SCIENTIFIC AMERICAN FRONTIERS PROGRAM #1502 "Cars That Think"

AIRDATE: January 26, 2005

CARS THAT THINK

ALAN ALDA Hello and welcome to Scientific American Frontiers. I'm Alan Alda.

We're used to the idea of there being computers in our cars, invisibly monitoring and controlling everything from the engine to the airbags. In fact, there are over 50 microprocessors tucked away in a typical car.

But the day is fast approaching when you won't be driving a car with computers so much as a computer with wheels. And while computers that crash are all too familiar, tonight we'll be looking at computer-based devices that are designed to prevent crashes — of the deadly kind.

We're going to Germany to drive some cars that watch out for dangers you might be missing...

We'll take a spin in a car that goes nowhere — but that's helping identify those potentially deadly moments when our attention wanders ...

And we'll chat to a car that likes to talk back.

That's all coming up in tonight's episode, Cars that Think.

WATCH THE ROAD

ALAN ALDA (NARRATION) We're starting with a quick trip into the past, to a moment I remember vividly even though it was ten years ago. I was driving a van on a German autobahn — or rather, and this was the point, not driving.

RESEARCHER We're now speeding up.

ALAN ALDA OK.

ALAN ALDA (NARRATION) The road was the test track for what was then Daimler Benz, and the van was a prototype of what Daimler researchers hoped would become a vehicle that could drive itself. In the windshield were cameras watching the lane markings in the road...

RESEARCHER So back here is the control area for the system.

ALAN ALDA (NARRATION) While in the back was a huge rack of computers tracking those markings and steering the van.

RESEARCHER With these ten windows here we can actually follow the road, we know the radius of the road, where we are in the lane and that lets us drive automatically.

ALAN ALDA (NARRATION) A self-driving car would obviously have to do more than just track the road...

RESEARCHER I'll activate the system now by hitting the green button here.

ALAN ALDA (NARRATION) It would also have to keep an eye on all the other vehicles sharing it.

RESEARCHER Once we get up to speed I'll have Christof pass us. OK, Christof... He will enter the road ahead of us here, the lane, we'll detect him, if he slows down we will slow down, if he speeds up, we'll speed up.

ALAN ALDA What if there was an accident, if we turn this corner and suddenly came up on an accident, there was a truck across both lanes?

RESEARCHER At the moment we probably would not stop. We have work going on now ...take control, the yellow...

ALAN ALDA Yellow, OK.

RESEARCHER We have work going on where we look for more obstacles, not only the back of vehicles, but also sides...

ALAN ALDA So you're really going step by step with this now aren't you, and as you get, as you solve these problems, so you get on to more complicated issues.

RESEARCHER Exactly, we're working our way up in complexity here, and we really have to be able to find all the obstacles on the road and there's an awful lot that could be out there, so it will take a while.

ALAN ALDA (NARRATION) Jumping forward ten years until today and the company — now DaimlerChrysler — is still working on trying to identify all those things out there on the road, from errant balls...

To preoccupied pedestrians.

But today, the goal of the research program has shifted radically. No longer do company engineers dream of cars that drive themselves: just imagine the law suits if you could blame your car instead of yourself for an accident. Now, with the knowledge that some 90 per cent of accidents could be avoided if the driver had been warned in time of danger, DaimlerChrysler has turned its technology to spotting things the driver shouldn't miss — like stop signs.

ALAN ALDA Do you think the car will recognize that stop sign up there?

GABI BREUEL Yeah, yeah, I'm sure, I'm sure.

ALAN ALDA Yeah, well, let's go for it.

GABI BREUEL OK.

ALAN ALDA (NARRATION) Driving the car on an empty airfield near Stuttgart in Germany is DaimlerChrysler engineer Gabi Breuel.

GABI BREUEL Look here, see.

ALAN ALDA Yeah,

GABI BREUEL Now it's got it. The system itself brakes for a short time...

ALAN ALDA And you didn't...

GABI BREUEL I didn't...

ALAN ALDA You kept your foot on the accelerator, right?

GABI BREUEL Yep.

ALAN ALDA Well, we were sort of well into the intersection by the time the car stopped.

GABI BREUEL No, it's just a tactile warning for the driver that she has to react.

ALAN ALDA I see. So in other words, if you feel the car stopping by itself, it's a good idea to take your foot off the accelerator and put your foot on the brake.

GABI BREUEL That's right, that's right.

ALAN ALDA How does it see the stop sign?

