"CONTESTS SPECIAL"
SHOW 403

EPISODE OPEN

ALAN ALDA (ON CAMERA) In our special all contests edition of Scientific American Frontiers we'll be racing across the country in cars like this.

ALAN ALDA (NARRATION) Also - people.., and computers. Can you tell which is which? Battling ping pong machines - they break their inventor's hearts. And a race beneath the sea, for human-powered subs.

ALAN ALDA (ON CAMERA) I'm Alan Alda. Join me now on Scientific American Frontiers.

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SUNRAYCE '93

ALAN ALDA (ON CAMERA) I bought this car a few years ago and I was really excited about it. What's so exciting about a 1985 Honda? Come on up - I'll show you. That's right - it's not really a Honda anymore. It's an electric car. Eighteen batteries. An electric charger. And up front an electric motor. It's exciting because you feel like you're at the beginning of a new way of using energy. Although there are still some pluses and minus. It certainly puts the fun back in driving - you have to think about what you're doing. You have to plan your trip. Can I make it up that mountain? Can I get around the mountain? Is there going to be a plug on the other side? After a while I really started to get interested in seeing some technological breakthroughs. Well, some of those breakthroughs may come from the people involved in our first contest.

RACE ANNOUNCER Our first car at the line is the Solar Eagle II from Cal State University.

ALAN ALDA (NARRATION) 34 cars, 34 eager and hopeful teams line up in Arlington, Texas at the start of the 1993 race for electric cars powered just by

sunlight. In pole position, Cal State, Los Angeles - fastest qualifier, and a top contender to finish first in Minneapolis, seven days from now. Dark solar panels, which make about enough electricity to run a hair dryer, cover the car's removable body shell. A couple of months earlier, I had visited the Cal State team for a closer look.

ALAN ALDA (ON CAMERA) Can I lean on this?

RICARDO ESPINOSA You can lean on the middle of this tube where there is a number, that's fine.

ALAN ALDA (NARRATION) Team captain and engineering student

RICARDO ESPINOSA explained the controls.

ALAN ALDA (ON CAMERA) Now, is that the brake?

RICARDO ESPINOSA Yeah.

ALAN ALDA Watch out!

ALAN ALDA (NARRATION) The rules allow limited battery capacity on board - that's what's powering the car right now. But once the race starts battery charging is permitted only with the solar panels.

RICARDO ESPINOSA He can't go fast enough to crash it, I don't think. Although he looks like he's going fast.

ALAN ALDA (NARRATION) The Cal State car is certainly fast - but the cars will need more than speed. At the midday stop - eighty miles from the start - Michigan rolls in first, followed within minutes by Pomona. All the way from Arlington there's been full cloud cover, so everyone's had to run on batteries. Pomona's battery choice - Sears Diehards!

ALAN ALDA (ON CAMERA) Now that's interesting because there are batteries that are made for solar vehicles that are a little more complicated than that, right? Why do you use Sears Diehards?

ALAN REDMOND This time they're limiting the batteries and the solar cells to keep the cost down for most of the universities.

ALAN ALDA (NARRATION) Universal choice for body shells is lightweight - and relatively cheap - composite materials.

TEAM MEMBER The whole car is composite material.

ALAN ALDA So a large percentage of this car is just air.

TEAM MEMBER Yeah. If you think of it that way, yeah.

ALAN ALDA Between these honeycombs.

ALAN ALDA (NARRATION) I was impressed with the car's technology, but I did feel it's ease of use left something to be desired. Of course, it is deliberately designed for a small driver, to keep the car light - total weight for car, driver and batteries will be less than 800 pounds.

TEAM MEMBER The canopy's right about here.

ALAN ALDA So, I can't do this ....so I see.

TEAM MEMBER With the top of the car on.

ALAN ALDA With the top of the car on? Yeah, I see that.

TEAM MEMBER You got to get your feet up here on the pedals and let me hook up the seat actually.

ALAN ALDA You really need a shorter person. I can't get the second leg in. I can drive this but I have to keep one foot on the ground. Which is good for braking or is that the braking system? We didn't talk about the braking system yet.

