OSC | 10
Ohio Safety Congress & Expo

Emerging vehicle safety technologies

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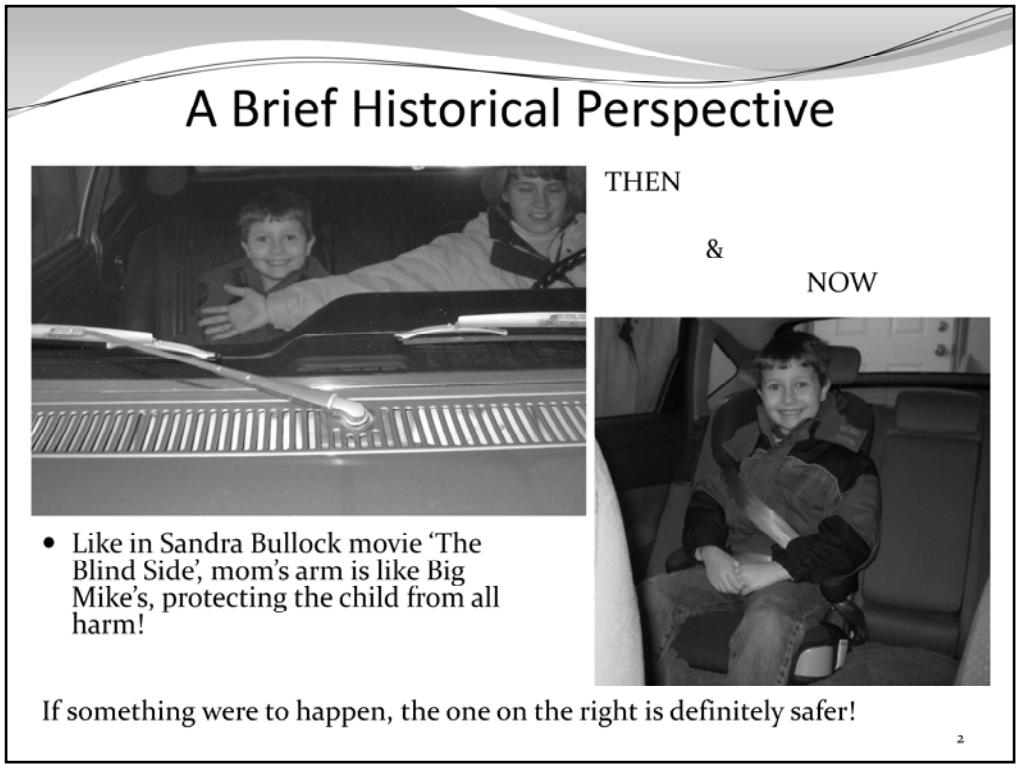
Scott Baldwin, Transportation Research Center Inc.

Wednesday, March 31, 2010 1:30 to 2:30 p.m.



Like in the movie 'The Blind Side' when Big Mike stuck his arm out to protect the boy from the airbag, moms of the past could stick their arm out to protect you from anything (whether you were 5 or 15). The mother's arm is an adaptive, adjustable, advanced safety technology that can quickly move to where it's needed based upon who or what it's protecting.

Nowadays, kids have to sit in the back seat so the airbag doesn't harm them, be boosted on a seat atop the seat so the seatbelt doesn't hurt them, and if they move too quickly then the seatbelt will tension up and prevent them from moving at all while riding in the car. Even though moms saved a lot of lives, in all seriousness, today's seatbelts, airbags and child safety seats do make us much safer than we were as kids (if an incident were to happen).

My Background – Who am I?

- Not developer of vehicle safety technologies
- Not technical expert on such technologies

- Education: Human Factors Engineering
  - Ergonomics, user interface design, man-machine interface, systems engineering, human decision making

- Profession: Automotive Research Engineer
  - Driver behavior, driver distraction
  - Run experiments: see how existing vehicles & technologies affect driver / driver performance
    - Test technologies w.r.t. human in the loop
    - Experience capabilities of some safety technologies as they emerge into market

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When I talk about automotive safety, the main questions that people ask are: what do I do and where do I work? Thus, I like to try to answer these background questions upfront as best I can. This slide and the next slide should give the audience a general understanding of me and my place of employment, as it pertains to automotive safety and emerging vehicle safety technologies.

My Background – Where am I?

- Research Engineer at Transportation Research Center Inc. (TRC Inc.)
- Brief history of TRC Inc. and the proving ground
- (1968) Original concept funded by State of Ohio highway bond issue, voter approved
- (1972) Ohio Legislature created TRC of Ohio & the center's mission:
  - Enhance health, safety, & general welfare of all inhabitants of State of Ohio
  - Create or preserve jobs & employment opportunities
  - Improve economic welfare of State of Ohio
- (1979) The Ohio State University contracted to manage operations & staff of TRC of Ohio
- (1988) TRC Inc. formed as non-profit Ohio corporation, affiliated with OSU, to operate Research Center as multi-user, independent test site
- TRC Inc. continues as non-profit owned by the Ohio State University
  - Any proceeds from services provided by TRC Inc. are returned to OSU, placed in endowment fund within Engineering College to support transportation research
- University's ownership of TRC Inc. allowed us to become one of the leading independent providers of testing, development & research in the world
- Now over 35 years helping transportation industry create safer, improved products
- We continue to accomplish this through our relationships as a contractor to NHTSA, other federal agencies & by supplying testing services to over 800 car manufacturers & suppliers worldwide

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Brief History and Background of TRC Inc., where we came from & where we are today:

- The original concept was funded by a portion of the proceeds of a State of Ohio highway bond issue approved by the voters in 1968.
- In 1972, the Ohio Legislature created TRC of Ohio and established the mission of the center to enhance the health, safety, and general welfare of all inhabitants of the State of Ohio, to create or preserve jobs and employment opportunities, and to improve the economic welfare of the State of Ohio.
- In June 1979 The Ohio State University was contracted to manage the operations and staff of TRC of Ohio.
- In 1988 TRC Inc. was formed as a non-profit Ohio corporation, affiliated with Ohio State, to operate the Research Center as a multi-user, independent test site.
- TRC Inc. continues to operate as a non profit owned by the Ohio State University and any proceeds from the services that TRC Inc. provides are returned to the university and placed in an endowment fund within the Engineering College to support transportation research.
- The result of the university's ownership of TRC Inc. has allowed us to become one of the leading independent providers of testing, development and research in the world.

For over 35 years we have helped the transportation industry create safer, improved products. We will continue to accomplish this through our relationships as a contractor to the National Highway Traffic Safety Administration, other federal agencies and by supplying testing services to over 800 car manufacturers and suppliers worldwide.

My Goal Today

- Provide you with basic information on variety of existing & emerging vehicle safety technologies
  - While minimizing use of technical details
- Discuss safety benefits of those technologies
- Provide the 'Human Factors' perspective of what end user (the driver's) experience might be

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In developing this presentation, it was obvious there were far more emerging safety technologies to talk about than can be covered in a one hour presentation. It was also easy to see it would be hard to organize the flow of information due to the various relationships and categorizations of these technologies. Hopefully, this covers a fair amount of them in a logical manner in the timeframe allotted.