GABI BREUEL How does it see? You have stereo cameras because they allow us to determine the distance and the size of objects in front.

ALAN ALDA How does the car recognize that what it sees is a stop sign?

GABI BREUEL The shape. And after it's got the shape of the sign, then the system is searching for the word stop.

ALAN ALDA What if it didn't have the word stop on there?

GABI BREUEL Nothing happens.

ALAN ALDA If you turn the stop sign around?

GABI BREUEL Nothing will happen.

ALAN ALDA Nothing will happen. We'll just go straight through.

GABI BREUEL Yeah. It's not a gimmick!

ALAN ALDA It could see the shape. But it couldn't, it didn't see the word. It's got to get both the word and the shape?

GABI BREUEL Both are necessary for...

ALAN ALDA So if you're coming up to a billboard that said "stop smoking," it wouldn't stop the car?

GABI BREUEL No.

ALAN ALDA OK.

ALAN ALDA (NARRATION) In the first demonstration, the car had warned Gabi she'd missed the sign by braking briefly. But the system could also be set to do the stopping all by itself.

ALAN ALDA OK. So at a certain distance from the stop sign if you're going too fast...

GABI BREUEL Too fast...

ALAN ALDA And it says, if this person hasn't stopped yet, they're not going to stop, that's when the car automatically stops.

ALAN ALDA (NARRATION) But again, DaimlerChrysler doesn't want to be sued if your car — and not you — could be blamed for missing a stop sign. So cars you may one day be able to buy will alert you to your errors, not try to correct them.

GABI BREUEL This will not be a system for the street, because our philosophy is that the ultimate responsibility for operating the car remains with the driver.

ALAN ALDA (NARRATION) Stop signs aren't the only things DaimlerChrysler's engineers don't want you to miss. Aided by the sort of digital map you can download into your car's navigation system today, this car knows where traffic lights are located, and keeps its eyes out for them.

ENGINEER You want to know the status of the traffic light at all times, because you don' t want to run a red light, it's expensive and dangerous. So we're able actually to issue a warning to a driver when he's about to run a red light.

ALAN ALDA So these cameras are turning now to see the light. Now that, it picks up a picture of the light from some distance, so they point straight ahead, and then it just keeps tracking the lights.

ENGINEER Very similar to a human head basically. With a head you look to the right. When there's some stuff coming out, you look to the left, then you look up. It makes sure you actually have green when you're going through that intersection.

ALAN ALDA Now what about if you're turning right? Do these cameras — can they look over there and see what you're turning into?

ENGINEER You can use prior knowledge from a digital map again, and you know there's an intersection coming up, the guys from the right side have the right of way so you can turn your camera ahead of time, because that's where you're expecting the danger from.

ALAN ALDA Now this is kind of... these cameras are kind of big and clumsy. I mean. It's kind of hard to see over them. What will you do when you're in a real car?

ENGINEER In a real car, we would actually take a much smaller active camera and you would put it up here right next to the rear view mirror and you would be able to hide it.

ALAN ALDA (NARRATION) So, ten years after I cavalierly took my hands off the wheel, a car that will drive itself remains an engineer's dream, unlikely to become reality. But at least one of the technologies being pioneered back then has met the road — the lane tracking assistant, already installed on many trucks in Germany to warn drivers that their rigs are straying, and now becoming available on some luxury car models in the United States. What makes drivers stray out of their lanes — and what a thinking car might do about it — is the subject of our next story.

HOLD THE PHONE!

JEFF GREENBERG All right, come on in.

ALAN ALDA (NARRATION) I'm about to take a drive on a busy highway — a highway that's notorious, I'm told, for drivers straying out of their lanes.

JEFF GREENBERG Come on around. And we have here our model T flat black Taurus, and you can go ahead and have a seat. It's set up as close to a normal Taurus as we can make it, so it has normal seat controls for your seat and adjustable pedals right here. So get yourself settled, buckle your seat belt and close your door when you're ready.

ALAN ALDA Shall I put on my glasses?

JEFF GREENBERG And put on your glasses, just as you would normally drive.

ALAN ALDA This feels OK.

ALAN ALDA (NARRATION) My passenger on the drive is Jeff Greenberg, a researcher for the Ford Motor Company, who'll be passing judgment on my driving skills.

JEFF GREENBERG OK, now the next thing we're going to have you do is we're going to have you put on the eye-tracker. This is basically a baseball cap; it's got just a Velcro adjustment here for your head. Slip that on, it should slip on right over your glasses. And what we'd like you to do is try to adjust it so that it's comfortable and that your left eye is looking directly through that tilted piece of glass.

