



DMITRY OLEYNIKOV, M.D.



SHANE FARRITOR, PH.D.

# SPACE-AGE ENGINEERING TRANSFORMS SURGERY

by CHUCK BROWN

**Technology that enables robots to explore the rocky and formidable terrain of Mars is being adapted to explore another new frontier – the inner human body.**

So it seems fate clearly intervened five years ago when a UNMC surgeon introduced himself to a University of Nebraska-Lincoln engineer with ties to NASA, launching a collaboration that is revolutionizing surgery.

UNMC's Dmitry Oleynikov, M.D., and UNL's Shane Farritor, Ph.D., met during a spring 2002 research retreat and proposal contest designed by the vice chancellors of the two schools to encourage cross-disciplinary cooperation among scientists from each campus.

After their initial meeting, Dr. Oleynikov gave Dr. Farritor a list of five ideas they could explore for their research proposal.

"Number three on the list was miniature surgical robots inside the body," Dr. Farritor said. "I like to joke with Dmitry

that his other four ideas were horrible – but he was onto something with the robots."

Dr. Oleynikov had just been recruited from the University of Washington by UNMC Surgery Department Chairman Byers "Bud" Shaw, M.D., to raise the medical center's profile in the world of advanced surgical technology.

Dr. Farritor – a native of Ravenna, Neb., and a 1992 UNL graduate – had helped make waves around the, well, galaxy for his contributions to the Mars Rovers.

Before returning to his alma mater in 1998, he worked in the Massachusetts Institute of Technology Field and Space Robotics Laboratory and the Unmanned Vehicle Lab at the C.S. Draper Laboratories in Cambridge, Mass. He also studied at the Kennedy Space Center in Florida and the Jet Propulsion Laboratory in Pasadena, Calif.

Together, their mini robot project captured the imaginations of the vice chancellors for research and received an award that came with \$60,000 in project funding.

DR. FARRITOR DISPLAYS TWO OF THE SURGICAL ROBOTS HE AND DR. OLEYNIKOV HAVE DEVELOPED. ON THE LEFT IS A MOBILE CAMERA ROBOT THAT CAN MOVE AROUND INSIDE OF A BODY CAVITY AND PROVIDE IMAGES TO SURGEONS. THE ROBOT ON THE RIGHT IS THE CEILING PAN/TILT ROBOTIC CAMERA WHICH PROVIDES A BIRD'S-EYE VIEW OF THE SURGICAL SITE.



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Even before coming to UNMC, Dr. Oleynikov was interested in surgical robots.

At the time, the world's most advanced robotic surgical solution was Intuitive Surgical's *da Vinci*® Surgical System – a large robot that mimics a surgeon's hand movements during an operation and is able to negate potential hand tremors that can hinder surgery.

UNMC was the eighth medical center in the country to acquire the *da Vinci* system – putting UNMC on the map in the area of computer-assisted surgery.

While the *da Vinci* enables more complex procedures to be performed on a minimally invasive approach, it doesn't remedy some of the major obstacles of laparoscopic surgery, in particular limited range and motion of the scope cameras and lights that enter a patient's body through a small incision.

"The scopes can only move so much because we don't want to make the incision larger, so it makes it hard to see everything around the area we are operating on," Dr. Oleynikov said.

To remedy this, Dr. Oleynikov began thinking small – really small.

He envisioned tiny robots the size of a lipstick case that could be placed in a patient's abdominal cavity and move around in a patient's body. Armed with cameras, lights and other tools, robots could provide surgeons with a much greater range of operation, he thought.

Traditional scopes, and even those associated with the *da Vinci* system, require their own incisions. Dr. Oleynikov envisioned robots that would be able to enter and exit the body through incisions made for other instruments – thus reducing the number of cuts and shortening healing time.

Drs. Oleynikov and Farritor decided to pursue miniature robots as their research proposal during an idea-filled lunch two months later at a Cajun restaurant in Lincoln, complete with napkin drawings of potential robot models.

Marsha Morien, executive director of the University of Nebraska Center for Advanced Surgical Technology, remembers the lunch as an energetic encounter with ideas flowing quickly between the two scientists.

"We realized we had a special opportunity and we were determined to make something happen," Morien said.

She recalls one other aspect of the lunch as well.

"I remember picking up the bill," she joked.

