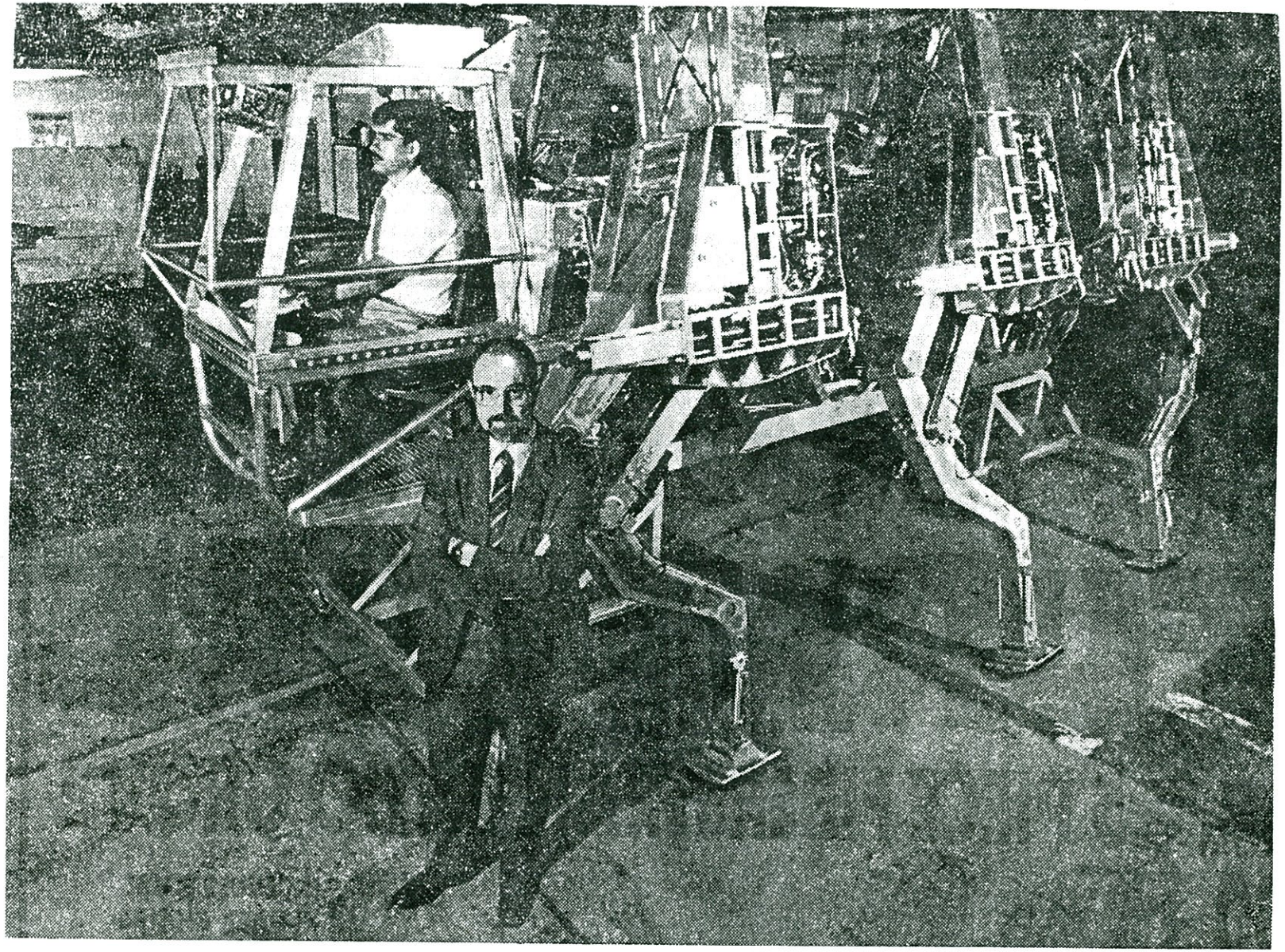


OSU photo

OSU's adaptive suspension vehicle debuts

6-27-85

Ohio State University's six-legged adaptive suspension vehicle, ASV, made its public debut Thursday inside a campus laboratory with electrical engineer Robert McGhee, foreground, making the introductions. A product of two decades of research, the three-ton ASV is designed to move over ditches and other difficult terrain carrying an operator and up to 12,000 pounds of cargo. The research is being done under a $5 million contract with the Defense Advanced Research Projects Agency.

Machine steps out

By Regina Sodelka
Lantern staff writer

Researchers at Ohio State will be busy during the upcoming summer and autumn months teaching their newest creation how to walk.

The creation, the Adaptive Suspension Vehicle, is a six-legged walking machine, 17 feet long, 8 feet wide and 10.5 feet high. The three ton vehicle is designed to travel over rough terrain, including mountainous and icy regions.

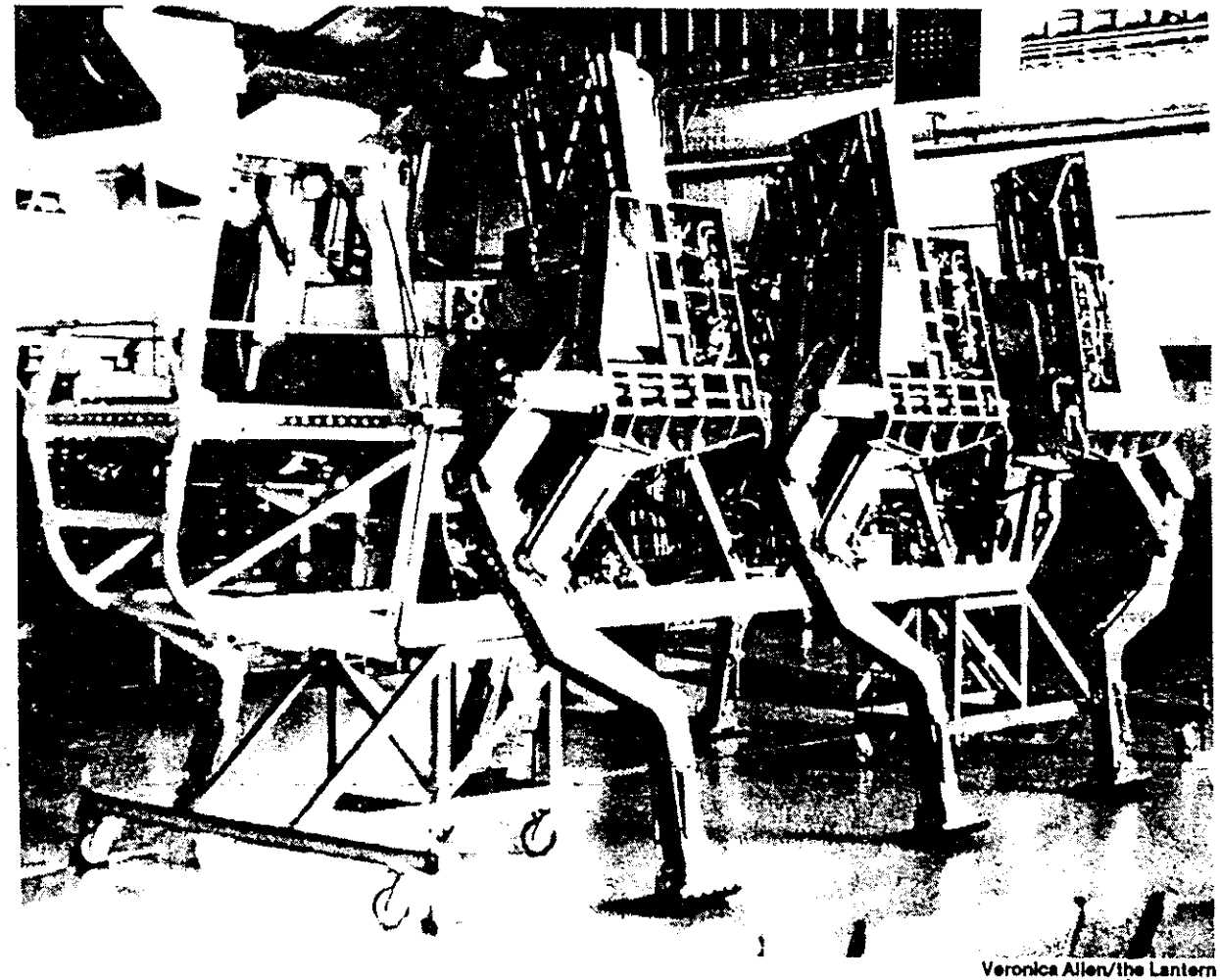
The next 18 months will be devoted to testing the machine and teaching it how to coordinate movement of its six legs.

The Defense Advanced Research Project Agency sponsored the research. So far the project has received $5 million in funding from contributors. Robert B. McGhee, professor of electrical engineering, and Kenneth J. Waldron, professor of mechanical engineering, are the principal investigators for the project. More than half of the 60 team members are students.

McGhee, who has been working on walking machine control problems for 20 years, said although this particular vehicle was built as a research tool, it does have potential uses.

Fifty percent of the land surface in the world is not accessible to wheeled or tracked vehicles. This type of vehicle could go where the other vehicles could not, he said.

The machine, made of lightweight aluminum, is designed to cruise at five mph but is capable of speeds up to eight mph. It should be able to step across nine-foot-wide ditches and step over walls 7 feet high, McGhee said at a press conference Thursday.



Veronica Allen/the Lantern

The Adaptive Suspension Vehicle, created by Ohio State researchers, employs a number of new technologies important to the field of industrial robotics. The vehicle has cost $5 million and has 16 computers onboard to receive commands.

Sixteen onboard computers interpret information received from three sources.

An optical radar system, located at the front of the vehicle, scans the terrain and measures it. For example, if there is an increase in elevation, the legs will be raised accordingly, McGhee said.

The operator transmits information to the computer in the form of a joystick, which is used to steer the vehicle. The computers then translate the simple movement of the joystick into the complex operations required to move the legs.

"The computer decides where to put the feet and the operator decides where the body can go," McGhee said.

Sensors connected to each leg also provide the computers with information

Waldron said "the objective (of the project) is to prove it is technologically feasible to do this."

He said when building the vehicle they had to develop new technology allowing them to explore a number of research issues that could be applicable to other areas such as industrial robotics.

"It was a very important project for allowing us to fulfill a strongly needed educational

As a result of the project, 21 students completed their masters thesis and eight students completed their doctorate.

Newsmakers

Walkin', yes indeed

The development of the Adaptive Suspension Vehicle (ASV) at Ohio State has received world-wide attention. The "walking machine" is designed to travel over rough terrain that a wheeled vehicle can't manage.

A *New York Times* article about the ASV was reprinted in the *Portland (Oregon) Oregonian,* and the International Herald Tribune in Paris, France. Also, the story was featured in articles in *McClean's,* a Canadian newsmagazine, and the *New Scientist,* a British publication.

Also, the Public Broadcasting System, the British Broadcasting Corp. and ARI, the Italian television service, have asked for video clips and information on the walker to use in future shows.

In America, *Science '85* magazine says, "Compared to building the six-legged Adaptive Suspension Vehicle, inventing the wheel must have been a cinch. Sixty Ohio State engineers and students labored four years to build the ASV, which has 16 computers to coordinate leg movements."

The New York Times comments, "...the robot will walk as no machine has ever walked before.

"As large as a dinosaur but with the agility and balance of a crab or insect, it will maneuver through forests, bogs and desert sand, up and down steep hills, across ditches up to nine feet wide and over obstacles up to seven feet high."

Robert B. McGhee, professor of electrical engineering, engineering administration and comuputer information and science, and Kenneth Waldron, professor of mechanical engineering, have spent much of their careers developing the ASV, according to the *Times.*

Possible military uses prompted the U.S. Defense Department's Defense Advanced Research Projects Agency to fund much of the $5 million needed to research the walker. Another $3.5 million has been committed to the project, according to *McClean's* magazine.

However, McGhee and Waldron told the media that the research could lead to walkers that can cross the Arctic tundra and work in the interior of nuclear reactors. Currently, the technology has found important applications in prosthetic limbs for human patients, the *Times* notes.

The Ohio State team has begun designing a more agile, four-legged machine, *McClean's* reports. The smaller machine would move at speeds up to 20 miles an hour. McGhee told the magazine that in four years he expects to have finished a machine that will prove the viability of four-legged vehicles.

OSU researchers test

By Mike Demana
Lantern staff writer

The weary sergeant tugged at his helmet, trying to keep the torrential rains out of his eyes. The hill his squad had been ordered to hold was a morass of mud, and no ammunition trucks could get through. He knew that if the squad didn't receive ammunition soon, it would have to retreat or surrender.

Suddenly, a shout from one of his men made him whirl. Swearing in disbelief, he watched as a strange, insect-like machine strode up the hill.

Its six, mud-spattered legs carried it easily through places a truck or tank would founder. Stenciled on the outside of the machine's wet sides, the sergeant could see the insignia of his army. But more importantly, he had a feeling that on the inside would be the ammunition his squad desperately needed. . .

This scenario could come true if a four-year-old research project at Ohio State proves successful in the next few months.

The project, the Adaptive Suspension Vehicle, is a six-legged, mechanical walking machine created to test the feasibility of a vehicle that moves by legs, instead of wheels or tracks.

The vehicle is expected to stand up on its own this month, then takes its first steps early next year, said Kenneth Waldron, professor of mechanical engineering.

Robert McGhee, professor of electrical engineering, said the chief advantage of a legged vehicle over a wheeled or tracked one is that it can adapt to the terrain, rather than just trying to roll over or around it.

