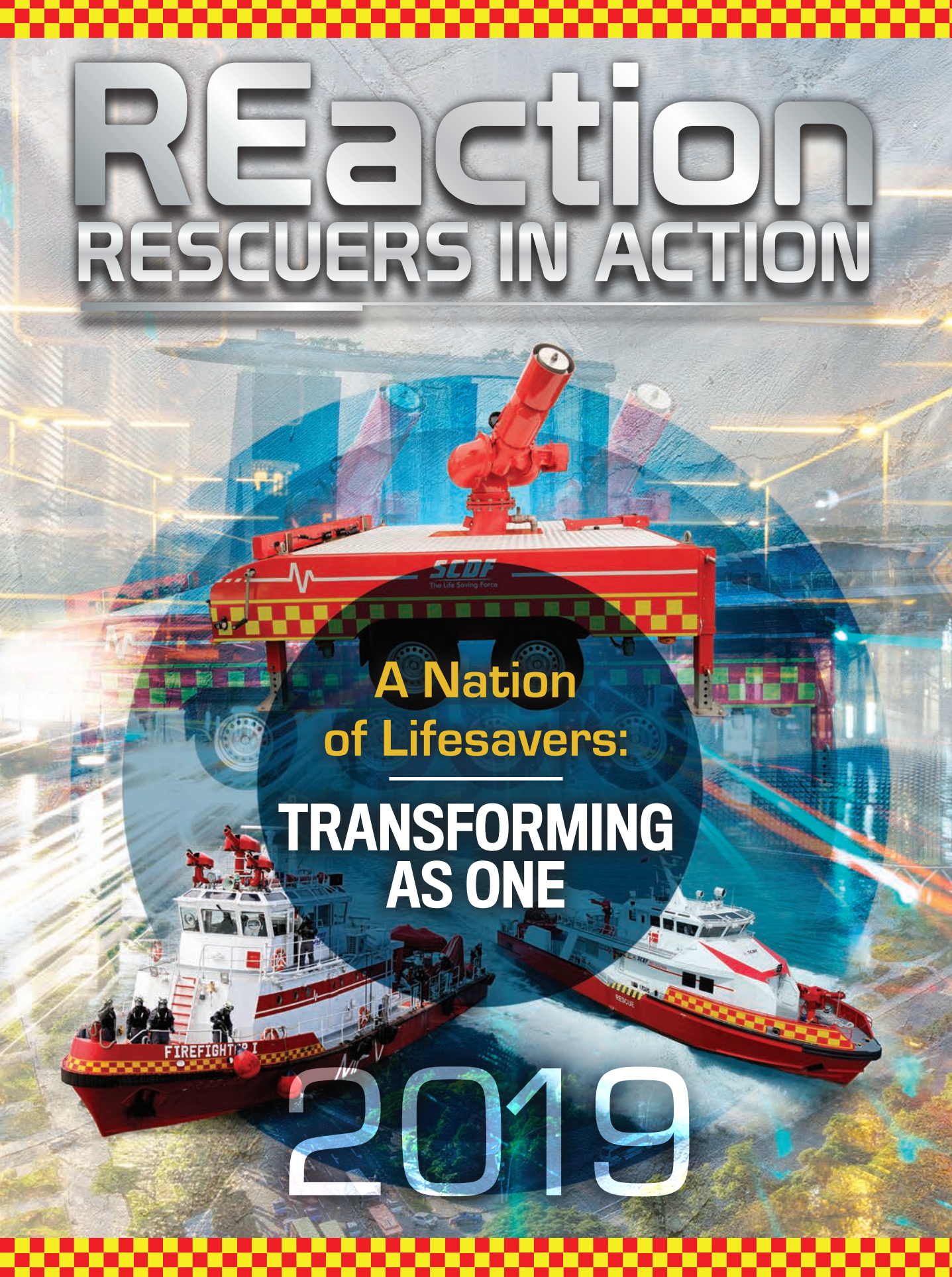
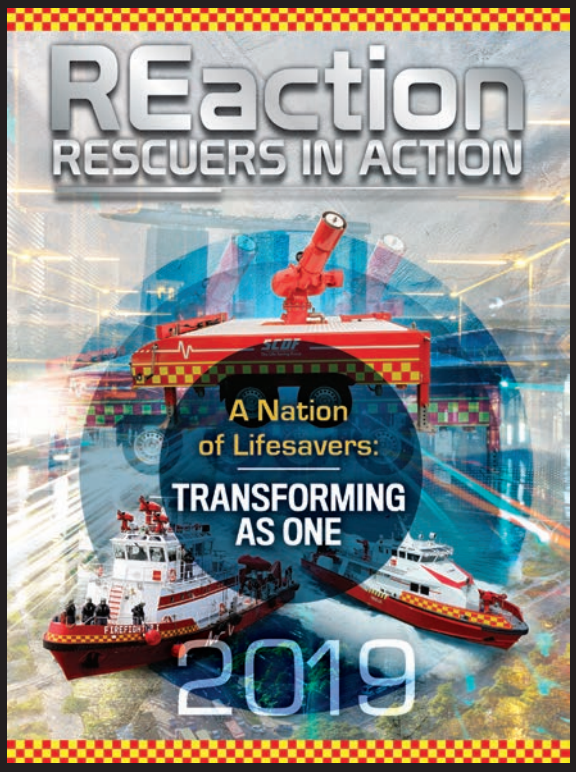
REaction
RESCUERS IN ACTION