ALAN ALDA (NARRATION) As Day One ends, everybody's still running on batteries. This is George Washington University, in third place after Michigan and Pomona. And this is Stanford, running fourth - but over an hour behind the top three, who are all within nine minutes of one another. The overnight stop is Ada, Oklahoma - 160 miles from the start. The cars have been able to do that on batteries alone - but now they have to get some sun. Well, the sun was out in Ada, so the leaders had several hours to charge up after they arrived. And that's what the top teams expected.

MICHIGAN TEAM We have a very good weather predicting capability, and if the weather changes a lot we can deal with that better than other teams.

ALAN ALDA (NARRATION) To get maximum sunlight from today's conditions, it was worth using precious battery power to get here fast.

GEORGE WASHINGTON TEAM We went from cloudy, to rain, to sun, to rain, to sun, and when you have all that changing you've really got to be on top of things.

ALAN ALDA (NARRATION) For top speed, the cars can use solar power and batteries together. Tomorrow that should be possible.

POMONA TEAM The preliminary reports that we had a day ago said that the weather would improve for tomorrow. So we should have more sun available and I think our batteries will be in pretty good shape after today.

ALAN ALDA (NARRATION) Tomorrow's conditions should suit Cal State, LA with their fast car, but they've lost four hours.

RICARDO ESPINOSA We're probably better than we could be, we could be stuck on the road. We were lucky that we could get the car running and our motor controller, or two of them blew up and we got back on the road.

ALAN ALDA (NARRATION) Day Two and once again the top three are racing towards the sun that's been predicted for the afternoon. Only minutes separate Michigan, Pomona and George Washington, although the stragglers are now twelve hours behind. Under full power conditions George Washington's lightweight car could be faster than Pomona or Michigan - so today G.W. makes a push for the lead. Pomona manages to keep up, and soon they're both out ahead, running at top speed - about 45 miles an hour. Right on schedule Pomona and G.W. run into the predicted afternoon sun. Michigan's now running third - it's probably the most energy efficient car, with the best range. But when the sun's out and batteries are full, it can lose on speed. And sure enough, Michigan lost Day Two to Pomona, who is now only 1 minute behind overall. Pomona came in ahead of G.W. as well.

POMONA TEAM We were pushing it there at the end, just running our own race basically. Jockeying around a little bit with Michigan and G.W. and right at the end it wasn't until the very, I think last 2 miles that G.W. had a problem they hit, their little wheels got caught in a rut right in town here and just stopped them right down and we happened to be just coming up on the right side and frankly didn't look back.

ALAN ALDA (NARRATION) Coming in fourth today - Cal State LA, pulling up from 17th place to 7th - although they're still hours behind the leaders.

RICARDO ESPINOSA A lot better than yesterday. We been running hard. I hope to get some sunshine though. We are really depending on it now. But we are really happy with how the car's performing.

ALAN ALDA (NARRATION) Day Three - sunny conditions forecast all day. It'll be another close race among the leading cars - and things are getting tense.

GEORGE WASHINGTON TEAM At this point it's a really, really close race we have a chance to get back into the lead, I mean we're a half hour behind because of what happened yesterday afternoon. Um, we can do this. We have a really good sunny day car and as far as our strategy goes, its gotta stay confidential.

CAL STATE Tomorrow looks bad. That's about it. You know drive on the high side of what we give em. Don't be always having us to push em up in speed.

MEGAPHONE GUY And the solar Eagle II is off the line.

ALAN ALDA (NARRATION) As Day Three begins, Cal State strategists have their eye on tomorrow. There are storms moving in, and when that happens, accurate weather forecasts and energy budgeting will become critical. RADIO Hey Rick, there's a pothole on the left. O.K., be careful and you are going to make a left. 10 - 4.

ALAN ALDA (NARRATION) But for today the strategy is simple - use up everything, because there'll be plenty of sun to re-charge with when they arrive.

CAL STATE TEAM That's what we're doing here is trying to set the speed of the car and adjust it along the way to make sure that when we end up the day we've just used up all our batteries and we don't have anything left but we haven't had to stop before we get to the finish line.

ALAN ALDA (NARRATION) Today Cal State LA hope to use their speed to move up the pack. Soon after the start, they get past George Washington. But it's going to be a frustrating day. A minor problem to fix...and G.W. re-passes. A few miles down the road - the two trade places again. And again a few miles later... Cal State's a match for third place G.W., but overall they're still several hours behind after their first day disaster. By evening Pomona, Michigan and G.W. are still the top three.