Overview

- Technologies grouped by areas of interest:
  - Driver Situational Awareness
  - Light Vehicle Stability & Control
  - Heavy Vehicle Stability & Control
  - Restraints, Airbags
  - Vehicle & Driving Environment Integration
  - Miscellaneous (*as time permits, located after Questions*)
- Summary and Conclusions
- Questions

Driver Situational Awareness

- Technologies to help drivers keep track of what's going on around them:
  - Provide important information of one's surroundings
  - Encourage drivers to keep mind & eyes on driving task
    - Video based technologies
    - Sensor based technologies (radar, ultrasonic, laser)
    - Integration of video & sensors (park assist example)
    - Heads-up displays (night vision example)

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Rearview Camera & Video Display

- Camera attached to rear of vehicle, backing aid
  - Image horizontally flipped for consistency with mirrors
  - Displayed on screen in front of driver
- Helps driver see & avoid objects in blind spots
- Physically easier than looking over shoulder

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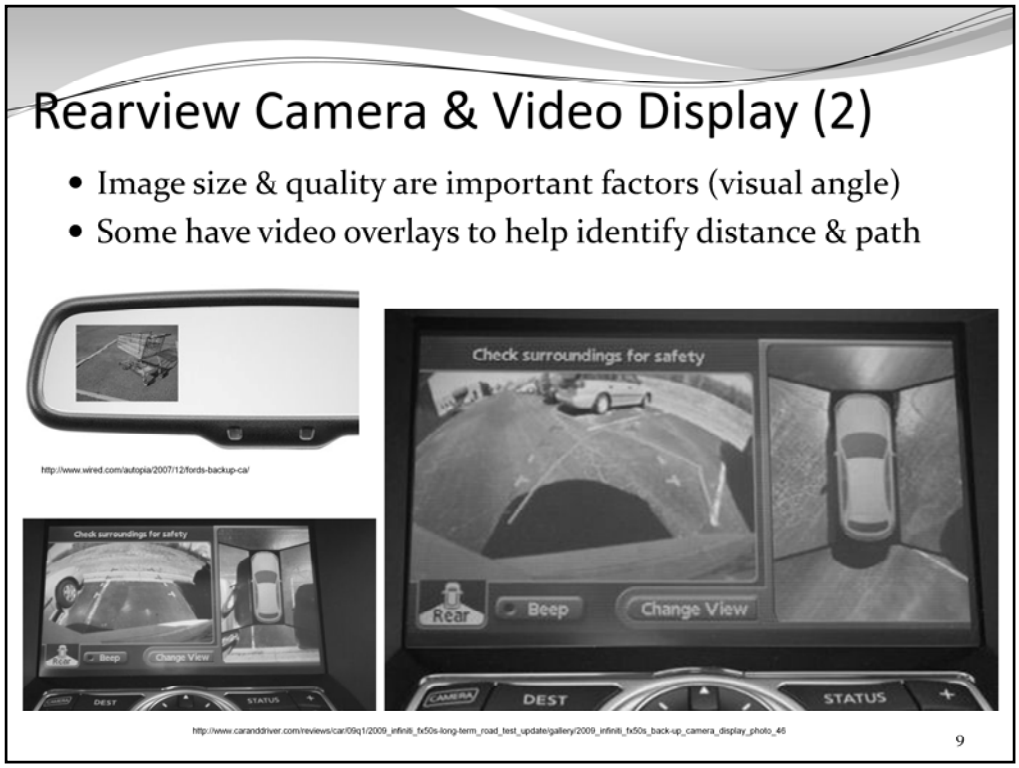
Many of the newer technologies make use of video-based systems for determining what is going on both within and around the vehicle. Video can be used to help the driver see things that are not normally visible (in blind spots, when driving in the dark, when the driver's not paying attention to a certain location, and so on).

Real time video processing can also support detection of things like driver inattention, driver drowsiness, vehicle lane departures and crash imminent situations, to name a few.



All videos / displays are not created equal. Image size and resolution are important factors in helping one identify potential dangers on a display.

Issues of skewed images, difficulty in judging distances in a video, a dirty or wet camera lens, reflections from bright lights / sun, and darkness are some of the sources that can affect successful recognition of objects in a video.

Good strategies for when to use the video (versus the mirrors versus looking over the shoulders) when backing may be situation dependent / driver dependent. For those with habits from many years of driving without video, getting used to using the video display to improve one's situational awareness can take some time and effort on the part of the individual.

Side View Cameras & Video Display

- Cameras mounted on side mirrors, coupled with rearview image, permit overlay of blind spots on one image
- Improves visibility in narrow passes or when parking
- Good situational awareness of surroundings without turning to look (especially helpful to those with limited mobility)
  - Currently most useful in low speed situations (backing, parking)

http://www.caranddriver.com/reviews/car/09q1/2009_infiniti_fx50s-long-term_road_test_update/gallery/2009_infiniti_fx50s_back-up_camera_display_photo_46

http://www.motortrend.com/photo_gallery/112_0712_2008_infiniti_ex35_gallery/photo_13.html

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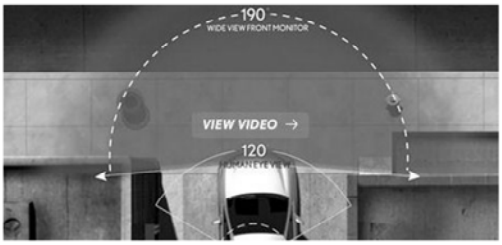
Current side view cameras are helpful in identifying objects in blind spots during low speed situations. Perhaps one day, a side view video could be used as much as, or more than, a side view mirror is used today. They could be good at identifying other vehicles in your blind spot when making lane changes on the highway.

Front View Cameras & Video Display

- Grille-mounted cameras enhance visibility during low speeds
  - Wider angle for intersections (190º field of view)
    - Help driver see intersection / cross traffic (when view obstructed)
    - Good situational awareness of cross traffic; could prevent incidents caused by pulling out in front of others
  - Normal angle to see distance to objects (forward parking)



http://www.lexus.com/HS#/road/advanced-vision

http://www.motortrend.com/photo_gallery/112_0712_2008_infiniti_ex35_gallery/photo_13.html

A wider angle camera or set of cameras, mounted to the front grille of a vehicle (to provide 190 degrees field of view), can help drivers see from the front of the vehicle when their view at the driver's seat is obstructed by some object (building, pole, sign, parked car, etc.).

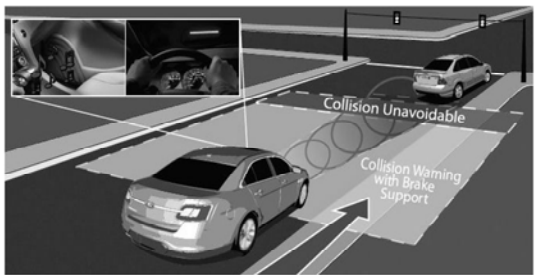
Cameras with normal angles may not help you see around corners / obstructions, but can be quite helpful in identifying objects directly in front of a car such that the driver can get close to an object without actually hitting it (like when parking a car in parking spot).

Collision Warning Sensors (1)

- System of sensors embedded in front & rear bumpers
- Warn driver of potential dangers surrounding vehicle
  - By proximity to other vehicles / objects

System examples:

- Forward Collision Warning
- Side Collision Warning
- Rear Collision Warning (Backup Warning)



http://media.ford.com/images/10031/Adaptive_Cruise.pdf

http://www.sportsimportsltd.com/paasvebase.html?gclid=CJPBgoq7si6ACFQdY2godMHccSw

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In addition to video-based systems, many technologies utilize laser, ultrasonic, and/or radar-based sensors to help the driver have a better understanding of the vehicle surroundings. Some systems can utilize both video and sensors to provide the driver with information and/or provide vehicle control inputs to assist drivers when needed. As these technologies advance, they ultimately integrate to where vehicle-to-vehicle and vehicle-to-environmental communications become possible (incorporating the use of GPS and wireless connectivity on a broader scale). In turn, more and more systems will develop in an attempt to control vehicles on behalf of safety.

Ultrasonic: proximity sensors on bumpers for object detection in low speed situations (bottom picture).

Radar (and sometimes laser): sensors for collision warnings in more dynamic, faster-paced environments (top picture).

Collision Warning Sensors (2)

- Driver's need to understand warnings ahead of time, to react correctly/quickly & avoid incident
  - Warnings tend to be directional beeps / tones
  - Rate of warning proportional to danger level (closeness)
- Warnings evolving to assist / intervene
  - Vehicle controls manipulated by warning sensed (steering, brakes, throttle)
  - Collision Avoidance Systems

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Collision avoidance system: system of sensors to warn driver of potential dangers on the road (including closeness to other cars, amount of speed reduction needed for going around an upcoming curve, and how close car is to going off the road). Advanced collision avoidance systems could someday send and receive signals to gain information from other cars, obstacles and traffic lights. They could also receive weather and traffic precautions.

One situation-specific example is protecting a driver from an accident when changing lanes when there's another vehicle in the blind spot, by warning of the other vehicle, and perhaps even automatically providing a steering control input to prevent the driver from changing lanes and hitting the other vehicle.