REaction

"REaction – Rescuers in Action" is the SCDF's annual technical publication that aims to be a platform to invoke thought-provoking discussions by sharing knowledge and case studies.

The publication provides an array of articles covering a myriad of subjects, as we envision it to be a repository of knowledge for both academic and practising readers in the emergency services fraternity. We hope that you have gained new insight and found REaction beneficial to you.

Please address all contributions and correspondence to:

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COMMISSIONER'S FOREWORD

On behalf of the Singapore Civil Defence Force (SCDF), a warm welcome to all guests and participants to the Singapore-Global Firefighters and Paramedics Challenge (SGFPC) 2019. It is heartening to see that what originally began as a local inter-unit competition has evolved into the present day SGFPC – a global platform for the sharing of firefighting, rescue and medical knowledge, and an invaluable dais for the demonstration of the rigors of our profession to the public. We are truly grateful for the support and participation of our valued partners, many of whom have also been involved in previous editions of SGFPC.

Last year's edition of REaction, published in November 2018, gave an in-depth view of SCDF's advancements in the areas of manpower transformation and infrastructural developments. The publication also introduced new hardware that emergency first responders can adapt to their rapidly changing work environment.

In support of SGFPC 2019's theme, "**A Nation of Lifesavers: Transforming as One**", REaction 2019 delves into the technologies and innovations that SCDF is implementing to push the boundaries of emergency response. This edition will give an insight into the application of the virtual environment in training and operations with Extended Reality (XR) which includes present-day immersive technologies such as Mixed Reality (MR) and Augmented Reality (AR). SCDF plans to embrace these features in its Simulation Centre in the new Civil Defence Academy as technology matures. In addition to republished articles from UK Fire Magazine and International Fire Fighter Magazine, we are also pleased to feature article contributions from Fire and Emergency New Zealand, and the Keio-NUS CUTE Centre. This supports our greater goal of extending our outreach, not only internationally, but also beyond the emergency response fraternity.

I would like to express my appreciation to all article contributors for REaction 2019. I wish you an engaging read and hope that the REaction publication continues to stimulate and invoke thought-provoking discussions amongst all readers.

Eric Yap
Commissioner
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BEYOND VR: EXTENDED REALITY

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A team of researchers and developers from the Keio-NUS CUTE Center at NUS has developed a novel extended reality (XR) platform to provide users with engaging multisensory interactions and unique player VR experiences. Achieving remarkable immersion by tapping into users' sense of sight, sound, touch, temperature and smell, the platform looks beyond traditional VR experiences to the potential of delivering a wide range of exciting multisensory applications.