Dr. Farritor was as intrigued by the idea of making robots that could navigate the body's inner organs as he was in designing robots that traveled the surface of Mars.

"In reality, the robotic concepts used to get robots to move on Mars or in the body are the same," Dr. Farritor said. "Both are 'remote environments' where the robot is operating in a strange place.

"This brings with it a lot of engineering challenges, such as how the robot is controlled, what sensor information is needed and how decisions are made.

"We were trying to make a robot that would drive around on the organs while not causing damage," Dr. Farritor said. "The environment is delicate, soft and slick and you don't want to get stuck."

As they moved into development, Dr. Farritor observed Dr. Oleynikov performing surgery to get a better understanding of what he was looking for in the robots and what issues surgeons face in their work.

The team experienced some challenges in getting the robots to where they could move across certain organs, Morien said.

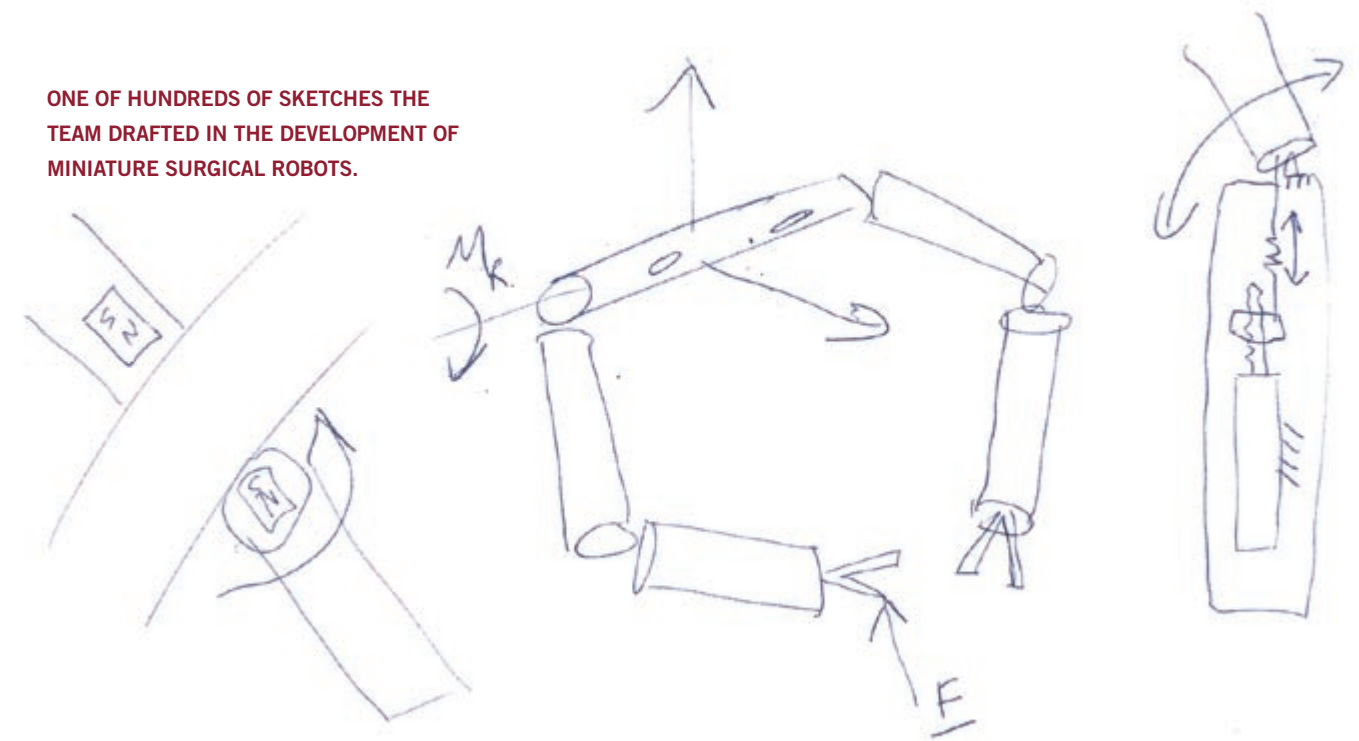
"Surfaces are different depending on the organ," Morien said. "The gall bladder is different from the liver, which is different from the bowel. Our robots had to be able to roll on all of them."

