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Cars that anticipate needs - just like a horse

- **Smart interaction to minimize driver workload**
- **Improving user interface and vehicle utility**
- **User-interface improvements also enhance convenience and comfort**
- **Presentation by Gerald Cilibraise, Director, Chassis Engineering Liberty and Technical Affairs Engineering Technologies and Engineering Technologies at the DaimlerChrysler Innovation Symposium, June 11 & 12, 2002 in Stuttgart.**

At the Liberty and Technical Affairs advanced technology development group in Auburn Hills, engineers are examining a whole range of different ways of increasing passenger safety through an improved human-machine interface. These features reduce stress and make life easier for the driver and passengers, with the vehicle anticipating needs - as intelligently as a horse - which is intelligent enough to compensate momentary inattention on the part of the driver. The driver and horse trust in each other's skill and judgment: The driver maneuvers the horse team in front of the gate and the horses bring the carriage through with centimeters to spare.

As a leader in innovation in the automotive industry, DaimlerChrysler has a strong vision of "accident-free driving". This aims at drastically reducing the number of road fatalities and injuries over the next 15 to 20 years. The company was a pioneer in the development of passive safety solutions, such as the "survival cell." Today, there is great potential in the area of active safety – for example in the design of human-machine interaction systems. For this reason, two new concepts are being trialed in two vehicles: the Chrysler 300MIT and the Grand Cherokee Concierge. These projects are part of an

ongoing commitment to enhanced vehicle safety and tie in with other "accident-free driving" projects.

Cooperation with MIT Media Lab

Chrysler Group engineers have a successful history of cooperation with the Media Lab of the Massachusetts Institute of Technology (MIT). The cooperation with MIT Media Lab works both ways. Engineers at Chrysler follow lab developments - which are not automotive-specific - and look for ways in which these can be applied to enhance vehicle safety and comfort. The other direction also been equally valuable. Engineers at Chrysler have drawn up a specification for a system to meet a need and have worked with MIT Media Labs to develop and test a system that meets that need. The 300MIT is an example of this approach.

300MIT - preventing sensory overload

Imagine you are driving at night in rainy conditions in an unfamiliar city. You are attempting to find the right freeway exit ramp. While you are reading the road signs and negotiating traffic, the car phone rings. This is a potentially hazardous situation, as you are clearly already under stress - the last thing you need at this moment is an added distraction.

Studies by the National Highway Traffic Safety Administration (NHTSA) indicate that most accidents are the result of a critical second of inattention or distraction. It has also been established that 80 to 90 percent of accidents can be avoided if the driver is given one second of warning - or the distraction is prevented in the first place.

This was the starting point for the 300MIT project. It began life as a project for management of a hands-free phone and evolved into a project to lower the burden on the driver by monitoring driver stress and activity levels and presenting information in an appropriate manner and at an appropriate time.

The aim: To develop and test innovative human-machine interfaces approaches that allow interaction with the driver in a safe, non-intrusive manner and to moderate information flow and regulate cell phone usage in a manner that minimizes distraction and does not aggravate customers.

Hands-on for hands-free

The unique thing about the Chrysler engineers' approach to the project is that it is very much a hands-on project. A 300MIT vehicle is planned as a testbed to invent and test new ways of interacting with the driver. Following trials on a closed course, these vehicles will be driven by MIT professors and students on public roads. In contrast, most automotive manufacturers carry out such testing in simulators. This "live testing" approach is possible because - while protecting the driver from sensory overload at critical moments - the 300MIT is non-intrusive. This non-intrusive approach is important for driver acceptance - both of the testbed vehicles and any production systems further down the line - the feature can be turned off at the flick of a switch.

Affective computing

The whole concept of the 300MIT is based on affective computing. Affective means "influenced by or resulting from the emotions". This is a new development in the human/machine interface that takes the emotional state and stress levels of the operator (in this case, the driver) into account during interaction. The on-board computer responds to different types of drivers, their driving style and their emotional state at the time.

MIT Media Lab has done a great deal of research and established a reputation for innovation in this area. DaimlerChrysler and MIT Media Lab have teamed - through the CC++ Car Consortium, part of the Media Lab - to harness affective computing technology for the automotive sector.