CUTE Center: Crossing the lines between virtual and reality

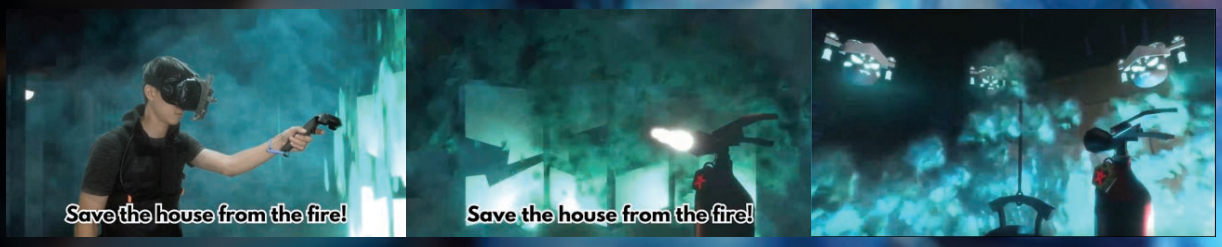
CUTE Center's tagline "Creating Unique Technologies for Everyone" embodies the centre's goal - to create new experiences that engage and blend the different senses with advanced technologies into novel and memorable experiences that is available to all.

CUTE aims to push the boundaries of what is possible in interactive, social and communication media with its multi-disciplinary team of designers, engineers, developers and researchers who are uniquely positioned to cross-pollinate topics and generate impact across engineering, design, computing and social science disciplines.

Consequently, CUTE Center has developed an expansive portfolio of projects, from VR training simulations for responding to mass casualty disasters, to novel multisensory approaches to digitally augmented eating and drinking.

What is 'The Lost Foxfire'?

A prime example of CUTE Center's recent multi-disciplinary work, 'The Lost Foxfire' is a 10-minute XR gaming experience that puts the user in the shoes of a caretaker who is tasked with looking after an old Japanese temple for an evening. The game sees players navigating the virtual environment to extinguish fires that are being caused by a wandering foxfire sprite - a spirit bride who becomes lost in the



Snapshots of gameplay from 'The Lost Foxfire' XR experience.

temple on the way to her wedding. Throughout the experience, players must skillfully avoid foxfire decoys that are summoned to distract the player from extinguishing the real foxfire and the dangerous fires it leaves behind.

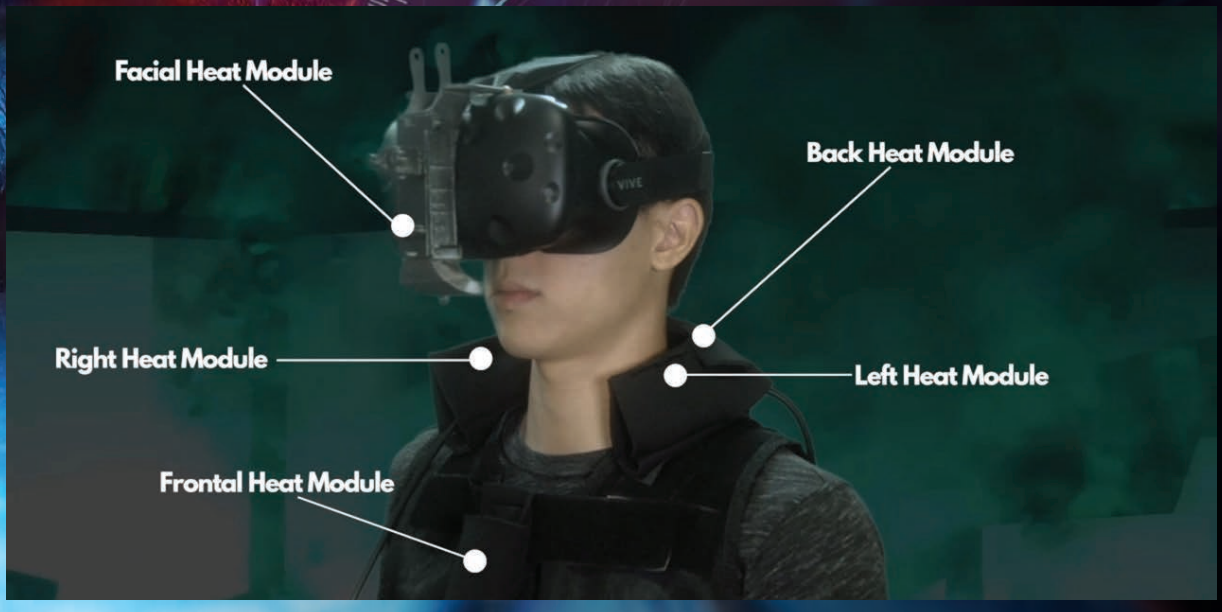
Unlike traditional audio-visual VR experiences, players of 'The Lost Foxfire' need to engage not only their senses of vision and hearing, but also their senses of olfaction (sense of smell), somatosensation (sense of touch) and thermoception (ability to sense intensity of heat) to successfully complete the game. For example, as players spray the original foxfire spirit with a fire extinguisher, they will catch a whiff of the scent of apples, a favourite fruit of foxes. In other scenarios, players who get close to the foxfire will experience real-world thermal cues representing heat emitted by the spirit.