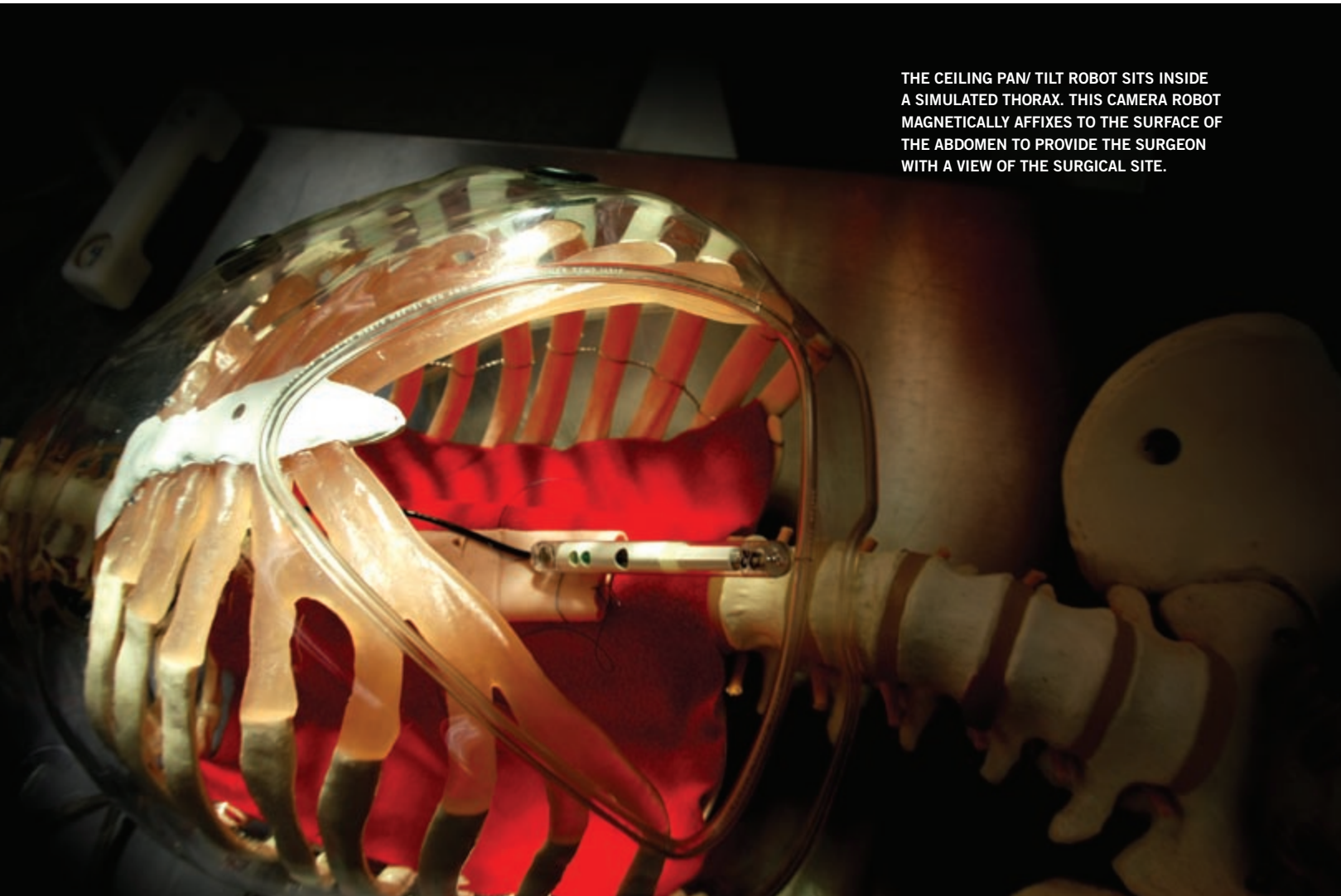
Within a year of their Cajun meal, the team had a prototype developed.

Drs. Oleynikov and Farritor have since designed a suite of robots, all about the size of a lipstick case. Some robots carry lights, others carry cameras and one is even capable of performing a biopsy.

They are all controlled through a computer, meaning surgeons can operate the robots from hundreds of miles away. This aspect made the robots attractive to the U.S.