Integration of Video & Sensors

- Park Assist System: example of sensors & video in combination to help driver park
  - Sensors measure distance to nearby objects
  - Video display provides driver parking info
    - *Some systems provide parking info without video (basic display messages)*
  - Central processor determines / controls steering inputs to park vehicle safely in chosen location
  - Driver controls brake & throttle during parking maneuver
- Takes time to get used to combination of vehicle steering itself (no hands) & looking forward at video (or basic display) while going backwards

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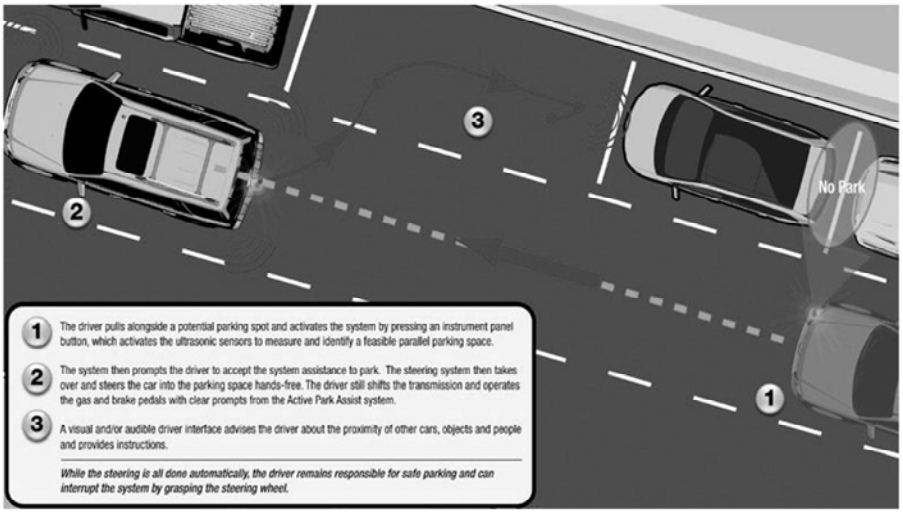
Parking sensors are (ultrasonic) proximity detectors embedded on vehicle bumpers to alert the driver of unseen obstacles during parking maneuvers. The sensors measure the time it takes for sound pulses to reflect back to a receiver, and then determine the distance to the object. Depending upon vehicle speed and distance to the object, the driver is warned by visual and/or auditory means about the risk of collision. Warnings generally indicate the direction and proximity of the object. Warnings are deactivated when the vehicle exceeds a certain speed, and can be switched off by the driver if desired.

A Park Assist System uses computer processors tied to the vehicle's ultrasonic sensors (and in some designs a rearview camera), to calculate optimum steering angles during regular parking. When the system is activated (driver presses button), the central processor calculates the optimum parallel or reverse park steering angles and interfaces with the electric power steering system to guide the car into the parking spot. The driver chooses the parking spot, and controls the brake and throttle pedals during the maneuver.

Developing a good driver interface is key to the usefulness of such a system. Some use ultrasonics with display messages and auditory alerts (eliminating video) while others prefer to use a video display that shows parking information on a video screen.

Park Assist System Example



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Inattention / Drowsiness Detection

- Attempts to warn driver of performance degradation (signs of distraction, inattention, fatigue)
  - Infrared LED detectors and/or eye tracking camera monitor driver
    - Some learn driver patterns by monitoring vehicle control inputs (steering, brake, throttle)
- Warnings: flashing lights, warning sounds
- Intervention: apply brakes if no response
- With all of today's distractions, warnings & interventions become more and more important
  - Hopefully driver's don't adjust to rely on such systems

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Inattention / drowsiness detection systems attempt to warn the driver when performance declines. They can be quite helpful to those who drive for long periods of time and those who are easily distracted by all of life's other activities while driving. Current systems learn driver patterns and can detect when a driver is becoming drowsy, inattentive or distracted. Eye movement, blinking, steering patterns, throttle inputs and other measures can all help these systems understand and know when a driver is not driving normally. Coupling this information with a collision avoidance system makes it possible to warn drivers of dangerous situations, as well as, warn of general fatigue or distraction, and intervene to protect the driver from harm.

Some systems use infrared sensors to monitor driver alertness. Some systems include a CCD camera placed on the steering column that is capable of eye tracking. If a driver is not paying attention to the road ahead and a dangerous situation is detected, the system can warn the driver by flashing lights and/or warning sounds. If no action is taken, the vehicle can apply the brakes.

Heads-Up Displays (1)

- Situational Awareness: the more a driver can keep eyes & mind on road, the better
- Location & design of displays & controls play important role
  - Keep primary driving info close to road scene
  - Less eyes off road time = safer driving

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Situational awareness is a key component of safe driving. The more a person can keep the eyes and mind on the road, the better. The location and design of displays, that provide primary driving information, can play an important role in maximizing the driver's ability to stay focused on the road for longer periods of time.

Heads-Up Displays (2)

- HUD defined: transparent display, overlay on driving scene
- Better HUDs require less change in eye focal point to see info
- Night Vision example: increase perception & sight distance in darkness & poor weather (project images on windshield)

Night Vision:
- Infrared light
- CCD camera
- Computer processor

http://www.flickr.com/photos/jurvetson/22226426/

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A Heads-Up Display (HUD), by definition in a vehicle, is a transparent display that presents data without requiring the driver to look away from the forward road scene. The origin comes from a user being able to view information in a head up, looking forward position, instead of looking down at instruments. In addition to HUDs, any important display that is closer in proximity to the forward road scene can be a benefit to the driver's situational awareness and ability to keep eyes on the road.

An automotive night vision system increases a driver's perception and seeing distance in darkness or poor weather, that are usually beyond the visibility provided by the headlights. One system uses headlight projectors emitting near infrared light aimed like the car's high beam headlights with a CCD (charge-coupled device) camera to capture the reflected radiation. That signal is processed by a computer which projects a black-and-white image on the lower section of the windshield. Passive systems do not use an infrared light source, instead they capture existing thermal radiation emitted by objects by using a thermographic camera (senses an object's heat and turns it into an image).

Light Vehicle Stability & Control

- Technologies that can:
  - Support driver in maintaining control of vehicles like:
    - Passengers cars, trucks & sport utility vehicles
  - Intervene to control vehicle due to perceived safety risk

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Tire Pressure Monitoring System

- Sensors in each tire electronically monitor air pressure
  - Real-time info by low pressure warning light (most common), gauge or display
- Helps driver maintain vehicle tires before more serious tire-related issue
  - Supports better vehicle stability & control, especially during adverse weather
- Don't be surprised to see Tire Pressure Regulating Systems in the future (car automatically keeps tires at proper inflation pressures at all times)?

