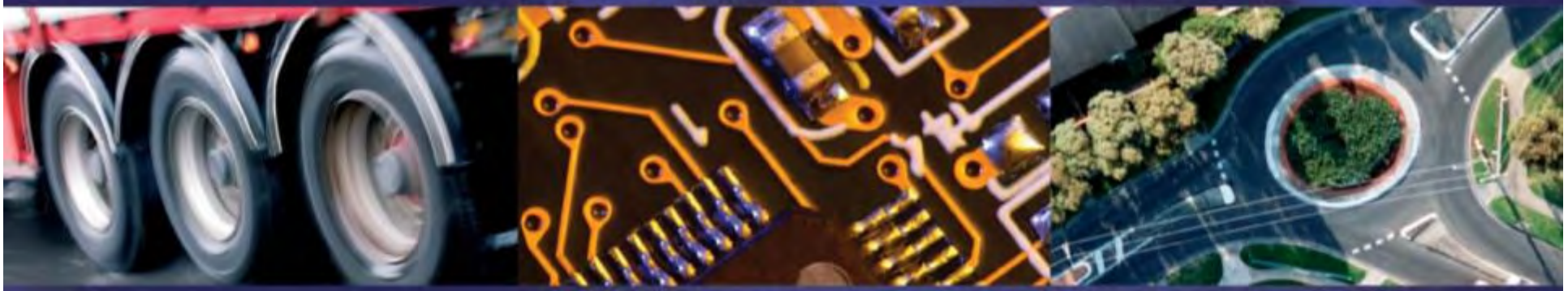


Electronic Braking Systems

Technology delivering safety and productivity benefits

Anthony Germanchev

ARTSA

PACCAR & DEALER TMC Technical & Maintenance Conference

arrb GROUP

Areas of technology

Safety

- Electronic stability control
- Rollover warning/protection system
- Lane -change warning

Productivity

- Vehicle tracking and monitoring
- On-board weigh-in-motion
- Electronic vehicle logbooks

Environment

- Engine and drivetrain efficiency
- Alternative fuels
- Low rolling resistance tyres

Electronic Braking (ABS, ESC, EBS, AEBS)

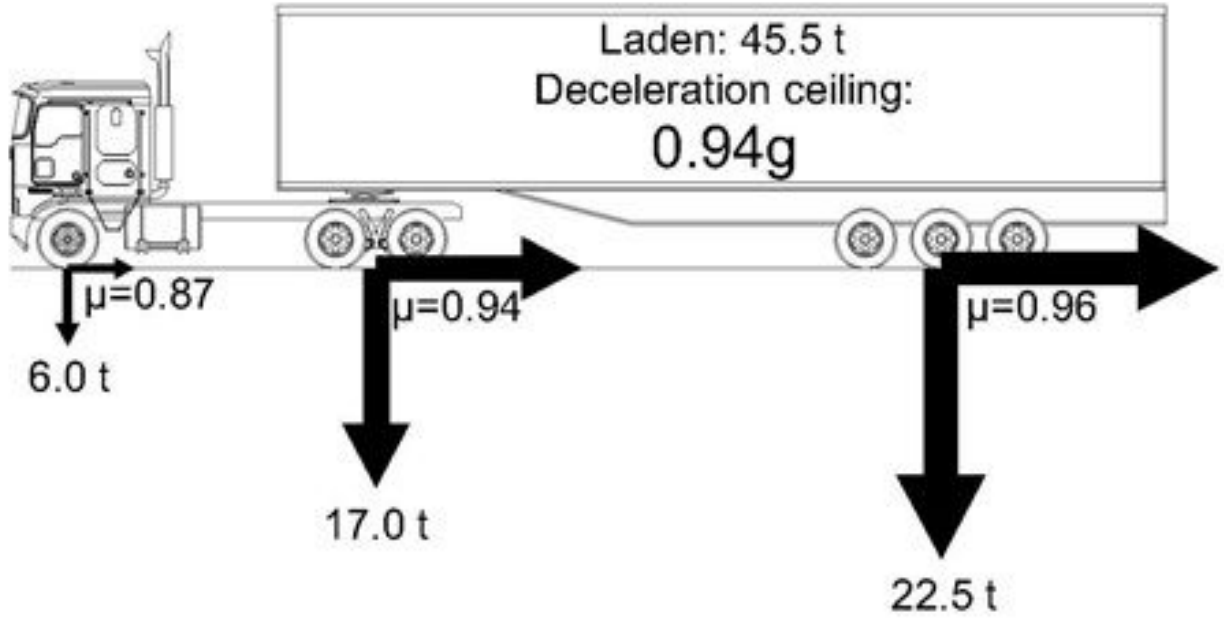
- Electronic stability control (ESC)
- Mandatory for new passenger cars sold in Victoria
- Available on both European and US makes of prime mover
- Monitors data and intervenes if a path deviation is detected
- Brakes individual wheels
- Can also prevent rollover, which is of critical importance to heavy vehicles (RSP)

Safety – electronic braking

- Anti-lock braking systems (ABS)
- Prevent wheel-lock, maintain directional stability
- Mixed views in Australia – concerns regarding operation on loose surfaces, unreliability in off-road conditions
- Mandated in several countries, not in Australia due to concerns regarding interoperability
- Nevertheless, most new trucks are fitted with ABS

Electronic brake-force distribution (EBD)

- Optimises braking force for wheels with different load
- Maximises the braking force for shortest stopping distance



