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IT'S 8:45 IN THE MORNING and I'm sitting in the Georgia World Congress Center in Atlanta, listening to Wild Cherry's "Play That Funky Music" bump through the sound system of a dark, cavernous convention hall.

Surrounding me, accented by neon lights, are a few thousand robotics engineers. We sip coffee, check our smartphones, and await the official kick-off to Unmanned Systems 2015, one of the world's largest conferences and exhibitions for drones and unmanned robots.

The music suddenly becomes dramatic and much louder, and huge video screens on either side of the stage depict animated drones and robots of all types swimming, rolling, and flying. Colin Guinn, an executive with the

company 3D Robotics and host of the event's general session, bounds onto the stage with the energy of a cannonball.

"Welcome to Unmanned Systems 2015—let's get excited!" Guinn exclaims, raising his arms and clapping his hands. "There are over 7,000 of you here from 55 countries, more than 200 education sessions, and 350,000 square feet of exhibit space—that's four football fields of drones and other fun stuff!"

An hour later, with the crowd sufficiently pumped up, we stream into the vast exhibit hall and encounter a world that could have come from the imagination of Willie Wonka's tech-savvy younger brother. Drones, sensors, robots, and gizmos of all sorts are suspended overhead, rolling across the floor, swimming in tanks, and flying in netted enclosures. Every inch of the convention hall's four football fields of space buzzes with industry elites, eager startups, deep-pocketed investors, and curious onlookers like me, all preparing for a future when these robots will be as familiar to us as the phones we now carry in our pockets. The conference has a strong "we-can-change-the-world" flavor, and exhibit booths are rampant with pithy slogans like "Lock In the Unmanned Advantage" and, my favorite, "Making Tomorrow Today."

That optimism is shared by many public safety agencies and first responders, who see vast potential for unmanned systems—land- and water-borne robots, and aerial drones—to save lives and make firefighters, police, and emergency medical technicians safer and more efficient. As the technology rapidly expands and federal restrictions on operating unmanned systems become more defined, public safety agencies are scrambling to figure out how they can unleash this vast potential in a safe and smart way. NFPA has held discussions internally and with outside groups about the need to develop new codes and standards to aid first responders looking to use drones and robots. "I think there is great value to these machines and it's an area where NFPA can really help, because we understand the needs of first responders and the unique environments they work in," says Ken Willette, NFPA's Division

Manager of Public Fire and a former fire chief. “I see this as potentially being a whole new group of standards within NFPA’s library.”

NFPA has not yet received a formal request to develop an unmanned systems standard, but Willette and others think that could happen soon. If it does, NFPA would likely first focus on developing standards on selection, care, and maintenance, as well as professional qualifications for operators of unmanned systems, Willette says.

Meanwhile, the National Institute of Standards and Technology (NIST) is currently working to develop standard test methods to ensure that unmanned systems marketed to first responders perform as advertised. Related research projects are also taking place at universities from North Carolina to Hawaii, and in just the last year two sizable regional fire service workshops on drones were held in Maryland and Oklahoma. The Fire Protection Research Foundation has applied for a federal grant to hold at least two more of these brainstorming sessions.

“We thought we would maybe get 20 to 25 people, and we had 110 fire departments show up from all over Oklahoma, Kansas, Arkansas, and Texas,” says Jamey Jacob, the head of the new Unmanned Aerial Systems graduate degree program at Oklahoma State University, which hosted one of the workshops for firefighters. Meetings and discussions are crucial, he says, because the technology has advanced much faster than the rules and regulations on when and how to use it. “If we don’t get a handle on this,” Jacob says, “a lot of the departments are going to go off and do it on their own.”

World of possibilities

Walking through the expo in Atlanta, it’s easy to understand the enthusiasm for these machines. The Association for Unmanned Vehicle Systems International (AUVSI), which puts on the Unmanned Systems conference

each year, predicts there will be 1 million unmanned drone flights per day in the United States within the next 20 years. AUVSI also estimates that the industry will contribute more than $82 billion to the nation’s economy in the next decade. After agriculture, industry experts believe public safety and first responder applications will be the largest civilian market for unmanned ground, air, and sea robots. They predict that aerial drones, or “unmanned aerial vehicles” (UAVs), will be by far the most utilized.