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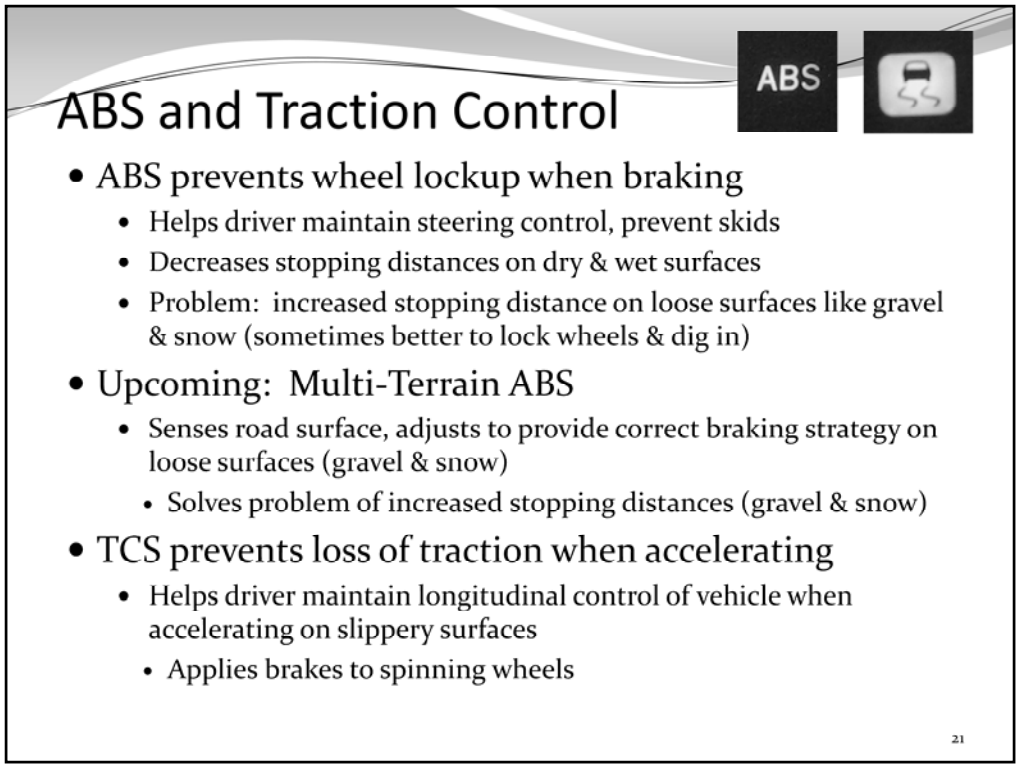
The tire may very well be the most important safety feature on a vehicle, for it's the one component that brings the vehicle and the road together. Proper tire inflation and tread depth can make all the difference in what the vehicle is able to do during an adverse situation. Everyone, especially fleet operators, should have programs in place to make sure tires are checked regularly for proper inflation pressure and tread depth. In addition, tires should be rotated and balanced at regular intervals. Vehicle stability and control characteristics start with the tire – one of the simplest vehicle components to maintain, that is often overlooked and taken for granted.

Direct System: A Direct Tire Pressure Monitoring System (TPMS) is designed to monitor the air pressure using sensors inside each of the vehicle's tires. These systems report real-time tire pressure info to the driver, either by gauge, display or a low-pressure warning light.

Indirect System (less common): These systems monitor wheel rotational speeds and other signals outside the tires, and compare that to information about a tire's diameter to assess tire inflation levels.



An Anti-lock Brake System (ABS) prevents the vehicle's wheels from locking up (or ceasing to rotate) when braking. A rotating wheel helps the driver maintain steering control under heavy braking by preventing a skid and allowing the wheel to continue to maintain traction with the road surface. ABS offers improved vehicle control, and can decrease stopping distances on dry and slippery surfaces. Unfortunately, it can increase stopping distances on loose surfaces such as snow and gravel (where a locked up wheel may dig in better to stop).

A traction control system (TCS) is designed to prevent loss of traction of the driven wheels to help maintain control of the vehicle when excessive throttle / torque is applied by the driver (typically on slippery surfaces like water, snow, gravel). TCS provides longitudinal control when accelerating.

Both ABS and TCS modulate brake pressure to specific wheels to support vehicle control and prevent wheel slip. ABS prevents the wheels from locking and sliding, while traction control prevents the wheels from spinning too fast. The vehicle compares wheel speeds to vehicle speed, so it knows when and where to pulse the brakes rapidly.

Many of the higher level stability and control systems have evolved from ABS / TCS technology, by using the brakes of the appropriate wheel(s) to provide vehicle control under adverse conditions.

Brake Assist

- Senses quick brake applications by driver & increases brake pressure automatically to maximize stopping performance
- Allows drivers to stop in shorter distances
  - Helps prevent collisions with other vehicles or objects
- All drivers have the ability to 'brake hard' if needed
  - Human strength is not as important as quickness

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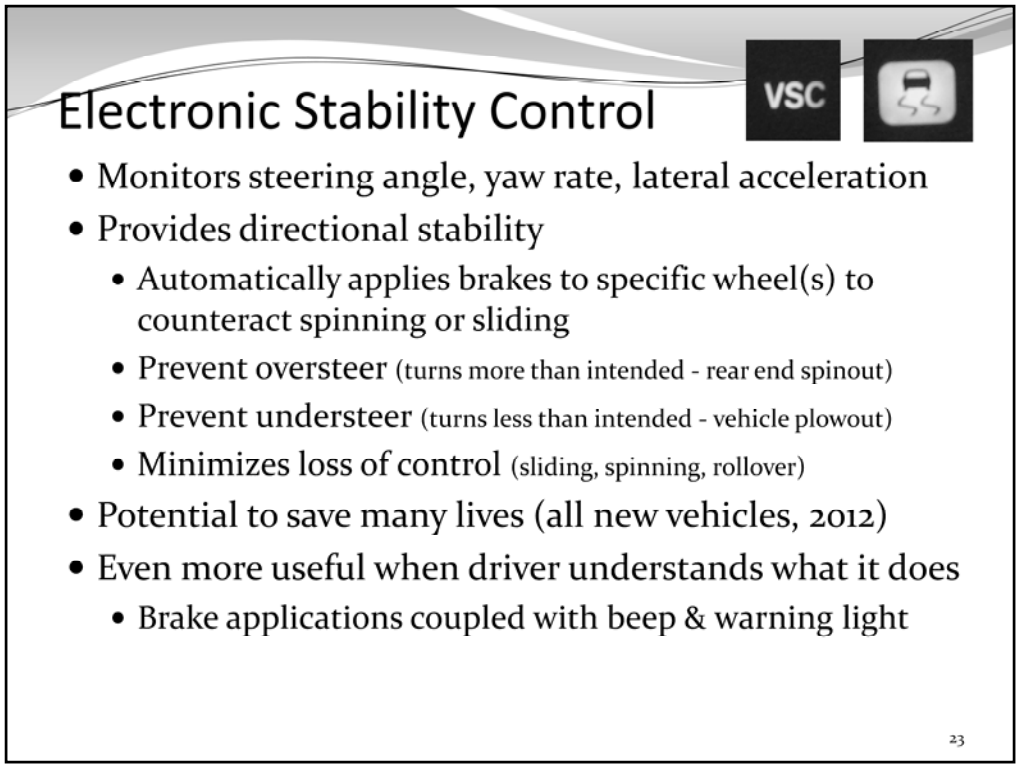
Brake Assist is a technology that increases braking pressure in an emergency situation. It senses when the driver applies the brakes quickly, and responds by increasing brake pressure automatically to maximize stopping performance. Thus, it provides all drivers with the ability to brake hard, if needed, without requiring a lot of strength by the driver.



Electronic stability control (ESC) is a computerized technology to improve a vehicle's stability by detecting and minimizing skids. When ESC detects loss of steering control, it automatically applies the brakes to help "steer" the vehicle where the driver intends to go. Braking is automatically applied to individual wheels, such as the outer front wheel to counter oversteer (rear end sliding around), or the inner rear wheel to counter understeer (vehicle plowing out instead of making the turn). Some ESC systems can even reduce engine power until control is regained.

Electronic stability control does not improve a vehicle's cornering performance; rather it helps to minimize a loss of control (rollovers, sliding, spinning out). ESC has the potential to save the largest number of lives, perhaps since implementation of the 3-point seatbelt? Estimates suggest up to 1/3 of all traffic fatalities could be avoided if all vehicles had this technology. US mandates to have it in all manufactured vehicles by 2012.

(Alternative description) An ESC system monitors steer angle and yaw rate, as well as lateral acceleration, to provide directional stability. It can prevent or reduce excessive oversteer (directional response to steering is excessive; vehicle turns more than intended; “spinout”), excessive understeer (directional response to steering is insufficient; vehicle turns less than intended, “plowout”). The ESC system applies brakes at selected wheels to counteract spinning, or to promote turning if the vehicle is understeering.