Measuring performance

System efficiency and compatibility

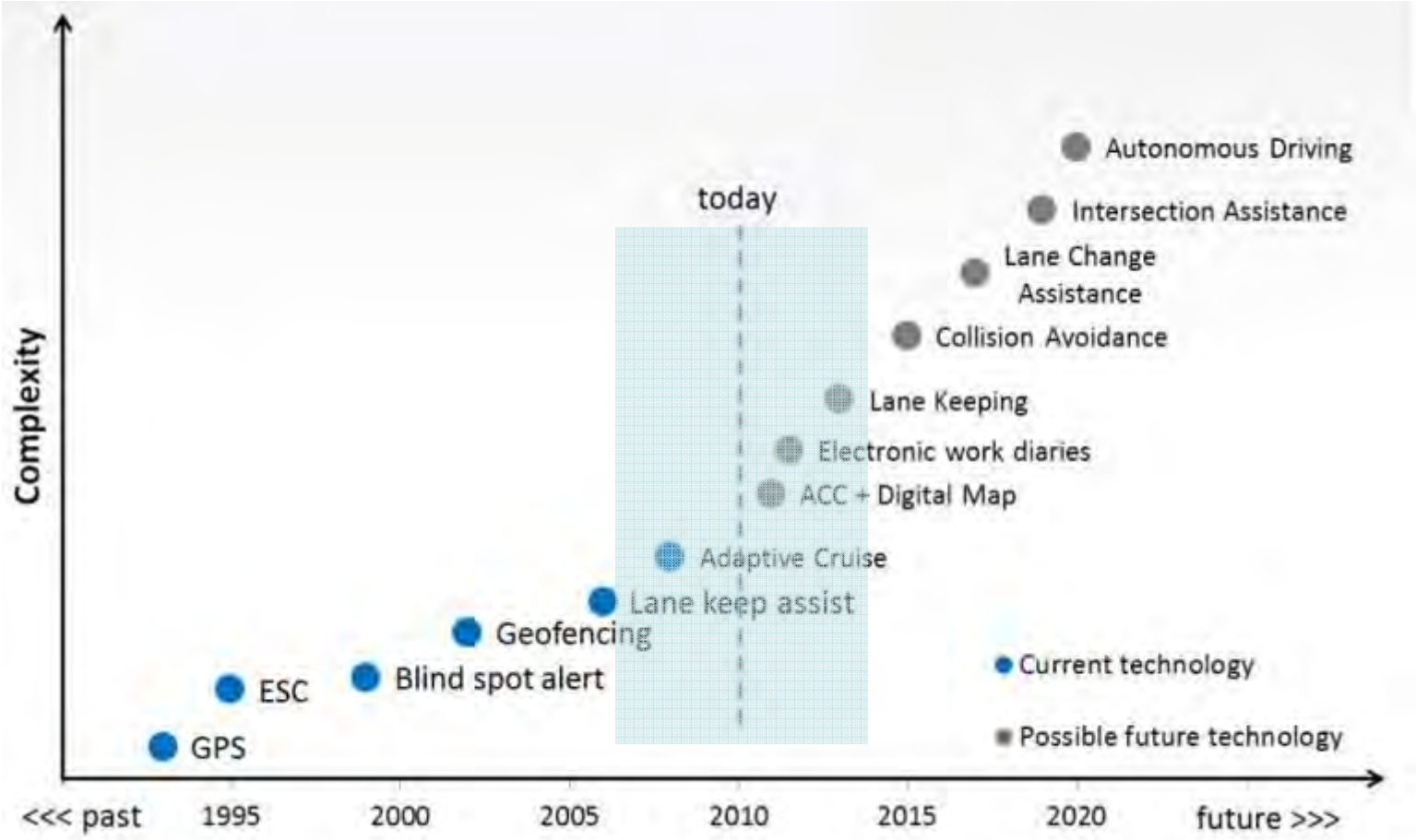
Under-braked axles greatly reduced system efficiency as all tyres are either below or above the optimum slip, both of which provide reduced braking force.

Advanced braking (AEBS)

- Various driver assistance systems available:
  - Automated braking , adaptive cruise control.
  - Vehicle to Vehicle (V2V)
  - Vehicle to Infrastructure (V2I)…..and V2X.

Source: Continental (2012)

Technology path



ARRB testing projects

- National road train test 2004
- Quantified dynamics and braking performance

ARRB testing projects

- Austroads 2010
- Sight distance requirements for HPFVs at railway crossings

EBS testing Stage 1

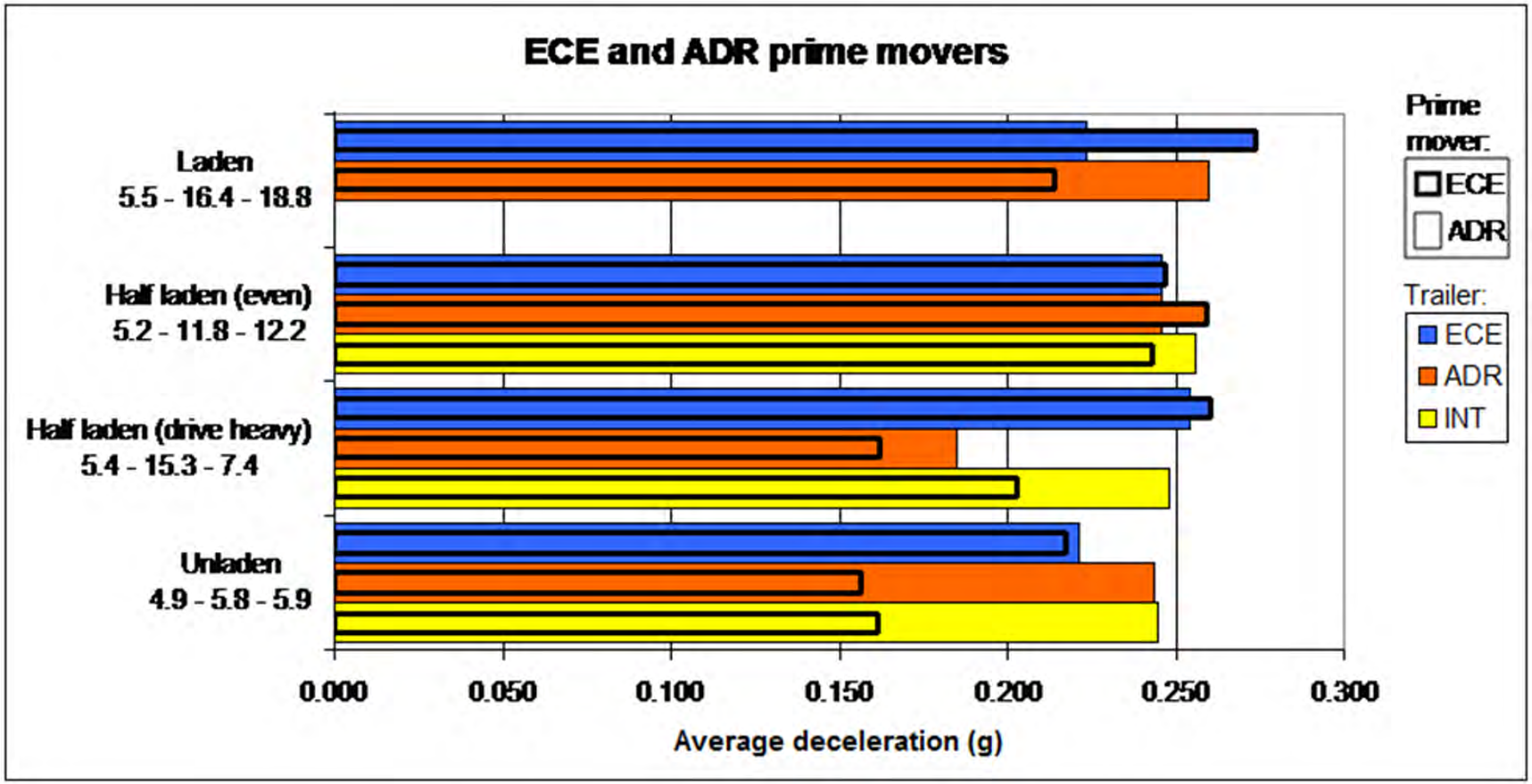
- Varying load distribution
- Varying brake force distribution