In order to do this, the MIT300 has to monitor the driver, constantly observing the position and state of the driver's hands and feet. For example whether the driver has both hands on the wheel, or is leaning on the door or console armrest, or holding the gearshift calmly or nervously. Head and eye movements are also monitored to see where the driver is looking, and whether the driver is alert (head and eyes roving) or the driver has gone into a vacant stare (indicative of inattention or fatigue). Is the driver calm, drowsy or fidgeting? The level and frequency of conversation with passengers and use of the car phone are also monitored.
The system must also monitor the vehicle's activities: Is the car cruising the freeway, accelerating or decelerating, or in a bend?

Based on the perception of the momentary driving situation, the 300MIT can act like spouse or co-pilot, providing information to the driver appropriately. As

an illustration, you would not expect someone to tell you that your windshield washer fluid needs replenishing at the very moment you are attempting to turn left across a busy intersection.

So if the phone rings while the driver is changing lanes on a busy freeway, the 300MIT suppresses the ringing tone, diverts the call to voicemail, and informs the driver when it is safe to do so. Vehicle warning lights and acoustic signals - unless critical - are also suppressed during maneuvers.

Attention reminders

Because the 300MIT monitors driver activity so closely, it is also able to help the driver avoid potentially hazardous developments. If, for example, it detects that the driver has not glanced at the side mirrors for an extended period, the computer causes an LED in the mirror to blink, attracting the driver's attention in a very non-intrusive way.

There are two new controls. One is a warning lamp that illuminates amber or red, depending on the severity of the alert. The lamp glows green when the alert has been acknowledged by pressing a button.
The other new control is a "busy" button, which allows the driver to prevent the car interrupting with non-urgent warnings, cell-phone calls etc. while preoccupied with tasks like finding the way or parking.

Keeping track

The 300MIT requires a whole host of sensors to keep track of the driver's activity, possible distractions, and state of awareness and readiness. These include:

- *Multiple optical cameras to track driver's eye and head movements.*
- *Multiple sensors – including grip force sensors – on steering wheel, instruments, shift know, arm rests, pedals etc. to determine where driver's hands, arms and feet are (for example, "ready to brake").*
- *Sensors in cupholder and ashtray.*
- Vehicle communications network monitors to determine speed, throttle position, brake pressure, steering angle, etc.
- *Accelerometers and GPS to determine vehicle motion, road quality and traffic situation.*
- Ultrasonic sensors on bumpers to determine proximity to other vehicles.

- *Seat sensors to indicate whether seats are occupied and ambient noise level meter to measure the level of passenger conversation.*
- *Carbon monoxide sensor to safeguard against CO-induced drowsiness.*

All this information is processed by a computer system located in the trunk of the vehicle. Using affective computing algorithms developed in conjunction with MIT Media Lab, the computer can then control the flow of information to the driver.

Jeep Grand Cherokee Concierge

The second human/machine interface project takes a very different approach in two respects: the aim and the source of the innovation.
The Grand Cherokee Concierge project started life as project to develop parking and exit aids - and became a project to enhance any user touchpoint to improve the safety, convenience and comfort of the vehicle. And whereas the technology of the 300MIT was developed with MIT Media Lab as a specifically North American project, in this case much of the technology has waterfalled from DaimlerChrysler research. It is interesting to see, however, that the technology has been adapted to the different needs and environment of the North American market.

The Concierge has 6 very different features - all with the common purpose of increasing safety, utility and ease of use:

- Front and rear parking aids with unique infusion of video
- Blind spot monitoring and lane departure warning
- Rear-view mirror with integral LCD display
- Automatic tire air pump
- Defibrillator
- CHMSL (Center High-Mounted Stop Lamp) with variable message capability*

Parking with confidence

Radar is one of the engineer's prime choices for obstacle sensing, because it has the highest speed of performance, the longest range, and all-weather capability. However, because of the triangular shape of the radar beam, multiple sensors - up to six - are required on the front or back bumper in order to provide seamless coverage. Each additional radar sensor drives up the cost of the system. The Concierge's parking and exit aid is unique in using a combination of radar and rear-facing video to provide optimum parking

assistance when reversing the vehicle. The range of the radar sensor allows faster backing and - since a video camera costs less than a radar sensor and many vehicles will be equipped with LCD displays for other features such as navigation aids and night vision - the combination of radar and video results in an optimum solution at lower cost.

