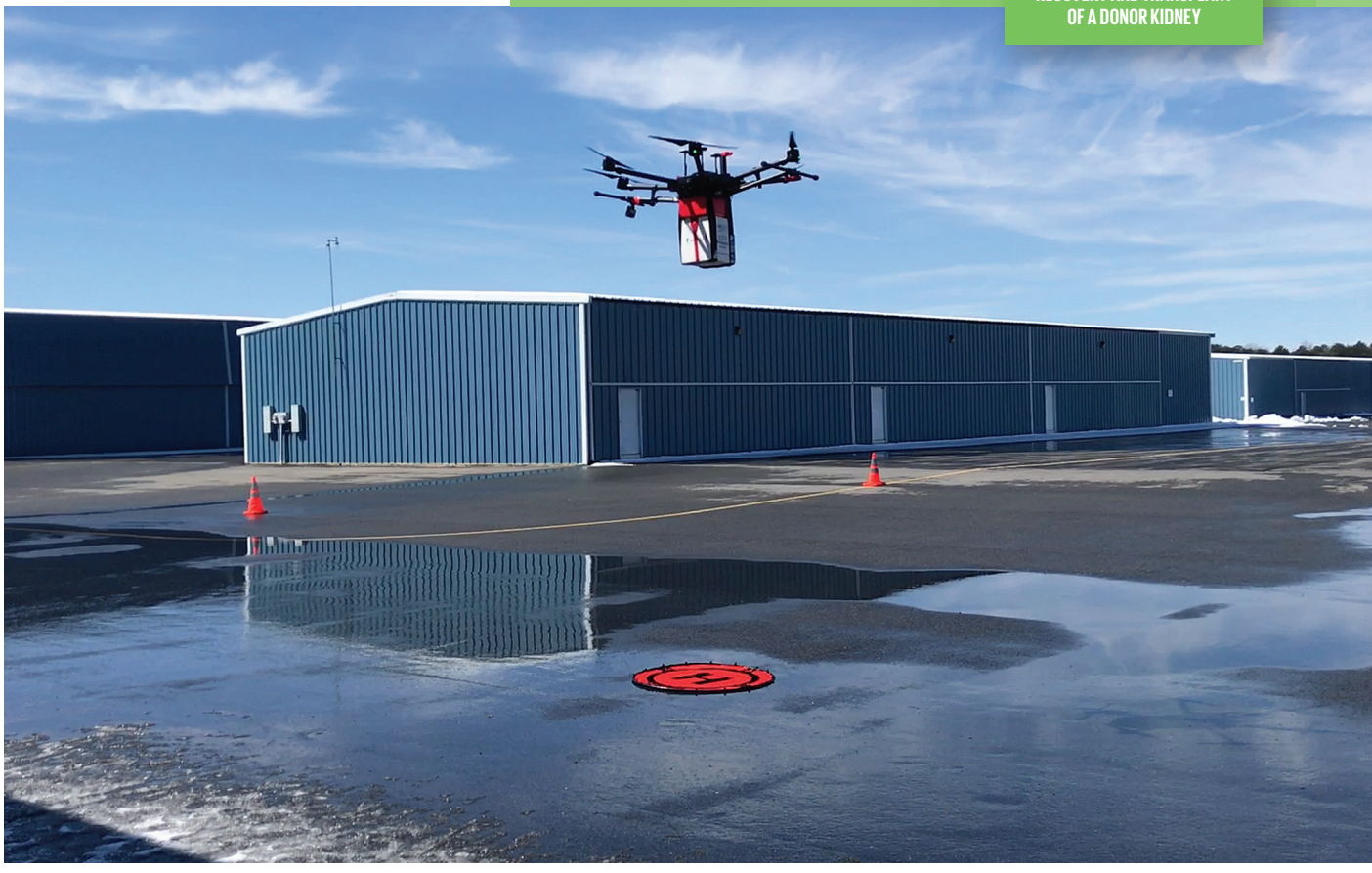
72 HOURS:
MAXIMUM TIME SPAN BETWEEN RECOVERY AND TRANSPLANT OF A DONOR KIDNEY



JOE SCALEA

DRONE DELIVERS HUMAN KIDNEY

The organ was flown several kilometers by a drone without incurring damage

SPECIAL DELIVERY: A frustrated transplant surgeon tested whether drones could transport organs to the operating room.

When a patient who needs an organ transplant is finally matched with a donor, every second matters. The longer the delay between the removal of a donor organ and its transplantation into a recipient, the poorer the organ functions afterward. To maximize the chances of success, organs must be shipped from point A to point B as quickly and as safely as possible—and a recent test run suggests that drones are up to the task.

One surgeon's personal experience at the operating table, waiting for organs to arrive, prompted him to think of new forms of delivery. "I frequently encounter situations where there's simply no way to get an organ to me fast enough to do a transplant, and then those life-saving organs do not get transplanted into my patient," says Dr. Joseph Scalea, of the University of Maryland Medical Center, in Baltimore. "And that's frustrating, so I wanted to develop a better system." »

He organized a group of researchers, including associates at the University of Maryland's department of aerospace engineering, to explore whether a drone could deliver organs. They selected a DJI M600 Pro for the experiment because its six motors lie directly below their respective rotors. That would keep the rotors far away from the smart cooler containing the organ (see top photo), and the separation would spare the organ from any heat emitted by the motors.