In this XR experience, the inclusion of multisensory cues is two-fold. Firstly, as the core aim of the XR platform is to immerse the user, the engagement of multiple sensory channels with congruent information helps the user to achieve a believable sense of presence in the virtual environment. Secondly, the engagement of multiple sensory channels also acts as a novel interaction mechanic by supporting the narration of the story and guiding users to fulfil the aims of the gameplay.

How do we achieve multisensory engagement in VR?

To simultaneously engage multiple sensory channels of the user, 'The Lost Foxfire' game system comprises a VR headset that is paired with a configurable multisensory suit, which delivers thermal, wind and olfactory stimuli to the players. As players navigate and interact with the XR experience, events in the virtual environment trigger corresponding multisensory stimuli in real-time.

The adjustable suit is equipped with five heat modules that enable players to sense heat on the front, back and the sides of their neck, as well as on their face. To deliver thermal stimuli to the user's skin, each module uses heating elements to control the temperature of air passing through the module and directed towards the user. In addition to thermal stimuli, the system also includes a smell emitting module that uses airflow to deliver scents to the user's nose. Catering for the unique thermal and olfactory sensitivity of each user, the system features functionality to calibrate these stimuli, customising the experience to



A diagram highlighting the placement of Heat Modules in the system.

an individual's personal tolerance of different temperatures and scents.

As described by Associate Professor Yen Ching-Chiuan, Co-Director of the Keio-NUS CUTE Center who supervises on the project, "The set up for 'The Lost Foxfire' game system is entirely portable so it can be put up in any room. The additional sensory cues in the form of heat and smell create a more immersive gameplay environment for the players, something rarely seen in current games."

The team comprising hardware and product engineers, artists, technology researchers and designers took nine months to develop the experimental game — from its conception, coding and building of special hardware, to graphic designing and animating. A patent has been filed for the technology behind the configurable multisensory suit.

What's next for 'The Lost Foxfire' and extended reality experiences?

'The Lost Foxfire' recently debuted at the Tokyo Game Show 2019, the world's largest annual video game event that spotlights the latest trends and cutting-edge technologies for video games, in September 2019. 'The Lost Foxfire', the only project hailing from Singapore, was one of 86 projects that were chosen from 320 independent projects around the world for the Sense of Wonder Night showcase.

Applications for Singapore Civil Defence Force (SCDF): Going Full Circle

Unknown to most, 'The Lost Foxfire' system originated from a fire escape prototype for which the suit was first developed. The prototype was developed with consideration for applications that will benefit SCDF and with an intention to educate the general public on fire safety and actions to take when escaping from a burning building.

In Fire Escape, players had to escape from a burning Housing Development Board (HDB) flat – the standard format of government-built public housing apartments - after a Personal Mobility Device (PMD) catches fire. In this scenario, players wore the thermal suit alongside hand-mounted heating modules to detect fires by feeling for heat coming from the other side of closed doors. Adding to the multisensory experience, players also had to physically crouch to avoid inhaling smoke. The headset was designed to emit a strong, choking, smoke scent that reduces in intensity as the player crouched, giving players that immersive experience not found elsewhere.

Play testers had commented that it was "stressful" playing Fire Escape due to how "real it felt", which was the intention. The prototype was a little too tense for game shows, and hence, it was repurposed with a game overlay, so as to make it more accessible to general gamers at Tokyo Game Show.