ANNOUNCER And they’re off .....

ALAN ALDA (NARRATION) Day Four. With storms moving in, it's going to be a day for the strategists. How far down can the batteries be run? Will there be sun to recharge later? The leaders head out with confidence - but holding their cards close to their chests.

POMONA TEAM If you were to ask me about the state of the battery charge, I don't think I'd give you a straight answer. You could ask me probably 3 times and I might give you three different answers.

GEORGE WASHINGTON TEAM That's where the guessing game is right now, where is everybody. What, where their state of charge is. Because once the clouds come up, it's your batteries that are going to make you win the race.

ALAN ALDA (NARRATION) It's clear the fast cars are going to try to stay ahead of the weather. By midday, almost the whole field has been caught by the storm. All except six of the cars have run their batteries down and have to trailer to the finish - incurring big time penalties under the race rules. But the leaders who made it in were rewarded not with sunlight, but cloud cover. Today's "run fast - charge later" strategy had depended on accurate forecasting.

POMONA TEAM That's basically what we were basing things on. Was to get out fast and get past what was going to be fairly bad weather around noon time and then get out and get here in charge, but the charge here is not so good.

ALAN ALDA (NARRATION) Cal State LA won today's leg - but things don't look good for tomorrow.

RICARDO ESPINOSA Well we're hoping for some light. We really need it and it might be a race where who can get further down the road and trailer in the least amount of miles.

ALAN ALDA (NARRATION) Over at the Michigan camp, they're not giving anything away.

MICHIGAN TEAM We really aren't too concerned with the weather. Just we pretty much always know what it is so whatever the conditions are we deal with them.

ALAN ALDA (NARRATION) If you think this should be enough to stop any solar car, think again. As race time approaches, here comes Michigan.

OFFICIAL 9 o'clock start. 9 o'clock start.

ALAN ALDA (NARRATION) Within an hour, everybody's either crawling along on their last few watts of battery power.., or they've ground to a halt. Except, that is, for Michigan. They're still running. So first into Des Moines at the end of the leg it's ...the Iowa State car? That's right - but it cost them a huge penalty for installing fresh batteries. The real winner today was Michigan - the only car apart from Iowa not to trailer in and get a penalty.

MICHIGAN TEAM Oh, my gosh, it pays it all back. I'm just so excited and so happy. This is the man who did it too. I am just so happy I can't believe we actually made it. I kept on, I kept on praying in the car saying come on keep it going, I was doing sun dances and everything.

ALAN ALDA (NARRATION) Suddenly it's a different race. Before, just minutes separated the leaders - but now Michigan has a massive two hours in hand. With sun all the way for the last two legs, the next three cars manage to chip a few minutes off Michigan's lead. But only some major failure can change things now. Energy efficiency, planning, strategy, weather forecasting. Michigan had simply done everything a bit better. And that's what won them the race

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MACHINES WHO THINK

ALAN ALDA (NARRATION) No, this isn't a missing scene from "Honey I shrunk the Kids". The kids are normal size - it's the computer that's giant.

ALAN ALDA (TO CAMERA) So giant in fact - 20 times life size - you can walk around inside it. This is the walk-through computer at the Computer Museum in Boston. And for someone who's crazy about computers like me, it's fascinating to see what's really inside one. This is the hard disc. I love a big hard disc. This is the random access memory or RAM for those of us who really know. And this is the heart of the whole thing - the central processing unit - the CPU. It's amazing to me that what's just a lot of hardware can seem so human. You can ask it questions and it responds. Sometimes in ways you didn't expect! Which poses an interesting puzzle. Suppose I were in here and had control of what this computer says, by hooking into this board that controls what's on the screen. How would you on the outside know whether it was me or the computer you were talking to?

JUDGE What is your favorite Shakespeare play?

SCREEN King Lear. I also like many of the comedies. How about you?

JUDGE Sonnets. Also the comedies, but the tragedies are my favorites. Are you familiar with Hamlet?