The Concierge has three radar sensors on the rear bumper. When reversing, it uses the central sensor to maneuver to within about 4 feet (1.5 meters) of an obstacle. At this point, a steady tone indicates to the driver that video surveillance is now operational. The video image is displayed in the rear-view mirror/monitor unit, allowing the driver to confidently park to within 1/4" (about 0.5 cm) of an obstacle of any shape. Visual feedback is so good that the driver can even close a matchbox with the rear bumper. The video camera provides 100% coverage of the area immediately behind the vehicle, including a small child who might be overlooked by a single radar sensor.

No more blind spots

The side rear radar sensors assist the driver with lane changes. Older drivers, in particular, have problems with the head and neck movements required to carry out a shoulder check prior to changing lanes. This exacerbates the blind spot problem. When the driver sets the turn indicator, the radar checks the blind spot and illuminates a green, yellow or red LED in the side mirror, indicating whether it is safe to change lanes. If the vehicle starts to depart its current lane without the turn indicator being set, this is picked up by the next feature, the lane departure warning.

In lane at the right speed

A combination of front-mounted radar and video sensors is used for adaptive cruise control and lane departure warning.

Currently, adaptive cruise control uses a 76 GHz "pencil" radar beam that locks onto the vehicle in front to adjust speed and maintain a safe distance. This works fine while the car in front remains directly ahead, but in curves (for example to the left), the radar may lock onto a slower car or truck in the right lane, thus causing the adaptive cruise control to slow the vehicle unnecessarily.

The Concierge uses infusion of a video signal from a camera mounted on the front of the vehicle to detect such situations and take appropriate corrective

action. If the video image, broad-beamed radar sensors and steering wheel deflection sensor indicate a curve, speed can be maintained.

The front camera is also used to detect lane departure. If no turn indicator is set - an indication of intentional lane change - a rumble strip warning sounds, alerting the driver. The use of infused video again saves the cost of radar sensors - in this case replacing two sensors for lane departure warning and one dedicated sensor for adaptive cruise control.

These features enhance convenience and safety for the driver and are fully in line with DaimlerChrysler's "vision of accident-free driving". In a later stage of the project, these same systems will be used for pre-crash detection. This has two benefits: Firstly, the driver can be warned, helping to avoid or mitigate the consequences of a collision. DaimlerChrysler engineers are currently examining what form this warning might take, as it is not clear whether a audible alarm will assist or merely startle the driver.

Secondly, pre-crash detection allows the vehicle's computer to calculate optimum deployment of smart airbags in the event of a collision. Airbags will still be triggered by the collision detection sensor, but precalculation saves valuable microseconds, helping to minimize injury. The system may, however, trigger seatbelt pretensioning, as this is a no-risk, reversible action. Seat occupancy sensors permit the system to prevent unnecessary deployment of airbags for vacant seats.

Pumping tires on the move

A further feature of the Concierge enhances convenience, safety and fuel economy: the automatic tire air pump. This is convenient because driver is relieved of the chore of checking tire pressures in the gas station. It is safe because the vehicle computer monitors tire pressures, keeping tires optimally inflated under varying conditions and temperatures. Many accidents are caused by incorrect tire inflation: too low and the tires overheat due to constant flexure; too high and the handling capabilities - particularly braking and roadholding - are impaired. And finally, fuel economy is improved, as the rolling resistance of the tire is kept to the optimum level.

Transatlantic cooperation

Both 300MIT and Concierge have benefited from cooperation between the Chrysler Group and Mercedes-Benz. The 300MIT project has involved close

cooperation between Chrysler engineers and the DaimlerChrysler research labs in Stuttgart, and human-interface research findings are being shared between these organizations and Motorola, supplier of the 300MIT computer.

The Concierge project has taken many aspects of technology developed in the Mercedes-Benz PRE-SAFE (Preventive Occupant Safety) project and adapted it to North American market requirements, with ongoing exchange between the development teams. In adapting the systems, engineers have tailored the systems to the North American environment in several ways. While giving priority to safety and convenience, solutions have to offer optimum cost-effectiveness: A high price tag will be a deterrent to purchase. The systems have been tailored to the NA market, for example, by reducing the number and range of backward-looking side sensors for blind-spot coverage as there is a lower speed differential on North American highways.

Futures

The 300MIT and Concierge are research projects aimed at developing and testing new forms of interaction between the user and the vehicle. They seek to increase safety, convenience and utility by anticipating customer needs. It is too early to say in what form these innovations will be implemented, but Chrysler engineers are confident that these highly beneficial systems will be incorporated in future Chrysler vehicles - as part of DaimlerChrysler's continued commitment to excellence in engineering and to the vision of "accident-free driving".