ALAN ALDA (NARRATION) The eye-tracking device will allow Jeff to see where I'm looking as I drive along — not on an actual highway, of course, but on a

virtual highway inside Ford's Virtexx driving simulator. Cameras monitor my every move as my virtual car speeds on its virtual way inside an enormous dome on stilts.

JEFF GREENBERG Just do a normal lane change, just a normal gentle lane change into your left lane.

ALAN ALDA (NARRATION) As I steer to the left I feel the car move to the left — because while the road is virtual, the movement isn't.

JEFF GREENBERG And then when you're ready just go ahead and do a lane change back to the right.

ALAN ALDA (NARRATION) Added to the realistic noise and vibration, the movement quickly convinces my brain that I'm driving for real. Which is just what Jeff wants me to feel.

JEFF GREENBERG Go ahead and look in your rear view mirror for a moment and see if you can see what that car does.

ALAN ALDA Yeah, it's erratic.

JEFF GREENBERG That's right. Well, when you see him stray out of his lane to the right, flash your turn signal to the right, and if you see him go off to the left, flash your turn signal to the left.

ALAN ALDA I would speed up to get out of this guy's way...

JEFF GREENBERG Yes, you would. We're going to ask you to, you know, bear with him and stay with him because there's more that's going to happen, OK? Look at the Explorer in front of you and you'll see that there's an erratic driver in front of the Explorer.

ALAN ALDA Right, you want me to...

JEFF GREENBERG Yeah, same thing. When you're not doing anything else, you're just driving like this, you get used to it, when we measure adults we find that 97% of the time they identify these events, they're just driving. Three per cent of the time they don't see them. These numbers change if they become involved in doing other things.

ALAN ALDA (NARRATION) No prize for guessing which other thing is the most likely to make the numbers change...

JEFF GREENBERG Go ahead and pick up your phone.

ALAN ALDA And make a call?

JEFF GREENBERG Yeah.

ALAN ALDA (NARRATION) I make the call while doing my best not to misdial while at the same time keeping an eye on what's happening in front ... as well as behind.

JEFF GREENBERG That kind of task takes a lot of visual attention.

ALAN ALDA OK, it sure does.

JEFF GREENBERG Now, you did see quite a few of the events that were in front of you that were happening. But there were also things that were happening behind you that were very, very difficult to track. When we do that, for adults for example, instead of missing 3% of the things that happen directly in front of them, they start to miss about 12 to 13% of the things in front of them, about a factor of four increase.

ALAN ALDA (NARRATION) It sounds bad enough that adults missed four times as many potentially dangerous events when dialing a cell phone. But the real shocker came when the Ford researchers tested teenage drivers.

JEFF GREENBERG Some people have speculated that because of video games and familiarity with computers and technology, that young people are just better at multitasking than adults are.

ALAN ALDA Is that what you found?

JEFF GREENBERG Well, in fact no. What we found was that when we did that same task that you just did, where on average the miss rate for adults rises from 3% to 13%, for teenagers it rose to 53%.

ALAN ALDA Fifty-three per cent?

JEFF GREENBERG Half the time that that happened they didn't see it. It comes down, as you might expect, to experience. If you look at the way that adults will do the task, they do it much as you did — they take the phone, and they brought it to the place where they minimized the amount of time they had to look away from it. They also break the task up into short bits, no more than a second long, so they're not looking away from the road. The teenagers dialed the phone much more quickly, sometimes almost twice as fast as this group of adults, but they

tend to do it without looking back at the road, and they do it because they seem to have an implicit assumption that the cars around them are going to behave themselves while they are off doing something else.

ALAN ALDA Nothing will happen, don't worry. That's the phrase that guides them.

JEFF GREENBERG That's right.

ALAN ALDA Whoa, the guy behind me's getting crazy.

JEFF GREENBERG Yeah, he is. You know, if you've ever been in traffic and you've had something like that happen in front of you, and I don't know if you've ever been in a crash, you get the feeling that, I don't think I'm going to be able to stop the car, and you get that kind of knot in your stomach. You don't have to have that experience very many times before you change the way that you behave in vehicles. And new drivers haven't had that experience, and they are very, very trusting of other traffic.

ALAN ALDA (NARRATION) American drivers spend something like a billion minutes a year talking on their cell phones — that's about 40% of all cell phone use. Research like Jeff Greenberg's has led several states to require drivers to use headsets or other hands-free devices in an attempt to minimize the driver distraction cell phones cause. But the Ford experiments, as well as several other studies, suggest just taking the phone out of the driver's hand doesn't make the problem go away.