Both Waldron and McGhee, co-directors of the project, called the experiment a "proof of concept" vehicle.

"The vehicle should adapt to the terrain in the same way you, I, or an animal does," McGhee said.

We flex our knees and vary the motion of our limbs in a way that, when we cross rough terrain, we don't experience the shock or vibration like a wheeled or tracked vehicle does," he said.

The more than $5 million funding for the project has come solely from the Defense Advanced Research Projects Agency. McGhee said the agency funds research with potential, long-range military applications.

William Isler, program manager for robotic systems at the agency, said the military is interested in a legged vehicle because, "army studies show that 50 percent of the earth's land surface is off-limits to the type of vehicles we have in the service, now."

"Our goal is to demonstrate the feasibility of using legged (vehicles) in those environments," he said.

Isler said examples of terrain that is impassable to wheeled or tracked vehicles are very rocky or muddy areas, or places with a lot of ditches.

"These environments are important to the military," he added.

"We have pictures of trucks stuck in mud up to their hubs," he said. "But a legged vehicle could essentially walk right through that type of area."

Waldron said OSU's vehicle should be able to deal with the above types of terrain.

He explained that the vehicle first takes a good "look" at the terrain it must cross. To do this, it mounts a laser optical radar system.

It uses and infrared beam to scan the area in front of it, which provides a model of the terrain for an onboard computer.

The computer, which is really 15 computers crammed together in a 2 foot by 4 foot box, is located behind the driver's cabin.

"It reads the commands from the driver, and the information from the terrain scanner, then issues commands to the legs," Waldron said.

The computer also has a safety feature allowing it to disregard commands from the driver that will damage the machine, and to pick the best path to go in the direction the driver wants.

"Each leg can move in three directions," Waldron said. It can be lifted up and down, moved forwards or backwards, and also shifted closer to the vehicle's body, or further away from it.

Waldron said this in and out motion can be used to crabwalk sideways, or for turning and going around curves.

The driver controls the vehicle with a joystick.

As for crossing ditches, McGhee explained that the vehicle first measures the width with its optical system.

"Then, (the computer) adjusts the motion of each leg, making sure it is lifted from the near side of the ditch and placed on the far side," McGhee said.

The vehicle is designed to be able to cross ditches up to nine feet wide,

McGhee said.

One limiting factor of the machine is its speed. Waldron projects the maximum speed will be eight mph.

He explained that this is due to the vehicle being a "statically stable" machine. This means if its motion were suddenly frozen, it would not fall, because it will always have at least three legs on the ground.

To go faster, the machine would have to behave like a man or animal instead of an insect, and give up static stability. A running man or animal is not statically stable, and would fall if their motion were frozen.

"This trotting or galloping would require a completely different machine," Waldron said. "However we are researching non-statically stable machines."

Isler pointed out that eight mph over rough terrain isn't that bad. "If you can go eight mph over terrain that you can't go over at all now, it's still an advantage," he said.

"The side that gets the mobility to traverse this type of terrain first, will have an advantage," Isler said.

He said the military would probably use legged vehicles as an alternative to trucks in rough terrain, rather than actual attack vehicles, like the Imperial Walkers, in George Lucas' *Star Wars*.

"You can visualize (legged vehicles) being used for reconaissance, to transport people, for route surveillance along roads, and to carry ammunition," Isler said.

"They can be used for almost anything trucks are used for right now," he said.

Waldron agreed with the possibility of OSU's vehicle being used in a truck's role. "Basically, it's a vehicle for carrying people and loads," he said.

However, McGhee saw other uses for the vehicle.

"I speculate that (the military) sees the vehicle as an alternative to a helicopter," McGhee said.

Although McGhee admitted the vehicle is being researched for military applications, he saw a wide range of possibilities for the vehicle's use elsewhere.

"Wherever humans are subjected to dangerous or tedious work, we ought to try to substitute a robot," he said.

"For example, the vehicle could be used in firefighting, forestry, underground mining, and in high radiation areas," McGhee said.

Since the vehicle requires a human driver, it is not technically a robot.

However, Waldron said the researchers here are working on making the vehicle autonomous.

"Very little needs to be done to make it operate autonomously," Waldron said. "We already have software in the computer capable of moving the vehicle in a straight line (without a human driver)."

Waldron said a series of autonomous demonstrations are planned for next year.

"Essentially, we just put a gyrocompass on the vehicle, and tell it which direction to go," he said.

"The military is very interested in autonomous operations," he added.

In a news release by the American Forces Press Service, the military said ". . . the vehicles could bring a whole new light to battlefield strategy, and if the same technology were applied to aircraft and ships, it could alter war altogether."

The release quotes Clinton W. Kelly III, director of engineering applications at the agency, as saying, "Robots will offer 'immunity from stress and fatigue'. . .because they will continue working hour after hour, even under dangerous circumstances, saving precious manpower for other jobs."

The 12 faculty researchers in the mechanical engineering, electrical engineering, and computer information sciences departments submit quarterly reports on the project to the agency.

If all goes well on the project in the next few months, researchers at Ohio State may one day change the way the military moves.

Maybe one day some army platoon will be singing "Over hill, over dale, as we hit the dusty trail, as the insects go rolling along."

walking war vehicle

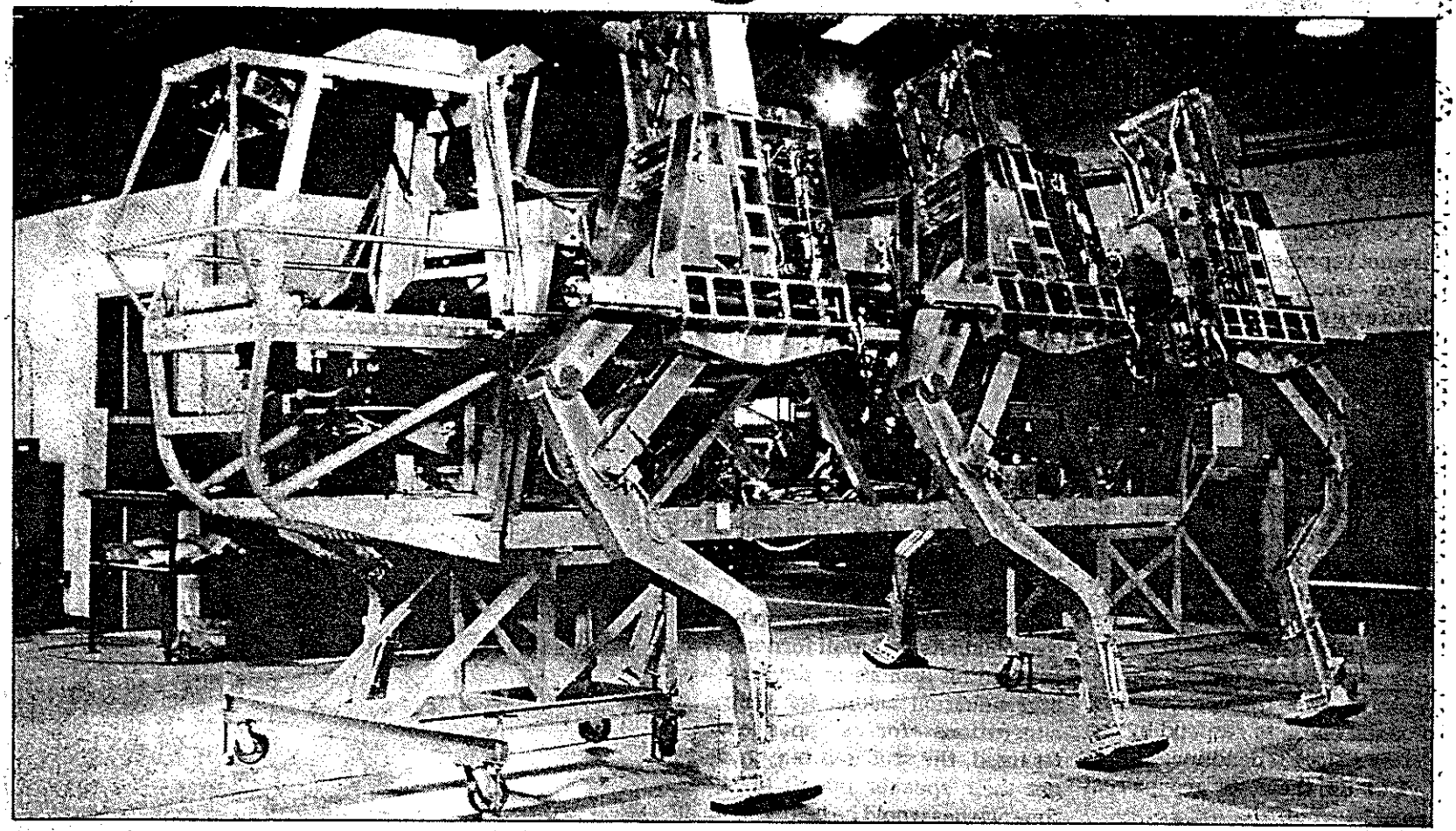


Photo courtesy of Ken Ku

This Adaptive Suspension Vehicle is a six-legged walking machine designed to walk in terrain that tanks and trucks cannot get through. OSU researchers hope it will soon be available for military use to carry ammunition and other cargo.

STEPPING OUT

After 20 years of research, Robert McGhee has something to talk about

Stories by David Lore

The Adaptive Suspension Vehicle, one of the strangest creatures in the history of technology, took its first step inside a Kinnear Rd. laboratory Dec. 27. As big as an elephant with insect legs and a computer brain, this 3-ton hybrid machine is expected to move cautiously out of its hangar-sized cocoon this summer, tethered to an overhead crane and under the watchful eye of its creator, Robert B. McGhee, an Ohio State University professor of electrical engineering.

The *New York Times* has called it "the embodiment of discoveries that have significantly advanced the field of robotics, computer control, biology, anatomy and even medicine."

In the past year, it has garnered OSU more publicity than any development since the firing of Woody Hayes. Reporters, magazine writers and film makers from as far away as Australia, England, France and West Germany have told us about the walker's workings, its unique capabilities and its special promise for the future. But what do we know about McGhee, the creator?

□ □ □

"I'm just an engineer," said McGhee, currently on a one-year appointment as a visiting researcher at the Naval Postgraduate School in Monterey, Calif. "I don't know if you'll find anything interesting in that."

A brisk, no-nonsense researcher and manager, McGhee has the reputation, deserved or otherwise, of being something of a loner in the OSU College of Engineering. It may just be he's been too busy for lunch at the Faculty Club. McGhee and his research partner, mechanical engineering Professor Kenneth Waldron, supervise a 60-member technical staff working under a $1 million-a-year federal contract.

McGhee credits his team for the creation of the walker, saying such projects today are too complex to be anything but a group enterprise. "The day of the individual inventor is pretty much gone except for simple inventions," he said.

Until recently, he vigorously avoided publicity, viewing press contacts as unwise and even unethical.

"GENERALLY SPEAKING, I don't think engineers should speculate about what they might do. They should discuss only what they've done. It's too easy to project science fiction as engineering, and the difference is profound," he said.

He returns telephone calls to reporters now because, after more than 20 years of research, his walking machine is a reality. "Now that it's finished, I have something to talk about."

McGhee, 56, came to OSU in 1968 from California, where he worked on missile guidance systems at the Hughes Aircraft Co. while teaching at the University of Southern California.

He's a Midwesterner by birth, born in Detroit and raised in Maumee near Toledo. From the very beginning, McGhee said, he was fascinated by biology and technology.

"By the time I was 6, I knew I wanted to be involved in science," he said. "I've always been interested in machines and living creatures and the relationship between the two."

It was in California in 1964, however, when a quarter horse named Teddy got McGhee thinking about building machines with limbs instead of wheels or tracks. McGhee, an engineer at Hughes at the time, bought the animal as a 10th birthday gift for his daughter, Elizabeth.

"Having the animal around, I became intensely interested in animal locomotion," he said. "I was terribly impressed how superior the horse's locomotion was compared with that of wheel and track vehicles I had worked with in the military. I photographed him often, studied his gait and then applied what I had learned about missile guidance to this biological control system."

Any engineer trying to replicate

living organisms quickly learns that man's most sophisticated technology is crude stuff compared with the wonders of bone, nerve and muscle.

THE WHEEL, for example, is a much simpler locomotion system than the leg in terms of construction, control and coordination, McGhee said.

So why didn't Mother Nature, in the interest of economy, just put wheels on cows?

"Biology doesn't need to look for the simplest way," McGhee said. "Biology can look for the most effective way. Wheels evolved over a few thousand years. But biology uses different materials, and the time scale of biological evolution is thousands of times longer."

Limbs are more effective because they allow animals more "degrees of freedom" in their movement, he said.

Because each of the walking machine's six legs can move up and down, forward and backward, right and left, McGhee's machine has 18 degrees of freedom. By comparison, the human body has several hundred degrees of freedom because the skeleton and muscles make it extremely flexible, he said.

In the 1960s, McGhee hoped to use electronics and mechanical parts to fabricate new limbs for amputees. But he quickly discovered that the technology of that era wasn't up to the task of simulating the complex, forward-falling walking action of the biped.

"I realized the environment in the knee would render this impractical — things such as human perspiration, the shock of leg action," he said. Miniaturization also was a problem because, although transistors were coming into use, the mid-1960s was still the era of the vacuum tube.