EBS testing Stage 1

- Braking during a tight radius turn

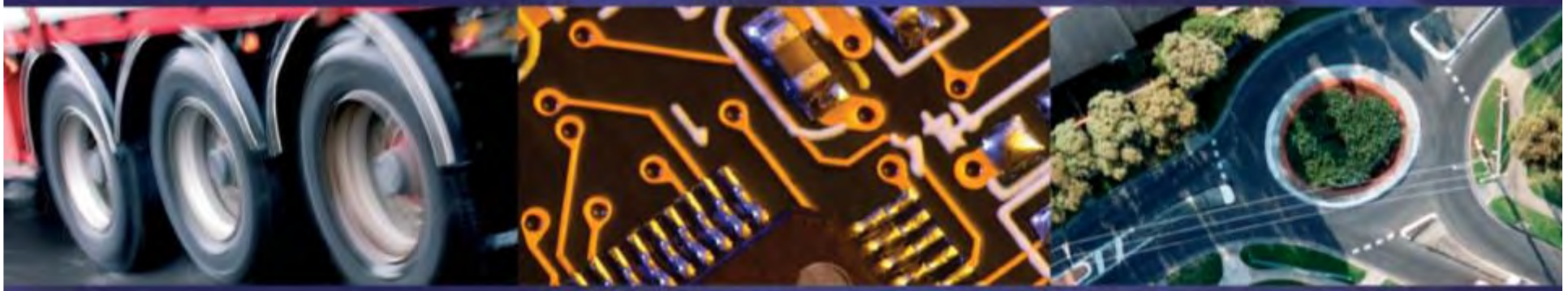
EBS testing Stage 1

Outputs from EBS testing stage 1



Outputs from EBS testing stage 1

- Quantified effects of brake force distribution on braking performance in a curve
  - Approximately equivalent performance between options for laden, half-laden and drive heavy load conditions
  - ECE prime mover set up with Australian trailer set-up produced lowest deceleration results
- Findings to be included in ARTSA Brake Code of Practice
  - providing practical advice on how to improve braking performance
- Stage 2 testing to evaluate effects of varying EBS set up between truck and trailers



EBS Testing

Bob Wright
ARRB Group

Aim

To test the stability of a semi-trailer with the following vehicle and trailer EBS set-ups: ESC and RSP functionality