Building on the success of 'The Lost Foxfire', the multisensory suit and experience can be extended and developed further to provide a truly immersive training experience that enables SCDF responders to sharpen their operational edge. With further customisation of the virtual environment and scenarios, the multisensory experience can provide an ultra-realistic simulation

to train responders on different elements of fireground operations such as risk assessment, firefighting technique, optimal movement for offensive firefighting and search and rescue in a hazardous high-heat environment.

Enhancements to the suit could see deeply realistic replications of the same salient sensory cues in a virtual environment – such as the distance and direction of heat from a fire, the smell of burning materials, airflow and vibrations from the impact of explosions or tactile sensations such as vibrations from various firefighting and rescue equipment. In parallel with engaging more of the user's senses, future system developments can look towards amplifying thermal stimuli with novel delivery techniques, such as providing contact heat and other haptic sensations through touch pads on the user's body.

Future development of the suit would be to extend the nature of the plug and play system to simultaneously engage one or more of the five senses in the human sensory system – visual, audio, touch, smell, and even taste. This will make the suit more flexible and portable to adapt to various situations. Users can configure the inputs based on their needs and requirements. This will enhance the experience delivered by the suit beyond entertainment and games, to simulation and education.

In summary, 'The Lost Foxfire' highlights the potential impact and applications that can be provided by future work in the field of extended reality. By developing an experience that engages additional senses beyond traditional audio-visual VR platforms, CUTE Center has drawn upon a range of capabilities - from technology to physical embodiments - to redefine immersiveness and showcase what they believe to be the future of VR towards extended reality.

Acknowledgment: *The research is supported by the National Research Foundation, Prime Minister's Office, Singapore under its International Research Centres in Singapore Funding Initiative.*

Definitions of VR/AR/MR/XR

- Virtual Reality (VR) is a simulated experience which uses computer technology to construct a virtual environment. Unlike traditional interfaces, VR places the user right in the middle of an experience, rather than viewing it off a screen.
- Augmented Reality (AR) is an enhanced version of reality created by superimposing computer generated imagery onto the user's actual environment in real time.
- Mixed Reality (MR) builds upon the technology present in AR by allowing physical and digitally generated objects to co-exist and interact in real time.
- Extended Reality (XR) interfaces VR/AR/MR technologies with physical tangible objects that users can wear, pick up and interact with. These physical objects usually provide different forms of sensory feedback in terms of touch, smell, heat, and even taste on top of the visual and auditory cues. The Lost Foxfire is a prime example of XR.

MIXED REALITY IN EMERGENCY MEDICAL SERVICES (EMS) TRAINING

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The National Emergency Medical Service Training Centre (NETC) aims to be at the forefront of Pre-hospital Emergency Care (PEC) training, incorporating modern pedagogies with the newest technologies to aid and enhance the learning process, and ensure greater knowledge retention and application. One of the tools used in this endeavour is the application of Mixed Reality (MR) technology.

Background of Change

With SCDF as the leading PEC provider in Singapore, the NETC functions as an independent national institution providing sustainable solutions for the increased training volume and re-certification requirements of our career paramedics, Emergency Medical Technicians (EMTs), Full-Time National Servicemen (NSFs), and Operationally-Ready National Servicemen (ORNSmen). Since the Civil Defence Academy (CDA) opened its doors in 1999, traditional methods employing "standardised patient[1]" and simple doll-like mannequins have been adopted. Over the years, we have also seen more sophisticated mannequin models entering the market and have bought some of them for our training use.

Current PEC medical simulation used in training and assessment in CDA includes the use of low and medium fidelity mannequins that are able to replicate the physiology of the human body such as laboured breathing, cardiac conditions, and even pre-recorded speech. However, replicating other conditions such as traumatic injuries, require moulaging skills which is time-consuming for multiple uses in a day. The use of mannequins also requires power connectivity. Often, the need for a constant power source limits the use of the mannequin to a clinical room setting. Otherwise, a mobile power source demands frequent charging for usage during long periods.

[1] Standardised patient is a common term used in the medical field for actors playing the role of patient. This simulated patient is an individual trained to act as a real patient in order to simulate a set of symptoms or problems.