Pre-Collision System

- Radar sensors detect an imminent collision
  - Preemptively retracts seatbelt to maximize protection
  - Prepares Brake Assist to help driver stop quicker when driver responds by braking
  - Provide warning to the driver (visual / auditory)
  - Some can automatically apply brakes (next slide)
- Minimizes severity of incidents
- Understanding why a seatbelt retracts (& warnings), creates benefit instead of distraction from what's really happening

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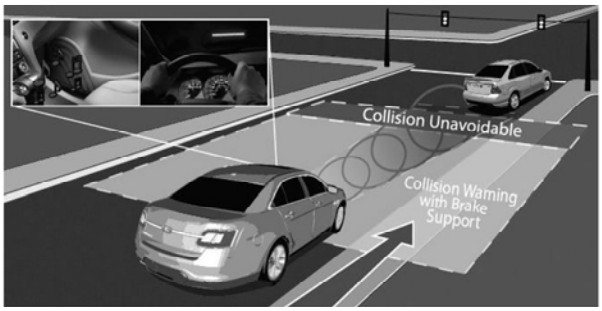
If a collision is determined to be unavoidable, the seatbelt pretensioners will activate, and the brakes will automatically engage to slow the vehicle. A pre-collision system is designed to reduce the severity of an accident. Most are also known as forward collision warning systems which use radar and sometimes laser sensors to detect an imminent crash. Depending on the system they may warn the driver, pre-charge the brakes, retract the seat belts to remove excess slack and automatically apply partial or full braking to minimize the crash severity.

Crash Imminent Braking System

- An active system using collision warning information to mitigate or avoid forward collisions
  - Automatically applies brakes if driver fails to respond to collision warnings (visual / auditory)
- Can prevent or reduce severity of collision

• User has to understand & get used to vehicle braking on its own
• And, be able to recognize why quickly



http://media.ford.com/images/10031/Adaptive_Cruise.pdf

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Crash Imminent Braking systems use information from collision warning sensors to automatically apply brakes if the driver does not respond to an impending forward collision. CIB systems may reduce the severity of the collision, or use the full braking capability of the vehicle to avoid the collision, if possible.

Additional terms for these types of systems are: Collision Mitigation Braking, Dynamic Brake Assist, and Automatic Brake Application.

Lane Keeping Support

- Lane Departure Warning: warns driver if vehicle moves out of lane on freeways / arterial roads (unless turn signal on)
  - Visible, audible and/or vibration warnings
- Lane Departure Intervention: provides steering input to keep vehicle in lane

- Camera & processor to detect road lines (need good lines to track)
- Systems minimize accidents caused by driver error, distraction & drowsiness

www.edmunds.com/ownership/safety/articles/100176/article.html

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A lane departure warning system is designed to warn a driver when the vehicle begins to move out of its lane on freeways and arterial roads (unless a turn signal is on in that direction). More specifically, it works well on roads that have well-defined edge lines (like in the picture), since the lines are what is being detected by the system. If edge lines are not good enough on a road, the system does not provide warning or intervention (to minimize false alarms). These systems are designed to minimize accidents by addressing the main causes of collisions: driving error, distraction and drowsiness.

There are two main types of systems:

Systems which warn the driver if the vehicle is leaving its lane (visual, auditory, and/or vibration warnings).

Systems which warn the driver, and if no action is taken, automatically takes steps to ensure the vehicle stays in its lane (like steering inputs).

Heavy Vehicle Stability & Control

- Technologies that can:
  - Support the driver in maintaining control of larger vehicles / trucks:
    - Tractor-trailers, buses & box trucks
  - Intervene to control the vehicle due to safety risk

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Light Vehicle Technologies In Heavy Vehicles / Trucks

- Many light vehicle technologies are emerging in larger vehicles as well:
  - Anti-Lock Brake Systems, Forward Collision Warning, Tire Pressure Monitoring Systems, & so on
  - Upcoming slides:
    - Disc Brakes
    - Electronically-Controlled Braking Systems
    - Electronic Stability Control (ESC)
    - Roll Stability Control (RSC)

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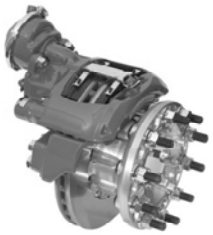
Heavy Truck Disc Brakes

- Disc brakes emerging as popular choice due to recent advances in brake system development
- Resist fade, cool down more quickly, & provide shorter stopping distances (compared to drum brakes)
- Linear, consistent response provides more control & better brake system feedback



http://www.kenworth.com/newspics/BendixBrakes.jpg

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Although disc brakes have been standard equipment on light vehicles for many years, drum brakes remain the predominant brake type on heavy trucks. Due to recent advances in brake system development, disc brakes are now becoming a popular choice for heavy trucks. Disc brakes resist fade, cool down more quickly, and typically reduce stopping distances when compared to drum brakes. Disc brake response is more linear and consistent than drum brake response, giving drivers more control, better brake system feedback and improved steering control.

Brake fade is a condition caused by heat building up on a brake's surface, usually caused by sustained or repeated brake applications. When heated, the brakes fade or have a reduction in stopping power.

Heavy Truck Electronically-Controlled Braking Systems

- Electronics supplement/replace pneumatic air brake control lines (kept for redundancy)
- Faster braking response: electronics faster than pneumatic control lines
- Shorter braking distance through improved control
- May improve the quality of brake system feedback
- Provides better brake diagnostics: monitors wear
  - Provides malfunction warnings for drivers

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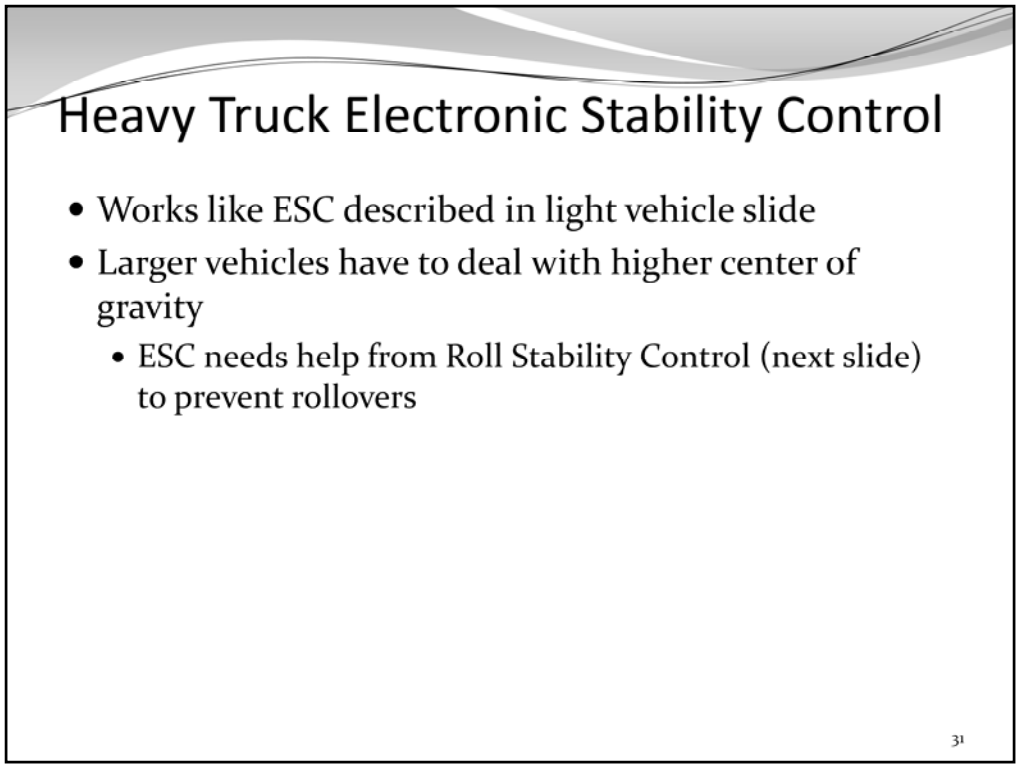
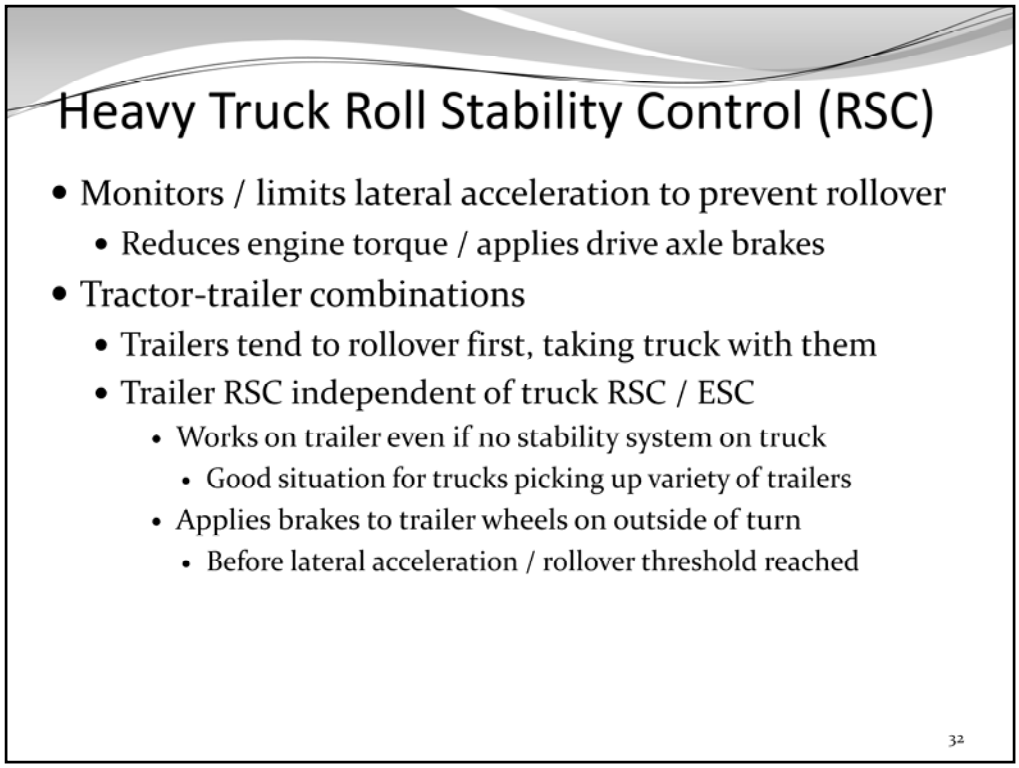
Conventional air brake systems use compressed air, not only to provide braking torque, but also to send the driver's input for braking to axle mounted brake assemblies through pneumatic control lines. ECBS replaces the pneumatic control lines with electronics. The safety benefit is faster braking response (electronics faster than hydraulics). In addition, ECBS is expected to improve the quality of brake control such that stopping distances are reduced. Pneumatic control lines are retained for redundancy. Additional benefits include brake wear monitoring, improved brake system malfunction warnings to drivers, and improved brake system diagnostics.