ALAN ALDA (NARRATION) We're eavesdropping on a conversation that's taking place on the screen of a computer terminal. Emy Gugsa is at one end of this lively exchange, asking lots of questions about Shakespeare. But Emy is really trying to find the answer to an entirely different question. You see, she doesn't know whether she's talking to another person or to a computer program. Her

conversation is being tapped.., by an audience at the Boston Computer Museum. These people are hot on the trail of the question ..."Can a machine think?" When Alan Turing, a brilliant mathematician and computer pioneer, explored that question in 1950, he came up with a test. Computers are finally powerful enough to take the test, and today are the historic first trials. The Turing Test is set up like this...in one part of the museum are ordinary folks who, like Emy, have no special computer expertise. They are the judges. It's up to them, not experts, to interview all the contestants and decide which are human and which are computer programs. Every 18 minutes the judges rotate and begin another interview. There are two groups of contestants. The first group - human beings - is hidden away in the bowels of the Museum. Their job is to conduct normal conversation with the judges over the computer terminals. The other group of contestants is made up of computer programs. They're also talking to the judges over computer terminals. Here's how the Turing Test will work. There are eight terminals. The judges have to figure out which ones are run by humans and which by computer programs. If one of the programs fools the judges into thinking it's a human, it's called "intelligent" and it passes the Turing Test. The audience members, watching from the sidelines, will have their own ideas about who's human and what is not. Now open-ended conversation is far beyond the capacity of even the most sophisticated programs. So, to give the computer program contestants a fair chance, this will be a restricted Turing Test. Each contestant has chosen a conversational specialty. And the judges' questions have to stick to these narrow topics. Let's look at this topic, "Problems with Romantic Relationships". We're going to give away the contestant's identity in this one just to get you warmed up.

JUDGE Where's the best place to meet men?

TERMINAL Perhaps you're not getting enough respect in the relationship.

JUDGE But I don't have a relationship.

TERMINAL You're not getting enough security in the relationship.

JUDGE But I don't have a relationship.

TERMINAL Perhaps you're not being appreciated enough.

ALAN ALDA (NARRATION) No one is fooled by this contestant.

AUDIENCE MEMBER That's obviously a computer program.

AUDIENCE MEMBER There's just no interaction going on there at all. They're just about three miles apart all the time.

ALAN ALDA (NARRATION) So the "Romantic Relationships" program fails the Turing Test. But as the test got under way, some of the conversations proved harder to judge. Shakespeare's Plays is driven by a human contestant. Cynthia Clay is a real Shakespeare expert. Now remember... Cynthia is hidden away...you know she's human...but the judges don't. Let's see what they're making of her conversation.

JUDGE Do you know much about the authorship to Two Noble Kinsmen?

CYNTHIA (ON THE TERMINAL) That is not among the 37 plays, unless that is some subtitle.

JUDGE Supposedly it was written by Fletcher and Shakespeare.

CYNTHIA Oh. That's interesting.

CYNTHIA (ON THE TERMINAL) But I'm required to only talk about Shakespeare. Why don't we just stick to the Bard himself?

ALAN ALDA (NARRATION) Unlike the "Romantic Relationships" computer program, Cynthia's on the ball. She understands the questions and her answers are to the point. So...all the judges recognize that the Shakespeare contestant is human...or do they?

EMY Which of his plays is your favorite?

CYNTHIA Let's see I'll give 'em a bizarre answer. Let's see...Pericles. I'll bet they've never heard of that one.

CYNTHIA (ON THE TERMINAL) Let's see Pericles.

EMY Why is it your favorite?

CYNTHIA Because he was obviously called in to play - doctor somebody's awful script. It was one of the few, maybe only two, plays written with somebody else.

EMY It was just specific information that sounds like something that would be programmable. So I just thought that was a little more on the machine-like side than human-like.

ALAN ALDA (NARRATION) One judge actually thinks Cynthia is a computer program...and the audience is split right down the middle.

AUDIENCE MEMBER Some of the answers seem too studied. As if they were somehow canned opinions that came from a large data base.

AUDIENCE MEMBER I think the Shakespeare one's human because of the way it answers questions. It can understand the larger meaning of the question. It's not just responding to one key word.

AUDIENCE MEMBER It seems overly intellectual. The responses are too perfect. So it makes me worried that they might just be big canned responses.

CYNTHIA They thought I was a computer because someone couldn't know that much. It's like...people go to school! People learn things! Think how much Doctors have to know!

ALAN ALDA (NARRATION) There's one more conversation that's a real puzzler and by the end of the day quite a crowd gathers around the "Whimsical Conversation" contestant. It's Judge Roseann San Martino's turn to put this one to the test.

