"SPECIAL FROM GERMANY"
SHOW 402

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EPISODE OPEN

ALAN ALDA (ON CAMERA) Hi, I'm

ALAN ALDA Alda. This edition of Scientific American Frontiers is in Germany, where the cars come from. We'll test drive the latest fully automatic model. No hands. And we'll experience this fine design from former East Germany.

ALAN ALDA (NARRATION) We'll take to the skies - then try to find the way home. We'll journey into the brain to cure a patient with epilepsy. And we'll witness death-defying aerial stunts.

ALAN ALDA (ON CAMERA) Join me now for our special edition of Scientific American Frontiers, from Germany.

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THE AUTOBAHN CO-PILOT

ALAN ALDA (ON CAMERA) Germany has a scientific tradition that's one of the oldest in the western world. And since we've been here, we've been impressed by how much that tradition really means to German scientists who are working today. A man you'll meet a little bit later told us very proudly how his field, the study of birds, began with Emperor Frederic 800 years ago. We've got a story on the very latest in medical imaging, and of course it was a German scientist who discovered x-rays 150 years ago. But first we'll take a look at the highest of high tech applied to a very familiar part of our lives. The modem highway. And, of course, the modem highway was invented in Germany.

ALAN ALDA (NARRATION) The first divided highway for fast, long distance travel was built in Germany in the early 1920's. Today packed with traffic, the Autobahn is at the center of Germany's obsession with all things automotive. There's no speed limit on most Autobahns - just traffic jams - and the freedom to drive fast is a cherished personal liberty. But the price is high. Fatal accidents are common - with human error the usual cause. Which is why Daimler-Benz, maker of Mercedes cars and trucks, has set out to teach basic driving skills to a new generation of drivers. Piloting this van is the first of these student drivers - not the man behind the wheel, but a system of video cameras and computers in back - the prototype of a system able to drive on the Autobahn by itself.

ANDREAS KUHNLE Would you like to drive?

ALAN ALDA (ON CAMERA) Yes.

ANDREAS KUHNLE O.K.

ALAN ALDA (NARRATION) Andreas Kuhnle is the chief engineer here at the Mercedes Stuttgart research center which features a 2-mile long section of test track doubling as a typical stretch of Autobahn.

ALAN ALDA (ON CAMERA) O.K. So, what happened?

ANDREAS KUHNLE Now you're all set. If you just put it in four, and start to drive, and when you feel comfortable, then just hit the green button up here, and the system will drive for you.

ALAN ALDA Will it start driving at the speed I'm at?

ANDREAS KUHNLE Yes it will, it goes exactly the same speed that you...

ALAN ALDA So suppose I get a little speed going then.

ANDREAS KUHNLE Right

ALAN ALDA Yeah. O.K., now I can take my hand off?

ANDREAS KUHNLE We are not quite in the center of the lane.

ALAN ALDA I see. Why are we veering here?

ANDREAS KUHNLE And then we adjusted to the center of the lane. We are going to speed up now.

ALAN ALDA (NARRATION) At this point, all I knew about how the system works is that video cameras are checking the lane markings in the road ahead, and looking for obstacles.

ALAN ALDA (On-Camera) Now see all this dirt in the road here?

ANDREAS KUHNLE Right

ALAN ALDA It doesn't seem to mind that. Andreas Kuhnle No it doesn't, that didn't look like a car or a truck to it.

ALAN ALDA (NARRATION) It was oddly exhilarating to be zipping along at 40 mph with my hands in the air. But what I wanted to know, of course, was what's going on in the back of the van that makes it possible.

ANDREAS KUHNLE So back here is the control area for the system.

ALAN ALDA (NARRATION) In case you're wondering - we are stopped now!

ANDREAS KUHNLE These are a set of windows, they are looking for marks here on the road, and you can see that they've actually marked them. And with these 10 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 (ON CAMERA) Do I understand this right? The information that the computer is processing is only information found within these windows?

ANDREAS KUHNLE That's right

ALAN ALDA All the rest of the picture is just not even getting communicated to the computer.

ANDREAS KUHNLE That's right. The rest of the picture is irrelevant right now. We have to do that right now because there is so much information in one of these video pictures, we have to ignore a lot of it.

ALAN ALDA Right

ANDREAS KUHNLE Why don't we demonstrate this actually.

ALAN ALDA Sure. Great. Great.

ANDREAS KUHNLE So we are going to get up to speed now, about 30 mph and we'll switch to automatic mode when we are up at speed.

ALAN ALDA I feel like we're doing one of those submarine movies.

ANDREAS KUHNLE Oops

ALAN ALDA I think they've spotted us.