In 1966, McGhee built a four-legged "Phony Pony" artificial horse, but it was found to be too wobbly in its gait. Only a six-legged vehicle based on an insect model could possess the necessary stability in motion.

MCGHEE SAID HE was not emulating the insect as much as he was putting a set of "training wheels" on the four-limbed vehicle to provide stability during rapid movement. If anything, the mechanical walker needed better brain and muscle coordination than most insects, which have rather primitive motor controls.

"Insects trip a lot over their legs," he said. "They fall down a lot, and it simply makes no difference because they're so small."

Even after vehicle stability was achieved, the necessary brain power to control and coordinate movement was lacking. In early models, the human operator's brain was the control center, directing the hands and

legs, which in turn controlled the movement of the mechanical limbs. The whole exercise was extremely difficult and tiring for the operator, limiting the practicality of the vehicle.

The problem was overcome in recent years by the development of very powerful but small computers. The current model, for example, is controlled by a cerebral complex of 16 on-board computers. Limb movement is based on directions from the operator and environmental data received from an optical radar in the front of the machine and terrain sensors in the foot pads.

After 20 years of research and $5 million to develop the Adaptive Suspension Vehicle, the work has achieved only its first goal — the development of a controllable limbed vehicle, McGhee said.

The challenge now is to perfect the control systems to make possible a four-legged walking machine that can operate independently in hazardous or dangerous terrain without the aid of a human operator.

"NOW I WANT to focus on the brain of the beast instead of its body," he said. "I understand how to put together an effective walking machine. Now the question is how to teach it to take its next step independently."

The 21st century could be the century of the walking vehicle, McGhee said. In areas as diverse as arctic tundra, mountain forests, ocean bottoms and even the craters of distant planets, walking machines could explore and deliver heavy loads across terrain where wheeled or track vehicles would bog down. Even now, for example, the Adaptive Suspension Vehicle is designed to climb a 7-foot embankment or step across a 9-foot-wide ditch.

There also has been interest in using robot walkers for hazardous industrial duties, such as climbing about the inside of a nuclear power plant, he said.

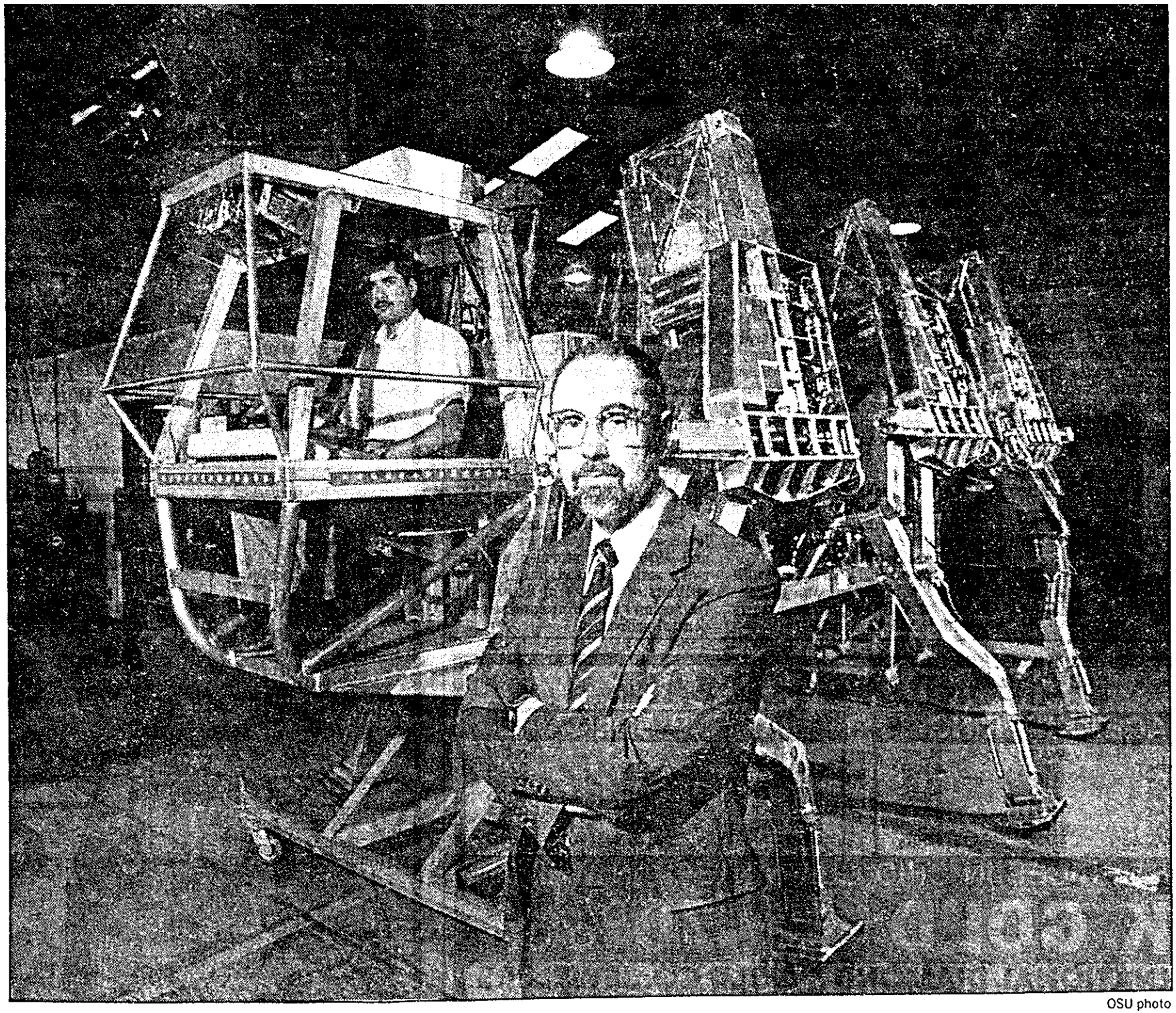
SINCE 1980, military interest in the project has revived. McGhee's work is supported by the Defense Advanced Research Projects Agency on an unclassified basis.

McGhee emphasized that his job is to prove that such vehicles can work in concept, rather than to develop specific prototypes for actual use.

But the ultimate challenge is to successfully mesh metals and electronics with flesh and bone, McGhee said. He hasn't worked on the development of prosthetics since 1980, but he's encouraged by the successes of other engineers and scientists.

"It's an extremely difficult problem," he said. "It's much easier to build a walking machine that is fully mechanical than it is to build an integrated biological and mechanical system."

David Lore is a science reporter for The Dispatch.



OSU photo

Robert McGhee and his Adaptive Suspension Vehicle. Dennis Pugh, a member of the design team, is at the controls.

Twice-Told Tales

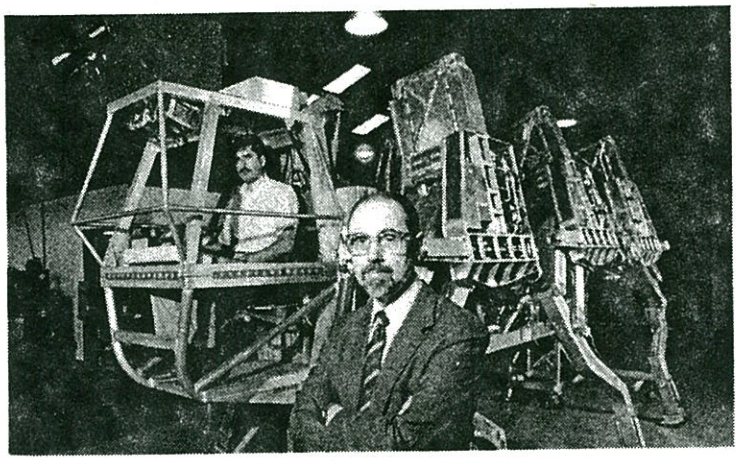
Catching up on past stories

1982

As this issue of *Quest* goes to press, one of the most famous products of Ohio State researchers is making history.

The Adaptive Suspension Vehicle (ASV) is set to take its first steps outdoors this summer.

The 17-foot-long ASV is expected to be the world's most advanced "walking machine." Its six mechanical legs will be able to cross nine-foot-wide ditches and walk at about eight miles per hour. It was created by Robert McGhee, a professor of electrical engineering at Ohio State; and Kenneth Waldron, a professor of mechanical engineering; along with some 60 other faculty, students, and technicians.



The ASV was the subject of two articles (Vol. 4, No. 4 and Vol. 7, No. 4).

The project has come a long way toward completion since the first story in June 1982.

In that, we detailed how McGhee tried to play host to a Soviet scientist who specializes in the advanced robotics that helped make the ASV possible. But because of national security concerns raised by the State Department and chilly relations between the U.S. and the Soviet Union, that meeting never took place.

Despite that setback, the research pushed on, and by last summer, the walker was unveiled to an eager and very interested media.

Last fall, McGhee left Ohio State to take a temporary appointment at a Navy postgraduate school in Monterey, California.

OSU walking machine's creator takes hike

By David Lore
Dispatch Science Reporter

The creator of Ohio State University's unique, 3-ton walking machine has taken a walk himself, accepting a new job in Monterey, Calif.

Robert B. McGhee, an OSU electrical engineer who has been working on walking mechanical vehicles for the military since the 1960s, is taking early retirement to stay at the Naval Postgraduate School in Monterey. He has been a visiting professor there since last September.

McGhee's machine, however, will stay at OSU because the university has a $1 million-a-year contract with the Defense Advanced Research Projects Agency for its development.

Vehicle testing has reached the point where outdoor trials are planned this fall without a safety tether on the walker, OSU spokesman Earle Holland said.

McGhee's machine is called the adaptive suspension vehicle. It is an elephantine structure of aluminum, 17 feet long and 10 feet high. It moves moves forward, backward and sideways on six legs. The vehicle has an on-board human operator and a computer control system that coordinates leg movements and processes information from optical radars and pressure sensors in the feet.

The walking machine is part of the research agency's larger effort to develop legged vehicles capable of moving across terrain where wheeled or track vehicles cannot operate.

McGhee's OSU research partner, mechanical engineer Robert Waldron, will take over as project director despite the fact that Waldron is on leave this year from OSU to work at Stanford University in California.

William Isler, project manager for vehicle systems at the defense research agency, said McGhee will continue to work with the team as a researcher under a separate $100,000 agency contract.

Since 1981, the U.S. Defense Department has spent approximately $6 million on the computer-assisted, six-legged vehicle after tests of cruder, four-legged walking machines proved disappointing.

Over the past year, the walking machine has prowled about inside its Kinnear Rd. research laboratory with an operator in the cab. With a safety tether attached to an overhead crane, the vehicle has been tested for its ability to carry loads, coordinate movement of its feet and maneuver in close quarters.

Isler said no decision has been made about what to do with the walker after this fall's tests. McGhee said last spring, however, that his research is focused on improving computer systems so walking machines can move without a human operator on board.

The 21st century will see walking machines operating in environments such as arctic tundra, forests, the ocean bottoms, the interior of nuclear reactors and the surface of other planets, McGhee predicted.

"Obviously, we're sorry to see Dr. McGhee leave OSU. But he's still part of the team, and we hope everything will move ahead as usual," said Hsien Ko, chairman of the electrical engineering department.

McGhee's departure is not a surprise. He had reportedly told several OSU colleagues earlier this year he planned to stay in Monterey.

McGhee earned advanced engineering degrees and worked in California between 1955 and 1968.

Suspension vehicle takes first steps

By Traci L. Cooke
Lantern staff writer

After five years of research, the Adaptive Suspension Vehicle took its first steps for the public Wednesday in front of a group of engineers and spectators from across the nation.

Vincent J. Vohnout, vice president of Mechanical Systems for Adaptive Machine Technologies, a subcontractor of the project, said this was the first public demonstration of the seven thousand two hundred-pound vehicle.