TERMINAL Do you have a pet?

ROSEANN Yes, I have a cat. Her name is Bon Ami. Do you have a pet?

TERMINAL Honeybunch the cat has been our pet for about eight years now. She's a regular little kitten factory.

ROSEANN It was all so personal in a certain sense. I mean we talked about our pets and it seemed to have a life.

TERMINAL I used to live in Connecticut before all the riff-raft moved in. But now I call this little townhouse home.

ROSEANN So you live alone?

TERMINAL Everything's been figured out except how to live. How ya' doin' Judge?

ROSEANN I'd like to have gotten to know this person, if it was in fact a person. For some reason I assumed that it was a guy. It just seemed guy like. You know, I would have liked to have met his cat, and seen his little townhouse, or whatever. And just chatted with him a little bit more.

ALAN ALDA (NARRATION) Roseann clearly hit it off with the Whimsical contestant. What do you think? Is this a human or a computer? The last round is over. No more conversation. Every judge has interviewed every contestant. Now the judges have to decide. For each conversation, were they talking to a human or to a computer program? It's these ratings that will determine whether any program passes the Turing Test. Dr. Daniel Dennet, one of the scientists who organized this contest, will announce the results.

DR. DENNET The winner of the 1991 competition is Whimsical Conversation, computer contestant Joseph Weintraub. Whimsical Conversation didn't just win, it was judged to be a human being by five out of the ten judges. Speaking on the topic of Shakespeare, Ms. Clay was judged to be a computer by two judges. But perhaps it will soften the blow for her if she realizes as well that she was judged the most human on the mean. So she wins both most human and most easily confused with a computer.

ALAN ALDA (NARRATION) The results of this first use of the Turing Test are not so important. What matters is that, as Alan Turing predicted almost 50 years ago, we are now at the point when distinguishing between humans and machines is a real challenge.

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PING PONG MADNESS

ALAN ALDA (NARRATION) It all starts with a box of junk. Students enrolled in MIT's Engineering Design course must create a machine solely from the materials provided. In six weeks their machines will compete in a wild night of mechanical combat. It's quite a challenge since most of the students have never built anything before. These science wizards are discovering that an idea is good only if it can be built. That means rolling up their sleeves and handling a drill as well as a calculator. And as 200 students compete for tools, life in the shop becomes frantic. This is the contest playing field: two tables, separated by horizontal pipes about 6 feet long. In the center is the goal - a plexiglass cylinder with a partition running down the middle. In just 30 seconds, the machines have to deliver ping pong balls to their side of the goal. Each machine can carry as many balls as you want...but the whole assembly must fit into a one foot cube. The machine that delivers the most balls wins. The biggest challenge is finding a good idea...and students look for inspiration anywhere they can. For example, Rob Graham plays football for MIT. The competitive strategy used on the field sparked Rob's plan: drive straight down the line. ROB My idea is to drive out on both cylinders and then once I get to the goal, dump my box of balls into the goal. So I'll start in a position about like this, and these will be my struts. And they'll start like this. And then I'll have pneumatic pistons that will force the struts down and drive out to the goal.

ALAN ALDA (NARRATION) As soon as Rob finishes building each element of his vehicle, he tests the whole design. Testing is the only way to avoid nasty surprises. And there are always surprises. ROB The problem is that it's too heavy and it falls through the middle of the pipes. So hopefully the box of ping pong balls will weigh less than the masonite.

ALAN ALDA (NARRATION) This is Heather Klaubert. Heather is an engineering major - and a member of MIT's fencing team. For her, competition means speed, aggression and accuracy.

HEATHER My basic concept is a frog. I want to leap, carrying all the balls with me, land on the target and dump them. To do this I have a frog, using the constant force springs, and it's going to launch off of a lily pad, or a weighted pad that won't move and will provide enough friction.

ALAN ALDA (NARRATION) Speed and aggression are there, but the accuracy needs work. And Heather's frog idea almost croaked. According to contest rules, you can't throw anything except a ping pong ball. She got around this by combining her launcher these coiled springs - with her ball carrier. So now she

has a jumping machine - and that's just legal. The students are scrambling -- and that warms the heart of their instructor, Professor Harry West.

HARRY WEST At this stage, when the student's machines don't work very well, they become very teachable. It's the machines themselves that are teaching. When the students has made a mistake the machine lets the student know because it doesn't work.