ALAN ALDA (NARRATION) Behind the wheel again, I soon discovered the system's limits.

ALAN ALDA (ON CAMERA) Now, there's a truck up ahead with workmen.

ANDREAS KUHNLE O.K.

ALAN ALDA What's going to happen now? The truck is standing dead still.

ANDREAS KUHNLE Right. I'm not sure what's going to happen.

ALAN ALDA You're not sure what's going to happen.

ANDREAS KUHNLE We may have to in fact, we do in fact have to, could you please brake.

ALAN ALDA Brake, Yes.

ANDREAS KUHNLE Yeah, he's actually not in the lane.

ALAN ALDA He's not in the lane. He was sort of like only about a foot over the center of the lane. Now what happened there, what did the computer do?

ANDREAS KUHNLE The computer, I'm not quite sure, I think started to slow down, I didn't want to take a chance.

ALAN ALDA Right

ANDREAS KUHNLE And so I had you re-take control

ALAN ALDA O.K.

ANDREAS KUHNLE Normally what would happen is...

ALAN ALDA I'm going .....

ANDREAS KUHNLE You can go back to green.

ALAN ALDA ...back to green

ANDREAS KUHNLE Okay now. We are now speeding up.

ALAN ALDA Okay.

ALAN ALDA (NARRATION) The truck incident was a reminder that the real challenge for self-driving vehicles is spotting and reacting to obstacles. While the lower camera tracks the lanes, that's the job of the upper camera.

ALAN ALDA (ON CAMERA) How does it recognize, for instance, the back of a car.

ANDREAS KUHNLE It's looking for, for example, the lower edge, the bumper, it's a horizontal line on the road. There's gotta be some vertical edges nearby, they have to be a certain distance apart. And also cars are symmetrical in the back, and you can look for symmetry in the picture ahead of you. And then with a reasonable accuracy say yes, that's a car.

ALAN ALDA (NARRATION) These characteristic features are now being used to literally teach a parallel processing computer how to recognize the backs of cars. It was time to try out the van's skills when it no longer had the test track to itself.

ANDREAS KUHNLE I'll activate the system now, by hitting the green button here. Once we're up to speed I'll have Christof pass us. He will enter the road ahead of us here, the lane. We'll detect him. slows down, we'll slow down. If he speeds up, we'll speed up.

ALAN ALDA (NARRATION) But of course the true response to a car ahead on the German Autobahn isn't to follow passively behind it...

ANDREAD KUHNLE We'll now overtake.

ANDREAD KUHNLE We've now passed Christof, and we'll move back to the right hand lane.

ALAN ALDA (NARRATION) Right now, the van has to be told when to move into the passing lane. Later, a camera will check the lane and give the order automatically. But in driving, it's the unexpected that can be deadly.

ALAN ALDA (ON CAMERA) What if there was an accident, that we turned this comer and suddenly came upon an accident, there was a truck across both lanes?

ANDREAD KUHNLE At the moment we would probably not stop, we have work going on now... If you could re-take control, the yellow...

ALAN ALDA The yellow, Okay.

ANDREAS KUHNLE ... we have work going on where we look for more general obstacles, not only the back of vehicles, but also the sides. I see, so you're really going step by step with this, aren't you? And as you get, as you solve those problems, then you'll get onto more complicated issues.

ANDREAS KUHNLE Exactly. We are 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 of them that could be out there, so it'll take a while.

ALAN ALDA Somebody walking across the road at this point, would not necessarily be picked up by your present equipment, will it?

ANDREAD KUHNLE We expect to have pedestrian detection, not at highway speeds yet though, next year. People have a certain way that they move, and we can actually look for objects that are moving in that way and find them.

ALAN ALDA And what about an animal, a deer crossing the road?

ANDREAD KUHNLE We haven't looked for deer yet, only humans.

ALAN ALDA If you have a deer that walks like a person, he's O.K.

ANDREAD KUHNLE Then we're in luck.

ALAN ALDA (NARRATION) The goal of the research isn't to replace the human behind the wheel, but to share the burden of watching for and reacting to hazards.

ALAN ALDA (ON CAMERA) I would think it would be really important to have a fully automatic operation here to know what's happening in these other lanes and maybe even what's happening on the other side of the divider. If something is coming at you, in an accident over there, and spinning out of control over here, wouldn't you need to know that?

ANDREAD KUHNLE We would like to actually have information 360 degrees around the car. And then given all that information, we can maneuver to be safe number one, and secondarily to get where you want to go. That's another thing we'd like to do, is to basically have a vehicle where you can get in and say I want to go from Boston to Minneapolis, and it will do that completely automatically for you. Read the traffic signs. And so our activities are seeing more what's around us, and then understanding and reacting to that, in a complete sense so the driver can really be safe, number one, and relaxed, number two.