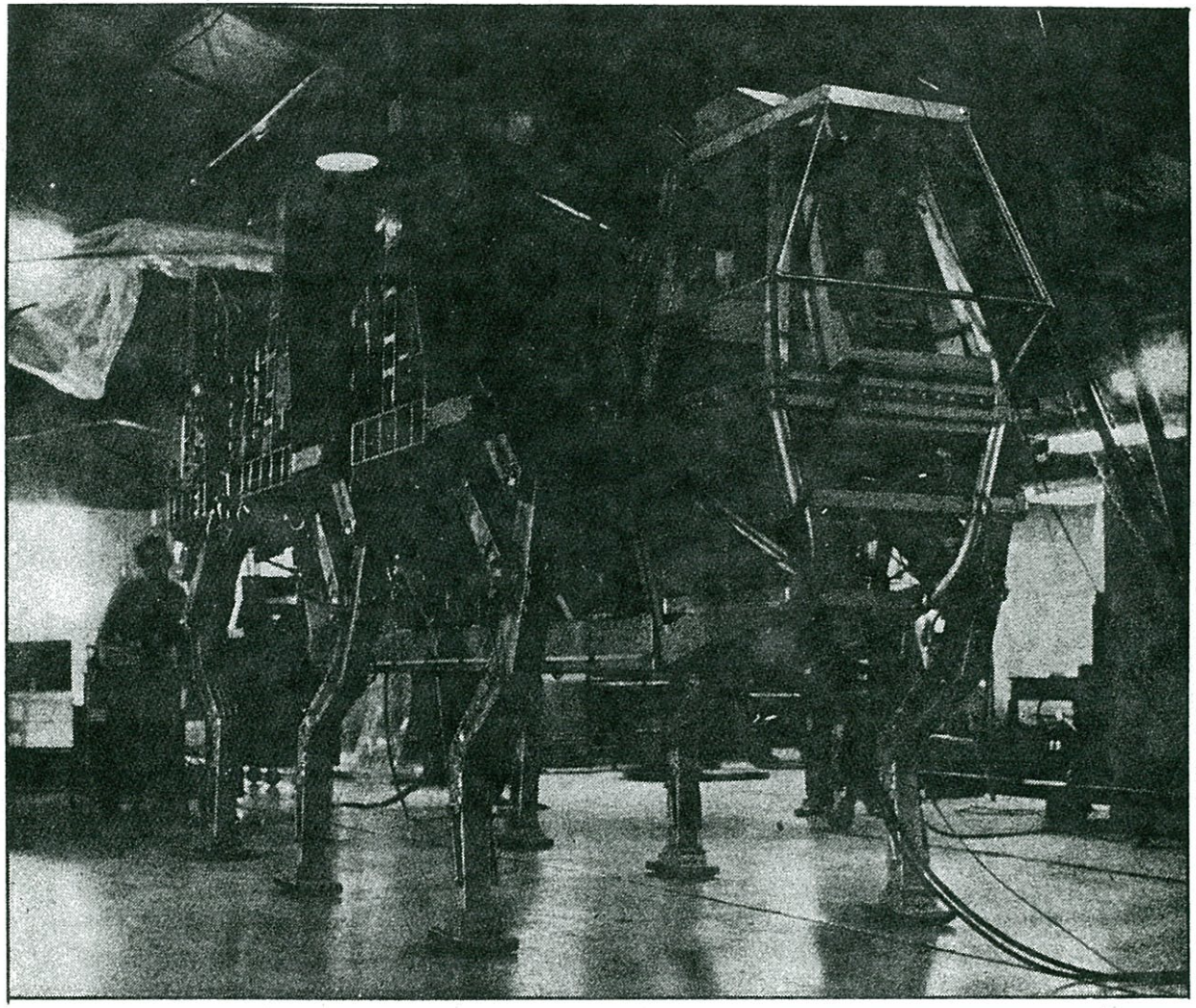
The vehicle, which has been under construction since 1981, has six legs, and 17 computers. The vehicle can also be maneuvered in six directions by a joystick, Vohnout said.

The demonstration was part of the 1986 Design Technology Conference sponsored by The American Society Of Mechanical Engineers.

The concept for the vehicle was based on a four-legged vehicle built by Robert McGhee, professor of electrical engineering. McGhee, who retired from Ohio State last month, and his colleague Kenneth Waldron, a professor of mechanical engineering, started work on the six-legged vehicle in 1981.

Vohnout said although other walking machines have previously been developed, this vehicle is the most effective. The joystick enables it to be more easily maneuvered than vehicles in the past.

"Patents have been around on walking machines since 1890 in the United States and Europe, but this is the first that works and is practical," Vohnout said.



The Adaptive Suspension Vehicle

File photo

OSU
The Ohio State University
NEWS

News Services
1125 Kinnear Road
Columbus, Ohio 43212-1153
Phone 614-422-2711

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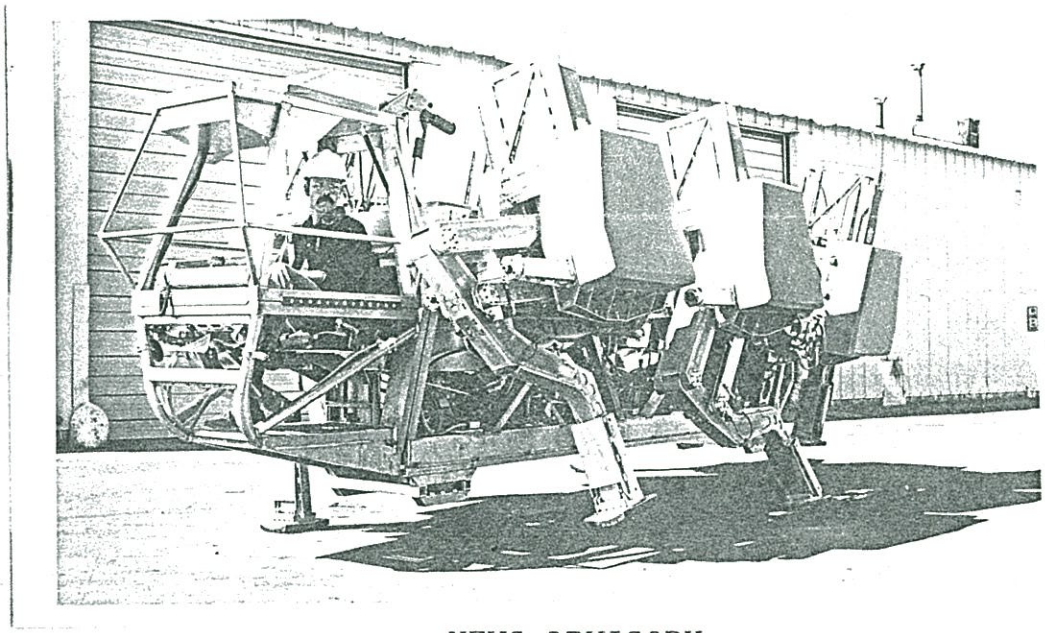


NEWS ADVISORY

Engineering researchers at Ohio State University will show off a giant six-legged walking machine at a special demonstration for the news media on Thursday (11/13) at 10:30 a.m. EST.

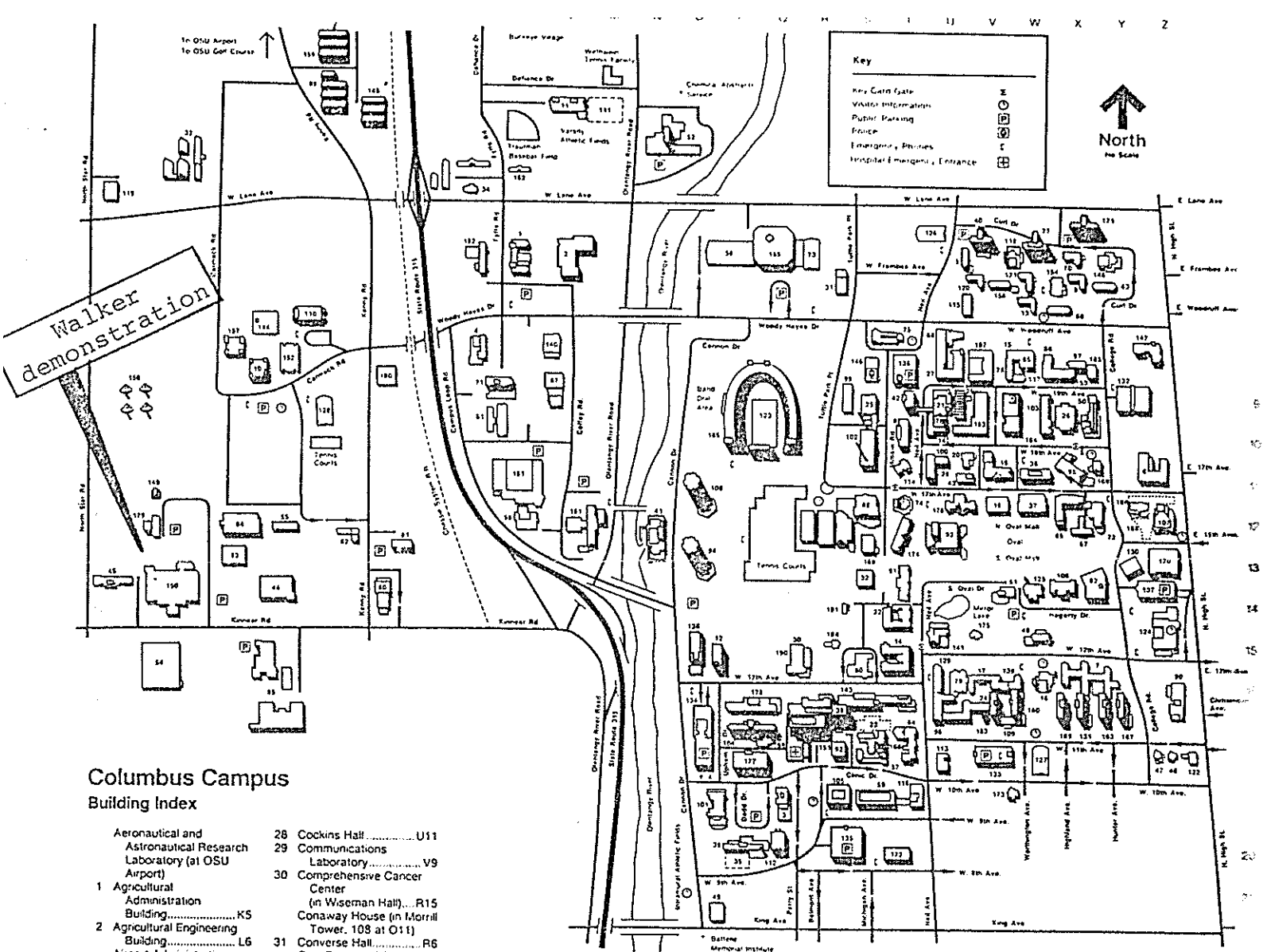
The "Walker," as it has been dubbed, is a 17-foot long, nine-foot high off-road vehicle designed to walk, rather than roll across rough terrain. Formally named the Adaptive Suspension Vehicle (ASV), the Walker is the product of six years and $8 million of research.

Supported by the Defense Advanced Research Projects Agency, the research and development wing of the Department of Defense, the new vehicle is designed to travel in areas where wheeled and tracked vehicles cannot go. It is capable of stepping over seven-foot high embankments or walls and stepping across nine-foot wide ditches.

The demonstration will be held behind the Building Materials Laboratory at the rear of the Ohio State University Research Foundation, 1314 Kinnear Road, Columbus.

Reporters planning to attend this demonstration should contact Earle Holland, Office of University Communications, 1125 Kinnear Road, Columbus, Ohio 43212; telephone (614) 292-2711.