JEFF GREENBERG When people used the hands-free systems, they were generally better in being able to pay attention to what was happening, but there was an important exception. And that was incoming calls. When a call comes in, whether it comes in on a hand-free phone or a hand-held phone, in our experiments, the drivers were just not able to answer the phone, find out who was calling them and why and still pay attention to the things that were happening around them. ALAN ALDA Just before the call started, or as the call was starting, they didn't see the car veering out of the lane?

JEFF GREENBERG The place where they seemed to be the most vulnerable was actually the point where they were conversing with the person to find out who it was that called. So the first thing you might say, and the best thing that you might say to drivers right now is, turn your cell phone off while you're in the car. But in the future, it might be that cars are smart enough to know when the situation that you're driving in is demanding. We may know, for example, from sensors that are in the car, when you're in heavy traffic. We may know when you're approaching an intersection, or in an intersection, or when you're in a

curve. And if a call comes in during a time like that, we may decide, this is really a time when it's most appropriate to send that call to voice mail and alert the driver later.

ALAN ALDA (NARRATION) The Ford researchers have also used their Virtexx simulator to see how tiredness affects drivers. Volunteers were deprived of sleep and stimulants, then asked to drive on the virtual highway at night for three long, boring hours. Meanwhile, the eye-tracker watched out for droopy eyelids.

JEFF GREENBERG Many of the drivers experienced long micro-sleeps. They averaged about two and a half seconds, which is a long way: at 70 miles and hour on the highway, that's close to the length of a football field with your eyes closed.

ALAN ALDA (NARRATION) If the driver strayed out of his lane, the simulator was rigged to give him a warning — the sound of a rumble strip... or a horn and flashing lights... or a vibrating steering wheel.

JEFF GREENBERG We found a lot of feedback from our test participants that if they're not drowsy, they don't want a warning, it's not helpful to them, it's really not going to provide them with any benefit at all. On the other hand, when they were drowsy and it was really helping them, they were enormously grateful it was there. So the key for us is to develop technology that's smart, that adapts to the driver, that provides you the information when you need it and doesn't bother you when you don't.

ALAN ALDA (NARRATION) This question of how best to keep a tired driver alert is one of the biggest challenges facing designers of cars that think — as we'll see in our next story. Meanwhile...

ALAN ALDA I'm glad to be back on earth.

SMART PASSENGER

ALAN ALDA (NARRATION) We're about to take a drive with Mahesh Viswanathan and his frequent traveling companion, Sally. This being an IBM parking lot, it should come as no surprise that Sally isn't a person but a computer — or to use a favorite engineer's term — a system.

MAHESH VISWANATHAN Today, most of the systems that you have in the car are what we call command and control. You give an instruction, it performs an action. What we are trying to do is to build the next generation, the next to next generation, where the interaction is more pleasant and the system is much more helpful than it is today.

ALAN ALDA So when I talk to the car now, the car will know what I mean, what I want.

MAHESH VISWANATHAN When you talk to the car, it will not only know what you want, it will also try to anticipate your needs. Good morning Sally.

SALLY How are you today, Mahesh?

MAHESH VISWANATHAN I'm fine... She identified me as I said "Good morning Sally" and we use that not only to greet me, which is nice, by name. In addition to that, she sets all my personal profiles, so she knows the address book that I have of interest, she knows my favorite restaurants, she knows my favorite routes.

MAHESH VISWANATHAN I need to go to JFK for a 3:30 flight.

SALLY Would you like me to find the quickest route to the airport?

MAHESH VISWANATHAN Yes please

SALLY It should take about 90 minutes to get there, allowing you 30 minutes for check-in.

ALAN ALDA You don't have to speak politely to Sally. You don't have to say please.

MAHESH VISWANATHAN No I don't.

ALAN ALDA I think I'd feed uncomfortable begging my car.

ALAN ALDA (NARRATION) Sally is actually listening in all the time through a microphone above Mahesh's head, but she responds only to words she's been programmed to recognize... like traffic.

MAHESH VISWANATHAN Sally, is there any traffic on the route?

SALLY Currently all looks clear, but I will continue to update you. Turn right onto Pines Bridge Rd.

ALAN ALDA What about if you were getting drowsy now?

ALAN ALDA (NARRATION) Sally's not only listening; the idea is that eventually the system will be watching, too. A camera will look for signs of drowsiness, like drooping eyelids. Then, like a real passenger, she'll try to wake you up.