Moreover, scenarios that detail the hazards and conditions found at the patient site are verbally given to trainees. In other words, the current training landscape does not provide the cognitive and exposure to skills that needs to be developed for the real-world setting.

So what is Mixed Reality?

In order to understand Mixed Reality (MR) technology, it is pertinent to define the two extremes that make up the spectrum within which MR operates. The technology of alternative realities began with Virtual Reality (VR) in its most rudimentary form – films loaded into a viewer in the 1950s. It has since developed over the next 60 years into its current form where an entire virtual world is created and where digital elements are fully interactive. The most popular examples are found in gaming systems and in learning and experiential platforms where the environment cannot be recreated adequately, such as in the National Aeronautics and Space Administration (NASA) training programmes.

Soon after, Augmented Reality (AR) was developed, usually by overlaying the virtual avatars over an object. This provided the possibility of introducing a digital object into "reality" and the ability to interact with it.

MR is the use of technology to combine real world and virtual objects. The two spectrums co-exist and interact to varying degrees depending on user preference. A virtual object can be built around a real-world entity allowing the user to move safely around the environment while interacting with the digital object at the same time. For example, a room can be filled with virtual objects to substitute the real-world dimensions of digital rendering such as furniture, a burning car, or even an avatar. The user can then interact with the virtual object, along with other audial, haptic, and somatosensory simulation inputs to create realistic and interactive environments to serve educational, entertainment and presentation purposes. The only limits of the possibilities that can be achieved in MR are those set by the developer's imagination.

MR in EMS Training

Although MR is a relatively new technology in the healthcare sector, there is great potential for MR to be employed for EMS training as it can replicate environmental hazards that would be beneficial for learning. MR also has the potential to address some of the training and assessment gaps, such as to increase the fidelity of training and the development of cognitive and decision-making skills of all PEC providers trained in CDA.

Scenario training

By incorporating MR technology into instructional methods, realism in training can be greatly enhanced. This will increase learning effectiveness and assessment efficiency in the conduct of EMS training. The MR-enhanced training environment will allow trainees to learn EMS skillsets in an environment that is safe yet mentally and physically challenging to allow for deeper imprint of learning objectives. Such a training environment will also allow for the exposure and conditioning of EMS personnel to different types of medical situations.

In conjunction with companies specializing in the development of virtual and mixed reality environments, SCDF has created a multiple casualty scenario in MR format as a pilot proof-of-concept. The moment the headset is donned, the space the user is in will be transformed into a scene depicting a fire with casualties suffering from injuries of various severities. The user is required to identify hazards, and perform their tasks while maintaining a safe distance. The user is also required to triage the casualties in the scenario in order of priority and render the appropriate treatment. Within the scenario, it will be possible to hear the accompanying chaotic sounds, such as the shouting and screaming from the injured, or the heavy breathing sounds of the patients. Besides visuals, MR presents auditory and somatosensory stimuli which will engage the trainees to make the best decision possible given the environmental condition and the resources at the time of assessment.

Because of the portability of the MR system, the scenario can be rendered in any room or outdoor space, allowing the trainer to see what the trainee sees via a laptop and the rendering software. Furthermore, the scenario incorporates rendering of injuries onto the mannequins currently in use in CDA, allowing the trainer to simulate the conditions with less manpower and in less time required otherwise to moulage the mannequin.

Initial user reviews have been positive, mostly surrounding the realism of scenarios that truly enhance decision-making, and provides a guide to the actions required to assess a casualty, which ultimately builds repetitive action indoctrination in patient assessment. The positive reinforcement training method and gamification of the scenario in the software also encourages learning and aids in building a competitive spirit amongst trainees.

In terms of areas of improvement, issues ranged from user familiarity with the headset to certain actions that were deemed difficult to execute. There were also some connectivity issues in the presence of high signal interference from other mobile devices. These are areas related to the technological limitations of the first-version device and software which SCDF aims to tackle by using alternative or upgraded models in time to come.

SCDF is also looking to develop programmes and leadership modules that will enable trainees to gain and retain knowledge as well as hone their scene appreciation skills respectively.

