



ABS Based Full Stability

CVSA Brake Safety Symposium

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Agenda

- Product Description: ABS-6 Building Blocks
 - Advanced - Electronic Stability Program (ESP)
 - System Architecture
 - Service and Diagnostics
- Stability Basics 101 and 102
- Where does full Stability help?
- Where from here?



Applications

- **All applications will benefit from ESP**
 - Fuel hauler
 - Bulk hauler
 - Concrete mixer
 - Line haul
 - Pick-up and delivery
 - etc.
- **ESP is applicable to both trucks and tractors**



4S/4M Standard System

Front axle



Rear tandem



4S/4M Advanced w/ ESP

Front axle



Traction Valve

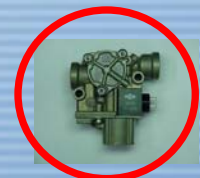


Pressure, Yaw,
Steering Sensors



Advanced ECU

Rear tandem



Trailer



Impact of an ABS-based Strategy

- Conventional air brake system remains
 - Reduces vehicle engineering efforts and simplifies vehicle assembly
 - All current service procedures will remain the same
 - Reduces fleet / OE training and inventories
- Architecture enables future technologies and supports needs for 15+ years
 - Ability to apply brakes electronically
- More cost-effective offerings (compared to ECBS-based)
 - Standard ABS systems for compliance
 - Advanced features / functions for those who desire



Warning Lamp

ABS warning lamp works as today. The ESP function lamp is denoted by the ATC or ISO symbol for stability. Works as ATC lamp works today (if function is active the lamp flashes---if a fault exists the lamp will be “ON” permanently).

DTC definition can be retrieved via warning lamp “blink codes”.

RDU:

Remote diagnostic unit gives the ability for ABS6 systems to be able to provide the wanted simple LED diagnostics.

ACOM PC based diagnostics:

PC based diagnostics, to work with all Bendix ABS products.



What happened to my LED's?

The Bendix answer is the Remote Diagnostic Unit (RDU)

- The RDU is:
 - Low cost diagnostic tool which provides the user with ABS fault information (same methods as used in previously in Bendix ABS products)
 - 10 LEDs
 - **1 Green LED**
 - » indicating power, communications with ECU
 - » ECU is operational
 - **9 Red LEDs**
 - » indicating location and component of ABS fault
 - **Magnetic Reset Switch**
 - A magnetic reset is located in the center of the RDU which will clear faults from the ABS ECU



The Wrong Kind of Publicity for Fleets

Tractor-trailer jack-knife on Nevada I-80



Brad W. (Carlin, NV) Just east of the Carlin Tunnels on I-80, there is a treacherous curve known locally as Moline Curve. This particular spot has been the site of numerous crashes. This eastbound big truck reportedly hydroplaned and its momentum started to carry it into the median. The driver **tried to correct but the truck jackknifed**, and got spun around 180 degrees, and the cab was nearly knocked completely free of the chassis. There were no injuries.

Truck rollover snarls 128 south during rush hour



WOBURN - A lumber truck rolled over at the base of the I-93 southbound offramp to Route 128, spilling its load across the highway and causing Route 128 south to be shut down for more than two hours just before the start of the evening commute. The ramps of the I-93/Route 128 interchange have long been a source of concern due to the high volume of traffic and large number of truck rollovers, mostly **due to speed** on the ramps...

Tractor-trailer rollover causes I-195 traffic jam



By Matt Apuzzo, *Standard-Times* staff writer

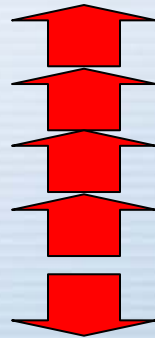
NEW BEDFORD -- Police closed a stretch of Interstate 195 yesterday afternoon when a tractor-trailer containing more than \$500,000 worth of seafood overturned in the middle of the highway, spawning a massive traffic jam.

"All indications are that the car may have come into the path of the truck," said State Police Lt. Jose C. Gonsalves. "The truck driver then took some sort of **evasive action..causing roll-over.**"



Need for Stability?