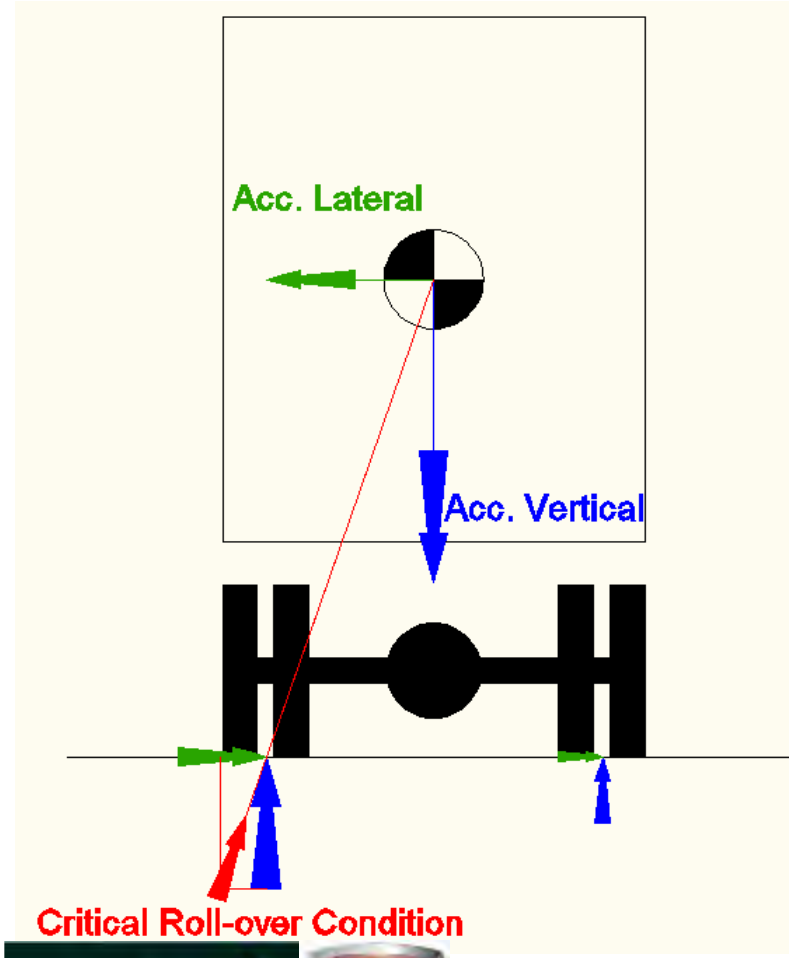
Vehicle and trailer EBS set-ups

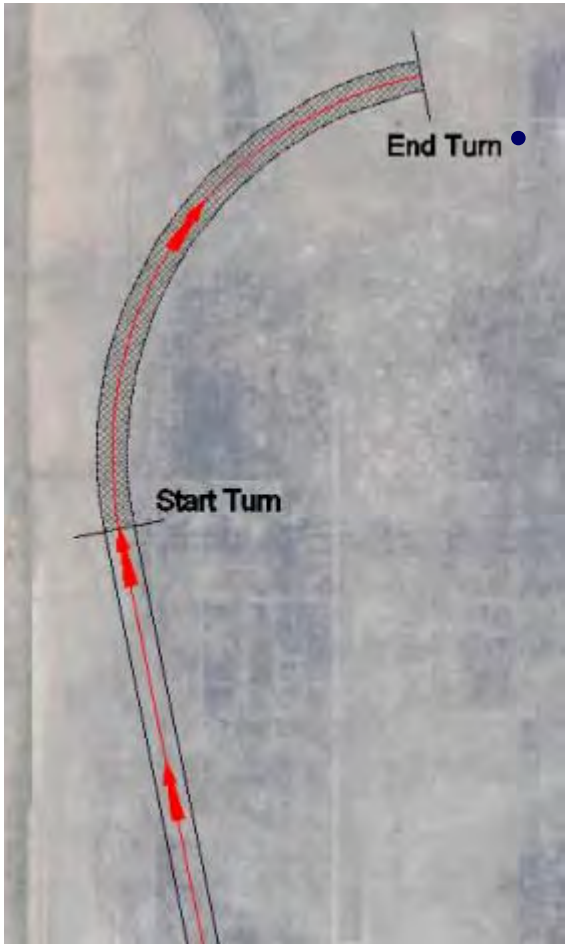
To test the stability of a semi-trailer with the following EBS configurations:

Configuration	Prime mover EBS	Trailer EBS
1	Enabled	Enabled
2	Enabled	Disabled
3	Disabled	Enabled
4	Disabled	Disabled

RSP System

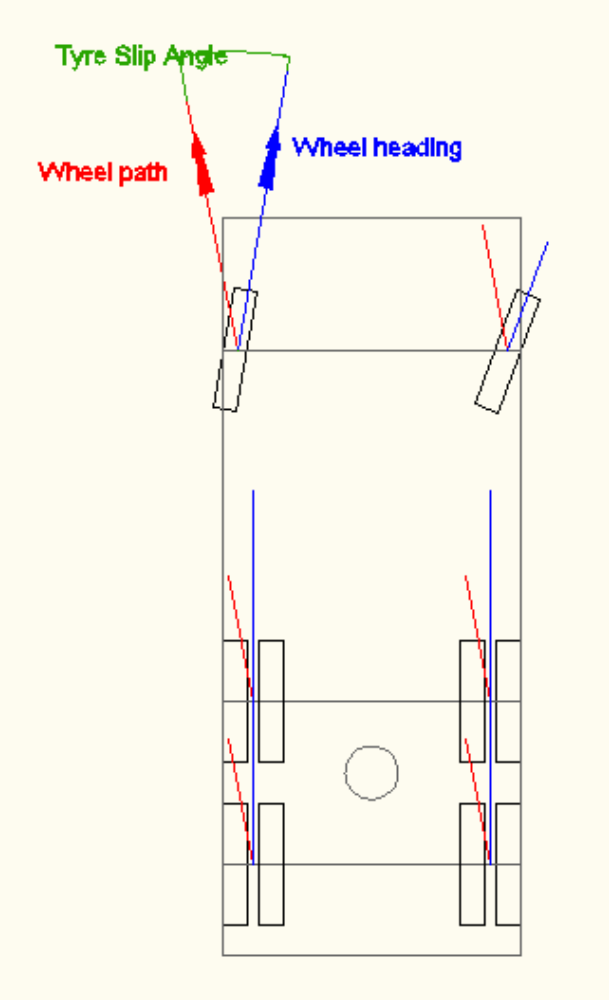
J- Turn Test

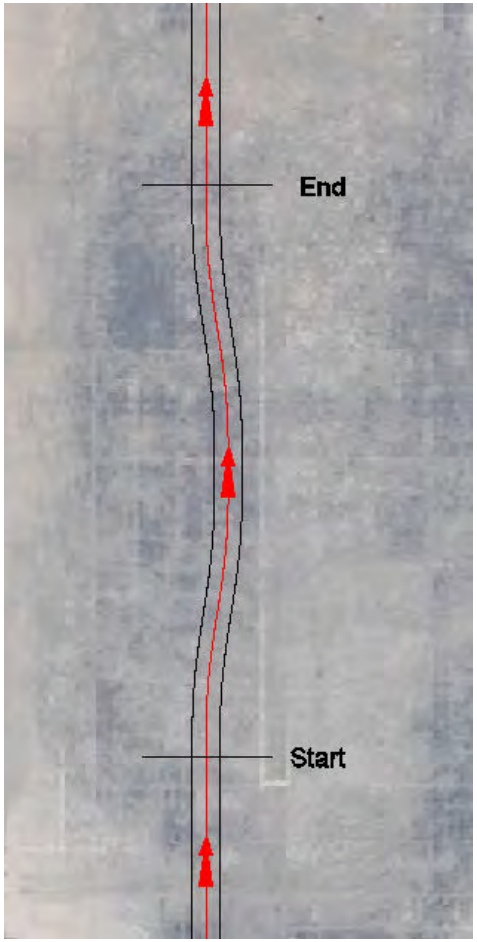




- J- turn
  - Operates within friction limits (vehicle rolls)
  - Used for RSP
  - Dry conditions

ESC System Double- Lane Change





Double Lane Change

- Operates outside friction limits (vehicle slides)
- Test used for ESC
- Wet conditions

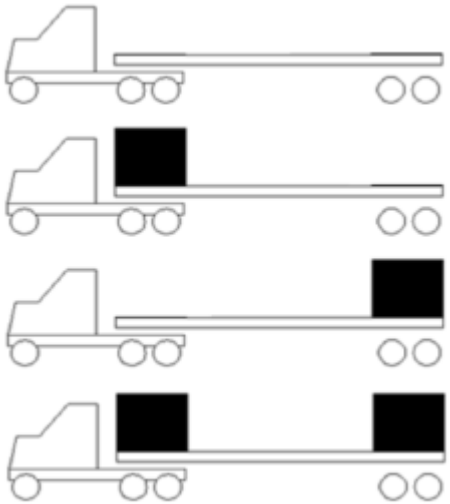
Instrumentation

The following parameters were measured:

- Speed, position and heading (GPS)
- Lateral acceleration and yaw rate (on both prime mover and trailer)
- Brake pressures for all axle groups
- Steering angle
- Articulation angle
- Brake input

Instrumentation

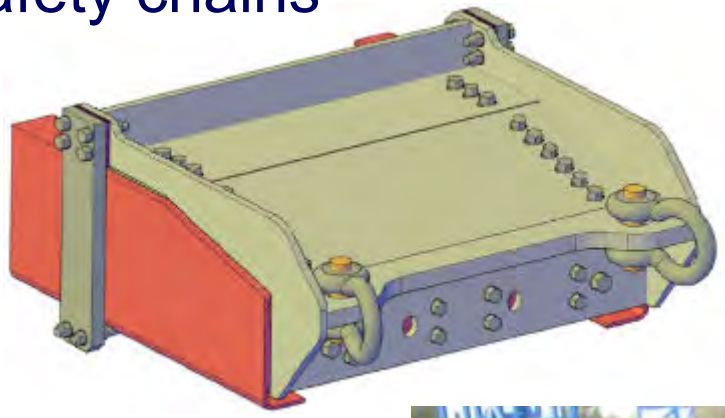
Load configurations



Load configuration	Steer axle	Drive axle group	Trailer Axle group
Unladen	6150	8825	8650
Drive heavy	6250	17350	12050
Trailer heavy	6400	9900	18950
Fully laden	6150	16350	19500

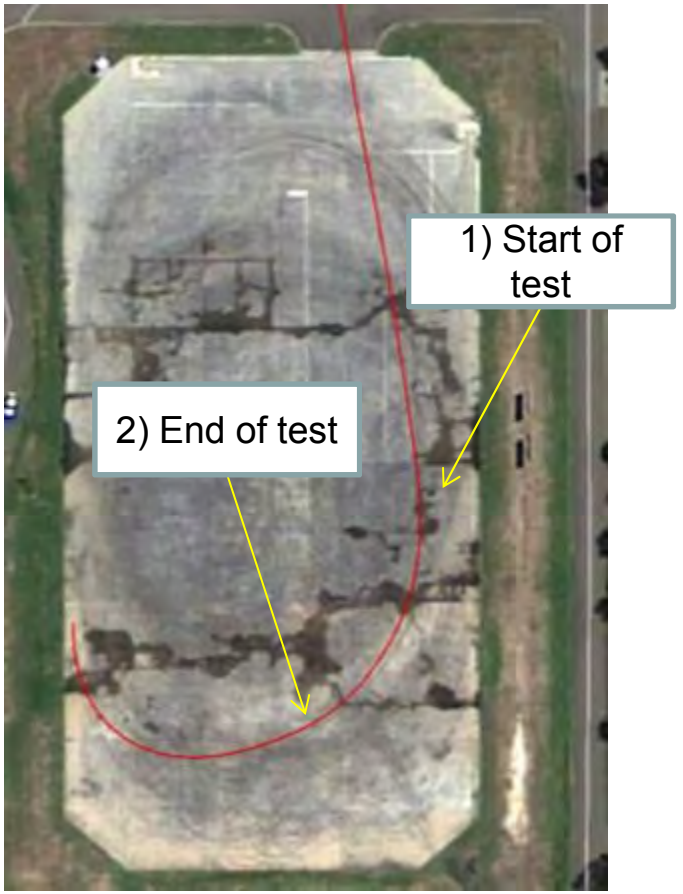
Safety

Anti- Jacknife Safety chains



J- Turn Test (RSP) – 150’ Radius (45.7 m)

- Vehicle tries to maintain a constant speed throughout the test (from 1 to 2)
- Test to be conducted in the dry
- The test is considered a fail if the outrigger touches the ground

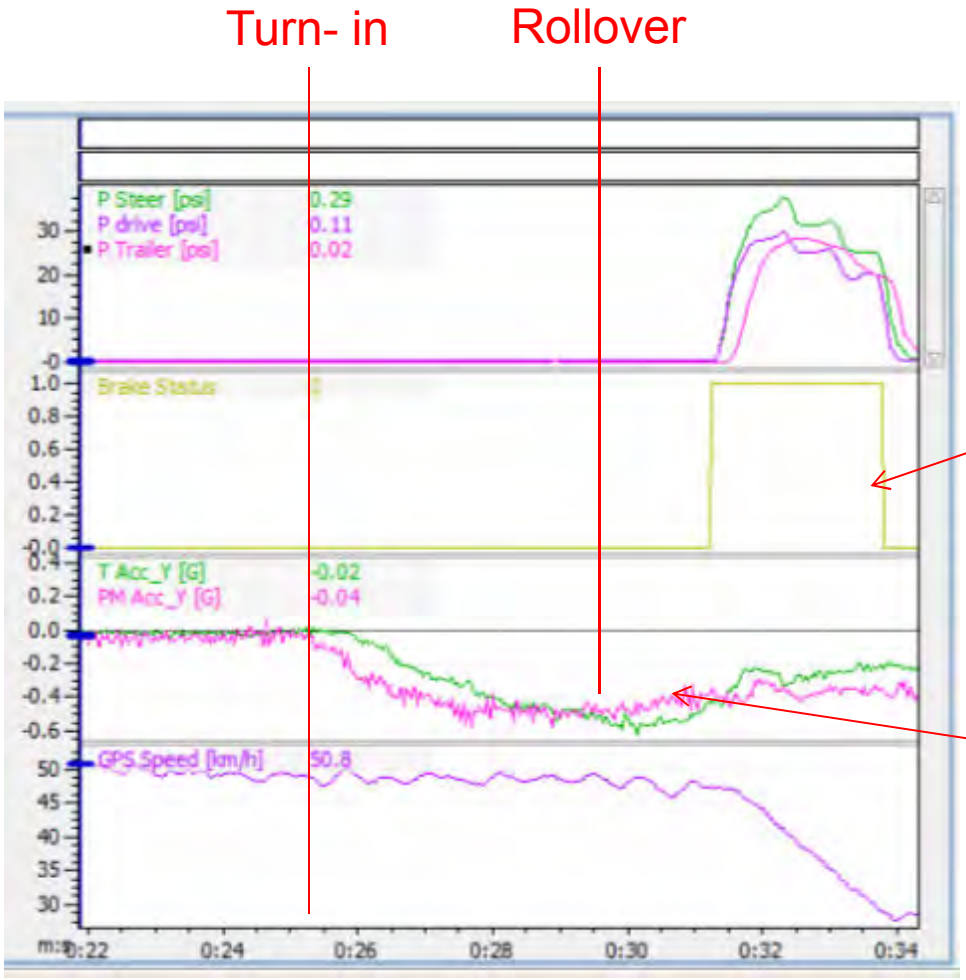


J- Turn Rollover

Trailer Axle braking intervention

Clear rollover with no intervention

J- Turn Rollover- RSP systems Disabled



Brake Application

Lateral acceleration of 0.6g

J- Turn Successful intervention. All systems enabled

Brake are activated by the EBS

(No Driver brake input)