ALAN ALDA (NARRATION) Ping pong balls are flying -- and so are rumors.

STUDENT I've heard rumors of a machine that can dump 40 ping pong balls in two seconds.

STUDENT Well, I heard about one that supposedly shoots 40 balls in 20, uh in two seconds.

STUDENT Yeah, I've heard about people who can get like 400 balls in, in like two seconds.

ALAN ALDA (NARRATION) The mystery machine is the brainchild of Kris Pfister.

KRIS I have 48 balls here inside the box which is attached to a string to the machine.

ALAN ALDA (NARRATION) The box is placed on a spring-loaded catapult. When released, the catapult launches the box through the air. It's a great design -- but it has one big problem: it's not legal. Unlike Heather's jumping frog, Kris' machine throws a projectile. That's against the rules, so he'll have to redesign it. Contest day. The students may not be in such good shape...but their machines are ready for action. You can shoot balls...you can reach out.., you can fight head to head...you can even drive off the road.., as long as you get the most balls in your side -- you win. Rob's vehicle on the white side of the table is competing against a pop gun design on the orange side. It's a slow start -- his wheels hardly hit the ground before the pop gun machine begins to fire. It's down the tubes for Rob.
ROB I had too much friction on the bottom of my machine. And these little knobs that I put on weren't, didn't lessen it enough so that I could drive off. So it didn't work nearly as well as I had hoped.

ALAN ALDA (NARRATION) For her first round, Heather is as jumpy as her frog. She's up against a Model "T". The leap is just short of the goal.

HEATHER I just added too many ping pong balls and it was too much weight. And the frog didn't jump as far as I thought it would.

ALAN ALDA (NARRATION) This is the former mystery machine, now completely redesigned. Kris has built an extending arm with a blocker attached to the front...defense and aggression combined. He's up against a vehicle -- and it's over quickly for Kris. Here's what happened. His arm shoots too low, so his blocker hits the center divider. Kris defeats himself.

KRIS The practice attempt that we made just before that was perfect so I don't know what happened. A little bit of luck is involved I guess.

ALAN ALDA (NARRATION) After three elimination rounds, every machine left can do the job. What matters now is how many balls you can deliver and how fast. For example, on this side 200 balls...over here, maybe 50. They're both vehicles, and after a rough start on the left, it's a pretty even match. They both get there, they both work - but 50 has no chance against 200. The Volume Vehicle scores a solid win. In this next match intense concentration takes over...as a light weight extender goes up against a vehicle. The Extender Contender is fast and fully loaded. It delivers all its balls before the vehicle even arrives. In round after round the Extender Contender sprints ahead of the competition. It's got speed and volume on its side. But there's another strategy showing a lot of promise: blocking. This Blocker is really fast. It delivers just two balls. But it wins because the opponent can't get by the defense to deliver any. But what happens when blocker meets blocker? This round is a test of brute strength. Both machines are quick -- they collide head-on. But Tom's Brute Blocker on the right gets there just fast enough to prevent the opposing blocker from deploying...he then delivers a full load.

TOM I was scared that I went up against him. But I thought I might be able to plow him out of the way, even if he got there before me.

ALAN ALDA (NARRATION) As we move into the semi-finals, it's Dokyun Kim and his Volume Vehicle, Tom Massie and the Brute Blocker, Paul Hsaio with the Extender Contender, and Chad Clizzer, also running an extender. Dokyun's Volume Vehicle is up first against Chad's elegantly simple extender. The Vehicle's stabilizing arm deploys slowly so the extender gets a head start. It may be slow, but the Volume Vehicle relentlessly delivers.., and delivers.., and delivers. It's a decisive victory. In the second semi-final, the Extender Contender faces the Brute Blocker. At this level of play, strategy can make all the difference. Tom packs his machine in hopes of gaining a volume advantage. The Extender is intimidating, and Tom's got the jitters. At the last minute Tom makes a reconnaissance foray...sees how many balls the Extender is carrying...and decides he can lighten his own load. Tom blocks out the Extender altogether. No Judge's decision necessary -- the Blocker is the clear heavyweight here. The final round: it's Tom's Brute Blocker against Dokyun's Volume Vehicle. Dokyun gets a final scouting report on the Blocker .... The news is not encouraging.

DOKYUN How fast does it go?