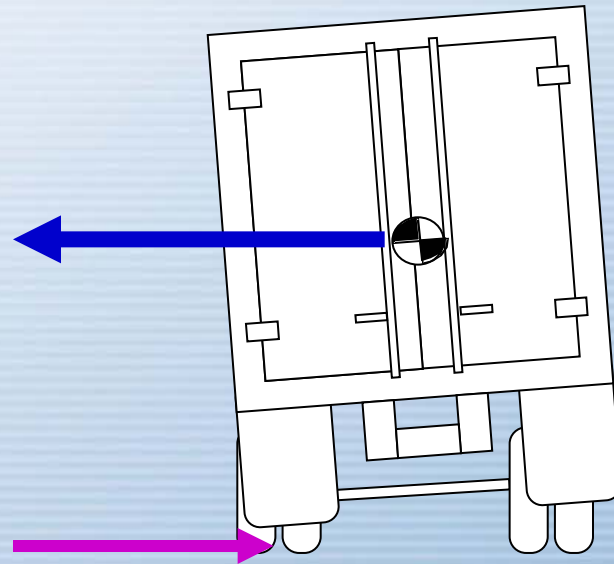
- Speeds
- Incident cost
- Liability cost
- Driver distractions
- Driver experience



- National Statistics (from various sources)
 - 15,000 commercial vehicle rollovers per year (9400 tractor trailers)
 - 1 per 4 million miles
 - 58% of driver fatalities occurred in rollovers
 - Heavy duty rollovers responsible for 95% of hazardous material spills
 - Average \$120k per rollover, jackknives less



Stability 101 - Roll



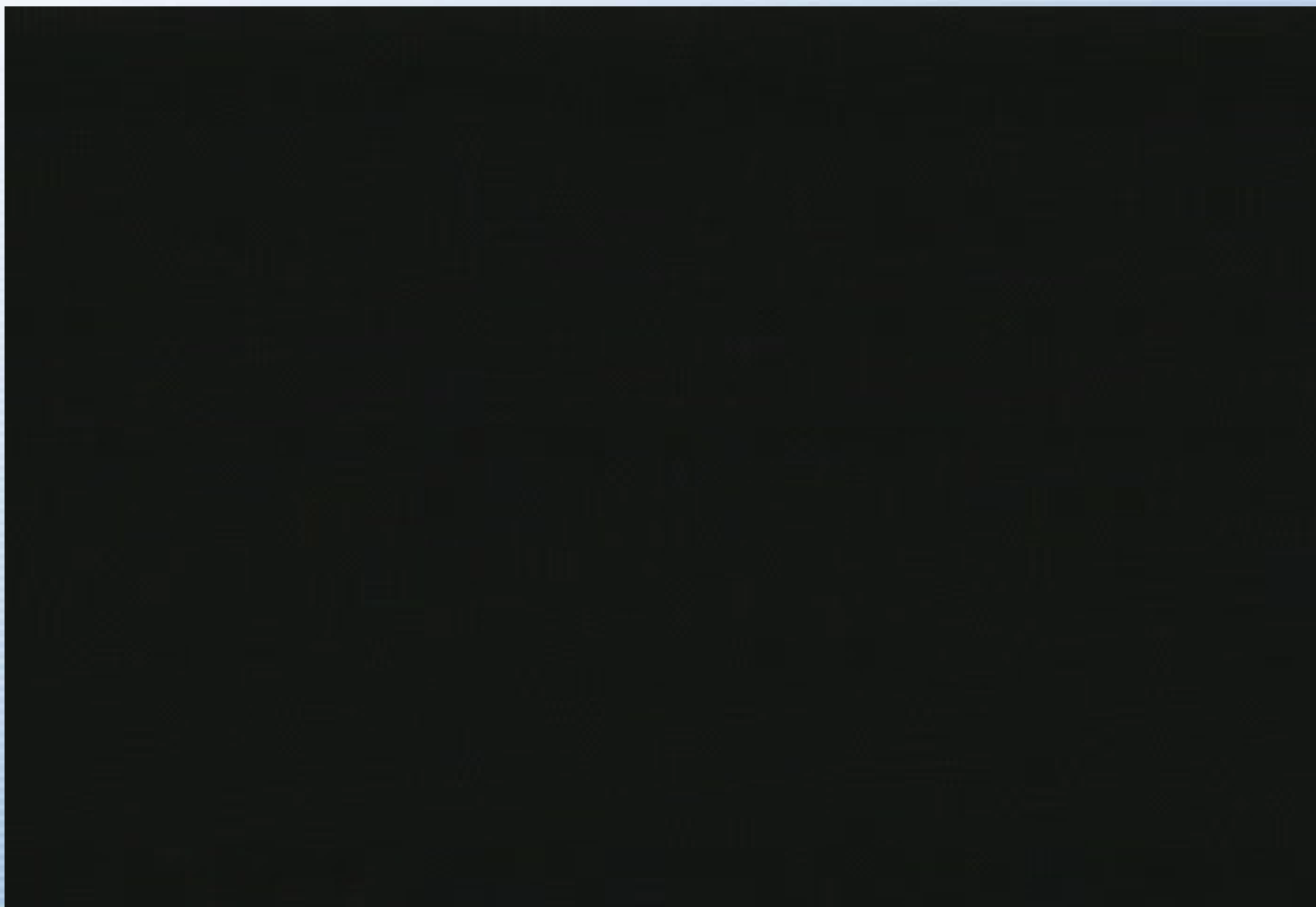
- Roll is caused by a lateral force at the CG (center of gravity)
 - Lateral acceleration (speed, turn radius ... $a=v^2/r$)
 - Mass, CG height
 - Friction at tires

