

SCIENTIFIC AMERICAN FRONTIERS

PROGRAM #1309

"You Can Make It On Your Own"

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A Factory On Your Desk

Never Forget a Face

The Toy Symphony

Teetering to Victory

A Factory On Your Desk

ALAN ALDA Sitting here, I can do things that a few years ago would have been a fantasy. Back then I could write on my electric typewriter and take photographs with my camera, but printing them together in a newsletter like this would have taken many days and many other people. With my word processor, desktop publishing software, digital camera and color printer I can do it all myself in an hour or two. Of course, that's been around for a while. Today I can create games and animations, shoot and edit my own movies and post them for family and friends to see instantly over the Internet. But all this power extends only to creating and manipulating digital information - words and pictures. Pretty much the only actual thing I can make myself is the printed page. But what if this printer were instead a little factory, capable not just of printing paper but of manufacturing objects --- making things --- things like... well, bicycles, for instance...

ALAN ALDA (NARRATION) We're on the campus of the Massachusetts Institute of Technology, outside the Media Lab where much of the digital revolution was pioneered. And it's here that today what Neil Gershenfeld believes will be the next revolution in personal empowerment is being explored.

ALAN ALDA Wait, wait a minute what's this? Did you make this in the lab? SAUL This is an all printed bicycle. This is basically a complete bicycle made from two-dimensional poly-carbonate cut on a water jet cutter.

ALAN ALDA (NARRATION) This machine - costing hundreds of thousands of dollars - uses an incredibly powerful jet of water to cut through materials ranging from plastic to steel, fabricating in a few moments objects designed on a computer. It's just one of the machines available to students taking a course Gershenfeld teaches called How to Make (Almost) Anything.

ALAN ALDA If I had one of these machines at home you could email me this bike.

SAUL My sister was actually emailed this bicycle in Sydney and she's riding one around.

ALAN ALDA You're kidding. Isn't that incredible? So wait a minute, so that means, that, if I order a bike from a company someday, it won't come in a truck. Everybody will have one of these machines, and a lot of what we order-lamps, furniture, bicycles-will get emailed to us. We'll have it a few seconds later.

NEIL GERSHENFELD The only thing wrong with what you said is it's not when you order the bicycle, it's when you design the bicycle. When you design the bicycle.

ALAN ALDA Okay. Alright.

NEIL GERSHENFELD Do you recognize what this is?

SAUL This is actually a model of Matisse's Blue Nude Number Two. You can see the leg here, the hind leg, another leg here, and a thigh, the arch of the back, the head, and the hand holding the front wheel.

NEIL GERSHENFELD In this how-to-make-anything project, it's not just that students learn to make a bicycle, they learn to make their bicycle. Every bicycle is different, and part of expressing yourself and the bicycle you want is what this is all about.

ALAN ALDA This is an exciting idea because as we're talking, I just thought of two things I want to make. I remember one thing. I came up with an idea for something and I wanted to make a model of it, and I went to the art store and bought cardboard. And I got so bollixed up in trying to get the cardboard to stick together I just through the whole thing away. And it's a good idea and I'd like to see it made; this sounds like I could make it.

NEIL GERSHENFELD So what is it?

ALAN ALDA It's a thing, so that you could take any flash camera that makes red-eye, because the light is too close to the lens, and there's a ratio, depending on the focal length of the lens. But if you put it about-I don't know-about that far away from the lens-it won't make red-eye 'cause it comes in at a different angle. So a little periscope to sit over the flashgun that would fit on any camera, to fit over anything. So all I need to see if it really works is to build a little periscope.

NEIL GERSHENFELD I'll make you a deal...

ALAN ALDA Yeah?

NEIL GERSHENFELD If you bring your camera, we'll sit down, measure it and zap one out.

ALAN ALDA Okay, alright, this will be great. Listen, work on that thing for me, will ya?

ALAN ALDA (NARRATION) So off I went on what is certainly the first nude bicycle I'd ever ridden. A couple of weeks later, back at his lab, Neil's making stuff with his 6-year-old twins Eli and Grace.

ALAN ALDA Let me see what you came up with when I was gone.

NEIL GERSHENFELD Okay.

ALAN ALDA Let's see how it fits on the camera. Oh, the other way around? Like this?

NEIL GERSHENFELD Yup. Yup.

ALAN ALDA So this is the flash here. And this mirror sends the light up to this thing up here. So that instead of the light coming out right into your eye it comes down a little bit.

ALAN ALDA (NARRATION) My immediate reaction is that the periscope needs to be longer, so Neil sets to work on a quick redesign.

NEIL GERSHENFELD So we'll add, say, a few inches to it like that?

ALAN ALDA (NARRATION) The periscope has slots all down it at different angles so we can vary both the height and angle of the mirror.

NEIL GERSHENFELD Okay, so here is a long periscope with teeth all the way down. So what we're going to do is take your design but print it with a laser that's so powerful that instead of just drawing a picture it can actually cut it out of materials that we can assemble into a periscope. And then when you come back in a couple of years we'll have new pieces added to the printer that can actually print not just the periscope but the rest of the camera.

ALAN ALDA (NARRATION) While this machine cuts out precise shapes in plastic, Neil's machine of the future will print out electronic circuitry, motors, sensors and everything else needed to make... well, whatever you want. Meanwhile...

ALAN ALDA We'll put it together, we'll stick it on a camera and maybe we'll take your picture, okay?

NEIL GERSHENFELD Now, what color are your eyes?

ALAN ALDA Are they red? They're not red? No.

ELI Blue.

ALAN ALDA They're blue, okay. If they come out red, then this thing doesn't work.

NEIL GERSHENFELD Okay.

ALAN ALDA And that'll be your fault.