The possibilities are enticing. Unmanned systems can quickly and safely go places humans can't: hovering outside the top floors of a high-rise fire, burrowing under rubble following an earthquake, searching contaminated areas following a chemical spill. They can also get to accident scenes faster than first responders because, as iRobot co-founder Helen Grenier tells me, “the quickest distance between two points is as the drone flies.”

Imagine an EMS crew being able to quickly dispatch a small drone to deliver anti-venom to a hiker bitten by a rattlesnake in a remote section of forest. Imagine deploying a fleet of three-foot-long autonomous boats, programmed to work in coordination to methodically complete a 10,000-square-mile ocean search in just hours. Imagine launching five-pound quadcopters to hover over a wildfire, where they can provide incident commanders real-time data on wind speeds and direction, thermal imaging, and visuals from multiple angles—all while providing a 4G wireless network for operation communications. How useful would it be if a drone could fly into a burning building, locate victims, quickly create a three-dimensional floor scan of the structure, and transmit that information to firefighters outside?

These are not fantasies—the technology exists, in various stages, and some of it is already in use. When the Chernobyl Nuclear Power Plant melted down in Ukraine in 1986, 30 workers and emergency responders died from radiation poisoning. However, in the similarly devastating 2011 Fukushima Daiichi nuclear plant meltdown in Japan, no fatalities were reported, in part because military ground robots called PackBots, outfitted with chemical, biological,

radiological, and nuclear sensors, were deployed to assess the scene in advance of emergency personnel. “They were able to gradually step into the problem, rather than throwing loads of men in to die later,” says Mike Edis, a product manager at iRobot, which manufactures the PackBots.

In 2014, rubber blast mats in a granite quarry in Branford, Connecticut, caught fire dangerously close to the dynamite being used to mine the rock. Branford Fire Chief Jack Ahern could not safely move firefighters in to extinguish the blaze because he did not know how far the fire was from the explosives. A volunteer on the department flew his hobby drone over the site to get a better look and was able to visually confirm that the explosives were a safe distance from the fire. Ahern ordered crews in.

There is a robot or drone application for seemingly any emergency. California has used drones to assist in wildfire efforts. Small drones were used in search-and-rescue operations after the Nepal earthquake earlier this year. Plans are in the works for drones to inspect bridges and survey train derailments involving hazardous chemicals. The U.S. Navy has even unveiled a prototype humanoid, bipedal robot to fight fires aboard its ships.

“In 10 years, UAVs will be just as important to firefighters as water to put on the fire,” Robert Doke, the Oklahoma state fire marshal, tells me. “They will be common pieces of apparatus for fire departments. With UAVs, the sky is the limit—it’s a bad pun, but it’s true.”

Regulatory complications

But aerial drones in particular face a significant challenge. While UAV technology is enormously promising and improving rapidly, there are few public safety agencies and virtually no fire departments in the United States currently using it. That’s because federal regulations on flying drones are so onerous, observers say, that they have effectively banned commercial UAV use in the United States for all but a few public agencies and businesses

willing to undertake a lengthy permitting process. Hobbyists, however, are free to fly with few restrictions.

This regulatory climate has frustrated the UAV industry for years. According to an economic impact report published by AUVSI in 2013, “the main inhibitor of U.S. commercial and civil development of the UAS is the lack of a regulatory structure.” Until the Federal Aviation Administration (FAA), which restricts the commercial use of drones on safety and privacy grounds, loosens its rules on drones, the nascent industry has little chance of taking off, according to the UAV business leaders I spoke with.

Drones, Robots and a World of Applications

See how first responders have already deployed unmanned systems.

As it stands now, in order to legally fly a drone, public safety agencies must first obtain a Certification of Authorization, or COA, and even then there are numerous restrictions on where, how, and when they can fly. The process of obtaining a COA can be long, difficult, and confusing for large fire departments with resources, and nearly impossible for small ones. “The FAA are bureaucratic ninjas—anything you throw at them, they’ll be able to push back on you and ask for more info and more details,” Jacob says.

The Austin (Texas) Fire Department, which about a year ago launched a new robotics emergency deployment team, is poised to become the first fire department in the nation to receive a COA to operate drones later this year. Coitt Kessler, who leads the team, told me that even with licensed aircraft

pilots on his staff, drones at their disposal, and time and indoor space to train and practice, the COA process has been arduous. “The rules are changing literally every week,” he says. “The FAA is trying to protect the airspace and is trying to do its best, but it is very confusing. There is no unified voice.” The FAA did not reply to requests by NFPA Journal for comment.