UNIVERSITY COMMUNICATIONS



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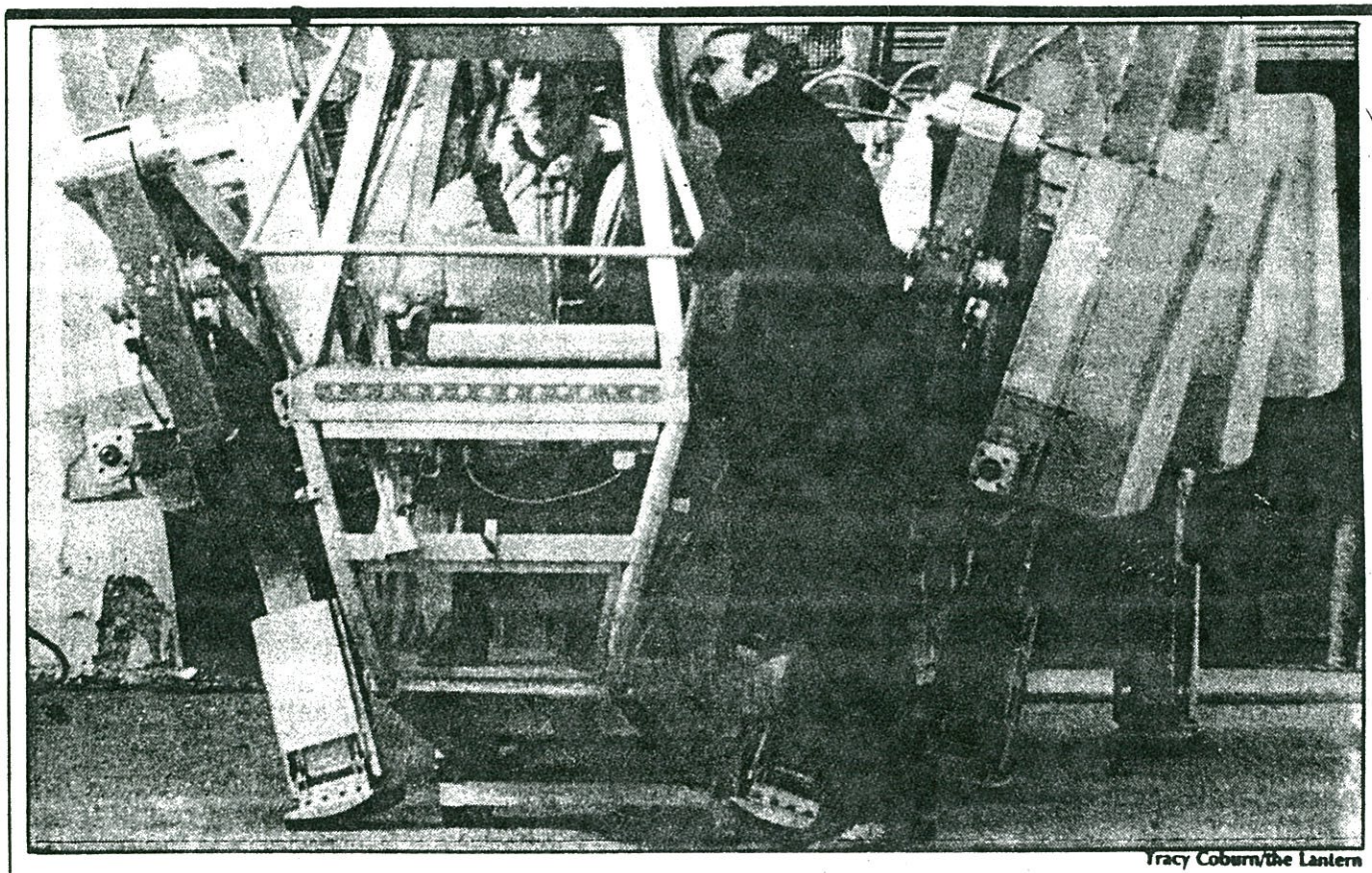
- 29 Communications Laboratory V9
- 30 Comprehensive Cancer Center (in Wiseman Hall) R15
- Conaway House (in Morrill Tower, 109 at O11)
- 31 Converse Hall R6
- Cow Barn (at OSU Airport)
- 32 Cunz Hall of Languages S13
- 33 Dairy Science Center, Waterman Farm Complex B3
- 34 Dakan Hall J4
- 35 Davis Medical Research Center P20
- 36 Denney Hall W11
- 37 Derby Hall W12
- 38 Doan Hall R17
- 39 Dodd Hall P20
- Don Scott Field (see OSU Airport)
- 40 Drackett Tower V5
- 41 Drake Union N12
- 42 Dreese Laboratories T9
- 43 Dulles Hall U11
- 44 Edison Welding Research Institute D14
- 45 ElectroScience Laboratory A13
- 46 45 West 11th Avenue Z18
- 47 53 West 11th Avenue Y18
- 48 Enarson Hall W15
- 49 Evans Hall (Franklin County Morgue) P21
- 50 Evans Laboratory X10
- 51 Faculty Club W13
- Farm Science Review Office (at OSU Airport)
- 52 Fawcett Center for Tomorrow N3
- 53 Fontana Laboratories X9
- 54 Food Facility A15
- 55 Foundry-Glass Building D12
- 56 French Field House O5
- 57 Fry Hall T18
- 58 Goss Laboratory K12
- 59 Graves Hall S19
- Greenhouses
- 60 Botany and Zoology S16
- 61 Howlett K9
- 62 Hagerty Hall Y13
- 63 Halloran House Y6
- 64 Hamilton Hall T17
- 65 Haskett Hall W8
- 66 Haverfield House X7
- 67 Hayes Hall X12
- 68 Hitchcock Hall U7
- 69 Hopkins Hall X12
- Horse Barn (at OSU Airport)
- 70 Houck House X6
- 71 Howlett Hall K9
- 72 Hughes Hall Y12
- 73 Ice Rink R5
- 74 Independence Hall T12
- 75 Ives Hall T7
- 76 Johnston Laboratory V9
- 77 Jones Graduate Tower W5
- 78 Journalism Building U10
- 79 Kennedy Commons U16
- 80 1900 Kenny Road G14
- 81 1960 Kenny Road G12
- 82 1991 Kenny Road F13
- Kepler Club House, 3065 Tremont Road (at Golf Course)
- 83 1212 Kinnear Rd. C13
- 84 1224 Kinnear Rd. C12
- 85 Kinnear Road Center D15
- 86 Koffolt Laboratories W8
- 87 Kottman Hall L9
- 88 Larkins Hall S12
- 89 Laundry Building E1
- 90 Law Building Z16
- 91 Lazenby Hall T13
- Libraries
- 92 Health Sciences R18
- 93 William Oxley Thompson Memorial (Main Library) U12
- Lincoln House (in Lincoln Tower, 94 at O13)
- 94 Lincoln Tower O13
- 95 Lord Hall X11
- 96 Mack Hall U17
- 97 MacQuigg Laboratory X8
- 98 Magnetic Resonance Imaging Ctr. O17
- 99 Maintenance Building S9
- 100 Mathematics Building U10
- 101 McCampbell Hall O19
- 102 McCracken Power Plant S10
- 103 McPherson Chemical Laboratory W10
- 104 Means Hall P17
- 105 Meiling Hall R19
- 106 Mendenhall Laboratory X13
- 107 Mershon Auditorium Z12
- Mirror Lake U14
- 108 Morrill Tower O11
- 109 Morrison Tower V17
- 110 Mount Hall E7
- 111 Multi Sports Athletic Complex M2
- 112 Murray Hall (State Health Laboratory) O20
- 113 Neil Hall U18
- 114 Neil-17th Building T11
- 115 Nellwood Gables U7
- 116 Newton Hall T18
- 117 164 West 19th Avenue W9
- 118 North Commons V5
- 119 2470 North Star Road A5
- 120 Norton House U6
- 121 Nosker House W6
- 122 Ohio Legal Center Z18
- 123 Ohio Stadium O9
- 124 Ohio Union Z15
- 125 Orton Hall W13
- OSU Airport, 2160 West Case Road
- Oval V13
- Jesse Owens Recreation Centers
- North U5
- South W18
- West E9
- 129 Oxley Hall U15
- 130 Page Hall Y13
- 131 Park Hall X17
- Parking Garages and Ramps
- 132 Arps Garage Y9
- 133 11th Avenue Ramp V18
- 134 Medical Area Ramp O17
- 135 Ninth Avenue Ramp R20
- 136 Northwest Ramp T8
- 137 Ohio Union Ramp Z14
- 138 Parks Hall (Pharmacy) O15
- 139 Paterson Hall V16
- Peppe Aquatic Center (in Larkins Hall, 88 at S12)
- 140 Plumb Hall L8
- 141 Pomerene Hall U15
- 142 Post Office, University Station U10
- 143 Postle Hall T17
- 144 Pressey Hall D7
- 145 Printing Facility F3
- 146 Public Safety Building S8
- 147 Ramseyer Hall Z8
- 148 Raney Commons Y6
- 149 Reactor Building A11
- 150 Research Center B14
- 151 Rhodes Hall—University Hospital R18
- 152 Rightmire Hall D8
- 153 Robinson Laboratory V10
- Ross House (in Morrill Tower, 108 at O11)
- 154 Royer Student Activities Center X6
- 155 St. John Arena O5
- 156 Satellite Communications Facility A9
- 157 Scott Hall C8
- 158 Scott House V6
- 159 Service Building Annex E1
- Sheep Barn (at OSU Airport)
- 160 Siebert Hall W16
- 161 Sisson Hall L12
- 162 Small Animal Building K4
- 163 Smith Hall Y17
- 164 Smith Laboratory W10
- 165 Stadium Scholarship Dorm O10
- 166 Starling Loving Hall S17
- 167 Steeb Hall Y17
- 168 Stillman Hall Y10
- 169 Stradley Hall X17
- 170 Sullivant Hall Z13
- Swine Barn (at OSU Airport)
- 171 Taylor Tower X5
- 172 Telephone Network Ctr. T20
- Tennis Courts Q13, E11
- 173 199 West 10th Avenue V19
- 174 Townshend Hall T13
- 175 220 West 12th Avenue V15
- 176 University Hall V12
- 177 University Hospitals Clinic P18
- 178 Upham Hall P16
- 179 Van de Graaff Laboratory A12
- 180 Veterans Administration Clinic F9
- 181 Veterinary Hospital K11
- 182 Vivian Hall H5
- 183 Walker House V17
- 184 Water Resources Center R15
- 185 Watts Hall X8
- 186 Weigel Hall Y12
- 187 Welding Engineering Laboratories V8
- 188 Wexner Center for the Visual Arts Z12
- 189 Wilce Student Health Center S13
- 190 Wiseman Hall R16
- 191 Women's Field House R14

OSU

The Ohio State University



Tracy Coburn/the Lantern

Dennis Pugh (left), vice president for control systems for Adaptive Machine Technologies, discusses a malfunction of the control panel with Vincent J. Vohnout, vice president of mechanical systems for the company.

Legged vehicle stops in tracks because of cold

By Pat O'Bryan
Lantern staff writer

Cold weather literally froze Ohio State's six-legged walking machine in its tracks yesterday at an outdoor exhibition to demonstrate the vehicle's mobility.

At first, it looked as if the cold weather would have no effect on the 17-foot all-terrain vehicle. It reared up on its six legs, stretching back and forth like some kind of metallic centipede warming up for a foot race.

But a computer foul-up temporarily immobilized the vehicle and the freezing winds behind the University Research Foundation, on Kinnear Road, turned the vehicle's hydraulic system into what one technician called "syrup."

Vincent Vohnout, vice president of Adaptive Machine Technologies – the company subcontracted by the university to help develop the vehicle, said the thickened hydraulic fluid caused massive amounts of power to be sucked out of the system when the vehicle attempted to move.

See Page 2, VEHICLE

VEHICLE: Cold weather stifles walk

Continued from Page One

Vohnout said he did not know why the vehicle's computers were not operating correctly, but speculated the malfunction may have been caused by cold weather.

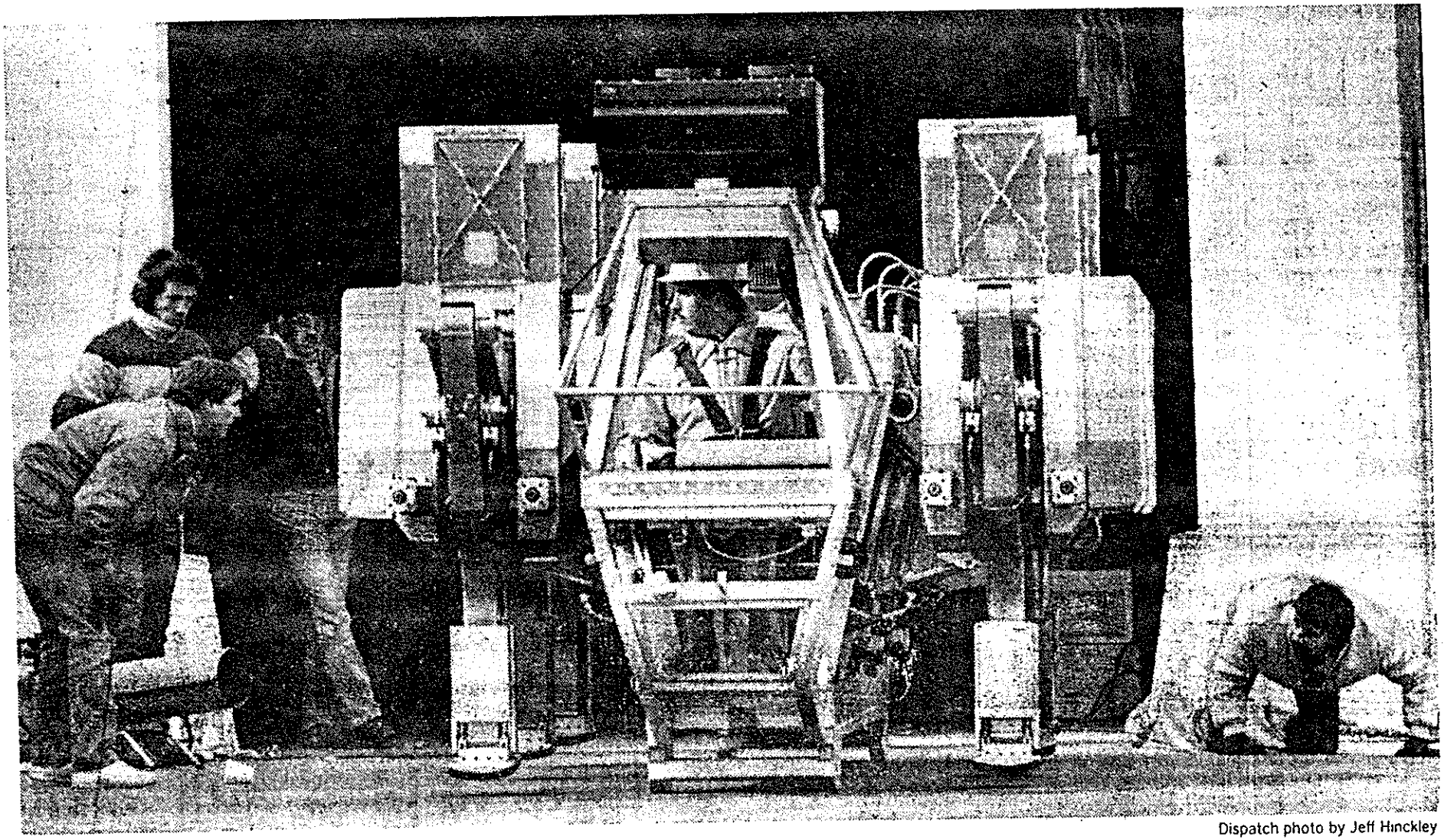
Vohnout said the vehicle is an experimental project designed to show it is technically possible to build such a machine. It is not the prototype for some mass-produced product. "It was never intended to be operated in these conditions," he said. "We've never run it this cold."

The Department of Defense has provided nearly $8 million to the university over the past six years to develop the vehicle.

William Isler, program manager of the Defense Advanced Research Projects Agency, which supports the project, said the vehicle is the most advanced project in walking machine technology today.

Sixteen single-board computers, each with the equivalent power of an IBM-PC, run the vehicle and allow it to keep its own balance. Together with an optical radar system, the computers also allow the vehicle to decide where to put its feet. The operator uses a joystick to tell the vehicle where to go.

The vehicle is powered by a 70 horsepower motorcycle engine which provides all of the vehicle's mechanical and electrical energy.



Dispatch photo by Jeff Hinckley

OSU's walker wouldn't

Ohio State University's $8 million walking machine sits on its haunches as researchers try to figure out what went wrong at a special demonstration for the news media yesterday. Driver Dennis Pugh revved the engine, but the 17-foot-long apparatus wouldn't budge. Cold weather was blamed for the machine's lack of locomotion. Details on Page 4 D.