Stability 101 - Roll

- ESP will reduce lateral force through speed reduction
- Factors affecting speed reduction performance
 - Brake force capability
 - Number of wheel ends braked
 - Brake size / output
 - Delay in and rate of application
 - Decision to apply
 - Sensor inputs
 - Thresholds
 - Pressure level applied

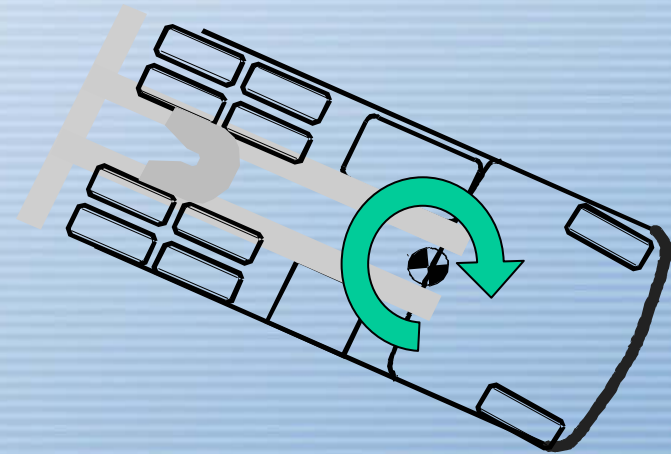


Stability 101 – Roll Video

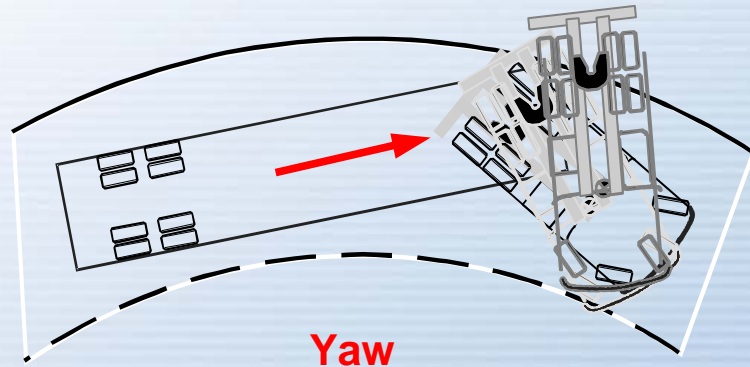


Stability 102 - Yaw

- Yaw = horizontal spin / rotation
- Compare desired direction (steering) to vehicle yaw rate
- Apply individual brakes to “pull” vehicle into desired orientation
 - Cannot be achieved by normal pedal activation