There is reason to believe this could all soon change. Under pressure from the drone industry, in February the FAA released proposed rules for small drones weighing less than 55 pounds. Under the proposal, drones could be flown without a COA, as long as operators passed a knowledge test and met a few other minimal qualifications. The rules included a number of conditions, including stipulations that drones only be flown during the day, within the line of sight of the operator, and below 500 feet. Many observers think it could take two years for the rules to be finalized, but recent developments hint it could happen sooner. In May, U.S. Senators Cory Booker, a Democrat from New Jersey, and John Hoeven, a Republican from North Dakota, introduced the “UAS Modernization Act,” with the aim of streamlining the regulatory process in the short term until the FAA’s final rules are set.

Drone industry insiders and those who follow it closely believe these developments could signal a sea change. “I think when we get a green light from the FAA, within a few months you’ll see fire departments utilizing UAVs,” says Doke, the Oklahoma state fire marshal. “In less than six months you’ll see fire department use increase rapidly as the price of UAVs falls.”

Currently, some hobby devices cost as little as a few hundred dollars, but more robust aerial platforms such as those likely to be used by public agencies can be in the thousands or tens of thousands of dollars—still substantially cheaper and easier to fly than any manned aircraft. Rapid adoption of the systems could bring costs down further, observers say, making them even more accessible.

The standards imperative

As the term suggests, disruptive innovation isn't always a smooth process, and public safety leaders warn that a lot of groundwork needs to be done before unmanned systems can become safe and effective tools. Without proper policies, procedures, training, and equipment, the unmanned era could flounder badly with missteps and wasteful spending before it ever gets off the ground. "We don't have the budgets to get it wrong—we have to get it right the first time," Kessler tells me. "That process starts with groups like NFPA setting standards."

There are a lot of considerations to weigh before the systems are ready for deployment—some obvious, some not, according to NFPA's Willette. For instance, is it safe or even possible to operate an unmanned system if the operator is wearing full personal protective equipment? Most unmanned systems are controlled via radio frequencies—will that affect fireground communication, or otherwise interfere with the other high-tech fire service equipment that uses wireless and Bluetooth technologies? Can unmanned systems withstand heat, chemicals, water, smoke, flying embers, and the other hazards they are bound to encounter on the fireground? "The standards need to look at safety from the operator's point of view," Willette says. A great deal of research is already going on in aspects of unmanned system performance, operation, and procedures for first responders, work that would likely inform any future NFPA standard on unmanned systems.

Among that research is the work taking place at NIST. If the Unmanned Systems 2015 event is a glittery Broadway production, then Adam Jacoff's laboratory at NIST is the rehearsal space. For nearly a decade, Jacoff, the test director of the Intelligent Systems Division at NIST, has worked to develop standard test methods to make sure that drones and robots perform as advertised for the Department of Defense and, more recently, the civilian public safety market. So far he has developed 15 standard test methods, with another five to be added this year, which reliably measure baseline robot and operator capabilities necessary to perform a specific task defined by the

military and emergency responders. These standard tests are currently published by ASTM International.

With so many robots and drones and so many possible scenarios and uses, it is a daunting task that will keep him busy the rest of his working life, he says. “Out of necessity, we very quickly got out of mission-specific tasks and focused on more robot-specific tasks—they all need visual acuity to some degree, radio communication, endurance, and mobility in terrain,” Jacoff says. “Once we start breaking it down into robot space, the job gets a lot easier, and figuring out where the gaps are is not so hard. We are getting quick at adapting and expanding the different test scenarios.”

NIST is currently documenting the capabilities of the unmanned systems and is leaving it to buyers to determine if those capabilities match their needs. It’s valuable information, but for many public safety departments, it may still be difficult to know exactly what to purchase. That’s where NFPA could help, Jacoff says. “NFPA’s experience in standards development would be very valuable to this,” he says. “If NFPA wanted to adopt or define the equipment-level version of what we’re doing at NIST—take that body of work and substantiate it as a standard robot with all of the thresholds set—that might be the perfect one-two punch.”

In May, NFPA officials met with ASTM International, which publishes NIST’s performance standards, to discuss how NFPA could complement the work being done at NIST to create an equipment standard for first responders.