NEIL GERSHENFELD My fault? You were the designer. I just work here.

ALAN ALDA I just thought it was a great idea. In theory it works.

ALAN ALDA (NARRATION) So - first a shot of Eli without the periscope.

NEIL GERSHENFELD That's right on Eli's face.

ALAN ALDA Okay.

ALAN ALDA (NARRATION) And now we can begin experimenting with the Alda All-Angle Anti-red-eye Periscope Prototype.

ALAN ALDA OK, the two of you together, the same as before.

ALAN ALDA (NARRATION) And there's an immediate problem.

ALAN ALDA You're both out of the frame!

ALAN ALDA (NARRATION) But this of course is exactly why it's so useful being able to make and test your invention while it's still being designed.

ALAN ALDA Can you see it?

NEIL GERSHENFELD No, angle it the other way.

ALAN ALDA OK, get you eyes out clear.

ALAN ALDA (NARRATION) Not only are Eli's eyes closed; the flash missed most of his face.

ALAN ALDA You know we had the angle wrong.

NEIL GERSHENFELD Oh, I think the angle... yeah, in fact you can see the reflection of the flash in my glasses. We need to angle it down more. That's what these are for.

ALAN ALDA (NARRATION) So, one more tweak of the astonishingly versatile Alda All-Angle... And bingo - the perfect shot, with Eli's blue eyes shining bright. Compare this to the first picture we took...

ALAN ALDA I'm really surprised to say that I think the eye looks bluer with the periscope on it.

NEIL GERSHENFELD I know. No, that's what I'm saying--.

ALAN ALDA I'm shocked because I didn't expect it to work. I think this periscope is going to be--. Of course--.

NEIL GERSHENFELD Do we share the rights?

ALAN ALDA Huh?

NEIL GERSHENFELD Do we share the rights?

ALAN ALDA Share the rights...yeah, oh you said it. Do we need a handshake on camera for that?

Never Forget a Face

ALAN ALDA (NARRATION) Not surprisingly, it was at favorite hangouts for MIT students in Cambridge Massachusetts that the once bizarre notion of wearing your computer first went public. Most wore their computers slung in pouches, with the displays mounted on eyeglasses - but some pioneers had opted for jauntier designs. Back then in 1995, the computers worn by this group of "cyborgs" as they called themselves, weren't networked together. But one of the Media Lab cyborgs was even then online most of the time. Steve Mann's wearable computer

was even equipped with a head-mounted camera, continually transmitting images from his everyday life to his Web page.

ALAN ALDA This is a medieval filing system you've got here...

ALAN ALDA (NARRATION) Steve Mann had already been experimenting with wearable computers for ten years... and most of them were still stashed away in his dorm at MIT. This is his first helmet-mounted rig, dating from the mid-1980's.

STEVE MANN ... over my head like this, and then I could see my screen here.

ALAN ALDA (NARRATION) Steve even had a pair of briefs equipped with a thermostat, wirelessly controlling his dorm-room air conditioner.

ALAN ALDA You never had to get out of bed to change the thermostat because your underwear was changing the thermostat for you?

STEVE MANN Yeah, yeah.

ALAN ALDA That's unbelievable.

ALAN ALDA (NARRATION) Surrounded by most of the cyborgs on the planet in 1995, I wondered about the next generation of wearable computers.

ALAN ALDA Do you have like, fashion conversations about... Do you give much thought to different ways that this stuff looks?

JENNIFER HEALY People give it a lot of thought, actually. There's a lot of debate whether it's good to cover the eye at all, whether you might want it on your arm, a screen. We have an undergraduate working on an even better private eye which would only take up a fraction of this space. It's a little prism that'll directly show you the screen and yet be here, and allow your eyes to be seen by the person you're having a conversation with.

STEVE MANN Hopefully be completely invisible. One won't be able to tell that we're wearing special glasses. We won't have these, this display's about six years old with a big cathode ray tube up on top of it. You know, they're getting smaller and smaller and eventually we'll have them built into a regular pair of spectacles and the only evidence that somebody is wired will be the fact that their eyes sort of go across in a sort of reading motion. We'll think that they're possessed by the devil or on the Internet.

ALAN ALDA (NARRATION) This first generation of cyborgs has now mostly scattered across North America, carrying their gospel with them. Meanwhile, back here at MIT's Media Lab, their predictions are coming true.

ALAN ALDA Now those glasses look familiar. You've been setting that up for me, huh?

RICH DEVAUL Well, they certainly should, yes.

ALAN ALDA And this is a computer, this thing?

RICH DEVAUL Well, it's actually several computers. It's a network of computers on your body and it's doing a number of things for you. But most importantly, it knows something about where you are and what you're doing and it can give you information that might help you doing whatever it is you happen to be doing at the moment.

ALAN ALDA Can I try it on?

RICH DEVAUL You certainly can.

ALAN ALDA And you can tell me what it does.

RICH DEVAUL Actually, can I show you the parts of it before you try it on?

ALAN ALDA (NARRATION) Inside Rich DeVaul's computerized jacket is a network of CPUs, hard drives, sensors and wireless cards, making it more powerful than most computers still sitting boringly on desktops - or even laps.

RICH DEVAUL One of the important design goals for the system is it should look mostly like ordinary clothing. Because I want to be able to go through my daily existence without people crossing the street to avoid me. And, believe it or not, this actually happens with previous wearables that I've used.

ALAN ALDA People would cross the street to get away from you?

RICH DEVAUL Yeah. I mean, you can imagine the difference wearing this with the jacket covering on and wearing with the jacket covering off. People will treat you very very differently. Because right now you look like Alan Alda wearing a slightly bulky jacket. And if we unzipped all this you would look like Alan Alda doing an extra stint on Star Trek.

