CRJ R&D: First responder safety

This issue's regular section, curated by **Ian Portelli** and **Megan Mantaro**, looks at how new technology could provide a solution to the increasing risk of firefighter fatalities, as well as looking at a device that can sense dangerous chemicals

In serious fires, it is usually firefighters who are most at risk. While developments in personal protective equipment have been significant, fire crews still often have to venture directly into the blaze. In 2014, there was a total of 92 onsite fatalities recorded by the US Fire Administration and 2015 saw a total of 87 fatalities.

While it is evident that we must continue to strive to improve the efficiency of fire prevention measures, in terms of enhancing personnel safety, robots and drones may prove to be an important solution to the increasing problem of firefighter fatalities.

Many different robots and drones are currently being developed in order to reduce the threats. One such example is the Aircore Turbine Aided Firefighting Machine (TAF 20), demonstrated by Magirus at Interschutz 2015 in Germany and which has recently gone into service in New South Wales, Australia.

The TAF 20 features an extinguishing turbine mounted on a compact crawler vehicle. The turbine is fitted with a nozzle ring that atomizes water and extinguishing foam to form fine particulate matter, distributed by a propeller. The spray action is variable, ranging from a mist that spreads over a wide area, to a water jet with a wide projection range. Thanks to the integrated lifting function and the adjustable angle of incline, the extinguishing agent can be distributed over a wide area, and changes in wind direction can be compensated for.

In addition, TAF 20 can be remotely controlled from a distance of up to 500 metres, keeping firefighters at a safe distance from the fire. The vehicle also features a fan to clear smoke and a bulldozer blade that can move aside large obstacles – such as cars and rubble.

Similar in many ways to TAF 20 is Thermite 3.0, a robot developed by Howe & Howe Technologies in Maine, USA. This is a much smaller unit, supposedly able to fit into an elevator. The compact robot's monitor nozzle operates at 600 to 1,000 gpm, a force that would otherwise require around six to eight firefighters to control. This machine can be controlled up to a quarter of a mile away and can easily traverse multiple forms of terrain.

Though fires on dry land are dangerous enough, the possibility of a fire on a vessel poses an even greater risk to passengers and crew onboard, as there is limited access to proper firefighting equipment and personnel. The US Navy, therefore, is working with researchers from Virginia Tech to develop the Shipboard Autonomous Firefighting Robot (SAFFiR).

Standing at 1.77 metres tall, SAFFiR is a humanoid robot designed both to prevent fires from occurring on board a ship and to tackle them should they break out. Its ability to sense dangerous gases, open doors and handle fire hoses, and navigate through them would be invaluable when assisting firefighters on any vessel.

Work is underway to develop omnidirectional walking capabilities for the robot so that it can balance in sea state conditions and traverse obstacles. In addition it can make use of a broad range of fire suppression technologies and will be designed to work with human firefighters, responding to gestures and commands.

Intelligence and assessment

Other robots are useful not just for stopping the fire, but also for gathering intelligence. Skyfire's Unmanned Aerial Vehicle (UAV) is a flying drone that offers a technology to provide vital situational awareness during firefighting operations.

The drone arrives at the scene within seconds and assesses the urgency of the situation by evaluating the local environment. It can access areas that are too hazardous for human responders and helps to perform search and rescue operations by locating victims. It can also be used to identify possible threats in order to prevent them from evolving into something more serious. The drone's cameras provide real-time video, while its gas sensors can evaluate possible causes for alarm, much like the US Navy's SAFFiR.

Meanwhile, researchers from KAIST, a public research university in South Korea, have developed a wall-climbing scout drone to fight fires in high-rise buildings. The Fireproof Aerial Robot System (FAROS) can pinpoint the source of the blaze and locate people trapped inside, transferring data in real time from the scene to the ground station.

An extended version of Climbing Aerial Robot System (CAROS) that the same research team created in 2014, the FAROS can also fly and climb walls.

The scout drone's movements rely on a quadrotor system; it can freely change its flight mode into a spider-like crawl on walls, and vice versa, facilitating unimpeded navigation in the labyrinth of narrow spaces

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filled with debris and rubble inside a blazing building.

The drone uses a 2-D laser scanner, an altimeter, and an Inertia Measurement Unit sensor to navigate autonomously. With the localisation result, and using the thermal-imaging camera to recognise objects or people inside a building, the FAROS can also detect the fire ignition point by employing dedicated image-processing technology.

The drone's body is covered with aramid fibres to protect its electrical and mechanical components from the direct effects of flames. The aramid fibre skin also has a buffer of air underneath it, and a thermoelectric cooling system based on the Peltier effect to help maintain the air layer within a specific temperature range.

It is important to note that these machines are not designed to replace firefighters per se. Current technology is far from being completely autonomous, because although some functions of these drones and robots do not require human control, many of them do. Indeed, their intended use is to facilitate firefighters' jobs instead, and keep them safe from harm. It is, after all, always preferable to lose a robot or a drone to an environmental hazard than a human life, no matter how expensive that machine may be. C•RJ

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- **Links:** *www.magirusgroup.com; www.firefightrobot.com; www.onr.navy.mil; www.skyfireconsulting.com; www.kaist.ac.kr*

Protecting first responders against unseen chemical hazards

The toxicity of smoke in major fires presents a significant threat beyond oxygen depletion, containing significant carbon monoxide, for example. Whenever present, the compound will bind to haemoglobin in a position ordinarily reserved for oxygen. Hydrogen cyanide, which drastically halts human metabolism, is also a potent toxin released when a building burns.

Symptoms of smoke inhalation include a severe cough, shortness of breath, reddening of the eyes, and a headache. However, these are generally short-term problems. Civilians are not often caught in situations where smoke can actually threaten their health, at least not as often as the firefighters who protect them. Firefighters confront not only the fire itself, but also the toxins in the smoke. Naturally, firefighters have breathing apparatus protection to deliver oxygen for a specified period of time. But despite that, there is still a constant exposure to the toxins.

Indeed, firefighting is a job where lung cancer can prove to be a serious occupational hazard. In 2010, the US National Institute for Occupational Safety and Health (NIOSH) began a lengthy study to evaluate the incidence of cancer among firefighters. By the end of its first phase in 2013, the study found that firefighters have a higher risk of developing cancer of the lungs, digestive, or urinary tracts. In particular, the study also found that firefighters are at twice the risk of developing mesothelioma compared with the general population. Cancer aside, in 2013, over 17,000 firefighters in the US suffered an injury from exposure to chemical hazards.

Hazardous chemical exposure can go unnoticed before the first responder feels any symptoms. It is therefore crucial that firefighters and other emergency personnel be able to detect these threats and remove themselves from the situation before receiving any harm.

The Department of Homeland Security has begun funding research to develop ChemTag, a personal chemical warning device. The goal is to create a device durable enough to withstand the harsh conditions faced by responders without burdening the life-saving efforts they provide. The low cost, user friendly device will detect levels of gasses like carbon monoxide, hydrogen cyanide and methane, alerting the wearer if these levels go above nationally-defined safe limits.

Partnerships have been developed with the Los Angeles Fire Department, Los Angeles Police Department, and the Chicago Fire Department to test the effectiveness of the device in the field.

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Robots and drones are being designed to keep firefighters safe, not to replace them. Pictured here is the TAF 20 from Magirus

Magirus