ALAN ALDA (NARRATION) Now, you should know that ! wasn't in the van for this next trip.

ANDREAD KUHNLE This is the big test for us. We are now entering a public road O.K., and I'll turn on the system now.

ALAN ALDA (NARRATION) And as it turned out, that was the right decision! Every time Andreas switched on the system, the van veered to the left - into the path of overtaking traffic.

ANDREAS KUHNLE Come on baby, come on. We're having a technical problem again, this drift to the left.

ALAN ALDA (NARRATION) After resetting the steering system, the van settled down in its lane - but now it became tempted by exits.

ANDREAS KUHNLE Oops, we were just about to leave the road there.

ALAN ALDA (NARRATION) The Mercedes engineers are the first to admit that their co-pilot has a lot to learn. But they also anticipate the day when the Autobahn's safest drivers will be the easiest to spot!

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HOMEWARD BOUND

ALAN ALDA (NARRATION) Dawn in Bavaria - and 6000 pigeons begin a high-stakes race. Every weekend, in hundreds of clubhouses across the country, pigeon breeders meet to register their birds in one of the most popular sports in Germany - the racing of homing Pigeons. Not just pride but big money rests on which pigeon makes it back to its home loft first. For researcher

WOLFGANG WILTSCHKO, these races pose a fascinating question. How do the birds find their way?

WOLFGANG WILTSCHKO You release this bird about eight hundred or a thousand miles away from home and it flies straight back to its home. Isn't that fascinating and worth to have an answer to this question?

ALAN ALDA (NARRATION) The birds are taken to the release site in a closed truck in the middle of the night, so they can't simply watch where they're going. Yet as soon as they're released, they set off unerringly in the direction of home. Of all the navigational tools they could be using, one of the more obvious is the sun. Wolfgang has performed a classic series of experiments to find out if pigeons do indeed use the sun as a compass. The experiment involves giving the birds a kind of "jet lag". Housed in this windowless room for a week, the birds' daytime - when the lights are on - is shifted 6 hours behind the real day time outside. So by the end of the week, when the birds think it's dawn, its actually 12 noon. Now comes the test. Rosie Wiltschko is Wolfgang's wife and collaborator. The yellow band is for a control bird - one whose internal clock hasn't been shifted, so he knows it's now noon.

ROSIE WILTSCHKO He is a control bird and home is in this general direction. I would expect him to go in approximately that direction.

ALAN ALDA (NARRATION) The bird sets off confidently. If it is using the sun as a direction finder, it must be taking its homeward bearing from where it expects the sun to be at noon - in the south. The researchers note the bird's "vanishing point" - the compass bearing it was following when it disappeared from view.

RESEARCHER #1 It flew off near that power line over there, by those highway signs. Take a bearing off the power line poles.

RESEARCHER #2 I see them. I've got a reading on the power line. 80 degrees.

ALAN ALDA (NARRATION) And for all the control birds, the vanishing point is to the east - in the direction of the home loft. Now for the birds whose internal clock has been shifted - and who are under the impression that it's 6 am.

ROSIE WILTSCHKO He is a clock-shifted bird. His internal clock has been shifted six hours slow, so he misjudges the time of day and for him it is early morning.

ALAN ALDA (NARRATION) This bird's loft is to the east, like the controls. But unlike them, he thinks its dawn, and since the sun rises in the east, off into the sun he flies. But since it's really noon, the sun is to the south ... and so it's not east but south that the clock-shifted birds fly. Experiments like this confirm that pigeons do indeed navigate by the sun. But they also show something else. Because while the control birds start arriving home 12 miles away after about 20 minutes.., only an hour or so later, the clock-shifted birds start showing up suggesting they had some other way to find home. In another classic experiment, Wolfgang discovered what that back-up navigational system employs.

WOLFGANG WILTSCHKO I have here a magnet which disrupts the magnetic field of the earth.

ALAN ALDA (NARRATION) Any internal magnetic compass a bird possesses would also be confused when the magnet is glued to its back feathers. The pigeons in the experiment have been raised without ever seeing the morning sun, so in this early morning release they can't use the sun to steer by. With both sun compass and any magnetic compass disabled, the bird indeed seems totally lost.

WOLFGANG WILTSCHKO I think that he doesn't know where to go under these conditions. He will fly just in a random direction.

ALAN ALDA (NARRATION) The control birds in this experiment have small non-magnetic brass weights glued to their feathers. With their magnetic compass unaffected, they set off to the home loft without hesitation. The experiment confirms that pigeons use the earth's magnetic field as well as the sun to find their way. But their direction-finding skills don't stop there.

