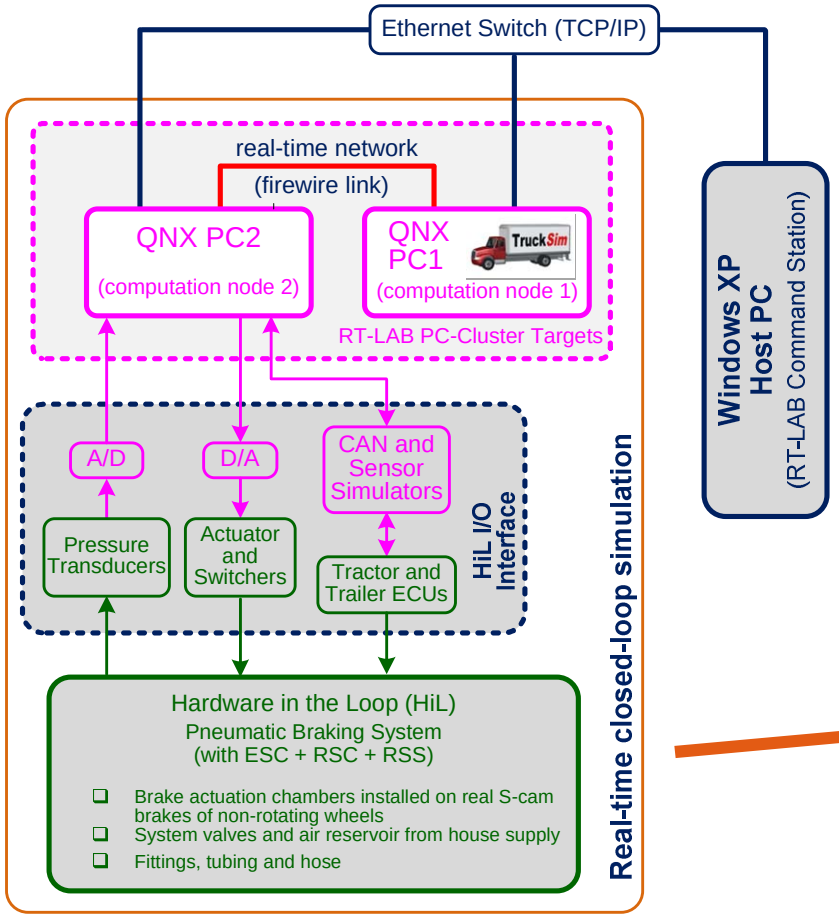
- Vehicles with Adaptive Cruise Control must be tested for compatibility, but how?
- Multiple vehicles can run in LabView
  - Full-fidelity Car*Sim* models
  - Four vehicles per CPU
  - Eight vehicles on dual-core CPU
- First vehicle is driven by Car*Sim* user in a Driving Simulator
- Following vehicles are controlled by adaptive cruise control



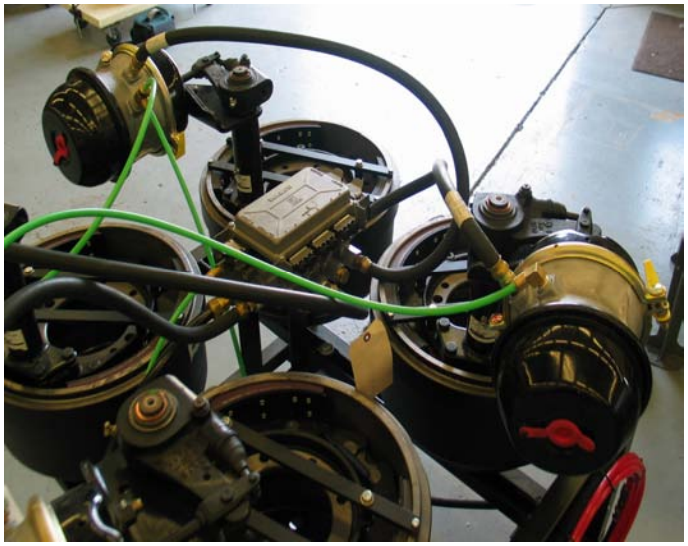
Car Number
1
2
3
4

Research: Truck ESC Evaluation

- How do you evaluate performance of truck ESC, RSC, RSS, ABS?
- University of Michigan uses Truck*Sim* in their HIL laboratory



- Truck hardware is installed in the laboratory
- Simulation evaluates performance over a broad range of real-world conditions



Ref: Vehicle Dynamics International, May 2008

Accident Reconstruction

- Applications of Car*Sim* and Truck*Sim* in accident reconstruction:
  1) Simulating the vehicle motions in an accident (difficult)
  2) Illustrating the accident with an animation (much easier)
- Using the animator to illustrate an expert's opinion
- Examples:

Conclusion

- There are many potential applications for vehicle dynamics simulation tools outside of the traditional vehicle community

- Stop by Mechanical Simulation booth to discuss more applications

Stand 3100, Hall 3