ONE OF HUNDREDS OF SKETCHES THE TEAM DRAFTED IN THE DEVELOPMENT OF MINIATURE SURGICAL ROBOTS.





THE CEILING PAN/TILT ROBOT SITS INSIDE A SIMULATED THORAX. THIS CAMERA ROBOT MAGNETICALLY AFFIXES TO THE SURFACE OF THE ABDOMEN TO PROVIDE THE SURGEON WITH A VIEW OF THE SURGICAL SITE.

The partnership between Drs. Oleynikov and Farritor is an example of a common theme being emphasized at research institutions around the world – collaboration across disciplines.

With an increased push toward clinical and translational research, scientists around the world are being asked to look beyond their own fields for collaborative partners.

The collaboration between Drs. Oleynikov and Farritor is a perfect example of such cooperation, said Tom Rosenquist, Ph.D., vice chancellor for research at UNMC.


“Drs. Oleynikov and Farritor have combined their considerable expertise and produced robots that could

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**Dmitry Oleynikov, M.D.**

“It really is an equal partnership with each one of us adding vital components to the mix,” Dr. Oleynikov said. “Without one, the other would not succeed.”

Dr. Farritor agreed, noting that the timing seemed right.

“It works well because he’s a medical guy who knows a little about robots, and I’m a robot guy who now knows a bit about medicine,” Dr. Farritor said. 

## Nebraska is NOTeworthy

The vision of Dmitry Oleynikov, M.D., of a world where robots replace surgeons’ hands within a patient’s body may already be catching up with reality.

A new push in the world of surgery is the development of what is called Natural Orifice Transluminal Endoscopic Surgery or NOTES.

The idea behind NOTES is for surgeons to enter the body through natural orifices such as the mouth, eliminating external incisions and visible scars for patients.

Dr. Oleynikov and Shane Farritor, Ph.D., have developed a special robot that enters a person’s mouth, moves down the esophagus and into the stomach, where it makes a small incision to gain access to the inner body and assist with surgery. The robot then exits the body the same way it entered and the surgeon laproscopically stitches the robot’s incision, leaving no visible scars.

The team has begun testing their NOTES robot on animals.

“Time will show that using our robots is the best way to do NOTES,” Dr. Farritor said.

This is so, Dr. Oleynikov said, because the current method of performing NOTES involves using tools not suited for the job, particularly a camera scope that is actually designed to remove polyps on the colon, not perform surgery.

“Surgeons who use our NOTES robots will have the right tool for the job,” Dr. Oleynikov said.

Department of Defense – which has authorized the team to receive grants of about \$6 million to advance development of the robots.

If a soldier is wounded on the battlefield, theoretically a medic at the site could insert a robot into a patient, allowing a remote surgeon to quickly diagnose a wound – potentially speeding treatment and reducing casualties.

NASA also has expressed interest in the robots under the premise that they could be used should a medical emergency occur in space.

The robots have proven successful in animal trials – assisting surgeons in the removal of a pig’s gall bladder with no harm to the animal.

“The robots performed very well and provided the kind of support we had envisioned they would,” Dr. Oleynikov said.

The team is now awaiting approval from UNMC’s Institutional Review Board to begin human trials. If human trials prove successful, Dr. Oleynikov said it’s possible the surgical robots could be on the market as early as next year.

To market the robots and other technology developed along the way, Drs. Oleynikov and Farritor have founded Nebraska Surgical Solutions – a start-up company that will let them capitalize on what could be a revolutionary development in the world of surgery.

“Robots are the future of surgery, I truly believe that,” Dr. Oleynikov said. “I envision a time when a surgeon’s hands no longer need enter a patient’s body.”

lead to a surgical revolution,” Dr. Rosenquist said. “They demonstrate how such collaboration can lead to scenarios where everyone wins.”

Their cross disciplinary approach and venture into surgical robots also drew praise from one of the world’s leading surgeons, Richard Satava, M.D., professor in the University of Washington Department of Surgery and founder of the international conference, Medicine Meets Virtual Reality.

“Such a revolutionary concept requires just the type of multidisciplinary team with tremendous experience in innovation that has been assembled,” Dr. Satava said. “This not only brings credibility to the project, but also greatly increases the chance of success.”

To both men, their work represents a perfect and simple amalgamation of the expertise they bring to the table.