Walking machine gets cold feet during debut

By Mary Carmen Cupito
Dispatch Staff Reporter

With dozens of reporters and television cameras watching, Ohio State University's $8 million, 10-foot-tall walking machine was supposed to take its maiden steps in public yesterday morning.

It cooperated — for a while.

The six-legged machine, which looks like part bug, part farm machinery, stood up. Its giant jointed legs bent forward, then back. It leaned to its left. It leaned to its right. It did a couple of deep knee bends. Its nose rocked toward the ground; its rear did the same.

Just when it looked all warmed up, it stopped.

THE DRIVER revved the engine. The walking machine shivered. The driver revved again. It sat down.

"Sometimes," said Kenneth J. Waldron, principal investigator for the project, "things go wrong."

What went wrong, researchers said, was the weather.

It was a frigid morning with the thermometer reading about 22 degrees, but the wind-chill factor made it feel more like 4.

The oil flowing in the walking machine's hydraulic veins apparently couldn't stand the cold. The oil apparently "turned into Karo syrup," said Vincent J. Vohnout, vice president of mechanical systems for Adaptive Machine Technologies, a spinoff company developing the walker with OSU.

The walker's 16 on-board computers also shuddered at the temperature and didn't work properly. Still, the machine walked perfectly in a private practice run the night before in equally cold weather, Vohnout said.

"It's not just the cold," he said. "Something is going on there we don't understand."

THE DEMONSTRATION began at 10:40 a.m. behind a research building at OSU. It ended about 11:40, when the partly frozen researchers finally admitted their baby wasn't going to walk, no matter who was watching.

Its technical name is the Adaptive Suspension Vehicle. Funded by the Defense Advanced Research Projects Agency, the machine was developed in the past six years by more than 60 people, led by electrical engineer Robert McGhee.

Photo on Page 1 A

In September, McGhee retired from OSU and took a job at the Naval Postgraduate School in Monterey, Calif. But he is still involved with the project, and he came to Columbus yesterday to watch.

The machine is designed to step over 8-foot-wide ditches and climb 6-foot embankments. It is supposed to walk at 5 to 8 mph.

McGhee has predicted that its successors, which won't need human operators, will work on the ocean floor, the arctic tundra, the inside of nuclear reactors. The Defense Department hopes they can go where tanks and other military vehicles can't.

BUT THIS machine, McGhee said, is so experimental that it is "not even a prototype" of future walkers.

"The crucial point, really, was when it stood up last December," McGhee said, comparing it to a baby learning to balance itself before it takes its first step.

At first, a human operator had to mechanically direct each leg to make the machine walk. Later, computers took over that task, and the driver merely indicated which direction the machine should go.

It has been walking — tethered to an overhead rope, just in case — since December 1985. Since Oct. 8, McGhee said, it has walked tether-free.

BUT NOT YESTERDAY. All researchers could do was show a videotape of how it had performed the night before on the same parking lot, with snow flurries whistling past its aluminum legs.

It moved in a surprisingly graceful, fluid motion, its legs rolling forward and back. It glided to the end of the parking lot. It lifted its rear legs, placed them to its side and turned itself around.

Flawlessly.

Waldron said the public will have to wait, maybe until the spring thaw, for a repeat performance.

RESEARCH FOCUSES ON TELESCOPE, WALKER

By Steve Benowitz, University Communications

Two of Ohio State's major research projects continued to make headlines.

The University of Chicago became the newest partner in a $60 million project to build the world's largest optical-infrared telescope. Chicago joins Ohio State and the University of Arizona in the effort.

The Columbus Project involves the construction of a huge 11.3-meter (38-foot) reflecting telescope atop Mount Graham in southeast Arizona.

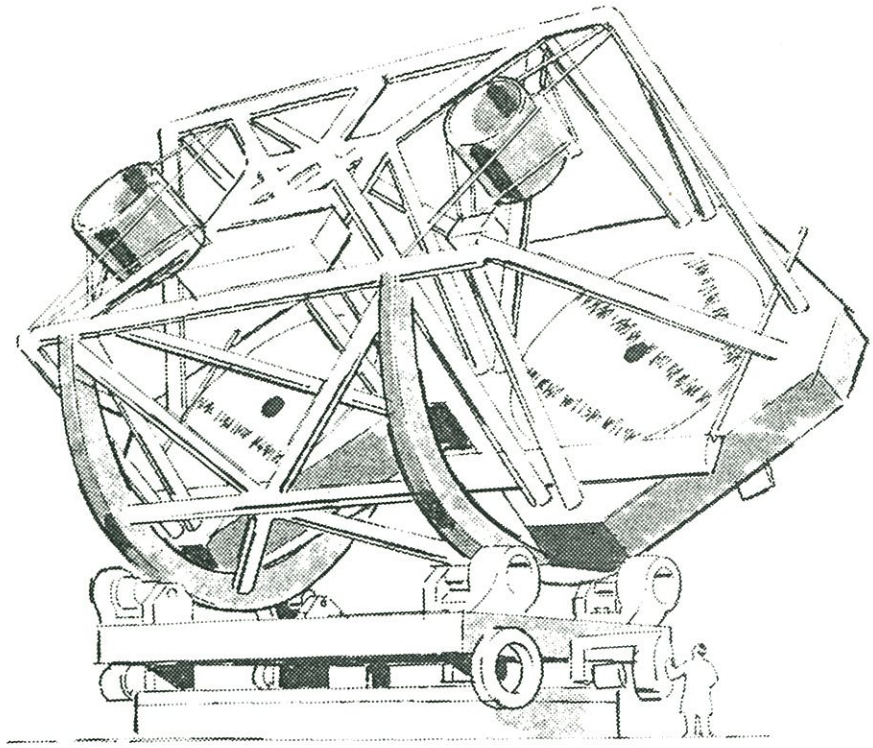
When completed in 1992, the "two shooter," as it is called, will be sensitive enough to detect the light from a burning candle at twice the distance to the moon—500,000 miles—or see a penny more than 500 miles away. It will be the world's most powerful telescope.

Current plans are for a telescope with two separate eight-meter (26-foot) mirrors mounted side-by-side and functioning like a giant pair of binoculars.

Each of the two mirror assemblies also could be used separately to allow astronomers to observe the same object differently at the same time.

The mirrors will be made with a unique manufacturing method called "spin-casting." The telescope mount and housing also will be radically new in design.

Astronomers will be able to remotely control the telescope from their respective campuses.



Optical infrared telescope will be able to detect candlelight at 500,000 miles. (Illustration by Jim Stephenson)

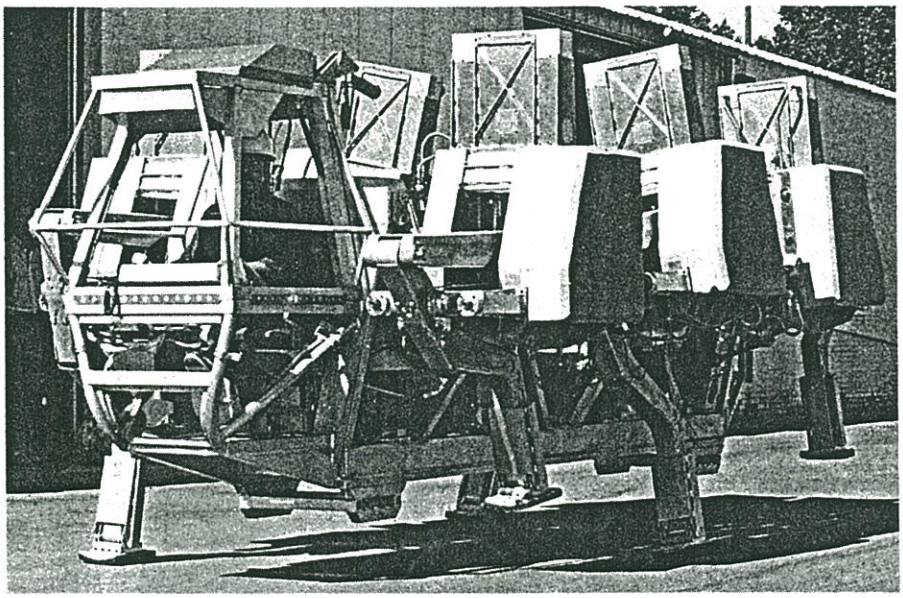
The twin-mirror design should be five times as powerful as the five-meter Hale telescope in California and nearly four times as powerful as the six-meter Soviet telescope, currently the world's largest.

Meanwhile, with feet firmly planted on the ground, the University's unique, 3-ton walking machine took its first, tentative — and untethered—steps earlier this month as engineers led it on a leisurely stroll near its Kinnear Road home.

Much of the public interest in the Adaptive Suspension Vehicle, known as the "Walker," has rested in its potential as a military vehicle, largely because funding for the project —approximately $8 million since 1981—has come mostly from the Defense Advanced Research Projects Agency in the Department of Defense.

The walking machine is part of the research agency's larger effort to develop legged vehicles capable of moving across terrain where wheeled or track vehicles cannot operate.

The six-legged, insect-like machine is 17 feet long and 10 feet high. Each of the seven-foot-high legs can move forward, backward and sideways. The vehicle has an on-board human operator and a computer control system that coordinates leg movements and processes information from an optical radar system.



Ohio State's Adaptive Suspension Vehicle can move in several directions. (Photo by Kevin Fitzsimons)

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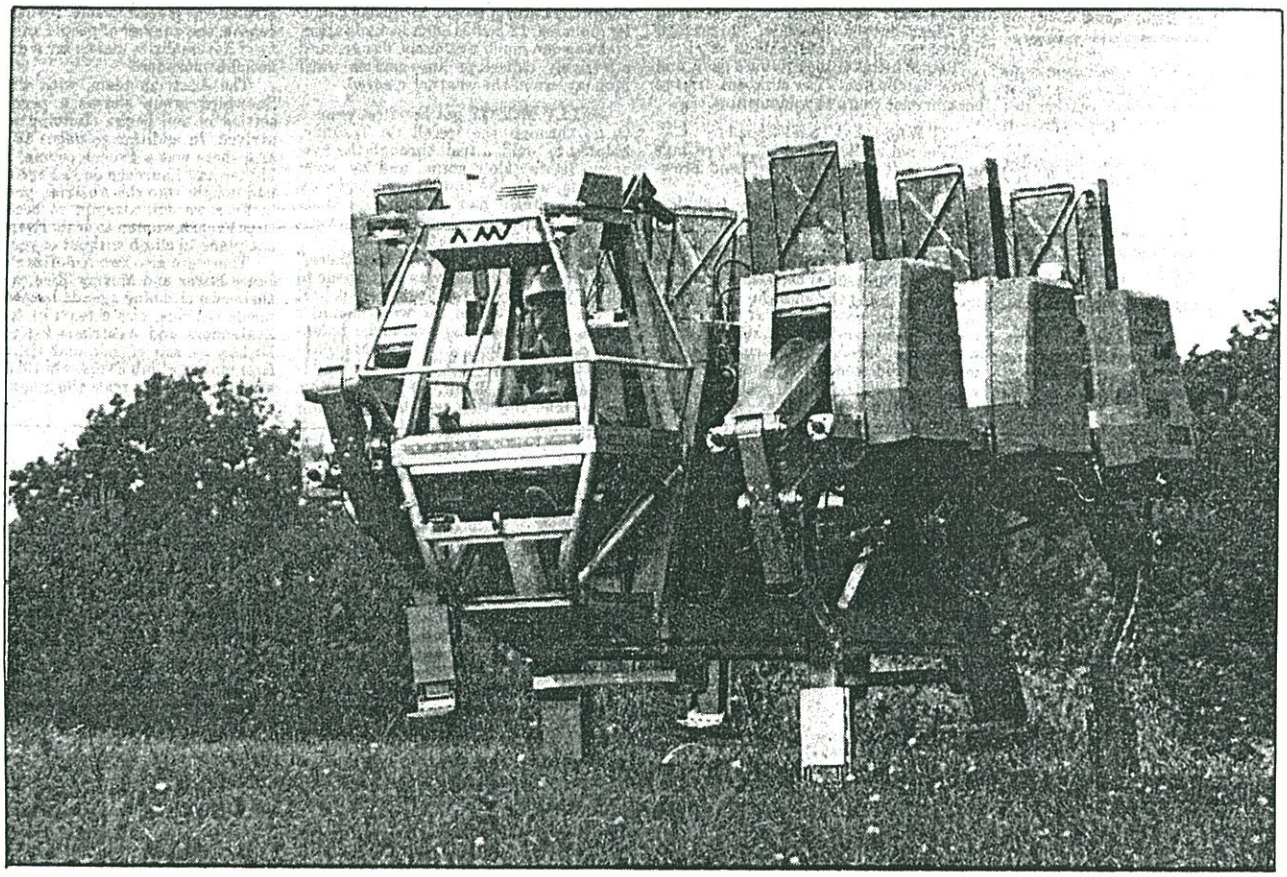


The Adaptive Suspension Vehicle on a test run

Dispatch photo by Doral Chenoweth III

HITTING ITS STRIDE

OSU's walking machine is strutting its stuff again

By David Lore
Dispatch Science Reporter

It is a shy beast, keeping to the back fields where the tall weeds grow, crouching on powerful haunches to play dead when strangers come to stare.

But on a sunny day, when the oil is warm and the electronics crisp, Ohio State University's walking machine friskily rambles the fields of the West Campus, its six massive legs smoothly stroking the ground like so many oars in a stream.