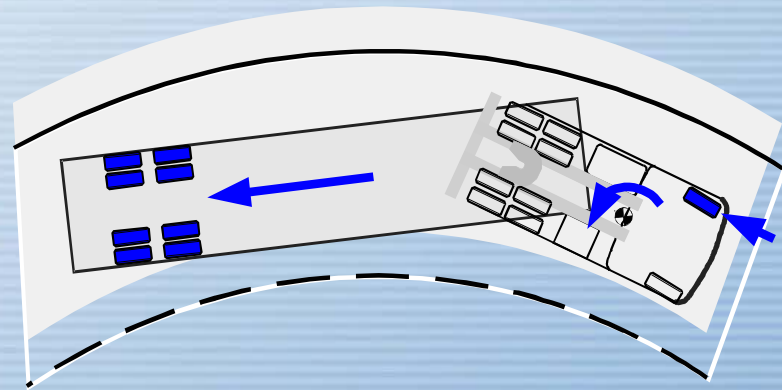


Stability 102 - Yaw



Yaw

Over-Steering (Jackknife)



With ESP intervention

- Similar factors affect yaw stability performance
 - Brake force capability
 - Delay in and rate of application

Stability 102 – Yaw Video



Roll Only VS. full Stability Simulation

- Simulation
 - 80k GVW
 - Driver steers around obstacle
- 3 simulations
 - ABS with Roll Stability only
 - ABS with ESP
 - ABS with ESP (brake forces shown)



Roll Stability Only



Full ESP



Full-ESP intervention forces shown



Where do full Stability Systems help?

<i>Results – Scenario Coverage</i>				Bendix ABS-6 Advanced w/ESP
Surfaces	Examples	Maneuvers	Results	
Dry	<ul style="list-style-type: none"> Concrete Dry asphalt 	<ul style="list-style-type: none"> Exit ramp Avoidance Lane change 	<ul style="list-style-type: none"> Rollover 	✓
Slippery	<ul style="list-style-type: none"> Wet asphalt Packed snow Ice 	<ul style="list-style-type: none"> Exit ramp Avoidance Lane change 	<ul style="list-style-type: none"> Under-/over-steer Jackknife Loss of control Rollover 	✓
Transitions	<ul style="list-style-type: none"> Patchy 	<ul style="list-style-type: none"> Lane change Lane correction 	<ul style="list-style-type: none"> Under-/over-steer Jackknife Loss of control Rollover 	✓
	<ul style="list-style-type: none"> Soft shoulder 	<ul style="list-style-type: none"> Vehicle drift Driver drowsiness 	<ul style="list-style-type: none"> Jackknife Loss of control Rollover 	✓



Maximum Bottom-Line Impact

The “P” is not Prevention

- ESP is not
 - Enhanced Stability Prevention
 - Electronic Stability Protection
 - Employee Satisfaction Program
 - Extra Sensory Perception

- Stability systems have limits
 - Limits of physics
 - Too fast, too heavy, too tight, too slippery
 - Mitigate the outcome of an incident

- Cannot address all situations
 - Impact with object (curb)
 - Fall into ditch



Drivers are Still Key

- **Stability systems are supplemental**
 - Operators should drive normally / prudently
 - Electronics can identify / react to certain situations faster than typical human reaction times

- **System educates the driver**
 - Notify the driver - light / brake application / other
 - Discourage drivers that push the envelope
 - Speed reduction beyond stability as a warning