WOLFGANG WILTSCHKO Birds are really amazing and much more sensitive to their surrounding world than we are, so they can sense the magnetic field. They also can see ultraviolet light. They are also very sensitive to minute pressure changes. They can hear infrasound and so their sensory world is much more extended then our sensory world is. And for orientation they are very opportunistic and make probably use of all these cues.

ALAN ALDA (NARRATION) So far we've only been talking about orientation - about how birds tell direction. But to navigate, you need to know what direction to go in. So we came to a 14th Century castle in southern Germany to visit with one of the true champions of long distance navigation, the stork. This is the research station of another bird navigation expert, Dr. Peter Berthold. His work involves tracking storks - but to do that he has to capture them. I was invited to help - but then he described how our stork might react.

DR. PETER BERTHOLD He can peck you to the eyes and to the neck. What they normally do...

ALAN ALDA The eyes and the neck?

DR. PETER BERTHOLD Oh, yes, especially very often to the neck. That's what they normally do when they attack each other at nesting sites. You see, white storks can easily kill each other. If there is a pair that has started breeding, and a single male is coming, they may fight terribly around the nesting site, the two males and also the female. And in some cases you may at the final end, you may have 3 dead storks. Because the bill has destroyed the blood vessels, may even have penetrated the neck. Fortunately our neck is fairly sized though, I think we'll not have that problem here.

ALAN ALDA But maybe we should just let them fly wherever they want to go.

DR. PETER BERTHOLD Yes

ALAN ALDA Maybe it doesn't really matter where they're going.

DR. PETER BERTHOLD And if you'll be really sure, you may put your neck like this

ALAN ALDA Ah, right, good advice.

ALAN ALDA (NARRATION) And it turned out there are a few other tricks a stork stalker should know.

ALAN ALDA (ON CAMERA) You grab him by the wings and then you grab him by the neck.

DR. PETER BERTHOLD If it's close to the fence or so then and it's standing more or less, then its best that you first go to the neck and then to the wing and then you take the whole bird. If it's flying against you, the best is you take it as you normally take your woman in the early morning and then you have it so.... no problem.

ALAN ALDA I don't grab her by the beak though, I'm sorry.

ALAN ALDA (NARRATION) Luckily, when the big moment came, the stork chose Peter as his target.

DR. PETER BERTHOLD This was a big catch.

ALAN ALDA (ON CAMERA) Doesn't it fit kind of loosely?

DR. PETER BERTHOLD No, no, no, that's O.K.

ALAN ALDA I mean if he closes his mouth and dips his head doesn't it come off, and then he has a pretty good shot at your eye?

DR. PETER BERTHOLD No, normally not. No

ALAN ALDA See, that's sort of what I sort of anticipated, I'm not that dumb, I can... Do you want me to hold the beak?

DR. PETER BERTHOLD Well, if you'd like.

ALAN ALDA (NARRATION) The point of all this was to strap a small radio transmitter on the stork - a transponder that can be tracked by satellite.

DR. PETER BERTHOLD We'll release the bird. O.K. Very good. So will you please come in.

ALAN ALDA Thank you

DR. PETER BERTHOLD Be careful with these steps here

ALAN ALDA Now, once you release these storks...

DR. PETER BERTHOLD Yeah

ALAN ALDA ...you can track where they are at any given moment.

DR. PETER BERTHOLD Oh yes.

ALAN ALDA Wherever they are?

DR. PETER BERTHOLD At least every day we are able to have several locations. So I think this one is especially interesting...

ALAN ALDA (NARRATION) The satellite tracking system can pinpoint each stork exactly as it makes its immense migration from Europe to Africa.

ALAN ALDA (ON CAMERA) And where is this bird right now?

DR. PETER BERTHOLD And this bird is right now, we can just see it here on the map. The bird is presently exactly in the area of the Bosporus. This really critical area where they have to cross here, and not to go too far to have to cross the Black Sea, or in other parts of the Mediterranean.

ALAN ALDA (NARRATION) The stork's extraordinary journey dramatically illustrates the importance of a bird's having some sort of map in its head - that it knows where it is and where it's going. And while researchers now have plenty of ideas about how birds steer, they are much less certain about what they use for a map. That's why Wolfgang Wiltschko's student Peko Kalpit is setting up a new experiment in this aviary back in Frankfurt. First, Peko puts 48 cups of sand in holes. Then she sets out a number of glass bottles and jars alongside some of the cups. Most of the cups don't have these landmarks nearby. Now she hides three seeds in each of just three cups - all near the glass landmarks.