ALAN ALDA And the bulk will come down as you use slower components and flatter--.

RICH DEVAUL Yes. In fact, this design is almost two years old.

ALAN ALDA Oh my gosh! I just looked at you and there came your picture on my little eye piece.

RICH DEVAUL Yes.

ALAN ALDA (NARRATION) It's the little tag on Rich's teeshirt that telling my computer who he is.

RICH DEVAUL And if you'll follow me this way as we walk over here...

ALAN ALDA (NARRATION) As I move, a map tracks my progress.

RICH DEVAUL I'll introduce you to my advisor, Sandy Pentland.

SANDY PENTLAND Hello. How you doing?

ALAN ALDA Oh! There you are! Oh, Just a nice big picture of you, friendly picture.

SANDY PENTLAND Yup.

ALAN ALDA And I see how to spell your last name.

RICH DEVAUL If you follow me around through the Borg lab, the map will be updating to show your location as you change. The red dot is shifting to show your present location. And we'll head over here to my colleague Steve Schwartz. And Steve, this is Alan.

STEVE SCHWARTZ Hello Alan, glad to meet you.

ALAN ALDA (NARRATION) The most useful feature of Rich's system comes when I face him a second time. My eyepiece gives a little flicker.

RICH DEVAUL It's one-third of a full video frame.

ALAN ALDA It brought back your name to me. Which I had actually temporarily forgotten and I realized your name is Rich, right?

RICH DEVAUL Well, very good. So--.



ALAN ALDA (NARRATION) Although too brief for me to register consciously, the flicker was actually a quick subliminal reminder of his name.

ALAN ALDA It's very interesting, though, because it flashed so fast, if I didn't really know your name and wasn't trying to recall it...

RICH DEVAUL That's right.

ALAN ALDA I wouldn't have got it.

ALAN ALDA (NARRATION) As I meet Sandy Pentland a second time, again his name is popped subliminally into my head.

ALAN ALDA You might not even realize you're being prompted to remember something you're trying to remember.

SANDY PENTLAND That's right. And that is a little bit spooky that you can have something that's sort of paying attention to what's happening, like, I'm meeting this person, then it's giving something back to you that you're not actually aware of. But you perform better as a consequence. So it's a little bit like a psychic crutch or something like that. For folks like me that don't remember names real well, that's pretty important.

ALAN ALDA What have you found out in wearing this that you didn't expect? Anything?

RICH DEVAUL I'm playing with reminders that will help me do things like, you know, if I'm working too late. Really simple stuff. I'm wearing the Wearable, it'll actually pop up a display that says "Rich, go home." Or, even, I forget to eat.

ALAN ALDA You forget to eat?

RICH DEVAUL I forget to eat when I'm working. So, if it's getting towards six or seven p.m., and I'm still in the Borg Lab, I probably haven't gotten dinner yet. So a little thing can come up and say "Rich, eat something." And if it sees me that I'm wandering towards the candy thing over there, it will say--.

ALAN ALDA Don't eat that. Keep away from there.

RICH DEVAUL It can say, "Rich, go to the restaurant." I mean, these are the kinds of things that I need because I can get very sort of obsessively wrapped up in my work.

ALAN ALDA Is this gonna be a new kind of space suit?

STEVEN SCHWARTZ It's gonna to be an addition to the existing space suit.

ALAN ALDA (NARRATION) Steve Schwartz, meanwhile, is literally wrapped up in his work

STEVEN SCHWARTZ This is going to be an addition to the existing American spacesuit.

ALAN ALDA And what will be different about this?

STEVEN SCHWARTZ What will be different is that in addition to the radios that they already use to assist them during their missions, they'll actually be able to receive wireless video information through a wearable computer we've designed.

ALAN ALDA (NARRATION) Building a wearable computer to fit inside a pressurized space suit turns out to be a tricky technological challenge - one that NASA so far hasn't solved.

STEVEN SCHWARTZ And it uses some very very low-power electronics in a flat and flexible form factor that'll contour to the human body. The reason for the low-power electronics is that the pressure suit is pure oxygen. And it's-you know--any kind of a spark ignition could cause a disaster. So we have to keep the power and the current extremely low to meet the safety requirements which are the most important requirements of a space suit.

ALAN ALDA Can I try that on to see what that feels like to wear that?

ALAN ALDA (NARRATION) The idea behind the project is that when astronauts are floating around in space working on the International Space Station, they'll have constantly updated video prompts in their little eyepiece.

ALAN ALDA I guess it'll lock onto my suit. But wait. Here's the--. Oh, I'm seeing--. What am I seeing? Part of the space station? This is great. Wow, look at that. First I see a wide shot. It's like directing a movie.

STEVEN SCHWARTZ That's right.

ALAN ALDA (NARRATION) Right now astronauts working on the space station have to use paper checklists velcroed to their arm. As the assembly and maintenance tasks get increasingly complex in the future, a video instruction manual could remind them how to do a task they'd been trained for months earlier.

STEVEN SCHWARTZ It's a combination of reinforcement and the good old John Madden chalkboard, so they could circle the little bolt or cable that they're supposed to be changing.

ALAN ALDA (NARRATION) And here in my eyepiece is the sort of do-it-yourself video Steve's talking about.

STEVEN SCHWARTZ So now we're putting in a D-ring.

ALAN ALDA I get the impression, that even if I had never trained to do this before, it's so clear what he's doing, that I could probably do it. You know, like in the movies when they have the stewardess fly the plane and land it?

STEVEN SCHWARTZ Yup. It's close to that.

ALAN ALDA That would be me.