ASSISTANT Shoots real quick.

ALAN ALDA (NARRATION) And sure enough Tom's off to a fast start. Dokyun's only hope now is to knock the block off - otherwise volume won't make any difference. But the Blocker won't budge -- Dokyun is just shadow boxing. It's a total knock out. For Tom the Engineering Title is a long coveted prize - ever since he first saw the MIT contest on this television series, seven years ago.

TOM Awesome! This has been a dream of mine since I was like in the eighth grade. It's incredible. I still can't believe this happened.

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UNDERWATER POWER PLAY

ALAN ALDA (ON CAMERA) Some of our most exalting contests are among machines that are powered solely by human muscles - machines that race on land, in the air, on and under water. All of which raises an interesting question - how much power can a human produce? Of course, it all depends what human you're talking about. Ed Pinkney of the Boston Celtics is truly a super athlete - and when he's really pumping he's putting out as much as 2.2 horsepower... Now wait a minute, how can a man be more powerful than a horse? Well it turns out he isn't, because a horse going flat out actually produces over 10 horsepower - although it can only do that for a very short time. With human powered vehicles, their human engines have to keep going for minutes - sometimes hours - at a time. So under those circumstances, a 130 lb. woman like Kim can produce about three tenths of a horsepower .... While a 160 lb. man like Alex can put out about four tenths of a horsepower. Now, of course, that's here on dry land. Imagine working that hard under water .....

ALAN ALDA (NARRATION) And that's exactly what's going on here. We're thirty feet underwater off the Atlantic Coast of Florida. This is a contest for submarines which run only on person power. The propeller is driven by a human engine. Florida Atlantic University, with their shark sub and its conventional propeller drive will set the contest standard. At Cal Polytechnic in San Luis Obispo, in the months before the contest the student Submarine Club is struggling to create a whole different kind of propulsion system. Although this concept has never been used in sub design, it has been thoroughly field tested ... by whales. Professional engineers at Battelle Institute in Columbus, Ohio are also pursuing a unique design. But their experience told them that complexity equals trouble. BRAD DEROOS The simplicity of the device was the real key. We kind of thought to try

and get something to swim like a fish would be akin to trying to fly with wings on your arms.

ALAN ALDA (NARRATION) In Ohio, this pool is as close as it gets to ocean conditions. And this is their first underwater test. The sub's body is slender, to cut easily through the water. But that makes the inside a tight squeeze - so once the navigator wedges himself in, the peddler has to climb right on top. On the maiden voyage, you can see Battelle's idea at work - and it looks promising. Race week, Riviera Beach, Florida. The subs will compete in seven days of one-on-one races around this quarter mile-long underwater racetrack. Organizing a race underwater is tricky. There are divers to position the boats. Underwater lights to signal the start. Buoys every ten feet to mark the course. Safety is a critical concern. Each sub has to tow a line to a topside marker float that can be tracked at all times. The subs come in all shapes ... from the pencil sharp ... to the wide bodied. Most have a few features in common... a rudder for steering left and right.., and dive planes for heading up and down. But the creative flair really comes out in propulsion systems --like this flexible tail that both drives and steers, --arms that push without churning up the water, --a six-bladed paddlewheel, --twin propellers that rotate in opposite directions, --and adjustable blades, on this flying bomb. These designs are strong contenders for the innovation award, but the real excitement is the speed race. In the first round, it's Florida Atlantic's shark sub against Cal Poly Pomona. The systems have been tested a hundred times, but the nervous drivers just can't resist one final check.

ANNOUNCER Green Light!

ALAN ALDA (NARRATION) Out of the gates Florida Atlantic is off to a blazing start.

ANNOUNCER The second boat's coming by now, running smooth. But they seem to be pretty far behind the other boat that came by.

ALAN ALDA (NARRATION) Five minutes later, it's an easy win for the shark - local favorites, Florida Atlantic.

ANNOUNCER Beautiful finish. We have a finish!

ALAN ALDA (NARRATION) Another front runner - the US Naval Academy. The midshipmen bring their spit and polish approach to sub racing. TIM We're wet sanding it to make the surface as slick as possible, get all the little nicks and stuff out. After this, we're going to wax it.

ALAN ALDA (NARRATION) They're up against a different kind of team.

INTERVIEWER What team are you guys with?

