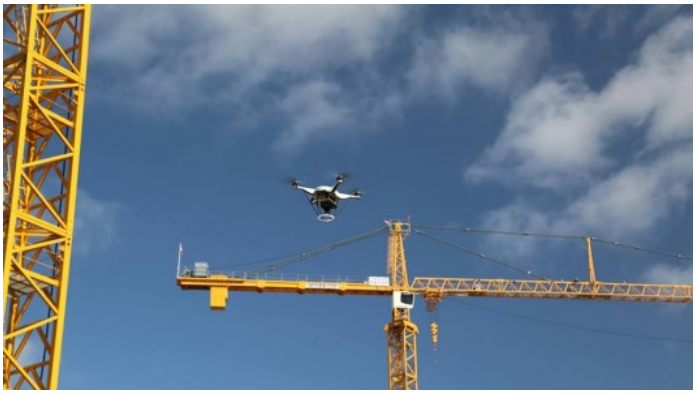
AIRCRAFT FEATURE

How drones are poised to help build the cities of tomorrow

By Nick Lavars
March 1, 2015

3 Comments
17 Pictures



Drones are already proving incredibly efficient at aerial mapping on building sites, but are they capable of more? (Photo: Skycatch)

Image Gallery (17 images)

Over time we have gotten used to machines assuming certain roles in society, but even at the dawn of the the age of robotics, some types of skilled labor still seem beyond their reach. After all, how does a machine wield a hammer and overcome the perpetual problem-solving involved in putting together a house or a high-rise? While we might be some ways off from watching buildings sprout out of the ground at the push of a button, flying robots are already carrying out surveying and mapping tasks on construction sites from the US to Japan. But leading researchers are adamant that when it comes to automating the building industry, these machines have more to offer.





View all

The value of drones in construction, at least for the time being, is more or less tied to their ability to venture where humans and heavy machinery cannot. This dictates that the vehicles remain small, agile and with minimal payload, zipping around with onboard high-res cameras and relaying progress shots and aerial surveys to construction teams on the ground. This might sound like little more than a negligible cost-cutting, but drones are already forming an integral part of business operations for innovative construction firms the world over.

In Japan, an aging population has the construction industry turning to new technology to help build the infrastructure of the future. Leading the charge is the multinational machinery maker Komatsu which has just announced the launch of a new service called Smart Construction, aimed at helping fill Japan's void of a fit young workforce with cutting edge information and communication technologies. The service includes a a platform called KomConnect that will connect machinery and workers to the cloud to improve overall efficiency, artificial intelligence-assisted control for operating machinery and, of course, drones.

Komatsu has turned to San Francisco-based drone service provider Skycatch to put UAVs to use in its Smart Construction venture. Skycatch's vehicles will be deployed to conduct surveys and produce 3D models, culminating in live interactive maps of the job sites.

"The map comes to life on our dashboard, so to speak, and clients can do things like impose overlays of plans onto what's actually been built, calculate volumetric measurements, and make annotations for themselves or to share with co-workers," Skycatch CEO Christian Sanz tells Gizmag.

In the view of Sanz, the potential of drones in construction is becoming too great to ignore.

"Right now, drone technology is providing a competitive edge to the companies who've successfully adopted it," he says. "They use their equipment and resources more efficiently, communicate better through accurate maps and data, and now have highly quantitative means of measuring their progress against their schedule. In the future, the construction industry will realize aggregate benefits such as a much better safety record and fewer projects that are completely late and off budget."

Though Komatsu prides itself on a history of technological innovation, it is far from the only construction company enlisting armies of flying robots. In all corners of the globe, firms are recognizing the aerial surveying potential of drones (a capability that has seen them used in applications as diverse as the hunting invasive plant species in Australia and warding off rhino poachers in Kenya.)

For the past three years, Siemens has been using drones to conduct surveying work above the Aspern Vienna Urban Lakeside project in Austria,

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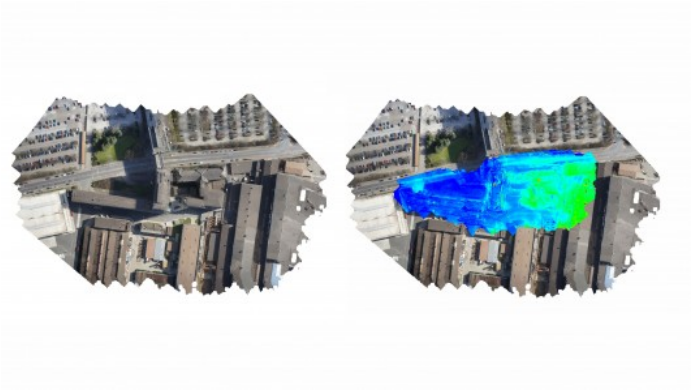
one the largest urban development projects in Europe. Last month it unveiled a pilot project whereby aerial data collected by drones combines with image processing software to visualize energy losses across entire neighborhoods. The data is then presented as thermal maps, making it easier to identify which buildings could be renovated to be made more energy efficient.