SALLY Would you like to play a game to fill the time?

MAHESH VISWANATHAN What game?

SALLY How about "Name that tune?" Here's the first one.

ALAN ALDA You put these songs in, so you know what they are, right?

MAHESH VISWANATHAN That's how I know what they are, I've lived in NY a long time, what do I know about country music? I don't even know if we have a country music station here. My guess is "Out of your shoes."

SALLY Good job

MAHESH VISWANATHAN You notice that slight massage where she says "good job?" To keep me occupied in the conversation.

ALAN ALDA Yes, to help keep you alert.

MAHESH VISWANATHAN Instead of just playing the songs back to back and have me answered, where I could get bored, it's nice to give a little feedback to the user, a pat on the back, and I'm there.

ALAN ALDA When you think of what games you want to put in there, do you go to the psychologist and say what do you think we should do, or do you come up with ideas yourselves?

MAHESH VISWANATHAN At this point, we just come up with ideas ourselves, because what we want to show is the power of interaction in keeping you alert. SALLY Now try this one...

ALAN ALDA (NARRATION) Sally will eventually be wirelessly plugged in to real time information about weather, traffic... and your schedule.

SALLY Sorry to interrupt, but I just heard, that your flight has been delayed by one hour.

MAHESH VISWANATHAN Maybe I can stop for a bit to eat.

SALLY I know you prefer German restaurants, but there aren't any within 3 miles. How about Italian?

ALAN ALDA Good

ALAN ALDA (NARRATION) Sally is currently only a demonstration model: Mahesh's questions and remarks are triggering prepared responses.

MAHESH VISWANATHAN Let's make it Italian.

ALAN ALDA (NARRATION) That is, if she hears them.

MAHESH VISWANATHAN Italian sounds good.

ALAN ALDA (NARRATION) Computer speech recognition remains a thorny problem — especially in the noisy environment of a car.

ALAN ALDA Voliamo mangiare pasta.

ALAN ALDA (NARRATION) Which is why something called the McGurk Effect is so fascinating to IBM researcher Stephen Chu.

DEMO Ba, ba, ba

STEPHEN CHU What do you hear?

ALAN ALDA I hear da, da, clear as a bell. And that's not what you're saying, is it? S

TEPHEN CHU Right, so try to close your eyes and listen to the same thing again.

DEMO Ba, ba, ba

ALAN ALDA I hear ba, ba really clearly, just as clearly as I heard da, da. It's amazing, it's the same recording.

STEPHEN CHU It's the same thing.

ALAN ALDA And what are you doing with your lips?

STEPHEN CHU Ga, ga, actually. So visually I'm ga, ga, but acoustically it's ba, ba, but your mind is playing a trick on you, so you're hearing neither ga, ga, nor ba, ba, but rather da, da.

ALAN ALDA This is wonderful, this is so great.

ALAN ALDA (NARRATION) Try it for yourself. Listen while you watch...

DEMO Ba, ba, ba

ALAN ALDA (NARRATION) Now listen again as we cover Stephen's mouth...

DEMO Ba, ba, ba

ALAN ALDA (NARRATION) The McGurk Effect beautifully demonstrates how much we rely on what we see as well as what we hear in interpreting speech. ALAN ALDA And McGurk figured this out? Who's McGurk? Is his name really McGurk or is his name McDurk? 1178889...

ALAN ALDA (NARRATION) IBM is now developing a speech recognition system that reads lips as well as listens in to what we say. When I tested it, accuracy improved from about 80 per cent with audio alone, to close to 100 percent. So the plan is that the camera in the car that watches for droopy eyelids will also watch your mouth, making Sally a better listener. Back in her car, Sally has one more trick up her virtual sleeve.

SALLY You just received an urgent email. Shall I read it to you now?

MAHESH VISWANATHAN Let me hear it

EMAIL VOICE Mahesh, this is Peter. I know your flight is delayed. Let's meet in the terminal lounge. See you then.

MAHESH VISWANATHAN Sally, take an email for Peter.

SALLY I'm ready.

MAHESH VISWANATHAN Peter, I received your message. I'll see you at 3. End

SALLY Your email reads: Peter, I received your message. I'll see you at 3. Shall I send it?

MAHESH VISWANATHAN Send it.

ALAN ALDA OK, right now I'll give you 50 dollars for this, you don't have to make it any better. I'll take it.

MAHESH VISWANATHAN 50 dollars?

ALAN ALDA Cash!