It is the Adaptive Suspension Vehicle, or ASV, a 3½-ton walking machine with a 50-horsepower motorcycle engine that steps out at a gentle but deliberate gait of 2 to 3 mph.

The brainchild of former OSU engineer Robert B. McGhee, the walking machine is part of a long-range Pentagon experiment on the potential of walking vehicles to overcome difficult battlefield terrain.

McGhee originally patterned the machine after a horse. Assembled, however, the machine's long body and powerful limbs give it more the appearance of a robotic grasshopper: a creature that seems to have lumbered out of prehistory to be re-engineered for the future.

It has the appearance of a robotic grasshopper: a creature that seems to have lumbered out of prehistory to be re-engineered for the future.

The ASV is controlled by a human pilot and 16 on-board computers. The computers have their own sensory devices, "feeling" the ground through pressure sensors in the foot pads and spotting objects up to 35 feet away through the forward-looking laser scanning device.

The laser scanner is a particularly tricky piece of new technology. It plots the machine's path in 6-inch-square bites, making a continuous map of objects and ground features in front, under and behind.

When the machine moves, it takes 50-inch steps, alternating kicks to maintain three-legged tripod stability at all times. The 7-foot limbs are made of welded aluminum. Jointed at the hip, they move in an almost delicate gait, incongruous for a mechanical brute weighing 7,200 pounds.

Too big for the laboratory, the ASV since last winter has been put out to pasture.

But project engineers hope it is not a case of early retirement. After $8 million and 6 years in development, the machine is hitting its stride, nearly recovered from the embarrassment of its aborted public "walk-out" last November. Shocked by chill air and hot lights, the machine that day refused to perform, only briefly shaking its giant limbs before settling back dead on its haunches, the victim of a power connector failure.

Its performance has improved over the intervening 10 months, but project engineer Kenneth J. Waldron still has to make excuses now and then for the walker's balky personality.

"There's an old saying," Waldron explained during one robotic temper tantrum, "that the probability of failure is directly proportional to the number of cameras pointed at this machine."

But when the walker goes out for its exercise,

Please see **WALKER** next page

it's hard to avoid a crowd.

The test site was moved well back from Kenny Rd. after motorists began pulling over to gawk. It has been invited to various parades and science fairs, but all such appearances have been refused. A British television station was allowed to film a documentary, however, and film crews from Italy, West Germany and France are still pressing. In certain engineering and technology circles, it seems, the walking machine is more of a symbol of Ohio State than the horseshoe stadium and the buckeye nut.

Yet, the walker is treading on pins and needles these days because of uncertainty about future funding from DARPA, the Defense Advanced Research Projects Agency.

The project's 3-year contract has lapsed, so current tests are being carried out under a 3-month extension.

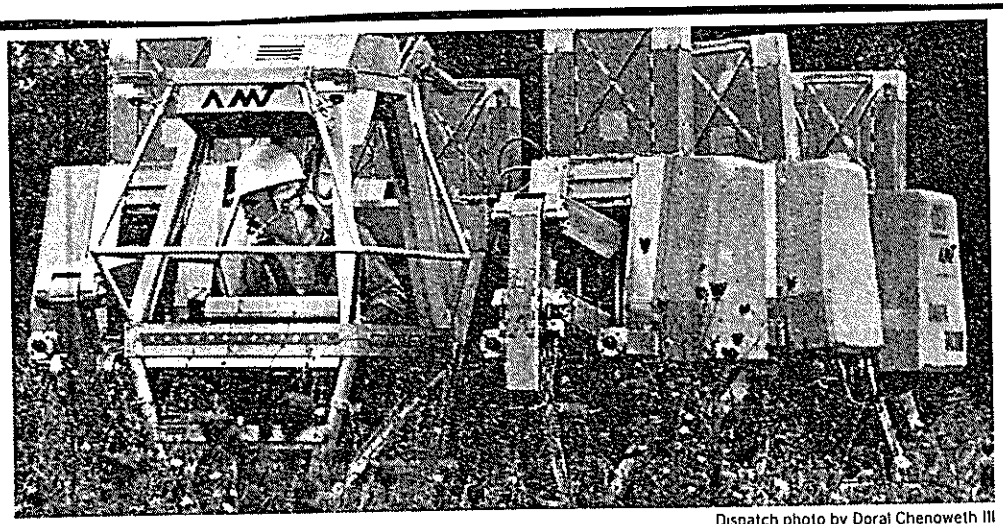
"WE'RE QUITE optimistic," Waldron said. "We think we'll be doing something, but we don't know exactly what."

If DARPA drops the project, it will be difficult to find a new sponsor. The walker, after all, is not a prototype for any line of military or industrial vehicles. It is simply a "proof-of-concept" machine that demonstrates that certain mechanical and control systems are possible. Since one doesn't shoot metal horses, "we'd sent it to a museum, I suppose," Waldron said.

Waldron and Vincent J. Vohnout, the machine's chief operator, think there's a lot more to learn from the ASV and walking vehicles like it.

The machine has successfully negotiated mud, snow and relatively gentle grades during its prowls this year about the West Campus.

In recent tests, for example, the walker has pulled a 2,000-pound sled without any heavy breathing. But Vohnout believes that, with improved computer instrumentation, it should be capable of pulling loads of 10,000 pounds or more as well as on-board cargoes of 500 pounds or more.



The walker makes its way through field near OSU

Dispatch photo by Doral Chenoweth III

THE MACHINE'S computer software has been under constant refinement. The laser scanner, for example, has been particularly troublesome. In addition, Waldron would like to see how the machine handles tougher challenges, such as steep hills, serious obstacles and heavier tow loads.

"Each leg is capable of lifting 4,000 to 5,000 pounds and the whole vehicle is over 7,000 pounds, so payload is not much of a problem," Waldron said.

In the case of heavy tow loads, the ASV's operator can simply switch to a different gait, pulling with four legs and then resting with two, or even "lurching" forward one pace with all six legs.

ASV, however, is a machine and walks like one. It doesn't work like a human or animal, Waldron points out.

"We'd like funding for a second-generation machine; one that is faster and more agile," he said. "This one is stable like a chair, in that it won't fall over, rather than being like an animal, which moves by falling and catching itself."

Vohnout rides in a cab at the head of the machine, controlling the direction of travel and monitoring the vehicle's basic systems, while the computers control gait, speed and balance.

"IT'S QUITE easy to drive," Waldron said. "It's simpler to learn than learning how to drive a car."

For the future, DARPA's priority is developing vehicles that function without an on-board operator, either autonomously or by remote control.

Such robots work better on legs than on wheels or tracks, Waldron said, because walking machines are less likely to get stuck or be stopped by obstacles in their path.

Men have been trying to build walking machines for more than a century, but Waldron says OSU is the first to unleash the beast.

"We've done what we set out to do, which is, prove you can build a machine of useful scale and develop all the necessary software to run it on irregular terrain," he said.

"Before we started this project, there were a lot of laboratory machines running around on level floors. But in terms of something to carry a substantial load over uneven terrain, this is the first."

NO PATENTS have been sought or issued on the ASV or its systems, and its creators say they have only the haziest idea about the commercial future for mechanical walkers.

Although the work has been funded by the military, Waldron and Vohnout think it could be more useful on the planting field rather than the battlefield.

ASV moves well in even deep mud, and someday it might allow farmers to worry soft dirt without rutting the soil or getting stuck.

"It's remarkably gentle with the terrain," Waldron said. "In the weeds, you can hardly tell where it's been, although it does leave footprints."

The legacy of the Ohio State walking machine could, however, be fields quite removed from transportation. It already has provided important information, for example, on how to design artificial knees and limbs.

"Even if walking machines are a blind alley," Waldron said, "there have been lots of lessons learned which can be used for other things, particularly in the area of robotics."

VOHNOUT THINKS it is too early to predict the future of this technology.

DARPA's primary interest, he said, is the development of autonomous vehicles — whether they be wheeled, tracked or legged.

"In 10 years, we could develo a machine that is field-deployabl and at least semiautonomous," Vohnout said. "And we're no talking about having to solve 'Sta Wars' kinds of problems.

"We're sort of at the sam point that the Wright Brother were at," he said. "How did the assess the demand for the flyin machine before anybody ha flown? We don't know exactl what options, what tasks, ther are for the machine."

Machines to follow in man's footsteps

Ohio State University's high technology metal walking machine evolved from the scra pheaps of Columbus.

"We've become famous for scrounging parts from people's trash," says Vincent J. Vohnout, vice president for mechanical systems of Adaptive Machine Technologies Inc. "It's turned out to be quite a bargain for the government."

Adaptive Machine, 1224 Kinnear Rd., is a research and development company organized in 1983 to act as a subcontractor to OSU on the Adaptive Suspension Vehicle project, because OSU was poorly organized for such hardware development.

"A UNIVERSITY is a difficult place for a project like this because of the bureaucracy and the civil service structure," Vohnout said. "It's very difficult for a university to be adaptive."

Vohnout became involved in the project as a graduate student in mechanical engineering at OSU. His partners at Adaptive Machine are two former OSU graduate students in electrical engineering: Dennis Pugh, vice president for control systems, and Eric Ribble, vice president for computer systems. The company, with offices in the OSU Research Park, has about a dozen employees.

Adaptive Machine was given a large university garage on Kinnear Rd. to build the machine. The project's relatively small $1 million-a-year budget, however, didn't allow the new company to shop in the same circles as do the major defense contractors.

Machine tools, materials and support vehicles were assembled from surplus and scrap being disposed of by OSU and the U.S. Defense Construction Supply Center. A one-time Air Force fire truck, for example, now takes the 7,200-pound walking machine out for its exercise. Another element of the convoy is the computer support trailer, bought used for about $2,000, Vohnout said.

"THIS ISN'T the way things are normally done in the aerospace industry," he said. A major defense contractor, he said, would normally spend more on just the computer trailer than Adaptive Machine has spent on the entire ASV project.

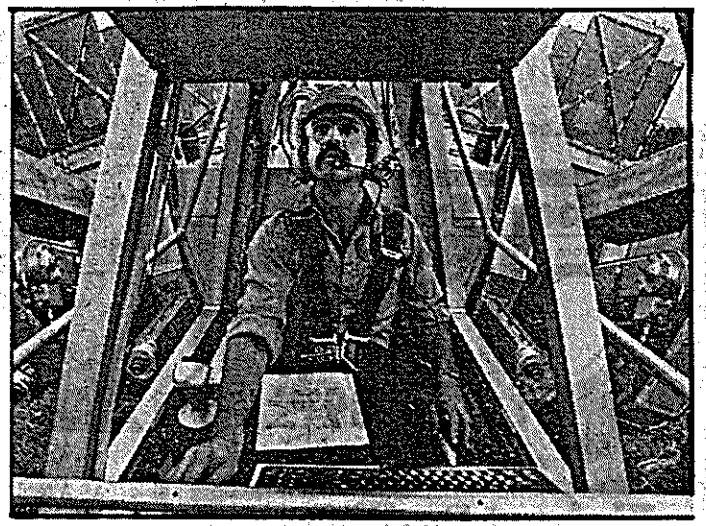
Although the company organized around the walking machine, it's no longer totally dependent on that project, Vohnout said.

The company has a $500,000 contract from the Defense Advanced Research Projects Agency to develop a robotic manipulator arm for vehicles such as the walking machine. Additional money is being sought from the National Aeronautics and Space Administration to perfect computer controls for such a manipulator.

"We have enough now to keep going even without the ASV," Vohnout said. "We're in the black. We're not making a lot of money, but we're making ends meet and we're scrounging for new contracts."

There is some commercial interest in the technology coming out of Adaptive Machine. But Vohnout said U.S. industry is usually too impatient to support such long-range developmental work.

"We had a call from somebody in Chicago who wanted to use the walking machine to build a pipeline across a muddy section of Africa. But this is not a shelf item, and that's the problem you have with industry, and that's why the Japanese are kicking our butt," he said. "For the Japanese, a 10-year development period is not a problem, but in the U.S., 6 months can be a problem."



Dispatch photo by Doral Chenoweth III

Vincent Vohnout at the controls

"A university is a difficult place for a project like this because of the bureaucracy and the civil service structure."

ADAPTIVE MACHINE'S niche, he said, is to build and test experimental machines and robots in support of university engineering projects.

There is tremendous interest in military circles, he said, in developing autonomous battlefield machines that can operate in chemical or high-radiation environments — warfare that would stop human soldiers.

Adaptive Machine, in fact, is part of a larger university group bidding for an Air Force contract to develop automated runway repair equipment that could patch up the runway or perform damage control missions under fire, he said.

It's also a matter of economics, he said. "The most expensive equipment out there on the battlefield is your standard GI."

On the basis of the walking machine project, Vohnout is convinced that machines can follow in man's footsteps.

"I think we could build a tree-climbing robot if somebody wanted to pay for it," he said.

OSU's 'walker' now in fast lane

By David Lore
Dispatch Science Reporter

The Pentagon wants The Ohio State University's next "walking" machine to hop, skip and jump.

Engineers on the project have been notified by the Defense Advanced Research Projects Agency that they have at least $1 million to begin work on an advanced system that would be more agile than the existing mechanical walker.

That model, the 3.5-ton adaptive suspension vehicle, must have at least three of its six legs on ground to maintain its stability.

NOW THE defense agency wants to explore the possibility of a mechanical walker that can keep its balance in a gait that puts all — or almost all — its legs in the air at the same time.