ALAN ALDA (NARRATION) So far we've been looking at wearable computers designed to help you with what you're doing. Brian Clarkson is wearing a computer that keeps its eyes on what he's already done.

BRIAN CLARKSON Well, basically I've been spending the last couple years trying to record my life.

ALAN ALDA With that-That's all you need to record your life?

BRIAN CLARKSON Yeah. This actually records about 360 degree video. Because there's two cameras-one in the front, and one in the back.

ALAN ALDA Oh yeah. Where's the recording device? In that thing?

BRIAN CLARKSON In the turtle shell.

ALAN ALDA The turtle shell.

ALAN ALDA (NARRATION) Wherever Brian goes, his turtle shell goes with him, spinning out a permanent video record of his waking life.

BRIAN CLARKSON It records about twenty hours. Which is good for about two days, say. And then, at the end of the twenty hours, I have to upload to a server, which I have in the back room over there. I have about 500 gigabytes and disc space which I just kind of drop my memories onto.

ALAN ALDA Isn't that hard to fish through and find out something significant?

BRIAN CLARKSON Very hard. What I'm relying on is someone's life isn't actually all that interesting day to day. There's a lot of routine and things that re-happen over and over again. That's perfect because a computer can find that and latch onto it and find, okay, the patterns in your day. There's a weekly pattern. You might have a daily pattern. You might get up every morning, brush your teeth, get on the subway, go to work and come back the same way. And so the computer latches onto that pattern that you have and then tries to find the deviations from that. And those are the interesting points. This is a timeline of a subsection of the hundred days of memory. This is about ten days worth. So we have front video, rear video, audio, and orientation being laid out in time. If I zoom in on this particular day, it expands out to this view. So we get a more detailed view of that particular day.

ALAN ALDA Have you found anything out that you didn't expect about its relationship to your own life?

BRIAN CLARKSON I found that my hypothesis that someone's routine is pretty much, someone's daily life is pretty much boring and nothing new really happens from day to day has been confirmed. At least for a graduate student, okay.

ALAN ALDA Many gigabytes to confirm that-

BRIAN CLARKSON Of me sitting at my desk, typing away, programming.

ALAN ALDA Tell me something. Of these hundred days have you searched for anything a little unusual and found something interesting? Something that you wouldn't have come across without the computer?

BRIAN CLARKSON I met a couple of new people who are kind of important in my life now. And usually you don't have access to those first couple of moments when you meet somebody for the first time when you're introducing them. And it's interesting to go back and see how you acted around that person and how -- you can kind of remember how you perceived the first impressions of that person. And now how, 'cause I-My current girlfriend-I met while I was wearing this. And I can go back and figure out and remember exactly how I was feeling when I first met her. And how I actually acted when I first met her. So here I'm meeting this girl and we're about to go on a business dinner/lunch. So we're getting on the elevator, leaving. We've all met each other for the first time here. I can speed this up.

ALAN ALDA You walked out of the Media Lab and you headed for a restaurant, right?

BRIAN CLARKSON Exactly. So I'm gonna zoom forward.

ALAN ALDA This is amazing to fast forward through your actual life. This is like an outer body experience. She knew you were taping this?

BRIAN CLARKSON Exactly. I think it is one of the things that made her interested in me. I was doing this kooky thing. I have something to talk about.

ALAN ALDA Well, I guess it's a good way to find out if people can put up with you.

BRIAN CLARKSON My friends always joke that whenever I'm wearing this, that not only do I get girls to talk to me, but I also get girls to talk to my friends who are with me. Because they're always like, "what is he wearing?" Kind of thing.

ALAN ALDA Well, she looks animated. She's talking to the guy next to her a lot, though.

BRIAN CLARKSON This is the rear view.

ALAN ALDA Oh, so you can see what she's looking at over your shoulder?

BRIAN CLARKSON She's checking out the waiter behind me.

ALAN ALDA She's checking out the guy over at this table over here.

ALAN ALDA (NARRATION) But while Brian can now play back his life any time he wishes, the rest of us who happen to get caught by his camera may not always be happy with the idea.

ALAN ALDA In restaurants now, they have signs up that say "no cell phones". And I can imagine that they will eventually have signs up saying, "Take-

BRIAN CLARKSON Etiquette--.

ALAN ALDA --Any edible camera at the door. Check it."

BRIAN CLARKSON Yeah. I expect this to happen. Basically what we need to do is inject this hardware and this device into society and then society will build an etiquette around it to sort of make it work right. Right now we just don't have it; it's new, so it's scary.

BRIAN CLARKSON How does it feel?

ALAN ALDA Great.

ALAN ALDA (NARRATION) Well let's see how scary it can be.

ALAN ALDA Let's see.

BRIAN CLARKSON Looks very cool.

ALAN ALDA Hi.

STUDENT Hi.

ALAN ALDA I pointed at him and he doesn't know I got a picture of him. I'll just follow this person here. Hm-hm.

ALAN ALDA (NARRATION) Of course, just like the other wearable computers we've seen, even an all-seeing one like this will come down in size to the point of being inconspicuous. Then we could all carry around with us a way of recording every moment of our lives - one that maybe one day could even smell the cherry blossom - and allow us to recall the high points - and even the low points -- whenever we wish. It could give nostalgia a whole new meaning.

OLDER WOMAN Hi Alan.

ALAN ALDA Hi. How are you?

OLDER WOMAN Good to see you.

ALAN ALDA (NARRATION) And wouldn't it be great for those, "no you said... then I said, no you said arguments?"

ALAN ALDA Don't you wish you had one of these? You wouldn't have to carry that on your shoulder like that.

ALAN ALDA (NARRATION) But in a world where increasingly surveillance cameras are all around us, the idea that they could move around invisibly among us is definitely unsettling. So what do you think? Would you want a permanent record of your life? Or are the costs -- both personal and public - just too great?