Down under, Australian firm Soto Consulting Engineers are using drones to monitor heavy industry and mining sites, scoping out large concrete structures, boilers and skyline conveyers to identify hard-to-spot structural problems.

"The high-res cameras allow us to pinpoint corrosion and use that as part of our report," Jim Allan, Chief Operating Officer at Soto explains. "The main benefit is the cost saving. It alleviates the need for cages and harnesses and safety requirements are reduced."

And according to Rory San Miguel, founder of Australian startup Propeller Aerobotics, there are significant savings to be made. Much like Skycatch in the US, his company offers drone services to companies looking for cheaper, higher quality aerial data. His aim is to create a standardized mapping interface for the surveying industry so that companies can benefit from consistent, easily digestible data.

"There is a AU$4 billion surveying and mapping industry in Australia, which at the moment doesn't involve drones," he tells Gizmag. "Surveyors are using tools like LIDAR that are very expensive and work very slowly. If we have a drone take off and fly in a grid pattern, taking a photo every 20 m (65.6 ft), we can cover the entire site very quickly and build 3D renders with true absolute accuracy. Like Google Maps on steroids."

So through monitoring and aerial mapping, drones are proving indispensable for forward-thinking companies looking stay one step ahead. By negating the need for expensive and heavy-duty safety equipment the robots are saving time and money, while also delivering precise information more reliably than is otherwise possible. But are drones capable of contributing more to construction than just gathering data?

Back in 2011, a team of roboticists from ETH Zürich's Institute for Dynamic Systems and Control offered a glimpse of what might be possible. The researchers presented a 6-meter (20 ft) tall tower constructed from 1,500 polystyrene bricks, every one of which neatly assembled without any assistance from a human hand. One by one, a fleet of flying robots dropped the pieces into place, guided by mathematical algorithms that took digital design data and translated it into flight paths.

In the time since, the team has continued to work on improving aerial construction and overcoming weaknesses such as payload capacity. Federico Augugliaro, a researcher at the Institute for Dynamic Systems and Control, says that no longer are the vehicles seen merely as passive onlookers capturing information about an environment, but are engaging with that environment in a meaningful way through manipulation, construction and the way they interact with humans.

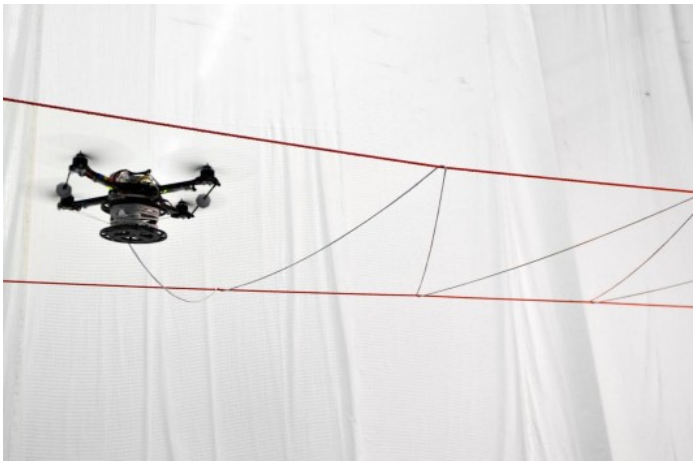
"Unlike cranes, drones have the ability to reach any point in space," says Agugliaro. "To have drones work close to humans on a construction site, however, their size has to be kept rather small. This limits the amount of payload they can carry and the amount of construction material that can be moved around."

The team is looking to more than just software and controllers to dictate the drone's movement, and are developing techniques that enable humans to reposition the drones with their hands.

"For the situations when drones and people will work closely together, some sort of compliant behavior on the drone side is desirable, both for safety reasons and convenience," says Agugliaro. "For example, instead of using a remote to pilot the drone, one can simply push the drone away."