TEAM MEMBER Santa Barbara

ALAN ALDA (NARRATION) The Naval Academy, with their small, sleek hull should easily out pace the bulky Santa Barbara boat. Navy takes an early lead.., but then ... a problem. Somehow they pull their marker float under the surface. That slows them down. The extra drag of the float nearly evens the odds. And the Naval Academy wins by only a nose ahead. The midshipmen are thrilled with their narrow victory. But it's a short-lived celebration -- because of the safety violation, the judges disqualify their run. Meanwhile, the Battelle sub is being prepped for its next run. Their frog-like device has been working flawlessly, and they're ready for the water. Their opponent: Texas A&M University. It's late afternoon and the seas are starting to build. Visibility is bad. Conditions are getting marginal. Nevertheless, Battelle gets a graceful start.

JUDGE We have a launch.

ALAN ALDA (NARRATION) Even the judges are impressed.

JUDGE Great!

ALAN ALDA (NARRATION) But on the first corner...a miscalculation. Unfamiliar with ocean currents, Battelle drives too close to the course markers and they snag their safety line. Stuck on the bottom, the sub and their safety float. The Battelle boat is somewhere beneath the chop, but no one knows where. WOMAN There's only one thing that would've stopped them. MAN I think they caught a buoy. WOMAN That's what I think. I think the currents are bad.

ALAN ALDA (NARRATION) The disadvantage of being a landlocked team has become painfully clear. The engineers from Ohio can only wait for help to arrive.

TEAM MEMBER We design on ideal conditions but then you have chaos out there.

ALAN ALDA (NARRATION) On shore, the students from Cal Poly San Luis Obispo have just gotten their whale tail up and running. But the whole sub has yet to be tested underwater. Right out of the gate, it seems they overlooked something: the boat won't stay level. They peddle furiously, but the whale-tail sub just dives into the sand. Exhausted, the crew abandons ship. After four days of racing.., the field is thinning out. There's back luck.., bad driving...and bad design.

ANNOUNCER She's coming to the top.

ALAN ALDA (NARRATION) One team is quietly confident - the Benthos Corporation, from Cape Cod. Their boat has a streamlined hull and an efficient propeller. They build submarines for a living and it shows.

TEAM MEMBER The prop was designed around our peddler. We found out his horsepower, used a computer program to find out the right shape for the prop, and then had a CNC machine it out for us. Other than that we've just kept it simple, we've got a lot of practice on it. We go for a good clean race and we're fast.

ANNOUNCER Okay, I see the first boat coming. It's the Benthos boat. Holy smokes - is it pulling! Whooee! The second boat is coming by the platform now. It's #25. It's looking good. It's got a ways to go to catch the other one. The other Flew by.

ALAN ALDA (NARRATION) Round after round, Benthos has beat all comers. They're demonstrating why real submarines use propellers - for humans, its the most efficient way to move water. Benthos heads in to the finals.

TEAM MEMBER One more race, that's all we got, one more race left. If they can get us off the starting block clean tomorrow we should have a damn good chance at it.

ALAN ALDA (NARRATION) In the final showdown, Benthos faces the shark sub - and the Florida Atlantic students are planning to pull out all the stops.

ROB COULSON Up until now we've kind of held back a bit, made sure we got around the course, didn't get tangled in any buoys. Today we've got to take a few chances.

ALAN ALDA (NARRATION) It's a contest between two machines driven by efficient propellers -- and two teams with plenty of ocean practice.

FLORIDA ATLANTIC Ogey, ogey, ogey. Oy, Oy, Oy!

BENTHOS Ugly, ugly, ugly. Yes, yes, yes. Is that what you meant?

ALAN ALDA (NARRATION) Into the starting gates go the students,.., and the professionals. They'll race twice around the track: a grueling half-mile sprint. Seven days and 60 races have come down to this match. And right from the start, it's too close to call.

BLOND GUY Let's go! Alright Benthos! Ahh ooo!

UNDERWATER ANNOUNCER They're going into the second turn now, to the back straightaway. They're still not more than five feet apart, it's Benthos from FAU. They're really moving now.

JUDGE The FAU boat is ... across the finish line! The other boat is right behind them. They're about eight feet apart.

ALAN ALDA (NARRATION) It's a big win for the students over the professionals. That's it for our special contest edition of Scientific American Frontiers. Join us next time. back to top