Heavy Truck Electronic Stability Control (ESC):

A heavy truck ESC system monitors steer angle and yaw rate, as well as lateral acceleration, to provide directional stability. It can prevent or reduce excessive oversteer (directional response to steering is excessive; vehicle turns more than intended; "spinout"), excessive understeer (directional response to steering is insufficient; vehicle turns less than intended, "plowout") and, for tractor-trailers, prevent or mitigate jackknifing. The ESC system applies brakes at selected wheels to counteract spinning, or to promote turning if the vehicle is understeering.

Heavy vehicle ESC/RSC versus light vehicle ESC (based on vehicle's center of gravity): ESC systems are placed in vehicles with a lower center of gravity to provide yaw stability control to keep the vehicle from sliding sideways, which happens to help prevent tripping and rollover events in those types of vehicles. Thus, roll stability control is not necessary in vehicles with a lower center of gravity. Vehicles with a higher center of gravity (like heavy trucks, trucks, SUVs), may need both ESC and roll stability control (RSC) systems to prevent both sliding and rolling over due to conditions affected by the higher center of gravity of those vehicles.



Heavy Truck Roll Stability Control (RSC):

A heavy truck RSC system monitors lateral acceleration and reduces engine torque and/or applies drive axle brakes before lateral acceleration increases to a point where rollover can occur.

RSC systems are also applied to semitrailers. In many tractor-trailer rollover accidents, the trailer rolls first and pulls the tractor over with it. Trailer RSC monitors the lateral acceleration of the trailer and applies braking to the trailer wheels on the outside of the turn before the trailer reaches its rollover threshold. It works independently of any stability system installed on the tractor and is effective even if the tractor has no stability system. This is a great situation for truck drivers who pick up a variety of trailers from a variety of locations. For as long as the trailer has RSC, it will work (without any special setup/hookup needed by the driver).

Restraints, Airbags

- Technologies that can:
  - Provide occupant protection during crashes & other adverse situations

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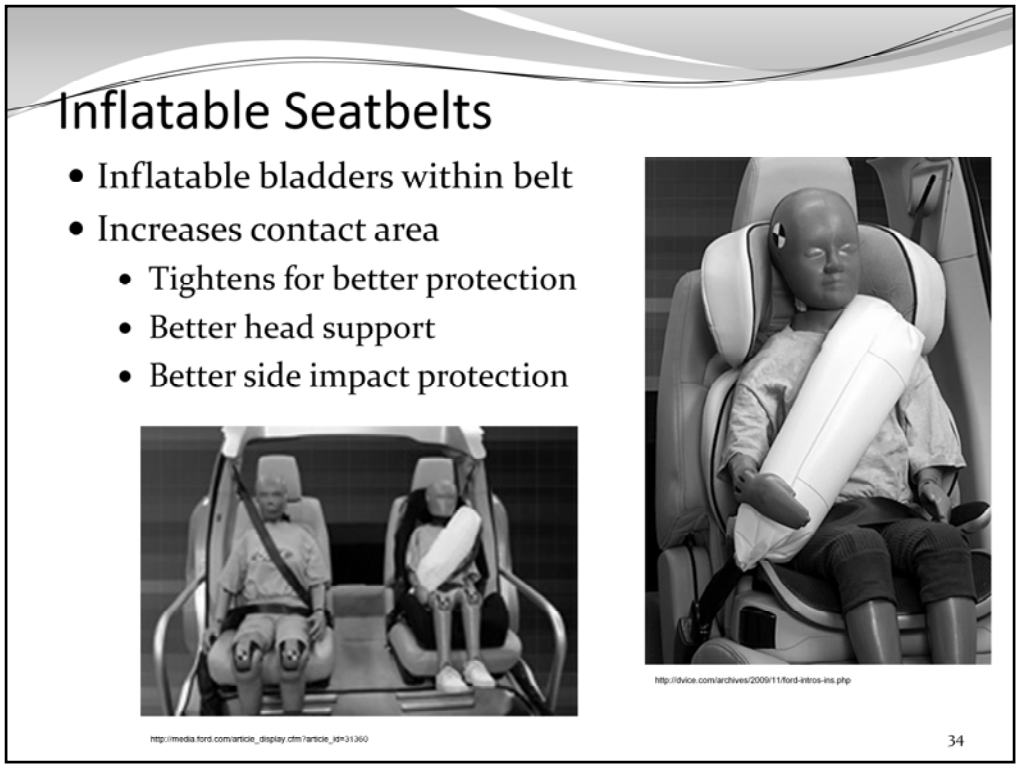

As humored in the initial slide, seatbelts are not perfect for all circumstances. Researchers are working on better seatbelts than provide protection under more of a variety of forces. The inflatable seatbelt provides promise for a more cushioned method for protecting the occupant from both the incident and the restraint itself.

The inflatable seatbelt uses tubular inflatable bladders that are contained within a outer cover. When a crash occurs, gas is introduced to inflate the bladder and increase the area of the restraint contacting the occupant. The length of the restraint is also shortened to tighten the belt around the occupant for better protection. The system supports the head during the crash better than a normal seatbelt. It also provides better side impact protection.