The Toy Symphony

ALAN ALDA (NARRATION) I'm contributing a note to a musical work called the Brain Opera - accompanied by a heavenly electronic choir.

STUDENT That was really good.

TOD MACHOVER That was good. Now sing not so well, darn it.

ALAN ALDA I think I just wrote "Chariots of Fire".

ALAN ALDA (NARRATION) I was at MIT's Media Lab testing some of the inventions of Tod Machover and his colleagues as they prepared for the Brain Opera's premiere. One of the ideas behind the Brain Opera was that it would involve new musical instruments that anyone could play.

ALAN ALDA This... what's that?

TOD MACHOVER You broke it!

ALAN ALDA (NARRATION) The Brain Opera has since been performed several times in concert halls all over the world.

TOD MACHOVER Yeah, all right!

ALAN ALDA (NARRATION) We caught up with Tod Machover again as he was in final rehearsals for his latest work, the Toy Symphony. Among his collaborators in the Toy Symphony is violinist Joshua Bell - one of classical music's superstars.

ALAN ALDA What made you want to be a part of the Toy Symphony?

JOSHUA BELL Well, they approached me because I think they heard that I played music...

TOD MACHOVER We heard he played the violin.

JOSHUA BELL And they also heard that I love video games and I love computers and I buy a new laptop every six months 'cause I like to stay ahead of technology. So I guess the combination of my interest in technology and my willingness to go there.

ALAN ALDA (NARRATION) Just where he's going, no one's quite sure at this point. But one thing he'll be taking with him is a computer program that can pick up the sound of his Stradivarius and instantly add to it - in this case, doubling the melody an octave lower. A few weeks later, at a performance of the Toy Symphony in Glasgow, Scotland, Joshua's enhanced Stradivarius shows off its new musical colors. In this piece, the Stradivarius is still front and center.

JOSHUA BELL We don't want to use it in a situation where you just miss hearing the acoustic sign of a violin, which is hard to beat, you know?

ALAN ALDA Yeah.

JOSHUA BELL And especially after spending four million dollars on this, I don't want it to be completely not useful anymore.

ALAN ALDA (NARRATION) But while Joshua won't be giving up his Strad any time soon, he and Tod are working together on one of Machover's latest musical instruments, called the hyperviolin. The idea is to take the musical skills and subtleties Joshua employs in playing the violin and translate them into novel musical sounds.

TOD MACHOVER What we're trying to do is take this instrument, which has the feel of a regular violin, has the proportions, the strings, fingerboard. So Josh can play it like a violin with really no adjustment. But it has lots of extra information, it gives the computer a lot of help as to how Josh is playing and what he's playing.

JOSHUA BELL The bow picks up all kinds of data like bow speed, tilt, pressure-it can take all this data from what I do naturally with the bow when I play the violin. And it can then isolate that and feed it into the computer.

ALAN ALDA Diane, there's a radio in here sending the data? DIANE Yeah, this -- there's a transmitter right here that sends all the data out by this wire here and we pick it up remotely in the studio.

ALAN ALDA You're capturing on the computer-- DIANE Right.

ALAN ALDA The tiny, almost imperceptible things that he's doing with his right arm to make the sound that he gets. DIANE Right.

TOD MACHOVER What it allows us to do is to make an instrument which starts from the basis of a violin but can then flower and expand into many other things and the other things are really just limited by our imaginations.

ALAN ALDA Like what?

TOD MACHOVER I don't know.

JOSHUA BELL What he says. Limited by our imaginations.

ALAN ALDA Any old thing will be fine!



ALAN ALDA (NARRATION) Here in rehearsal, Tod and Joshua experimented with different sounds in preparation for the Glasgow concert. At the concert itself, the hyperviolin joined a children's chorus, a full symphony orchestra and some other instruments hatched especially for the Toy Symphony - Beatbugs.

GILI WEINBERG It plays it back to me. I can stop if I don't like it and try something else.

ALAN ALDA (NARRATION) My introduction to Beatbugs came from one of Tod Machover's graduate students, Gil Weinberg.

GILI WEINBERG And now I can start to manipulate it. I can change the pitch. The more I press the higher the pitch goes. Now I can also change the rhythm. Ornament it. Stop it. Try something else.

ALAN ALDA (NARRATION) Beatbugs are supposed to allow even someone with no experience at all at playing an instrument the ability to create -- and collaborate.

GILI WEINBERG If you're happy with the motif, hit the bug hard, and it's sent to a third friend of ours. What you played is recorded. I can't change what you played, I can enhance it. I can use different rhythmic values and different numbers.

ALAN ALDA Right. You can sort of hide it.

GILI WEINBERG Develop it. So, you can take this and play with it, and when you point it towards me, I can play with you.

ALAN ALDA (NARRATION) The Beatbugs made one of their first public appearances at a trial run of the Toy Symphony in Berlin last year. The children spent about a week working together to create their composition. Tod Machover's goal is to give children a hands-on experience with music even if they've never even touched a conventional instrument.

JOSHUA BELL For me as a kid, when I was four years old, I heard music in the family but there were no toys, no musical toys for me to play with. And I actually invented my own when I was three, four-I used to string rubber bands on my dresser drawers and open up the drawers to different lengths, to different amounts--,

ALAN ALDA It would give you different sounds.

JOSHUA BELL And I would create pitches and copy different tunes because I didn't have anything else to play with.

TOD MACHOVER It's interesting, toy companies understood right away that music is something which is very little exploited for young kids. I mean, they're really--not just in terms of the instruments, but in terms of the activity. I started Toy Symphony because I have now eight and four year old daughters. I was just looking around for music training for them. And it's so conservative and just not interesting. It's much less expressive and musical than they are. Than any kid is.