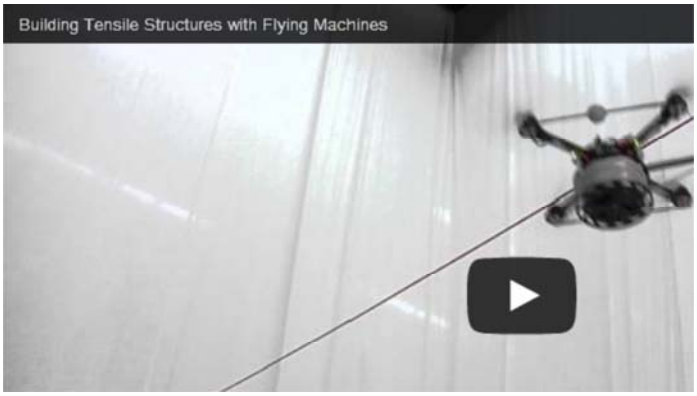
At the same time, the team is partnering with ETH Zürich Chair of Architecture and Digital Fabrication to investigate the kinds of structures drones might be capable of building.

"Aerial robots are generic and can be equipped with different tools to transport and manipulate material in different ways, but a key subject hereby is weight," Ammar Mirjan, a researcher at the Chair of Architecture and Digital Fabrication, tells Gizmag. "This motivates the investigation into lightweight construction systems. We are particularly interested in the fabrication of tensile structures such as cable-net structures and three-dimensional suspension structures that could not be built with other fabrications methods."



In Mirjan's view, a drone has a unique set of attributes that sets it apart from conventional construction machinery. The most obvious being that they are capable of flight, but also that they aren't limited to working in the one area and can access spaces that simply aren't accessible otherwise. This could

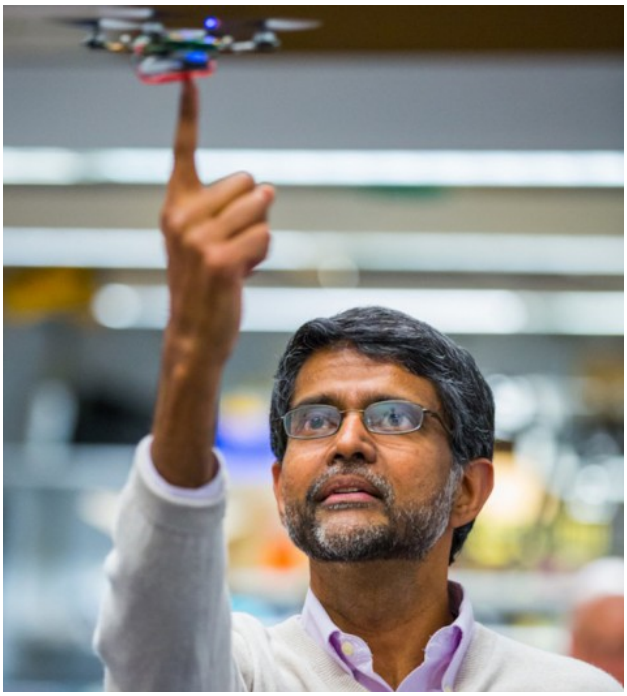
see them carry out construction in hard-to-reach places like between buildings or sites without access to streets. Furthermore, they have the ability interact and collaborate on structures that cannot be built by single machines (like cranes that are limited to individual tasks) and can also move through and around materials during the process.



"Since it will be difficult to imitate existing construction processes because the tools are so radically different, it is likely that the conditions of how things are designed and built will be altered and hence resulting in new forms of architectural materialization," says Ammar. "History suggests that new tools and technologies often shift existing processes. Drones in construction will enable architectural materialization in ways we cannot imagine."

So while architectural practices may be adapted to suit the capabilities of drones in the future – optimizing a system by which they can work productively with lightweight materials is one way of overcoming the payload problem – it's not the only way researchers are approaching this dilemma.

In February of 2012, Indian roboticist Dr Vijay Kumar delivered a TED Talk revealing the work of his engineering team at the University of Pennsylvania robotics lab. He presented a video demonstrating a fleet of robots flying in tight, centimeter-perfect formations, requiring them to calculate control commands 100 times per second to avoid crashing into one another. Banding together to form neat squares, rolling figure eights and various other patterns, the choreography on show certainly made for an impressive spectacle, but held more value than was reflected by the wows in the audience. As explained by Kumar, with an ability to fly in effect as one solid shape, it follows that the strength and carrying capacity of the drones multiplies.



Among the research currently underway at the Vijay Kumar Lab at the University of Pennsylvania is a project called "Cooperative Manipulation and Transport." This seeks to solve the problem of how autonomous robots can be made to work together to move large payloads by looking to nature. The team draws inspiration from ants and the way they collaborate to transport items of food much larger than the individual ants themselves. Kumar tells us that since his presentation in 2012, his team has improved the system in two ways. The first is the use of sensors, such as cameras, to determine the position of the neighboring robot, negating the need for communication between vehicles. The second is an ability to enroll larger numbers of small, ant-like robots in cooperative tasks. "Now theoretically, we can do hundreds," he says.