Bringing books 'alive'

The first step in becoming a paramedic, or any other health professional, is to have a keen understanding of the human anatomy and physiology. When there is a good appreciation of the way the human body functions, it leads to the paramedic having the ability to then discern between a healthy individual and a severely-ill person. Besides rote learning methods, in modern pedagogy, trainees are taught these concepts through peer assessment, small group learning, and e-learning. In order to take teaching methods

to a higher level, SCDF has endeavoured to take advantage of the fact that most of the current generation of young adults are exposed to games where they interact with digital objects in a virtual world, although not fully immersive. There are also educational programmes that already employ such AR applications. As such, it becomes logical to continue education in that facet and move away from traditional methods of teaching.

The idea is to develop a fully virtual world where a human body can be explored layer by layer, system by system or even down to a cellular level depending on the topic that is being taught for the day and the objectives that the trainer is aiming to achieve. In a context where formally only those who are audial or visual learners would excel, the virtual body will enable the kinaesthetic learner to be fully engaged in the environment as they learn about anatomy and physiology via MR.

Skill mastery

With the modern day learner being more technologically-savvy, there is a need to shift away from traditional learning methods towards self-learning. Self-learning kiosks will be made available in the NETC skills lab to allow learners access to the MR application at their own convenience and own pace of learning.

Along with anatomy and physiology training, there will also be MR applications developed with medical task trainers such as IV arms, airway and BCLS mannequins. The purpose in breaking the processes into tasks aided by MR is to develop the cognitive ability of repeated actions so that in an emergency situation, the action is no longer a conscious-thought process. The practice of such actions in an MR-assisted application allows the trainee to practice in a risk-free environment before executing the actions on a real patient.

CDA also currently handles huge volumes of personnel attending certification tests. By implementing a self-assessment component aided by MR, the NETC can support such functions with a fraction of the manpower compared to that currently required. This will also be paired with a test at the end of the module to enable trainers to keep track of trainees' progress and to gauge their readiness for subsequent levels of training. By minimizing the number of instructors at each skills-testing station, instructors can be better deployed to critical areas of certification testing that requires closer supervision.

Enhancing leadership skills and team work

Besides clinical aspects of medical teaching, NETC also aims to train paramedics holistically by inculcating leadership and decision-making skills as part of the curriculum. Previously, it was neither cost- nor resource-efficient to conduct multiple large-scale exercises and recreate scenarios to judge the leadership capabilities of a single element or test the decision-making capabilities of trainees. With this project, it becomes possible as the current capabilities of the Advanced Command Training System (ACTS), already in place in CDA, is further enhanced. The NETC will be developed in a space large enough to simulate an external environment with an emergency situation that can be projected with MR. By combining two or more smaller lecture rooms, the aim is to make it possible for multiple users to interact with each other in the environment in multiple roles such as a Rota Commander, a Section Commander, a paramedic and even as Singapore Police Force (SPF) officers so as to better understand the different roles of other agencies in a large-scale incident. To cater to PEC training, the scenario is aimed to be built with multiple casualties that can be attended to, triaged, cared for, and evacuated to a hospital. At the same time, the lead paramedic would also have the option to choose the site of the First Aid Point (FAP), the layout, the evacuation routes; and have the ability to choose the appropriate hospitals and make command decisions for additional support such as accounting for casualty numbers and reporting to the incident commander. These are useful aspects that need to be inculcated and assessed early in their training phase.

Advantages of MR in EMS Training

Increased flexibility

Equipped with a laptop and multiple sets of MR lens, trainers can set up a simulated scenario anywhere and at any time simply by "placing" virtual assets in the real-world environment. There is also no need to transport a variety of heavy props around. Not being restricted by the

availability of training venues and accessibility of props will allow greater flexibility when conducting training.

Simulation of high risk training in a safe environment

Using MR technology, we can blend virtual objects with the real world. This enables learners to be trained in simulated scenarios and still be fully aware of their surroundings. Virtual simulations of scenarios with high risk factors (e.g. highly flammable objects lying within close proximity of the casualty) allow learners to train under safe conditions.