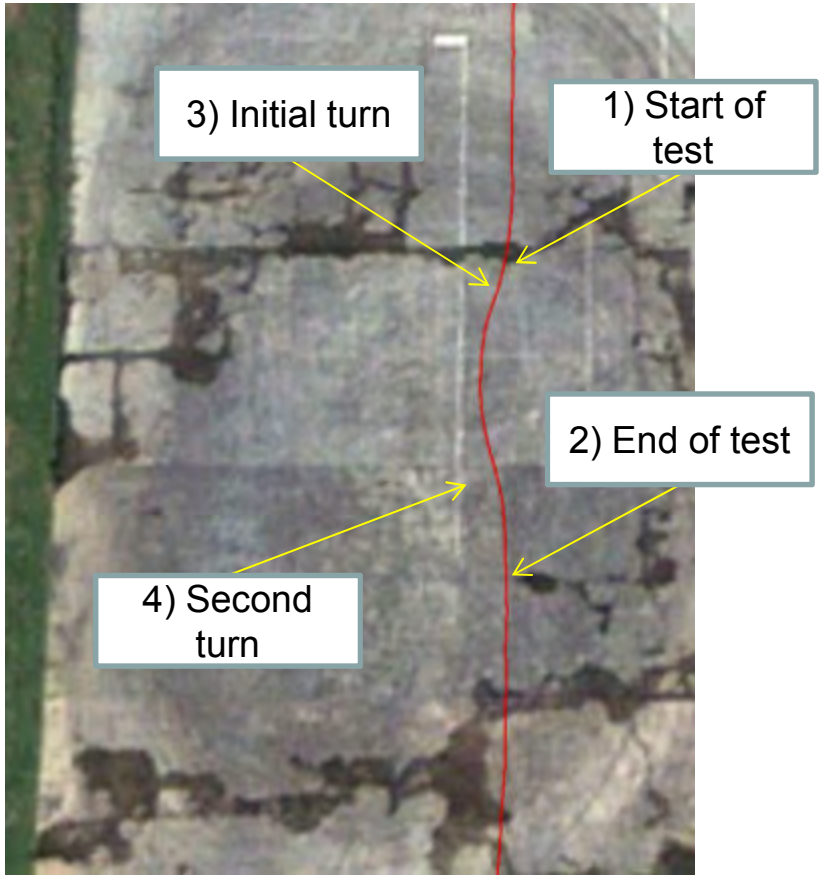
And keeps lateral acceleration below 0.5 g

Which reduces vehicle speed

J- Turn Rollover

Double Lane Change – ESC Testing

- Vehicle tries to maintain a constant speed throughout the test (from 1 to 2)
- Test conducted on wet surface
- Pass/fail criteria was determined by ‘lane excursion’



Double Lane Change Video

Clear Double Lane Change run

Failure to negotiate the later part of the manoeuvre due to understeer

Completed tests

The table below shows the number of test runs recorded

	EBS prime mover	EBS trailer	Fully laden	Drive heavy	Drive light	Unladen	Total
J-Turn	Off	Off	4	14	12	0	30
	On	Off	8	9	11	0	28
	Off	On	5	9	12	0	26
	ON	On	7	8	8*	0	15
Double Lane Change	Off	Off	0	6	11	12	29
	On	Off	0	11	16	9	36
	Off	On	0	9	12	11	32
	ON	On	0	9	9	12	30
Total number of runs							226

Next steps

- Further data analysis
- Testing Different manufacturers
- Testing multi combination vehicles (B-doubles/road trains)
- Test on different surfaces
- Test at higher speeds

Thanks to

- TMR
- Volvo Group Australia
- BPW
- Knorr-Bremse
- Air CTI
- ARTSA

Knorr-Bremse/Bendix ESP Technology
What happens in practice

October 2012

What are the foundations of an ESP system?

Knorr-Bremse/Bendix® ESP Technology

- Anti-Lock Braking System (ABS) OR Electronic Braking System (EBS)
- Automatic Traction Control (ATC) & SmartATC
- Drag Torque Control (DTC)
- Electronic Stability Program (ESP or ESC)

Delivering the Active Safety Future

Emergency Braking
•Always On

Active Cruise+
•Engine Retarder Braking
•Always On

Stability
•Brake Control

Lane Departure
•drowsy driver

Collision Warning+
• static object

Broad Vehicle Coverage
•Tire Pressure
•Integrated Side/Rear

Following Distance
•forward vehicle

Stability Threshold
•speed

1996	2005	2008	2009	2011-2015
ABS	ABS	ABS	ABS	ABS
	Stability	Stability	Stability	Stability
		Radar	Radar	Radar
			Side/Rear	Side/Rear
			TPMS	TPMS
				Video

ESP enables active safety

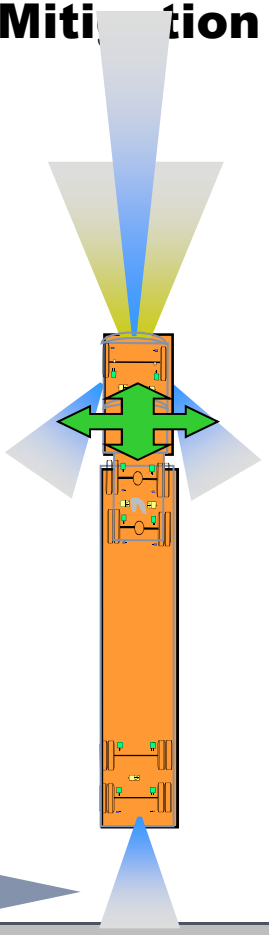
Radar enables predictive / peripheral safety