When it comes to overcoming the payload limitations of drones with a view to using them in construction, Kumar believes having them work together is the best way forward. While scaling the vehicles up could render them capable of moving heavy materials like girders and beams, this will also make them more cumbersome and sacrifice one of their key strengths: agility.

"Making individuals more powerful or stronger is possible, although this would make this large, unwieldy, heavy and awkward, especially when there might be need to maneuver in tight spaces and or adapt to differently sized payloads," he says. "This is why we prefer the small, modular solution. It is not only bio-inspired and elegant, it is also more practical and economical."

In Europe, a consortium of robotics professors from across the continent have come together to put this thinking into action. The Aerial Robotics Cooperative Assembly System (ARCAS) project is aimed at taking cooperative robot flight and using it to build real world structures. First though, it must establish solid scientific grounding for real world deployment of a flying robot workforce, and like other research efforts, is creating and solving new problems as it goes through the process.

"By using the cooperative control techniques we are developing in the ARCAS project, it will be possible to share the weight of the carried structures over a platoon of robots, hence further increasing the overall payload capacity," says Professor Vincenzo Lippiello from the University of Naples Federico II and one of the ARCAS researchers.

But Lippiello says this brings on another set of challenges, including designing control laws that take into account the destabilizing effect of having several drones hold onto the same object in the air and how sensing capabilities might be best integrated.

Another hurdle that the ARCAS project is working on overcoming is determining the ideal payload for the drones, a predicament that pretty well seems to hang over all researchers working in this area. Its first prototype tested indoors had a payload capacity of 6 kg (13.22 lb), the second saw this increased to 9 kg (20 lb) per vehicle. An upcoming prototype drone will have a total payload of between 15 and 20 kg (33 and 44 lb). It does say, however, that external factors could bring about advances in the carrying capacity.

"It is true that technological limitations exist and are mainly linked to the power to weight ratio of the current batteries," says Lippiello. "But the recent improvements of battery technology, mainly related to the cellular business, have also generated benefits for the drones performance in terms of autonomy and or payload."

So the value of drones in construction in terms of aerial mapping and surveying is pretty well established, if not yet entirely realized by the industry. As successful firms such as Komatsu, Siemens and Soto Engineering continue to lead the way, it seems logical that there will be more to follow, especially when we consider that the technology is only becoming cheaper and its benefits harder to ignore.

But for actually building the structures themselves? The general line of thinking among the experts we've spoken to for this story is that the technology is at least five to ten years away. But it appears that if it does come to fruition, it will come with its share of limitations. Drones as construction machines may spawn a new niche in architectural design just as the team at ETH Zürich anticipate, or they may cooperate to make light work of moving heavy materials, but even then it seems they will only amount to a technology that complements the construction industry, rather than truly disrupts it.

What we also know is there will need to be a serious economic case to get the drones out of the lab and onto construction sites. Delivery drones were unheard of until Amazon came along and professed that they had the potential to turn its business model on its head, and now here we are, with the technology more or less there and pilots projects being carried out all around the world. For flying robots to form part of construction sites of the future, their capabilities will need to align with the private interests behind them. This might involve scenarios where it is just not cost effective or physically possible to put human workers on the job.

"It's likely to be somewhere where labor is prohibitively expensive, or workers cannot go there," imagines Dr Kumar. "Think of us colonizing Mars. The first things that build for us there will be robots."

So if you think that using drones in construction is a pretty out of this world idea, in the end, you may just be proven right.

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About the Author

Nick was born outside of Melbourne, Australia, with a general curiosity that has drawn him to some distant (and very cold) places. Somewhere between enduring a winter in the Canadian Rockies and trekking through Chilean Patagonia, he graduated from university and pursued a career in journalism. He now writes for Gizmag, excited by tech and all forms of innovation, Melbourne's bizarre weather and curried egg sandwiches. All articles by Nick Lavars

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You can use it to carry small loads (but really small).

I have some doubts regarding use in textile craftsmen or as flying.

Germano Pecoraro
2nd March, 2015 @ 01:21 am PST

I have a problem with the use of the word 'drone', which I associate with the military. Drones for killing and surveillance, and 'aerobots' for other applications. These terms should not blur the meanings of constructive and destructive uses.

These aerobots have an enormous potential, and we will be seeing them applied in countless ways for our benefit.

owlbeyou
2nd March, 2015 @ 05:42 am PST

owlbeyou - I have a problem with the word "aerobots".

As for this article, I don't see DRONES building things anytime soon, they can't lift much, and have relatively small batteries.

Derek Howe
2nd March, 2015 @ 04:40 pm PST

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