Next, the team designed a specialized wireless biosensor to measure temperature, barometric pressure, altitude, vibration, and GPS location of the organ while it's en route. With the drone and wireless biosensor ready, all the researchers needed was an organ to complete the experiment.

Last March, they received news that a kidney—one not healthy enough to be used in a transplantation—was available for research. Over the course of roughly 24 hours, the kidney was shipped more than 1,600 kilometers to Baltimore, and the drone was set up for its first delivery mission. The results were published in the *IEEE Journal of Translational Engineering in Health and Medicine* in November.

In total, the bean-shaped organ was airborne for a little more than an hour over the course of 14 flight missions. For the farthest mission, the kidney flew 2.4 kilometers, a distance similar to the length of potential shipment routes for donor organs between inner-city hospitals.

The researchers found that the temperature of the kidney remained stable, at a cool 2.5 °C, throughout the test runs. Air pressure corresponded with altitude, and the drone-borne organ achieved a maximum speed of 67.6 kilometers per hour.

In an interesting twist, the kidney was subjected to slightly fewer vibrations when transported in the drone compared with how many it received on a control delivery mission in a fixed-wing plane (a dual-engine turboprop King Air). Biopsies of the kidney before and after drone transportation revealed no damage from the journey, suggesting that the experiment—which the research team believes is the first-ever use of a drone for organ delivery—was a success.

"I think that what we did here is very cool," says Scalea. "This is the first step among a series that I think will get patients closer to their life-saving organs quicker, and with better outcomes."

Dr. Italo Subbarao, a senior associate dean at William Carey University College of Osteopathic Medicine, in Hattiesburg, Miss., studies how to use drones to deliver medical supplies to remote areas after natural disasters. He applauds the research group in Maryland for their demonstration.

PRECIOUS CARGO: Researchers measured whether a kidney, stowed in a cooler, could be delivered safely by drone. A custom sensor inside the cooler monitored the temperature and vibration of the organ during its trip.

JOE SCALEA (3)

"The study was elegantly done with a focus on short transport time and distance, which is ideal to demonstrate potential feasibility," Subbarao says. But he also says follow-up studies would need to show that it could work over longer distances and delivery times.

So how soon can hospitals receive organs by drone delivery? Subbarao and Scalea both cite the same hurdles moving forward: A drone operated in the United States must remain within a pilot's line of sight throughout the entire flight. And U.S. Federal Aviation Administration regulations state that a drone may not fly higher than 122 meters (400 feet) above structures within the area in which it is flying.

These limitations will affect not only the transport of vital organs but also access to a swath of medical supplies for which drones are being explored as a delivery method.

"Based on the national discussion about drone technology, I think that these things are going to be addressable and that we will be able to overcome each of them," Scalea says. "Not without hard work, but I do think we can do it."

After working on this project for three years, Scalea says he is thrilled that the team was able to provide a proof of principle that drones are a viable option for organ delivery. He is now working with other research groups and hospitals across the United States to identify scenarios for which drone delivery could work.

Although the group's recent experiment did not involve the kidney being transplanted into a living person, that is the obvious next step. Scalea believes that such an experiment will happen in the very near future, perhaps early in 2019. "Stay tuned," he says.

—MICHELLE HAMPSON

A version of this article appears on our Human OS blog.

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AUTOMATED EYES WATCH PLANTS GROW

Crop scientists hope to replace traditional painstaking monitoring methods

A decade ago, a group of crop scientists set out to grow the same plants in the same way. They started with the same breeds and adhered to strict growing protocols, but nonetheless harvested a motley crop of plants that varied in leaf size, skin-cell density, and metabolic ability. Small differences in light levels and plant handling had produced outsize changes to the plants' physical traits, or phenome.

The plunging price of genomic sequencing has made it easier to examine a plant's biological instructions, but researchers' understanding of how a plant follows those instructions in a given environment lags. "There is a major bottleneck for a lot of breeders to be able to get their phenotypic evaluation in line with their genetic capabilities," says Bas van Eerdt, business development director at PhenoKey, in 's-Gravenzande, Netherlands.

Breeders would like to be able to know whether a plant—or better, a whole crop—is growing on track and how it's responding to local weather conditions, by observing the way it grows. Now, with cheaper sensors and more powerful artificial intelligence algorithms, researchers are inching closer to that goal. Their hope is to make the typical 1.3 percent annual yield improvement in crop production look more like Moore's Law.

The go-to technique for this work is still optical imaging. Some researchers are now writing soft-

CROP VISION: Photon Systems Instruments, in the Czech Republic, sells automated phenotyping systems for use in greenhouses and in the field.

PHOTON SYSTEMS INSTRUMENTS