ALAN ALDA (NARRATION) Just how musically expressive kids can be if they have the tools was beautifully demonstrated in Berlin, when the German Symphony Orchestra played a piece composed by a ten-year old boy. The composer hadn't written his score using musical staves and key signatures and semi-quavers, but with a software program called Hyperscore... His score had then been transcribed for full orchestra.

ALAN ALDA Oh, great!

MARY FARBOOD That's the idea.

ALAN ALDA I'll give you fifty dollars for this program, right now. Cash.

MARY FARBOOD Actually, it's free on the web.

ALAN ALDA Ah, no kidding?

MARY FARBOOD No kidding.

EGON PASZTOR Everyone can download it.

ALAN ALDA You have to give me the link.

EGON PASZTOR Absolutely.

ALAN ALDA This is great!

ALAN ALDA (NARRATION) Hyperscore uses colors, shapes and textures instead of musical notation.

MARY FARBOOD So if you move the notes close together ...

ALAN ALDA (NARRATION) You start by creating a little musical "motive" or tune using purple teardrops...

ALAN ALDA Okay, now I have no idea what I'm doing.

EGON PASZTOR Well, hit the space bar.

ALAN ALDA Hit the space bar, okay.

ALAN ALDA (NARRATION) There's a lot more you can do with Hyperscore, but in the spirit of this show, why don't you go to the website and see how You Can Make It - music that is -- on Your Own.

ALAN ALDA I love it. This is great.

Teetering To Victory

ALEX SLOCUM 3-2-1-go.

ALAN ALDA (NARRATION) We're ending with a contest that's the essence of learning how you can make it on your own -- the annual battle of machines built by students at MIT.

ERIC VARADY Now comes the fun part. Calling my mom.

CROWD Double win! Yeah!

ALAN ALDA (NARRATION) This year's contest -- hatched six-months earlier -- involves a teeter-totter beam and a swinging 8lb ball. The challenge is to build a machine that starts out sitting on the beam and that after exactly 45 seconds has managed to tilt it in its favor -- against an opponent trying to do the same thing. There's a 10lb weight limit for each machine... and a box of parts to make it from. Each of the hundred plus students in the contest -- which is actually a course in mechanical engineering -- gets an identical kit of stuff -- including several electric motors from home power tools as well as things which seem like mechanical leftovers.

ALAN ALDA What would you do with this?

ERIC VARADY Nobody in the class knows what that is. We had a...

ALAN ALDA Is that true? No one knows what it is?

ERIC VARADY No one knows how they're gonna use it.

TEACHING ASSISTANT Usually people just do this: pop it in, take the motor and do something with the motor and then toss that back in there. What it is good for is--.

ALAN ALDA It is a mistake to toss that away?

ALAN ALDA (NARRATION) After several weeks of brainstorming and designing their machines on paper and computer, the class sets to work manufacturing them. And it's now that some of the strategies the students have come up with begin being tested. Grinding sharp spikes is Jessica Baker, one of several with a plan to have their machines reach down and grab the carpet underneath the beam. Alex Slocum is the professor running the course, and one of a dozen MIT staff helping the students translate their designs into reality.

ALEX SLOCUM Oh! So that's about ten or fifteen pounds up. From one tooth. Imagine if you had twenty teeth.

ALEX SLOCUM When they build a machine and they do the calculations right, the machine works, and you get this intense "er", just like a geek gasp from knowing that what you created in your mind and on the computer is actually doing what you told it to do.

JESSICA BAKER It's gonna be dropped from up above there by the strings. And these things grab into the carpet, theoretically. If I can grip the carpet well enough, I can harness the full power of the motors.

ALAN ALDA (NARRATION) Here's another plan to pull the beam down.

WILL LARK This locks on to prevent the whole mechanism from falling off the beam once it drives to the end. It takes about 15 seconds.

ALAN ALDA (NARRATION) This is Will Lark.

WILL LARK Once it's flipped open, this rock represents the car, which will drive over here, attach with magnets and reel the beam in.

ALAN ALDA (NARRATION) In contrast to Jessica and Will's plan to tug the beam downwards, Nick Martin intends to jack it up.

NICK MARTIN It will drop off the beam, drive over to the opponent's side, and then raise the jack to raise the beam, thus changing the angle.

ALAN ALDA (NARRATION) Ernesto Blanco has been helping students in this course for over 20 years. The contest changes, but not its intent.

ERNESTO BLANCO Practically everything in mechanical design is involved here. And we're happy to be able to give the students that kind of an experience. And at the same time, a little bit of frustration.

TULIKA KHEMANI It's an awesome class. It's very very productive and I've learned so much in this course. It's amazing. But it's also very stressful.

ALAN ALDA (NARRATION) It's now just a few days before the contest and a hundred machines are taking shape.

ALEX SLOCUM About mid year there were some worries that maybe the contest was a little too complicated. And, oh my goodness, the students were having a really tough time. But in reality, what they were doing is they were hidden in their warrens, working away on solutions that, when they surfaced, just "whoa!"-blew our minds with how elaborate and cool they were.

TEACHER Folks, it's two days before delivery time, so let's see what you got.

ERIC VARADY So the plan is, this guy, all he does is he goes from here to here and then these syringes apply 500lbs of force...

ALAN ALDA (NARRATION) Eric Varady has a plan similar to Will Lark's.

ERIC VARADY And it clamps down so it can't be moved.

ALAN ALDA (NARRATION) He drops a car off the beam and uses it to place magnets on a metal strip, then winches his side of the beam down. The car is then free to roam...