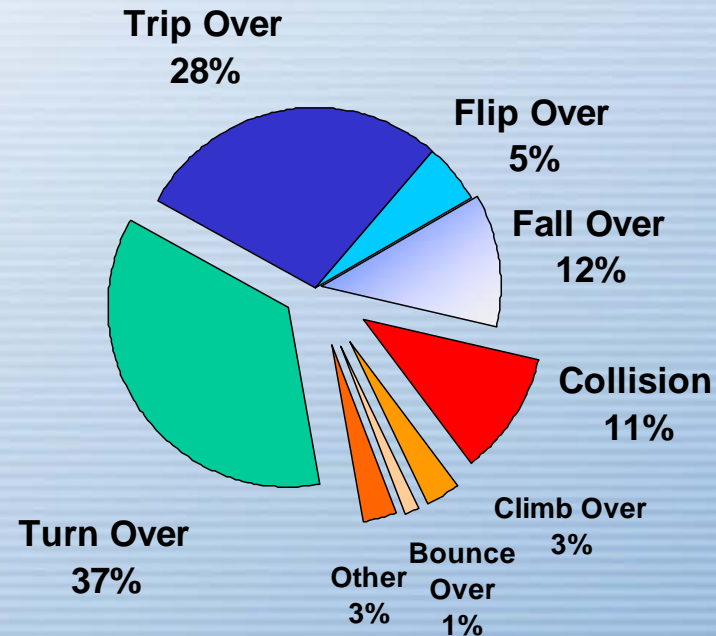


Making the Stability Decision



Frequency and Cause

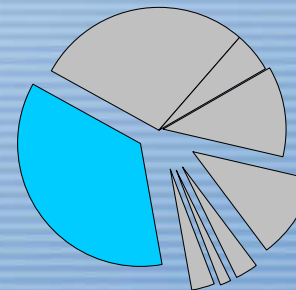
- Frequency may result from
 - Driver experience level
 - Routes
 - Traffic
 - Driving conditions, etc
- Determine cause of the incident
 - Speed
 - Loss of control
 - Attentiveness
- The result may be a rollover
 - Other causal factors
- National studies in process
- National databases being established



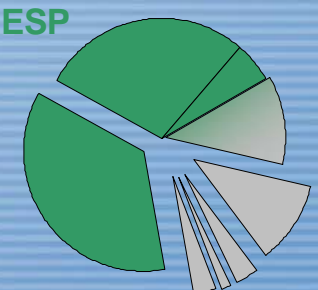
Source: Large Truck
Crash Causation
Study Interim Report
NCSA

Incidents potentially mitigated by:

RSP



ESP

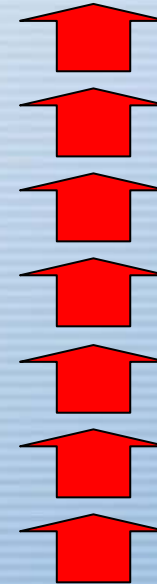


Understand the True Cost

- Tractor/trailer/truck damage or replacement
- Cargo damage
- Driver injury
- Liability (property damage and personal injury)
- Clean up
- Lost time (vehicle and driver)
- Insurance premium increase

- \$120 k per incident
 - \$150k to \$200k with injury
 - \$250k - \$ xx M extraordinary incident

Trend



Value Analysis

- **National statistics** (based on study by Chris Winkler, UMTRI)
 - 15000 commercial vehicle rollovers/year, 9400 are tractor-trailer
 - One rollover every 4 million miles
- **Example fleet**
 - 600 tractors * 125,000 miles/year = 75 million miles/year
 - 75 million miles / 1 rollover every 4 million = 19 rollovers per year
 - \$120K average roll incident cost * 19 rollovers = **\$2.2M cost to the fleet per year!**



Driver Assistance Systems System Evolution

automatic obstacle avoidance
BSM

automatic lane keeping
Urban ACC (Stop & Go)

ACC with additional features

LDW+
ACC+

ESP

ATC

ABS

partly automating complex maneuvers
assisting in complex maneuvers
(turning, passing)

partly automating lateral control
further automation of longitudinal
control

more safety by emergency braking in
certain situations

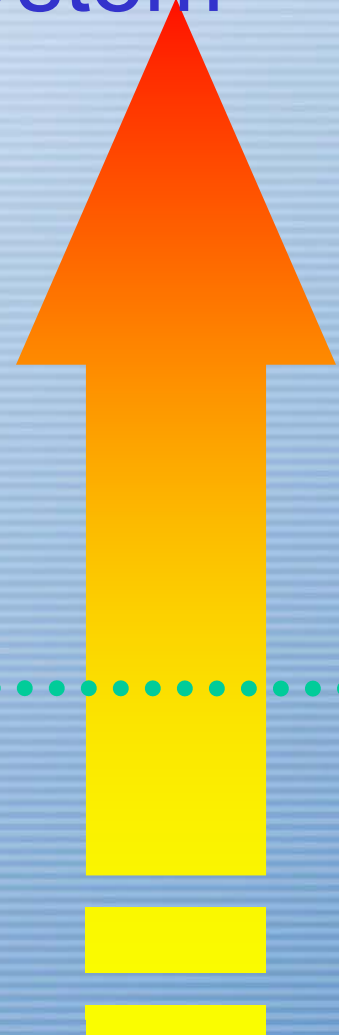
assisting in lateral control

partly automating longitudinal control

Full Stability ESP (autonomous brake
intervention) enabler for future
systems

assisting in improving launching and
limited lateral control impr.

assisting in longitudinal control



Thank You!