"The goal will be being able to handle the flight phases when there's no legs on the ground, or maybe only one," Vincent R. Vohnout said.

Vohnout is chief operator for the walker and vice president of Adaptive Machine Technologies, 1224 Kinnear Rd., which is developing the technology under an OSU subcontract.

The walking machine was developed over two decades by former OSU electrical engineer Robert B. McGhee as part of a program, funded by the Pentagon, to develop walkers that can cross terrain impassable to wheeled and tracked vehicles.

Funding for the walker ran out Oct. 1, but Vohnout said the defense agency agreed this month to allow OSU to begin a new three-year program, subject to yearly reviews. Spending will be slightly more than $1 million the first year and could reach $4.2 million over three years, he said.

McGhee, now on the faculty of the Naval Postgraduate School in Monterey, Calif., will continue his involvement as a subcontractor on the project.

The new machine will not be prancing about the campus any time soon, Vohnout said.

It will take three years to come up with the general design and specifications for the new machine using the existing walker as a test vehicle, he said.

Vohnout said six-legged insects are not stable when more than three legs are off the ground, although they can recover their balance quickly.

"NATURE WENT for six legs and then to quadrupeds, but we're not constrained to follow the evolutionary path of nature," he said.

It has not been decided whether the new walker will have four or six legs. "I'm dying to build a biped because they're neat and lots of fun, but nobody is listening to me," Vohnout said.

Neither has it been decided whether the new machine — like the existing one — will have an on-board operator or whether it will be remote controlled.

The OSU walking machine, as well as an earlier six-legged model, will be on display Tuesday and Wednesday at the Ohio Center at a conference of the Institute of Electrical and Electronic Engineers and the Instrument Society of America.

Steps readied to market OSU's walking machine

By David Lore
Dispatch Science Reporter

The builders of Ohio State University's walking machine might take their creation on the road to generate commercial interest.

The walker is a six-legged, 3.5-ton "adaptive suspension vehicle" developed for the Pentagon.

IT IS AN agile machine that can move through, or over, obstacles such as mud, trenches or barriers that would stop wheeled or tracked vehicles. The principal investigator at OSU is engineering professor Kenneth J. Waldron.

Adaptive Machine Technologies, 1224 Kinnear Rd., is developing the walking machine under a subcontract.

Vincent R. Vohnout, president of the company, said the original backer, the U.S. Defense Advanced Research Projects Agency, appears to be losing interest in the project, although it is still under a defense contract. This is forcing the developers to look harder for industrial applications.

After years of research and development, Vohnout said, the machine is ready for commercialization.

He said it could be used as a cargo carrier in logging, construction or mining, or as a nimble robot in hazardous environments.

"THE PROBLEM is that the technology is so far from what is accepted normally," said Vohnout. "It's so bizarre looking to them (businessmen), that even when you show them the practicality and the potential, they basically don't believe you."

Selling the machine brings problems similar to those faced by the Wright brothers.

"The Wright brothers couldn't demonstrate the full potential of the airplane, so early aviation had to make its money barnstorming, doing demonstrations," he said.

"We find that most of our calls are people wanting us to do just that."

Vohnout said public interest in the mechanical walker remains high. Adaptive Technologies is asked frequently to demonstrate the machine at robotics and electronics conventions, and foreign film and television crews are frequent visitors to the Kinnear Road laboratory.

The question now, said Vohnout, is whether Adaptive Technologies should start accepting more such offers to get the technology before the public.

"We were very reluctant to do it, but now the machine is behaving so well, we're getting more confident with it."

The walker will be working out on the agricultural fields on campus near Kenny Road next month.

OVER THE winter, the machine was outfitted with a more powerful computer which allows it to climb over large obstacles. With its old computer, the onboard operator had to help out.

In a company magazine this month, Hitachi Ltd. of Japan boasts about its work on a four-legged walking machine the company is developing for the Japanese government to patrol the inside of nuclear power stations.

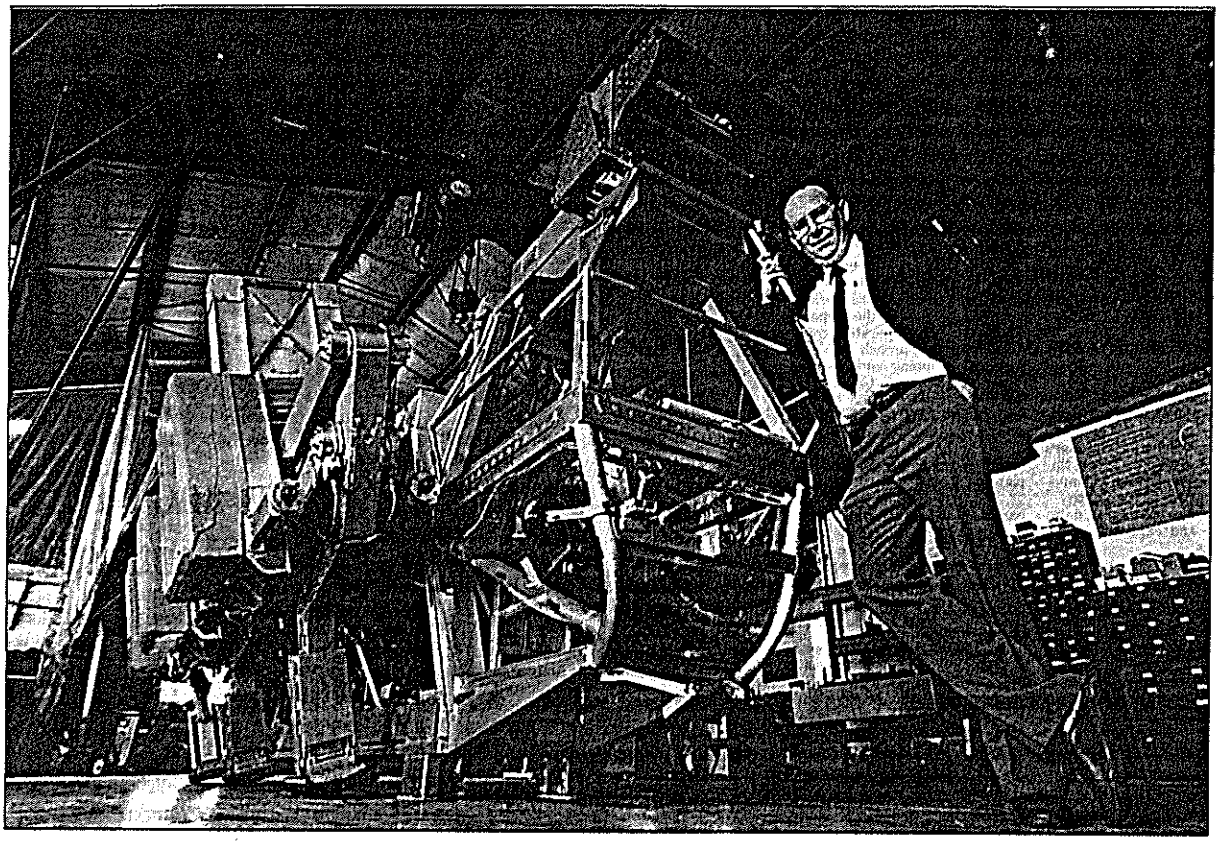
"We think our technology is ready, but if you look at Hitachi, that's still a laboratory device," said Vohnout.

"As far as we can tell, we have the only practical, self-contained system."

IN STEP — COSI will welcome its new robotics exhibit with a home-grown mechanical marvel.

The six-legged Adaptive Suspension Vehicle developed by The Ohio State University will be clomping around at the Center of Science and Industry on Saturday.

Broad Street will be blocked off in front of the building from 11 to 1 for the free demonstration. The ASV will remain at COSI through the weekend.



Dispatch photo by Tom Dodge

Engineer Kenneth Waldron with The Ohio State University's walking machine

Out Of Space Race

Rejected by NASA, OSU puts walking machune to use on Earth

By David Lore
Dispatch Special Projects Editor

After two decades and $9 million worth of development, The Ohio State University's pace-setting walking machine doesn't have the "right stuff" for space.

Instead, the robotic space race seems to be between "The Ambler," a six-legged walker developed by Carnegie Mellon University in Pittsburgh, and "Robby," a six-wheeled slinky out of the Jet Propulsion Laboratory in Pasadena, Calif.

Both vehicles, as well as several other wheeled and walking machines, are being prepared by NASA for reconnaissance and other missions on the moon and, eventually, Mars.

Meanwhile, OSU's adaptive suspension vehicle, or ASV, is getting ready for a quite different environment: a logging camp in the forests of Virginia.

In a test being organized by foresters at the Virginia Polytechnic Institute, the OSU walker will be rated on its ability to climb slopes, move across wet terrain, maneuver in close quarters and carry logs without damaging the soil.

"Basically, we believe there are commercial applications in the forestry industry, and this set of trials will be to demonstrate that potential," said Kenneth J. Waldron, the OSU engineer who is principal investigator on the project.

The walker evolved out of research begun by former OSU engineer Robert B. McGhee in the late 1960s with Pentagon financing. The Defense Advanced Research Projects Agency wanted a tough, agile battlefield transport that could climb over or around barriers that would stop wheeled or track vehicles.

Military funding ended last October, and OSU backers had to look for other applications.

Vincent Vohnout is vice president of Adaptive Machine Technologies Inc., 1218 Kinnear Rd., a small engineering firm which has the walker's maintenance and development contract with OSU.

Jet Propulsion Laboratory photo

Robby, the Jet Propulsion Laboratory's rover project

Vohnout said he attended a Jet Propulsion Laboratory workshop several years ago, hoping to interest NASA officials in using OSU's technological head start to build a modified walker for planetary exploration.

"Everybody was there — all the big guys," Vohnout said. Space agency officials were not receptive.

"They really don't speak very directly," he recalled. "But what they indicated was that somebody our size would not really be considered for something of that magnitude."

It was a political rather than a technical process, Vohnout contends.

"To get that kind of money out of NASA, you need to lobby pretty heavily for it," he said. "You really can't just give them a technical proposal and tell them you know what you're doing, or that you've done it before.

"That and 50 cents get you a cup of coffee."

OSU was not interested in hardball lobbying for the contract, Vohnout said.

Waldron said he was "gently discouraged" when he suggested to officials in OSU President Edward H. Jennings' office that Ohio congressmen be contacted about the contract.

No such discouraging words were heard at Carnegie Mellon, where, in 1987, the school's Field Robotics Center won a five-year, $7 million contract to build a walking machine for NASA's planetary rover program. "Ambler" had its public "walk-out" last month.

OSU's walking machine and Carnegie Mellon's Ambler are not exactly look-alike robotic Rockettes.

- The OSU machine is sort of an engineering compromise between a horse and a grasshopper. Although it weighs 7,200 pounds, it is quite agile, capable of moving each of its six legs up, down, sideways, backward or forward. Powered by a 50-horsepower motorcycle engine and controlled by a driver and 16 on-board computers, it is designed to move at 2 mph to 3 mph while dragging loads of up to 10,000 pounds.
- Ambler is smaller and lighter, about 4,500 pounds, and does not require a human driver. Is is slower and less agile than the OSU walker. The machine's six legs are grouped into two sets of three to provide a stable platform for scientific instruments. Ambler moves by sticking out a leg and then dragging itself forward in what is described as a "circulating gait."

"Ours is a slow, deliberate machine," explained David Pahnos, assistant director at the Carnegie Mellon robotics center.

"It reflects the kind of restraints on a planetary mission: extreme reliability,

Please see **WALKERS** next page

extreme ruggedness, and low power consumption."

Pahnos praises the existing OSU machine as "a real seminal piece," but he said it would not work in space. All that agility and speed takes too much power and too many complicated parts that could fail, jeopardizing a mission.

At the Jet Propulsion Laboratory, a lot of skepticism exists about any mechanical walkers.

A seven-legged walker called the "walking beam" is being developed for the laboratory by Martin Marietta Astronautics Group in Denver, said Waldron, a consultant to the company. "It looks for all the world like an oil derrick. It's very light and very slow."

Brian Wilcox, supervisor of the laboratory's robotic sensing and perception group, said many questions remain about the stability of walking machines.

"With legged vehicles, you always have the risk if one leg falls through a shell material on the ground, it could fall through and not be able to recover," he said. The Martin Marietta walker, he said, is being built low and squat to minimize this risk.

Robby, Jet Propulsion Laboratory's in-house rover project, is less likely to get stuck, at least on the relatively smooth surface of the moon, Wilcox said. Rather than legs, it has six wheels and a flexible, segmented body that allows it to roll over obstacles up to 5 feet high.

"It has less mobility per volume than do legged vehicles, but in the community it's considered more reliable, and simpler," he said. "Legged vehicles such as Ambler or the OSU walker are considered somewhat more complex."

Rovers, whether walking or rolling, would be equipped with robot arms and other tools to handle a number of chores, such as moving cargo, laying utility lines or setting up lights and other facilities in advance of human occupation.

"In the case of the moon, they'd move cargo from the landing site to the habitat site or the nuclear reactor site," Wilcox said.

The surface of Mars, however, might favor walking machines.

"Mars is a pretty rugged place, and the scientifically interesting places are those which are more rugged," Wilcox said.

"It has a grand canyon, for example, three times the size of ours, and a volcano twice the size of Mount Everest." This encourages NASA to continue development of both walkers and wheelers, he said.

Field trials will take place in Antarctica's Dry Valleys, and possibly on the moon, to decide which model makes the first trek across the red planet.