PEKO KALPIT The first pigeon that's going to come in here has been trained to dig in this certain sector, in this, this and this cup. So I'm now hiding these seeds in there and the bird that comes in has forty-eight choices but hopefully will only dig in these three cups.

ALAN ALDA (NARRATION) Remember, the bird has been here many times before, and the seeds have always been in the same cups.

PEKO KALPIT OK, heading for the right cup. This is the first right probe right there and he's eating. He cannot see the seeds unless he probes and he found the first cup. Now he has two more to go .... OK, that's the second one. That's two out of three .... Kind of indecisive. Ok, this would be a wrong probe, because it's in the wrong sector. This also. Now he's obviously going random because he couldn't find the right cup.

ALAN ALDA (NARRATION) Now 2 out of 3 is pretty good - and it seems likely that the bird has used the glass landmarks to help find the corn. To test this hypothesis, Wolfgang and Peko move the glass bottles from the sector where the corn is hidden to another sector. But while the bottles move to new cups, the corn stays where it was. Now another bird enters the arena. Like the first, he's always found the corn near the bottles. But this time...

WOLFGANG WILTSCHKO So the first choice was an original sector.., the second one is right.., and the third one is right and the experiment is over!

PEKO KALPIT Not one single mistake! It went in there and probed three times, three correct choices. I'm speechless.

WOLFGANG WILTSCHKO Amazing!

ALAN ALDA (NARRATION) If I were a pigeon, I might be using those nice shiny bottles as landmarks. But the pigeons obviously aren't. What they are using as maps remains a mystery - it could be other landmarks outside the cage - and it's Peko Kalpit's challenging task to learn to look at the world strictly from a pigeon's point of view.

PEKO KALPIT We as humans would say we have this kind of bottle, this shape, and if I only head for this one bottle I will always get my food, my reward. But the bird obviously doesn't think that way. That's what the whole idea is about - we trying to get into what the bird is thinking, how the bird is reacting to our environment, and how it sees it. And this is one first step.

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GO, TRABI, GO

ALAN ALDA (NARRATION) It was the fall of 1989 - and the Berlin Wall, the most powerful symbol of the Cold War, was coming down.

ALAN ALDA (ON CAMERA) All through that summer of '89, people from eastern Europe had been streaming across the newly opened borders into the west. Well, when I say streaming actually I mean driving, because almost everybody who came drove in one of these. It's called a Trabant. So many people made their trip to freedom in a "Trabi" that it's earned its place in history here on a section of the Wall. Even today this odd little car inspires feelings of love, hate, frustration and affection.

ALAN ALDA (NARRATION) Television news footage of the exodus to the west made the Trabi famous throughout the world. It had been a well known - and highly desirable - car throughout Eastern Europe for over 30 years. But now nobody wants a Trabi. I got a chance to find out why, when longtime owner Vanessa Rorger introduced me to the unique driving experience that is the Trabant.

ALAN ALDA (ON CAMERA) So, what's first?

VANESSA RORGER First is up.

ALAN ALDA And what about second?

VANESSA RORGER Second is here ... three ... fourth.

ALAN ALDA Not so easy, huh?

VANESSA RORGER Rorger No!

ALAN ALDA Ok, this is first, right?

VANESSA RORGER No, that is reverse!

ALAN ALDA Oh, oh, oh. Excuse me ... no horn, there's no horn.

VANESSA RORGER Oh, here is the horn.

ALAN ALDA Danke. Which way should we go here?

VANESSA RORGER Right.

ALAN ALDA There's no signal! I have to put my arm out the window.

VANESSA RORGER Here is the signal.

ALAN ALDA Oh, that's the signal? Oh, I see.

VANESSA RORGER You have to make it for yourself back. It's not automatic.

ALAN ALDA It takes the bumps nicely.

VANESSA RORGER Very not quiet.

ALAN ALDA No, it's a little noisier than a Rolls Royce, but not much. I like the way it has this kind of seaside motion. So I'll go right here? Oh, I still have the signal on from the last turn so that's good, it saves you a lot of trouble.

ALAN ALDA (NARRATION) While its easy to make fun of the Trabant today.., in the East Germany of the 1960's it was Communism's answer to the Volkswagen Beetle - a cheap, economical "peoples car". When the first Trabant was designed in 1952, its engineers faced a unique challenge. Werner Reichelt.

DR. WERNER REICHELT In the early days of East Germany we didn't have any steel, so we had to find a substitute. What we did have in abundance was cotton waste and phenol resins. From those two waste products we came up with a very durable material.