4 Point Seatbelt Harness

- Protect occupant uniformly
- Better upper body support
- Better side impact protection
- Seat integration, to get 4 attachment points

http://www.theautoaccessory.com/car-safety/seat-belt.html

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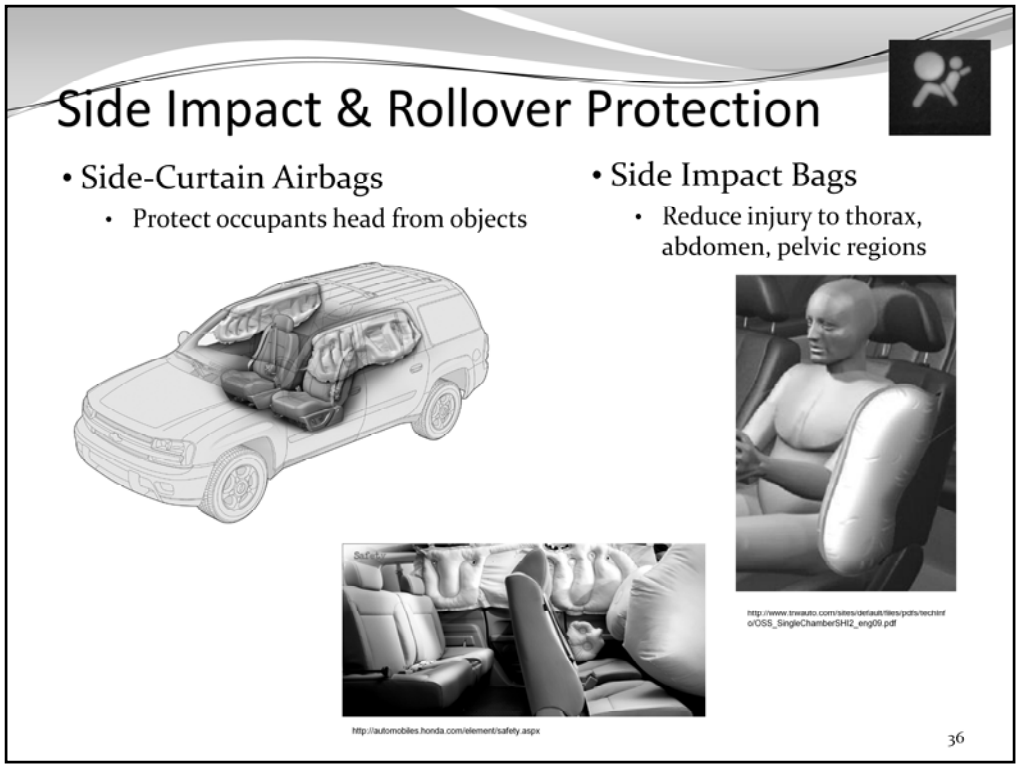
As humored in the initial slide, seatbelts are not perfect for all circumstances. Researchers are working on better seatbelts than provide protection under more of a variety of forces. The 4-point seatbelt harness provides promise for protecting the occupant more than a 3-point harness. 4-point harnesses would be integrated into the seats, instead of being attached to the vehicle's pillar.

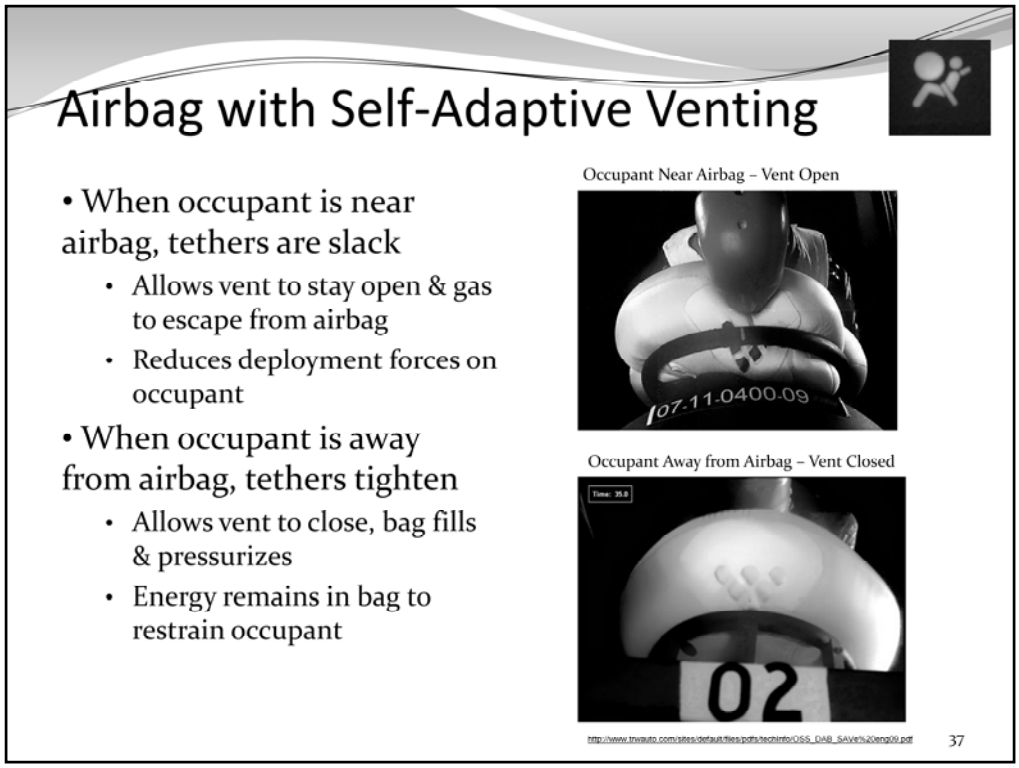


An airbag is an occupant restraint consisting of a flexible envelope designed to inflate rapidly in a collision to prevent vehicle occupants from striking objects such as the steering wheel or windows. Airbags are evolving: incorporated to cover more and more positions, and becoming smarter to activate only when needed and in the amount needed. Airbags will continue to get more protective and less damaging.

Advanced airbag technologies are being developed to tailor airbag deployment to: the severity of the crash, the size and posture of the vehicle occupant, belt usage, and how close a person is to the actual airbag. Many of these systems use multi-stage inflators that deploy less forcefully (in stages) in moderate crashes than in very severe crashes. Occupant sensing devices let the airbag control unit know: if someone is occupying a seat adjacent to an airbag, the weight of the person, whether a seat belt or child restraint is being used, and whether or not the person is close to the airbag. Based on this information and crash severity information, the airbag is deployed at either a high force level, a low force level, or not at all.

(Left Picture) Side Curtain Airbags: This kind of airbag will become mandatory by federal law in all new vehicles sold in the U.S. of model year 2013. They are stored in the headliner above the doors. Two types of inflatable curtains are used. One type is designed to absorb the energy of a direct side impact called First Impact. The inflation makes the curtain deploy in the passenger compartment, providing protection between the occupant's head and any hard objects (such as a pole). The other type of curtain is able to reduce partial and complete occupant ejections up to 6 seconds in rollovers.

(Right Picture) Side-impact airbags or side torso airbags are a category of airbag mainly located in the seat frame, and inflate between the seat occupant and the door. These airbags are designed to reduce the risk of injury to the thorax, lower abdomen and pelvic regions of the occupant. The side impact bag is typically inflated within 12 thousands of a second; four times faster than a frontal airbag.



Yesterday's frontal airbag system is a passive supplemental restraint used to cushion the driver or passenger during frontal impacts. Today's airbag system is a ''smart'' adaptive restraint system that tailors the airbag to the restraint needs of the occupants, as well as identifying when occupants are out of the typical seating position, and either reduce the force or suppress the airbag altogether. Today's airbags also have child seat sensing to disable the airbag when a child seat is present.

In real world situations, sensors determine the size, shape and force that the airbag should deploy, or if the airbag should be suppressed completely, within milliseconds.

An example is illustrated in this slide. Upon deployment, the inflating bag "senses" the occupant position and distance from the module.

Advanced airbags began being phased-in in 2003 and have become required in all light vehicles.

Active Head Restraints

- Raise & shift forward toward head during rear-end collision
  - Integrate with Pre-Collision System for faster response
- Reduces neck injuries, whiplash severity during crash

• With any head restraint, driver responsible for making sure HR in best position for driving
• Adjust your HRs for best protection!

http://www.edmunds.com/ownership/safety/articles/46912/article.html (from Saab Cars USA)

Vehicle & Driving Environment Integration

- Technologies that can:
  - Create a safer transportation system
  - Create advanced transportation systems
    - *Expert panel, Session 305, next*
  - Mitigate or warn of certain types of issues:
    - Potential vehicle to vehicle collisions
    - Possible intersection conflicts (red lights, crosswalks, traffic)
- Synergy of various technologies to:
  - Take over more & more vehicle control
  - Take vehicle occupants safely to destination

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Dedicated Short Range Communication

- DSRC: short-to-medium range wireless channels
- Specific for autos: Intelligent Transportation Systems
- Use of GPS & wireless communication:
  - Vehicle to vehicle
  - Vehicle to roadway infrastructure
- Supports larger scale situational awareness & safer driving environment (info sharing)
  - Emergency warnings, intersection collision avoidance, vehicle safety inspections, signage / info, vehicle platooning, & so on

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Using GPS and wireless communication technologies, vehicles of the future will be able to communicate with one another and with the roadway infrastructure to support a larger scale situational awareness and safer driving environment.