TPMS enables tire safety

Video enables robust safety

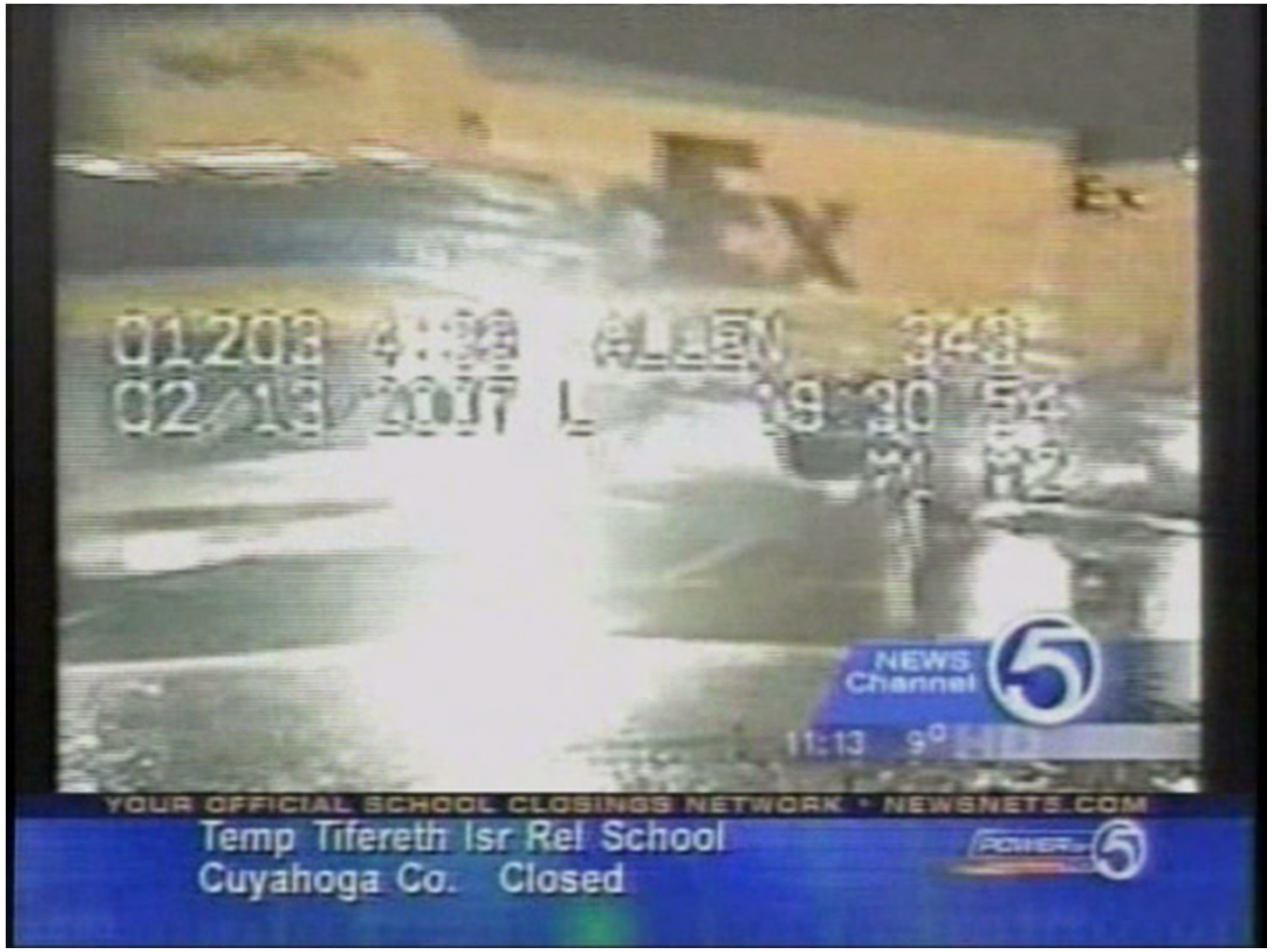
Our goal…

Accident Mitigation



Because trucks keep rolling over…

…and, trucks keep sliding around!