ALAN ALDA (NARRATION) The cotton waste came from Russia - the phenol resins from the East German dye industry. Combined into a sandwich, they made a plastic called Duroplast. The Trabant's body was the world's first made entirely from recycled materials. It was strong and so durable that the average Trabant's life was 28 years! Over 3 million rolled off the production line in Zwickau - and there are still more than a million on the road .... much to most people's distress. The car's two-stroke engine sounds like a noisy lawn mower and spews out 10 times more pollution than a modem car. So today, there's not only no market for new Trabi's, but they're trying to get rid of the old ones. In a neat twist of fate, that job has fallen to the Trabi's designer, Werner Reichelt.

DR. WERNER REICHELT In this factory the plastic bodies for three million Trabants were made between 1955 and 1991. We employed 11,000 people here.

ALAN ALDA (NARRATION) And today, the Zwickau plant where the cars were made is the site of an ambitious program to destroy them. The usual way of getting rid of an old car is to crush it. But with the Trabi, that's more easily said than done. That Duroplast body that was once such a neat solution to East Germany's metal shortage, just won't go away. Burning it would release harmful chemicals into the air - and the same chemicals might leach into the groundwater if the bodies were buried in a landfill. So here where the world's first recycled car was made... Werner Reichelt is figuring out how to recycle them once again. First come the easy parts. The glass... and the little 2 stroke engine - mostly useful only as scrap metal. But then there's that 1400 lbs. of plastic body...

DR. WERNER REICHELT Here's a piece of a Trabant. This is all that's left after we recycle the car. You can see the Duroplast. These cotton fibers reinforce the layers of phenol resin.

ALAN ALDA (NARRATION) This chemical sandwich is the real challenge. But Herr Reichelt is experimenting with an ingenious scheme. First, the Duroplast is shredded into small pieces. These are then mixed with cement. And in a process Herr Reichelt claims is completely effective - but also a trade secret - the material is then treated to render the potentially dangerous phenol residues safe and inert. The result - bricks. So the little car that helped destroy the Wall may soon become the building blocks of new walls - a process that for the German environment, as well as German sanity, can't come a moment too soon.

ALAN ALDA Thank you.

VANESSA RORGER You're welcome.

ALAN ALDA Now I can't get out. This is unbelievable, I can't get out! The thing wouldn't close before, now I can't get out. Thank you very much. That's good, that's nice, somebody gets out and opens it for you. Look at that, now it works!

VANESSA RORGER Well, sometimes it works, sometimes no. That is spedal Trabi!

ALAN ALDA That was great, thank you.

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BRAIN STORM

ALAN ALDA (NARRATION) Epilepsy has destroyed Manfred Pelz life. His increasingly frequent seizures prevent him from working. He's been waiting for this moment for years.

MANFRED PELZ I feel pretty nervous right now, but I'm not sure whether it is the operation or the camera crew that's making me that way.

ALAN ALDA (NARRATION) Epilepsy affects one in 100 people. Most can have their seizures controlled by drugs. But for Manfred, as for many other epileptics, the only hope of a normal life lies in the hands of surgeons like Dr. Michael Buchfelder.

DR. MICHAEL BUCHFELDER He has taken all the drugs which were available and they have not been able to stop his epilepsy. And this kind of surgery is his last chance to get rid of his epilepsy.

ALAN ALDA (NARRATION) But today, the surgical treatment of epilepsy is rare - because as you're about to see, it requires a complex and nerve-wracking procedure before the surgery can even begin. The goal of that surgery is to remove from deep within Manfred's brain the tiny speck of tissue that's the source of his disease. But right now, his surgeons have only a very rough idea of where that epileptic focus lies. So first they must find it. And that means opening his skull. The next step is to reveal the brain itself by cutting through and peeling back the membrane protecting it. This array of electrodes is what will locate the epileptic focus - by placing it directly onto the surface of Manfred's brain.

DR. MICHAEL BUCHFELDER Emotionally we think don't let others touch our brain. But in terms of actual figures, arithmetically, it's pretty safe, as compared to gall bladder surgery. Isn't that striking?

ALAN ALDA (NARRATION) The electrode array in place, Manfred's skull is closed up again - temporarily. The next day, he's resting comfortably, with the electrodes on his brain connected to a monitoring system. He's also being observed by video cameras. Now the medical team watches and waits - for Manfred to have a seizure. Here's what happens during an epileptic seizure. It begins when the nerve cells at the epileptic focus suddenly start firing off abnormal bursts of electricity. These set off nearby cells.., and soon the whole brain is caught up in an electrical storm. By this time, the electrodes on Manfred's brain are all picking up this furious activity.., and Manfred himself is unconscious, in the full throes of an epileptic seizure. But now look again at what happened - this time at the moment the seizure was triggered. At this point, the only electrodes picking up abnormal signals are those nearest the epileptic focus. These signals are displayed on the screen even before the seizure itself begins. And because the position of each electrode is known, this information allows the epileptic focus itself to be located. In Manfred's case, the focus is deep within his temporal lobe - and close to the center that generates speech. So before the surgeons can destroy the epileptic focus, they have to be sure they won't also damage his speech center - which means that too must be precisely mapped. To do that, the electrodes on Manfred's brain are used again - this time not to record its electrical activity, but to stimulate it. Neurologist Hermann Stefan.