Dedicated short-range communications (DSRC) are one-way or two-way short-to-medium range wireless communication channels specifically designed for automotive use. DSRC is to be used by Intelligent Transportation Systems.

<u>Possible safety applications:</u>

Emergency warning system for vehicles

Cooperative Adaptive Cruise Control (vehicle platoons)

Cooperative Forward Collision Warning (prevent multi-car pile up)

Intersection collision avoidance

Approaching emergency vehicle warning (Blue Waves)

Transit or emergency vehicle signal priority

Commercial vehicle clearance and safety inspections / normal vehicle safety inspections

In-vehicle signing

Rollover warning

Highway-rail intersection warning

Route Planning & Guidance

- With tools like DSRC, vehicles can receive key info to avoid traffic problems & help driver adjust route
  - Safer & more efficient travel
  - Traffic reporting technology advancements
  - Navigation system advancements

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GPS (Global Positioning System) and traffic reporting technologies will be able to provide vehicles/drivers with key information for avoiding traffic problems and adjusting ones route to get to a destination safer and more efficiently.

GPS is a U.S. space-based global navigation satellite system. It provides reliable positioning, navigation, and timing services to worldwide users on a continuous basis in all weather, day and night, anywhere on or near the Earth which has an unobstructed view of four or more GPS satellites. GPS has become a widely used aid to reliable navigation worldwide, and a useful tool for map-making, land surveying, commerce, scientific uses, tracking and surveillance.

Summary and Conclusions

- What to tell fleet operators & business owners about emerging vehicle safety technologies?
  - Emerging technologies can greatly increase the level of safety benefit
  - Personnel need at least a basic knowledge & understanding of technologies to:
    - Prevent error, misuse or counterproductive actions, due to misinterpretation of a vehicle's response to a situation
    - Maximize proper use of available safety features
    - Feel comfortable with driving a vehicle having so many new technologies

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Questions?

Thanks for attending!

Thanks to my colleagues who helped bring this presentation together!

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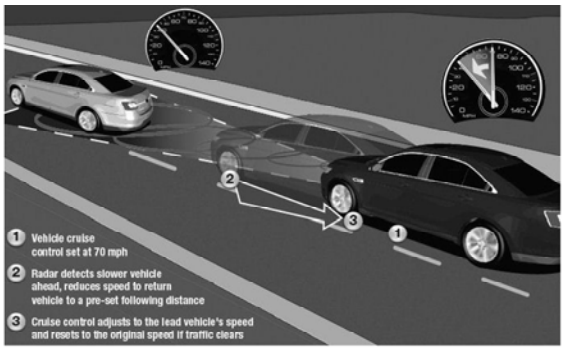
Miscellaneous

- Technologies that may fit well in multiple areas of interest, or are somewhat unique:
  - Adaptive Cruise Control
  - Crawl Control
  - Lighting Technology
  - Alcohol Interlocks

Adaptive Cruise Control

- Vehicle can sense other vehicles
- Automatically slows down to safe following distance
  - Resumes to cruising speed when path clear again
- Driver pre-selects safe, comfortable following distance

- Help prevent rear-end collisions by inattentive drivers
- Improved traffic flow



http://media.ford.com/images/10031/Adaptive_Cruise.pdf

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Cruise control has been around for a long time, and is widely accepted by the driving population. Adaptive or autonomous cruise control takes it a step further, allowing for the vehicle to sense other vehicles in front of it, such that the vehicle will automatically slow down to follow a lead vehicle at a safe distance until the lane is clear again. When the lead vehicle is gone, the car will resume to the cruising speed the driver set previously. Many of these systems will also allow the driver to choose the 'safe following distance' to meet his/her level of comfort.

As this technology evolves, the vehicle could be permitted the full range of control to speed up and slow down the vehicle as necessary to stay with the flow of traffic in front of it. These systems use either radar or laser sensors, allowing the vehicle to slow when approaching another vehicle and accelerate again to the preset speed when traffic allows. ACC technology is a key component for future generations of intelligent cars.

Crawl Control

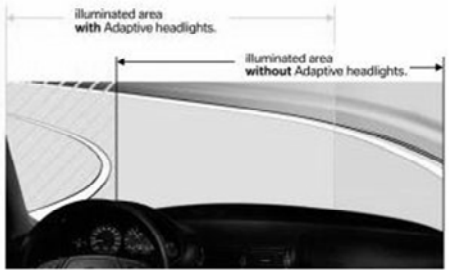
- Off-road equivalent of cruise control
- For hills & rugged terrain
  - System on, feet off pedals: throttle / brake automatically to maintain even, crawling speed (while driver steers)
    - Toggle control for different speed settings
  - Minimizes tire slippage, pitching & bouncing over rocks & uneven surfaces

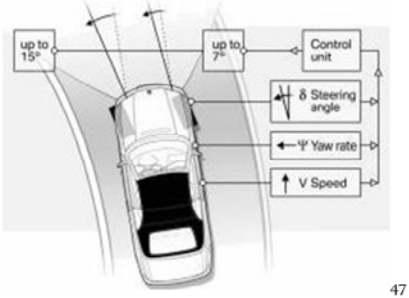
Crawl control is the off-road equivalent of cruise control. Could be useful for any low speed task where you might want to maintain a constant speed without using the vehicle pedals.

Maybe this would be popular for delivery vehicles that have to traverse long gravel driveways full of potholes and other issues?

Lighting Technology

- Headlights track vehicle's intended path
  - Processing of steering inputs, vehicle motions
- Headlights adjust intensity, direction based on:
  - Ambient weather, visibility conditions, traffic
  - Vehicle speed (faster = need to see farther)
  - Road curvature & contour factors





http://www.usautoparts.net/bmw/technology/lighting.htm

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Lighting can be adapted to optimize use of the headlights. Headlights could be movable to shine on the intended path (determined by steering input and vehicle motions). Headlights could also adjust intensity based on using sensors to determine ambient weather and other visibility conditions. Vehicle speed and road curvature and contour information could also be factored into an advanced lighting system.

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are working their way into more and more automotive lighting applications.

Lighting can also be used to make vehicles more conspicuous to other vehicles or roadway systems. For example, motorcycles benefit greatly by becoming more conspicuous to other traffic. Another example includes lights that make cars more conspicuous in adverse weather conditions.

As all these vehicle sensors become integrated to know what's going on with the driver and driving environment, technologies such as lighting can adapt to maximize their safety benefit to the driver under a variety of circumstances.

Alcohol Interlocks

- Driver must exhale into sensor before engine starts:
  - BAC > .02: vehicle won't start
- Random, periodic exhale samples needed during drive:
  - In case 'friend' started your vehicle
  - BAC > .02: lights flash, horn honks until car turned off
- Alternative designs:
  - Alcohol sensors take regular air samples (found in vehicle)

http://www.stopdwi.com

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For companies with fleet vehicles that are used by employees both on and off the job, an alcohol interlock could be a good technology to make sure your drivers are not driving your vehicles impaired. In addition to a safety benefit, there could be savings on things like insurance and workers comp.

An alcohol interlock (a breathalyzer) is installed in a motor vehicle's dashboard. Before the vehicle's engine can be started, the driver must exhale into the device. If the breath-alcohol concentration is greater than the programmed blood alcohol concentration, the device prevents the engine from being started. At random times after the engine has been started, the system requires another breath sample to help prevent a friend from breathing into the device, enabling the intoxicated person to get behind the wheel and drive away. If the breath sample isn't provided, or the sample exceeds the interlock's preset blood alcohol level, the device will log the event, warn the driver, and then activate an alarm (e.g., lights flashing, horn honking) until the ignition is turned off or a clean breath sample has been provided.