ERIC VARADY If there are any robots on the ground, which is what I'm really afraid of, it can take them out.

ALAN ALDA (NARRATION) Nick Martin, meanwhile, has almost finished his mobile jack. NICK MARTIN The goal is to drop the robot off the beam, onto the ground, drive to the other side of this beam, and then raise this jack, and then push their side of the beam up. This strategy of winching to the magnets will produce a lot of force. I'm worried about robots like his.

ERIC VARADY I'm worried about him, so hey!

ALAN ALDA (NARRATION) Jessica Baker's carpet grabber is also almost done - and testing well.

JESSICA BAKER I think I need to perfect that carpet driver so it digs in more. But I'm happy with how the rest of it works.

ALAN ALDA (NARRATION) Sarah Mendelowitz's machine is designed to give her opponent a jolt -- then, like Jessica's, drop a carpet grabber to the floor. A winch then hauls the beam down.

STUDENT Nice. That's sweet.

TEACHER Okay ready? We're gonna have a run.

ALAN ALDA (NARRATION) Will Lark, meanwhile, has built his car but dropped the idea of using it to place magnets. Now he plans to simply drive away, pulling out telescoping rods to maximize his leverage.

TEACHER We have a winner against the brick.

ALAN ALDA (NARRATION) After 14 weeks of design, construction and testing, the machines face one last hurdle.

LAB ASSISTANT Fit it in the box, however you can get it in.

ALAN ALDA (NARRATION) To qualify for the contest, every machine must fit within the box its parts came in.

LAB ASSISTANT Is it in straight?

TULIKA Yeah.

LAB ASSISTANT Put the lid on please.

TULIKA Wo-hoo!

ALAN ALDA (NARRATION) The machines must also weigh no more than the 10lb limit.

ERIC VARADY Oy!

LAB ASSISTANT What can you get rid of?

ERIC VARADY I can drop one of these clamps.

LAB ASSISTANT Do whatever you have to. You have less than two hours.

ERIC VARADY Heh.

ALAN ALDA (NARRATION) Kateri Garcia machine just slips in under the weight limit -- as does, eventually, Eric's.

ERIC VARADY Yes! Yes!

KATERI GARCIA Everybody has to put their machines away with the lock placed backwards, so they know you've been impounded. And you're not allowed to touch your machine until Tuesday morning, the morning of the competition. At that point you can decorate or do whatever you want. As long as you don't change any of the mechanics of your machine. So I'm glad it's out of my hands and I'm really excited for the competition.

ALAN ALDA (NARRATION) It's now the first of two days of head to head competition -- with no second chances. One loss, and your machine is eliminated.

ERIC VARADY I'm nervous and I'm a little stressed out by that because, I mean, it's all fun. But I spent so much time on this, so much time that, ah, I want my money's worth.

ALAN ALDA (NARRATION) Before an expectant crowd in MIT's ice hockey arena...

ALEX SLOCUM 3-2-1-go!

ALAN ALDA (NARRATION) ... Nick Martin's machine, flawless in tests, doesn't give him his money's worth. NICK It fell over, and that's kind of depressing. I've never seen that before. I tested it, I ran it, but, you know, I guess that's what engineering's all about.

ALEX SLOCUM Go!

ALAN ALDA (NARRATION) Nick's isn't the only machine to dash weeks of hard work in a few seconds of competition. Her opponent's crash means that Kateri Garcia's machine this round simply has to cling on. Sarah Mendelowitz's jolting mechanism fails to flip open. But her carpet grabber takes a firm grip and pulls her to an easy victory. Will Lark's already made it through a couple of easy wins. And again his machine works as advertised -- almost. His car never really finds its feet, but still pulls the telescoping rods out far enough to get the leverage to win. Here's the view from above the beam -- featuring a robot that's using the bulldozer technique: shove the opponent off the beam -- then drive back to your end to tilt the beam down. The bulldozing robot was built by Malima Wolf.

MALIMA WOLF It's a pretty powerful robot, and, it's pretty simple, but, like, it doesn't have a problem falling off the beam which a lot of the robots do. So, it works. It's simple.

ALAN ALDA (NARRATION) Here's another mobile jack. Dropped off the beam, it's driven over to the opponent's side and smoothly lifts it into the air. Will DelHagen is the piston's designer and builder, and it's obviously a machine to be reckoned with. Now watch carefully. See that projectile flying over the yellow ball? It's attached to a string from a robot that's just been bulldozed off the beam.

ALISON WONG Oh my god!

ALAN ALDA (NARRATION) But Alison Wong's not out of it yet. By grabbing the pendulum, Alison manages to keep most of the weight of the whole system on her side of the fulcrum -- and pulls off a win that seems to surprise her more than anyone. Eric Varady's already breezed through several early rounds. The magnets and the winch have provided all the power he's needed. So far his car has had no opponents needing to be harassed.

ERIC VARADY It worked perfectly. So, if it keeps up, I got a really good chance.

ALAN ALDA (NARRATION) Jessica Baker's also been doing well with her carpet grabber. But this time it's up against another of those mobile jacks. And before Jessica has a chance to do any serious winching...

JESSICA BAKER He has a really nice machine. I was hoping to get down there really fast and lift up the carpet so he wouldn't be able to drive over there, but he drove over there too fast.

ALAN ALDA (NARRATION) While Jessica had the bad luck to face a jack, Sarah's carpet grabber's been having a fairly easy time. This round her opponent's magnets fail to get a grip.

SARAH MENDELOWITZ Nice job. I seemed to have gotten lucky a lot of times. I haven't had to go against a jack yet. So I think it's a lot of luck, who I picked. But I'm glad things are working well. And so far so good. I'm excited that I got this far.