DR.HERMANN STEFAN We stimulate one channel and if the patient has stops talking then we have found his speech area.

MANFRED PELZ (Counting in German)

ALAN ALDA (NARRATION) Manfred is asked to count. One by one the electrodes are activated.

MANFRED PELZ Counting in German

DR.HERMANN STEFAN The electrode ....

ALAN ALDA (NARRATION) This time it's electrode number 19. It will be switched on as Manfred gets to 10 in his counting. There's a slight hesitation, suggesting electrode 19 is close to the speech center. Now it's electrode number 20. And this one is even closer.

DR.HERMANN STEFAN We stimulated this electrode here, and there was an arrest of speech.

ALAN ALDA (NARRATION) It turns out that Manfred's epileptic focus and his speech center are about 3 cm apart - dose, but cutting out one without damaging the other should be possible. Manfred's surgery is scheduled for 3 days from now. But for some epileptic patients, even the elaborate brain mapping that will permit Manfred's surgery just isn't accurate enough. Felicitas Kaiser is an apprentice furniture restorer.

FELICITAS KAISER If I was talking with someone, suddenly I could see their lips move but I could not hear them, and I could not speak. When I came to I had no idea where I was. I was disoriented. Sometimes it took half an hour until I regained consciousness.

ALAN ALDA (NARRATION) When Felicitas' brain was mapped electrically, her epileptic focus appeared to be right on top of her speech center - meaning surgery couldn't even be attempted. But at that time, 2 years ago, a revolutionary new brain mapping machine was first being tested. In a room shielding it from the earth's magnetic field, this machine - called the Krenikon - maps the electrical activity of the brain by picking up the faint traces of magnetism it produces - signals a billion times weaker than the earth's magnetic field. The Krenikon is the German entry in an international race to produce scanners based on detecting biomagnetic fields using super sensitive microchips. Cooled by liquid helium in a giant thermos, the detectors can map the electrical activity of nerves, the heart and - in Felicitas Kaiser's case - the brain.

DR. HUMMEL We can clearly identify three spike events on the screen.

ALAN ALDA (NARRATION) So sensitive is the machine that it can pick up the abnormal spikes produced by an epileptic focus even when they're not strong enough to trigger a seizure. What's more, it can locate the focus much more accurately than any previous method could. In Felicitas' case to a spot that could be clearly distinguished from her speech center. DR.

HERMANN STEFAN The red spot shows the center of the focal epileptic activity localized by MEG. And the speech center is above, let's say, one centimeter.

ALAN ALDA (NARRATION) That one centimeter was enough to allow Felicitas to get the same surgery Manfred is about to undergo. It's 3 days since the electrodes mapped his brain - and now Dr. Buchfelder and his team are using that map to find and cut out the focus of his epilepsy. First, Buchfelder identifies some landmarks that will lead him toward the focus.

DR. BUCHFELDER We will look for the optic nerve and the carotid artery. This whitish structure here, that's the optic nerve, and that's the carotid artery, and we'll follow the carotid artery ....

ALAN ALDA (NARRATION) Probing down between nerve and artery - damage to either could be catastrophic for Manfred - the surgical team gets to the right region of the brain. After an hour of painstaking progress, they are close enough for some last minute, on-the-spot mapping with an array of electrodes that probe directly into the brain.

DR. BUCHFELDER This is the part of the work which makes me feel uneasy. Really, it takes so much patience.

ALAN ALDA (NARRATION) Buchfelder plans to destroy and remove a piece of Manfred's brain - so he can't afford even the tiniest error. The electrodes he's put in place are now picking up the brain's electrical activity directly, confirming the exact position of the epileptic focus. DR.

HERMANN STEFAN These are the positions of the electrodes, on the brain, and this is a map, the field of the electric activity. And this is the maximum of the epileptic activity in the hippocampus.

ALAN ALDA (NARRATION) Now everything is ready for the critical moment.

DR. BUCHFELDER We know where to go and what to take out, namely the focus. We found it. That's it. And we are going to resect it.

ALAN ALDA (NARRATION) It's these tiny white scraps of brain tissue that have ruined Manfred's life. This sort of surgery is still uncommon - despite its effectiveness - because its so hard to find the epileptic focus. But with new mapping methods - especially those using biomagnetism - that's about to change.