“It plays to our strengths perfectly—we don’t necessarily have the expertise to assess the technical capabilities of unmanned systems, but we do have the knowledge necessary to select, care for, and maintain highly technical pieces of equipment,” Willette says. “We also have experience in the area of breaking down what a responder needs to know and the capabilities they need to have.”

Having serviceable drones and robots and being able to operate them is just the start—stakeholders also have to know when to use them and how, says Jacob of Oklahoma State. “You have to know what type of vehicles should be deployed, in what manner you should deploy them, and how you should integrate them” into current operations, he says.

There appears to be no shortage of people trying to answer these questions. The National Disaster Preparedness Training Center at the University of Hawaii, which prepares training programs for the Federal Emergency Management Agency, is working to develop a course on how to integrate unmanned systems into existing disaster procedures and to create new procedures. In 2012, the Institute for Transportation Research and Education’s NextGen Air Transportation Center at North Carolina State University conducted a series of wildfire-related tests using four drones at varying heights during a controlled burn in Florida. Researchers were trying to determine how well the drones’ sensors can detect key changes to conditions on the fire ground, as well as how to transmit that information to incident commanders and then disseminate it to firefighters on the ground in real time.

“That’s the important thing—having some concept of operations,” says Tom Zajkowski, a flight operations manager of the NC State center’s UAS program. “Without that, a drone is really just a shiny toy in the air.”

There are numerous federally funded unmanned systems test sites around the country, including one in Oklahoma funded by the Department of Homeland Security specifically geared toward testing small UAVs for use by first responders. The site hosts two or three vendors per month running through various mission scenarios, including search-and-rescue, active shooter, and wildfire.

From the Rubble

From Fukushima to DARPA, the evolution of robots.

In addition to testing the capabilities of unmanned systems, a primary focus of the Oklahoma program is on developing operational procedures, says Stephen McKeever, a professor of physics at Oklahoma State and the state’s secretary of science and technology. “The technical community can solve the technical issues,” he says. “There will be drones specific to these vocations that have all the right sensors. But being able to get data is one thing—how to use it is another. That’s where training comes in.”

NFPA’s involvement might also help lend credibility to the concept of unmanned system use in the fire service, says Kessler, who, as a leader of one of the few fire departments to seriously explore the use of drones, understands how delicate the proposition can be. The public remains unsettled about the use of drones from both a privacy and safety standpoint, even in emergency situations where the deployment of drones could offer a clear benefit. Following the deadly March 2014 mudslide in Oso, Washington, for instance, county officials wanted to deploy drones to search for survivors in

areas where it was next to impossible for first responders to reach. Those efforts were scuttled for more than a month, however, when neighbors, citing privacy concerns, lobbied officials to not allow the use of drones. A drone was allowed to fly for 48 minutes in late April to make a 3-D model of the slide area for engineers to use for reconstruction and recovery.

In the future, having an already established consensus standard on procedures for operation and data retention could go a long way toward quelling some of those fears, Kessler says. “I think if we can show professionalism from the start, which NFPA can help with, perhaps that trust game with the public goes a little bit faster for the people following us,” Kessler tells me. “But right now we are the pioneers. I’m sure that the fire departments that follow will have a lot easier time with this issue than we have had.”

The future belongs to users

At the Unmanned Systems event in Atlanta, the conference hall still hums with activity. A group of young engineers poses for a picture in front of a full-sized unmanned Apache helicopter. A guy casually peruses the exhibit floor while operating a remote-controlled vehicle—the tank-like machine appears to weigh several hundred pounds—that prowls the aisle in front of him. A metallic orb-shaped drone buzzes in the air ahead of me as the inventor tells onlookers that it can crash through a window, right itself, and take off again. In a small upstairs conference room, during a talk on unmanned maritime systems, Bruce Hanson, an executive with a company called MARTAC, displays a three-foot-long robotic boat—an “unmanned surface vessel.” The craft, sleek and low-slung, looks like it was hatched during a meeting of Batman’s design team.

You can’t help but be in awe, and at the same time wonder what on earth (and air and sea) we’re going to do with all of these things. It’s a question for which most conference attendees have an answer chambered and ready. But in reality, Hanson tells his audience, it’s really up to all of us—including fire departments, emergency management officials, law enforcement agencies, standards developers, and more—to decide. “If the technology is cheap enough, the users will innovate what they do with it,” he says, brandishing his Batman boat. “There are so many applications for these unmanned systems. We don’t even know what most of them are yet.”

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