ALAN ALDA (NARRATION) Malima and her bulldozer are up again -- this time against another pendulum grabber.

ALEX SLOCUM She got to winch and hope that she doesn't get off the beam.



ALAN ALDA (NARRATION) But Malima simply goes into reverse, dragging everything with her.

ALEX SLOCUM Oh! Amazing! Absolutely amazing!

MALIMA WOLF It works pretty well right now. And it seems to be making it. It hasn't broken yet, so--.

ALAN ALDA (NARRATION) Now here's a confrontation we've been waiting for -- Sarah's carpet grabber against Eric's magnets and car. Sarah gets a grip -- and yanks so hard she makes Eric's magnets lose theirs, leaving them dangling helplessly. Now Eric's only hope is his car. But Sarah hangs on -- and Eric's streak is over.

ERIC VARADY She deserved to win. That was awesome.

SARAH MENDELOWITZ That was my toughest match so far, so, I'm looking good. I'm really excited.

ALEX SLOCUM 3-2-1-go!

ALAN ALDA (NARRATION) This is the first match-up we've seen between mobile jacks. One jack maneuvers into position more quickly than the other...

ALEX SLOCUM He may have it. Don't get greedy.

ALAN ALDA (NARRATION) The faster jack is driven by Alex Jacobson. Jack's that work well, like Alex's, are beginning to look unbeatable. Here's another face-off that promises to be fun -- Will's drive-away car against Malima's bulldozer.

WILL LARK As long as the front part stays on its hooks, it should be fine.

MALIMA WOLF I think I can do it. I don't know. Who knows, we'll see.

ALAN ALDA (NARRATION) Malima's bulldozer attacks -- but it's stopped short by Will's lock-on clamp. Will's heavyweight car does its thing -- and its extra leverage keeps Malima's bulldozer hanging high.

ALEX SLOCUM That was good. Excellent!

WILL LARK Oh man!

ALAN ALDA (NARRATION) Only a few machines now remain in the running. One is the mobile jack built by Will DeHagen. Alex Jacobson has the other

almost identical jack -- here literally ripping a carpet grabber out of the contest. Kateri Garcia's bulldozer has been steadily plowing its way through the opposition. It does it again. But as time is about to expire... With both machines off the beam, it ends up a tie. KATERI The controls are really touchy and this thing likes to take off and I shouldn't have touched it, I should've left it alone.

ALAN ALDA (NARRATION) So there's a rerun. This time Kateri's bulldozer fails to dislodge her opponent ... whose carpet grabber clings on

ALEX SLOCUM Look at the climb on that! Amazing angle! There she goes, up up up and away!

ALAN ALDA (NARRATION) But Kateri's heroic climb isn't enough to dislodge the carpet grabber.

ALEX SLOCUM I've never seen, literally in seven years of teaching, a student design a machine set to go up a 45 degree angle almost.

ALAN ALDA (NARRATION) Will Lark's car is still going strong -- this time pulling the telescoping arm as far as it will go. With this win, he's in the semifinals.

WILL LARK Whoa! I've got to take a breather for a second.

ALAN ALDA (NARRATION) Sarah's luck, meanwhile, looks to have run out, as she finally confronts Will DelHagen's all-powerful jack.

SARAH MENDELOWITZ I did a lot better than I thought I was gonna do. I came up against a really tough opponent. I don't know if there was much I could do, so I did my best. Having it done on time and having the opportunity to practice really helped a lot. I think that was a big part of how well I did.

ALAN ALDA (NARRATION) But then -- an unexpected reprieve from the judges.

SARAH MENDELOWITZ So now I guess I'm rerunning since my control system stopped working again. So they're gonna let me rerun.

ALAN ALDA (NARRATION) Remember Jessica Baker's plan to try to pull up the carpet before the mobile jack could get into position? It looks like Will DelHagen's jack has finally met its match -- until Sarah give one last tweak on the controls. She tries to recover -- but it's too late.

SARAH MENDELOWITZ I got too greedy I think. I didn't want him to get underneath and I popped off. I think if I didn't get so greedy I might have been able to beat him, but it was really close. It was good.

ALAN ALDA (NARRATION) The first semifinal. And now it's Will Lark's turn to face Will DelHagen's jack. Almost before the car has even jumped off the beam, the jack is hoisting it up. All Will DelHagen has to do is stand and watch as Will Lark's car desperately tries to hook around the jack and yank it away.

WILL LARK Winch it, winch it!

ALAN ALDA (NARRATION) For Will Lark, it's the end of a great run.

WILL LARK The only way to get him was to mess him up.

ALAN ALDA (NARRATION) The second semifinal. It's Alex Jacobson's mobile jack against a simple extender that has quietly made it through round after round. For a moment it looks like Alex has gotten trapped by the corner. But then... So for the finals, it's mobile jack against mobile jack.

ALEX JACOBSON A lot of things I wanted to get done I didn't get done, but everything I needed I guess I finished, so...

ALAN ALDA (NARRATION) We tracked Alex down behind the scenes... ALEX JACOBSON I gotta go.

ALAN ALDA (NARRATION) Where, it turned out, he'd been conspiring with Will. Good friends, who've been comparing notes ever since the class began, Will and Alex now plan a final collaboration.

WILL DELHAGEN Alex, come on!

ALEX SLOCUM Up and away...

ALAN ALDA (NARRATION) Carefully choreographed, the two robots jack the whole apparatus an inch off the ground -- with the beam dead level. The result is a tie...

ALEX SLOCUM Double win?

ALAN ALDA (NARRATION) ... or in MIT-speak, a double win.

ALEX SLOCUM This has never, never happened before. And I so glad it did, because we like to be different.

CROWD Double win! Double win!

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