DR. BUCHFELDER Brain surgery is more and more an appropriate treatment for otherwise untreatable epilepsy, because due to the modem imaging methods and the information which we get about the source of epilepsy, we can localize it more precisely, so that it's much safer than in the past, and much more effective.

ALAN ALDA (NARRATION) A week after Manfred's surgery, he's doing fine. - His head still hurts, but he can talk and so far he hasn't had a seizure. As for Felicitas Kaiser - she's now been seizure free for 2 years following her surgery. She's back at work, at last able to be just like everyone else.

FELICITAS KAISER A lot of things have changed. I'm not afraid to be around people, so I can make friends now. I can ride my bike without worrying. At work I can operate the machines. It's a totally new life for me.

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EMPERORS OF THE AIR

ALAN ALDA (NARRATION) On a hunting preserve near the north German town of Braunschweig, George Ruppell is after his favorite quarry - one he's hunted all over the world. More elusive than the deer or game birds most hunters track here, George's goal is nature's most versatile - and ancient - flying machine, one that's been around for over 200 million years.

GEORGE RUPPELL Here we have caught a large dragonfly. One of the best fliers we have.

ALAN ALDA (NARRATION) Its large thorax filled with flight muscles, this species is strong...

GEORGE RUPPELL Ouch! It will bite me. Ouch!

ALAN ALDA (NARRATION) ...and aggressive. What fascinates George about dragonflies is that they have to pack so much action into so little time. They spend up to four years as larvae underwater. But once they emerge as adults, they have just a few weeks to reproduce and ensure the species' survival.., and for that their flying skills are critical. George Ruppell is well known not only for what he's discovered about dragonfly flight, but how he's learned it.

ALAN ALDA (ON CAMERA) How do you look for them? Do you scan with your eyes?

GEORGE RUPPELL Yes. I scan with my eyes and then I detect little blue and black bodies.

ALAN ALDA (NARRATION) Dragonflies can reach speeds of up to 30 mph - and they can stop, start and reverse direction apparently instantaneously. For capturing high speeds events like this, the slow motion camera is the scientist's standard tool - but unlike his colleagues, George shoots in the field.

ALAN ALDA (ON CAMERA) So what's the idea? Why come out to the pond and shoot? Why don't you take the dragonflies into the laboratory, where the conditions are controlled?

GEORGE RUPPELL Yes controlled, but the dragonflies don't behave normally. They only show here in natural conditions their full behavior and even their full flight behavior and therefore we have to go out. Please let us have a look. There is a dragonfly sitting on a stem ... I hope I can film it.

ALAN ALDA (NARRATION) The technique here is to plunge in and go where the dragonfly takes you.

GEORGE RUPPELL Yes, I got it. Did you see it?

ALAN ALDA No, I'd have come closer but my foot is stuck in the mud. Thank you. ... now I've got both feet stuck.

ALAN ALDA (NARRATION) George Ruppell's slow motion footage reveals the extraordinary aerobatics allowed by two sets of independently operated wings. Hovering like a helicopter. Backward flight using all four wings together. But the real advantage of filming in the field is the insight into dragonfly behavior. Here a male is beating all four wings at once in an attempt to persuade a female to go off with him to mate. She's testing his strength - and he doesn't measure up. Here, a more successful male is flying lead in a tandem flight after mating. There's a reason for his being so solicitous. The female needs to dip her tail into the water to lay the eggs he's fertilized - and by riding shotgun he's providing cover against both predators and other males. Much of the male's behavior is driven by the need to get his own genes passed on. Here, another male appears, and switching from hovering flight to full forward thrust, he tries to ram the first male away. A third male joins the brawl. In the melee, the first male gets dunked - and the attacker, going into high powered backward flight, pulls away with the female. Then something very strange occurs. The male throws the pair of them into a somersault - and tiny drops of liquid fly from the female. The first to capture this on film, Ruppell believes that the male is emptying the female of any fertilized eggs so that he can be the father her offspring. Tandem flight has another advantage. Sometimes four pairs of wings can be better than two. Sometimes... but not always. There are some 2000 species of dragonflies, so George Ruppell is never going to be at a loss for new behaviors to observe.

GEORGE RUPPELL Here there are a lot of such small damselfly species. They fly even in cool weather. Because their body is not so thick. They can warm it up by muscle contractions. If I warm it up ... it will fly.

ALAN ALDA You're lucky it didn't fly into your mouth!

ALAN ALDA (NARRATION) George Ruppell does what all good scientists do - open the eyes of the rest of us to the endless astonishment of our world. Till the next Scientific American Frontiers - Aufwiedersehen.

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