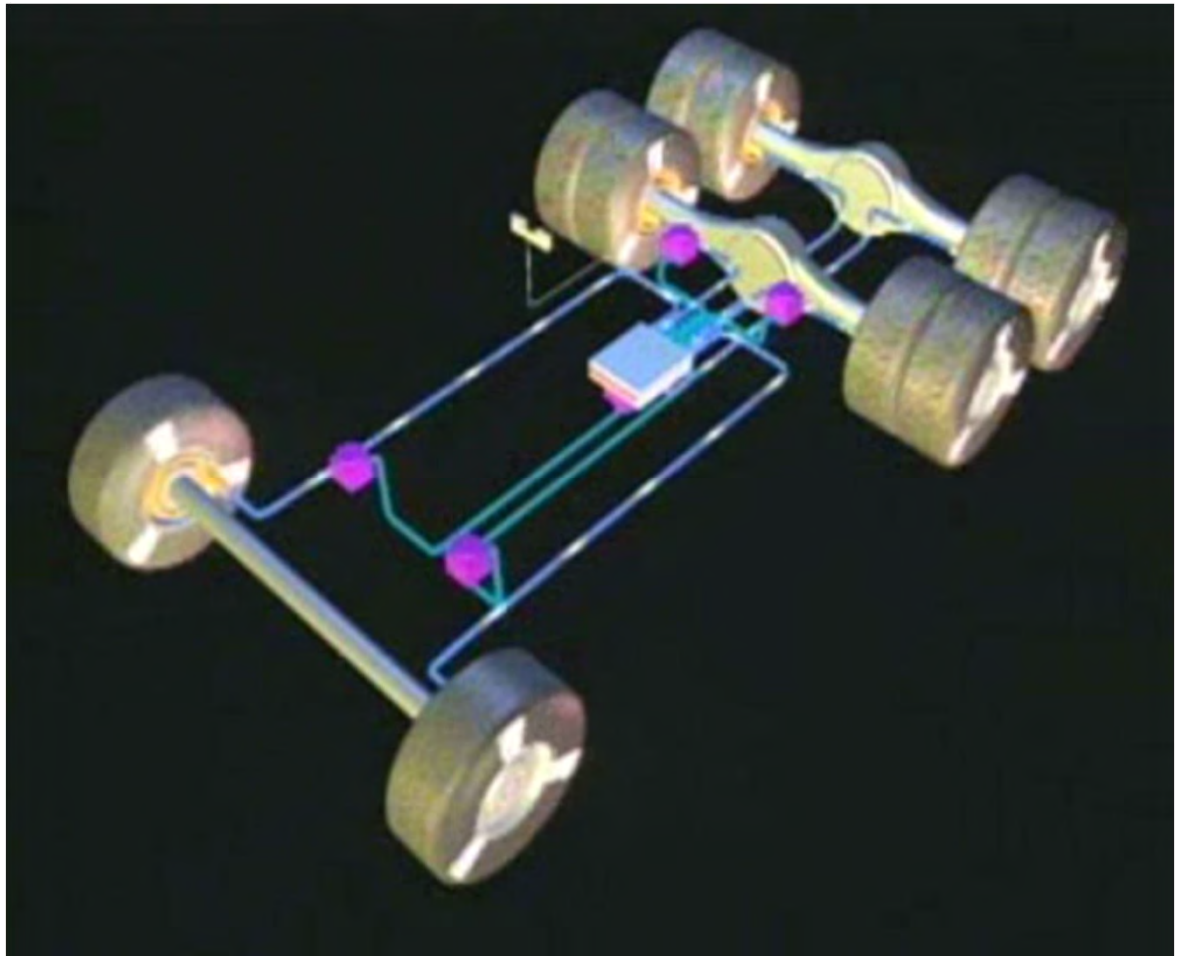
RSP/ESP testing

ESP Full Stability – For Tractors, Trucks & Buses

No Stability = No Control

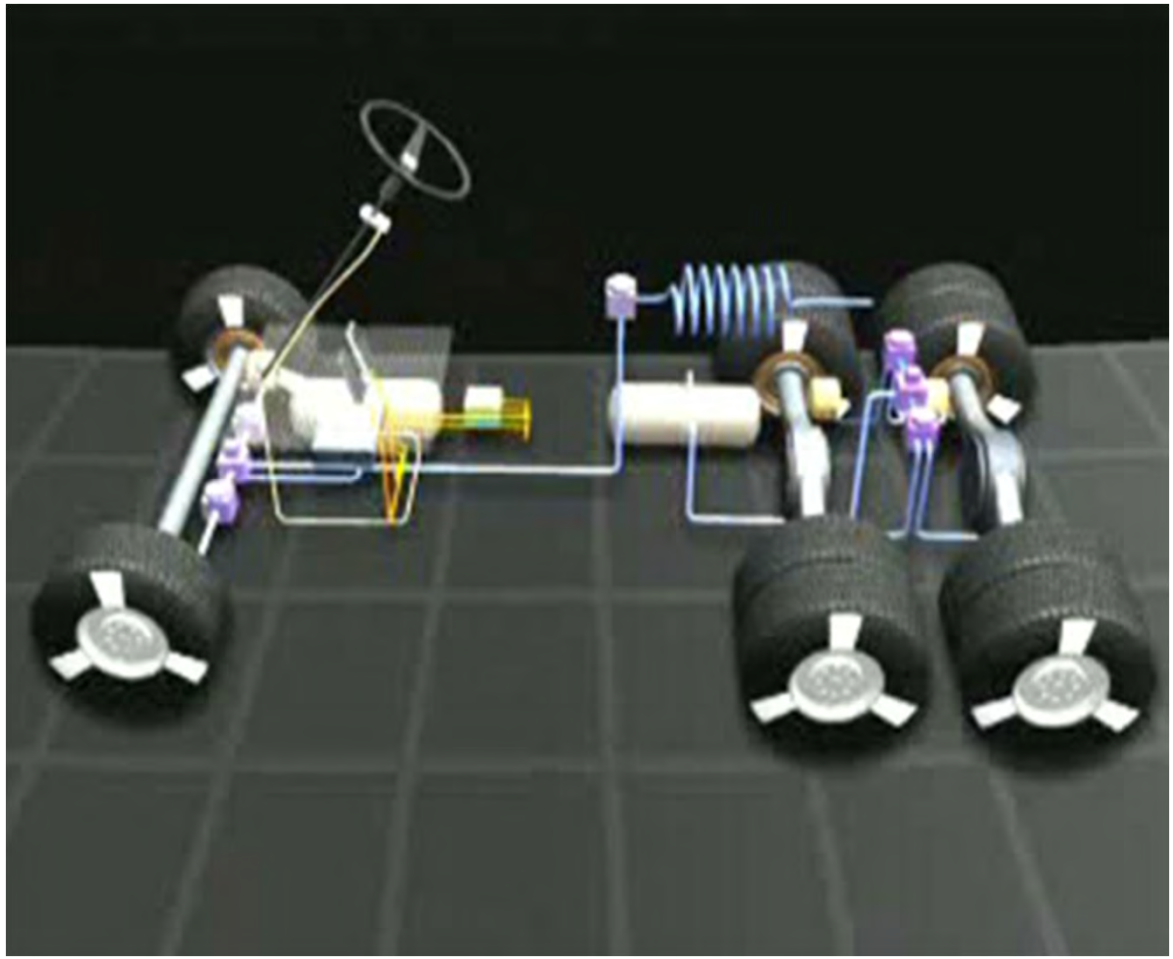
ESP = Full Stability, not just Roll Stability

How it Works - ABS



How it Works - ATC

How it Works - ESP



Good Drivers Still Needed!

Active Safety Technologies Support Good Driving Practices

- Operators should drive normally / prudently
- Electronics can identify / react to certain situations faster

Systems can help educate the driver

- Notify the driver - light / brake application / other
- Discourage drivers that push the envelope

All systems have limits & may not address all situations

- Limits of physics
  - Too fast, too heavy, too tight, too slippery
- Mitigate the outcome of an incident
- Impact with objects / Off road situations

Active Safety Technologies won't make bad drivers good, but can help good drivers avoid bad situations!

Let's Talk About Accidents

Bumper ripped off during RSC testing Feb 2009.

900' radius, 25 MPH, loss of control – vehicle hit snow bank after loss of control

Are they Really "Rollovers"?

- When investigating crash data, we see the rollover is typically SECONDARY
- Loss of control first, then a rollover

Bendix ESP is designed to keep the vehicle going in the intended direction, on the road

- If it stays on the road, it's much more likely to stay undamaged and shiny side up!
- NHTSA mandated ESC for passenger car based on this philosophy

Thank you very much for your attention

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