Team building

Members of the EMS team will be able to train in the same scenario. They will be able to communicate and interact directly with one another while looking at the same simulated scenario. This increases the fidelity of team work as compared to working with virtual avatars of the team members.

Scalability

The MR technology can also be integrated with external peripherals such as sensors and/or haptic equipment. This will allow for further customisation of the application to cater to different training needs. As there are numerous equipment in EMS that requires precision, this function will allow learners to be trained effectively.

Cost efficiency in training

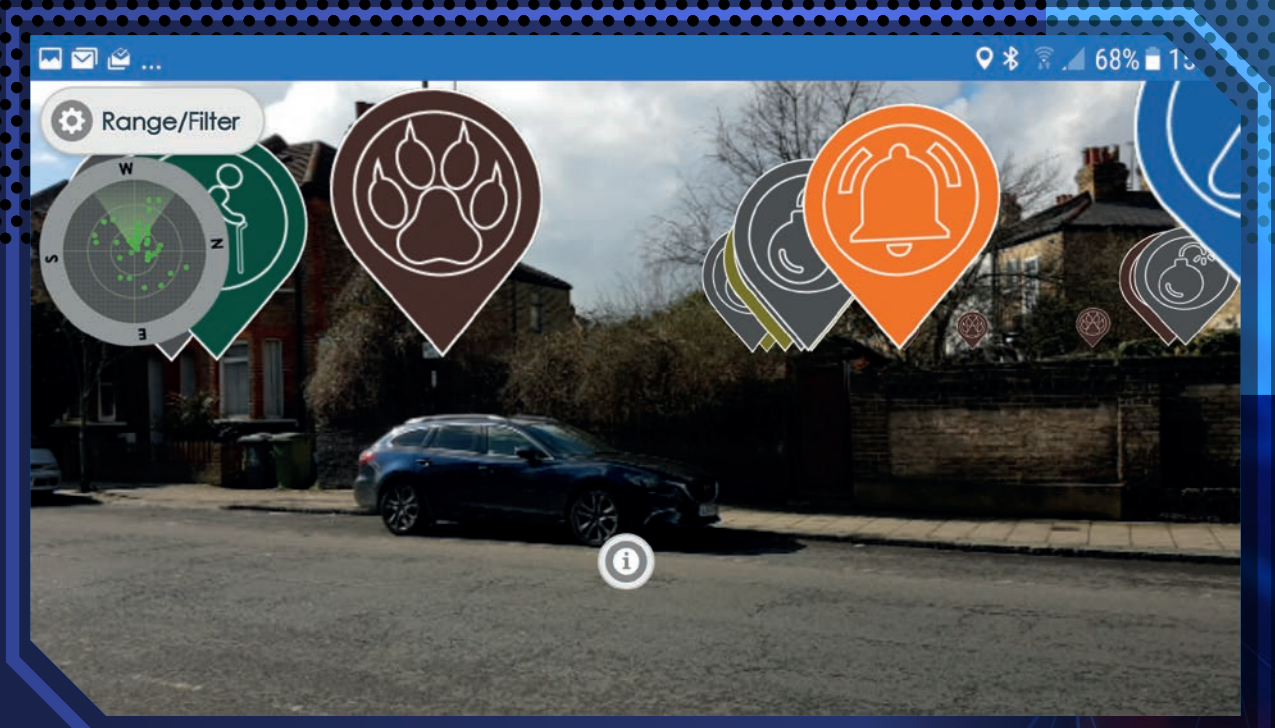
Without requiring multiple purpose-built rooms to model a simulated environment, the need for additional physical resources (e.g. props, multiple high fidelity mannequins, actors posing as casualties) will also be reduced. The leads to cost-savings for the organisation.

Conclusion

VR and it's related technologies have matured over the last two decades, and is increasingly being applied in the fields of engineering, architecture and medicine. The future NETC aims to be at the forefront of the MR landscape as it expands the training capabilities it can provide. In both the infancy stage of the programme as well as in future development plans, the guiding principle for the use of MR remains the same; that is to incorporate technology into pedagogy and utilise this affiliation to achieve training objectives in a more effective and efficient way. This will better prepare our trainees to face real-life emergencies that they will come to deal with as professionals of the Life-Saving Force.

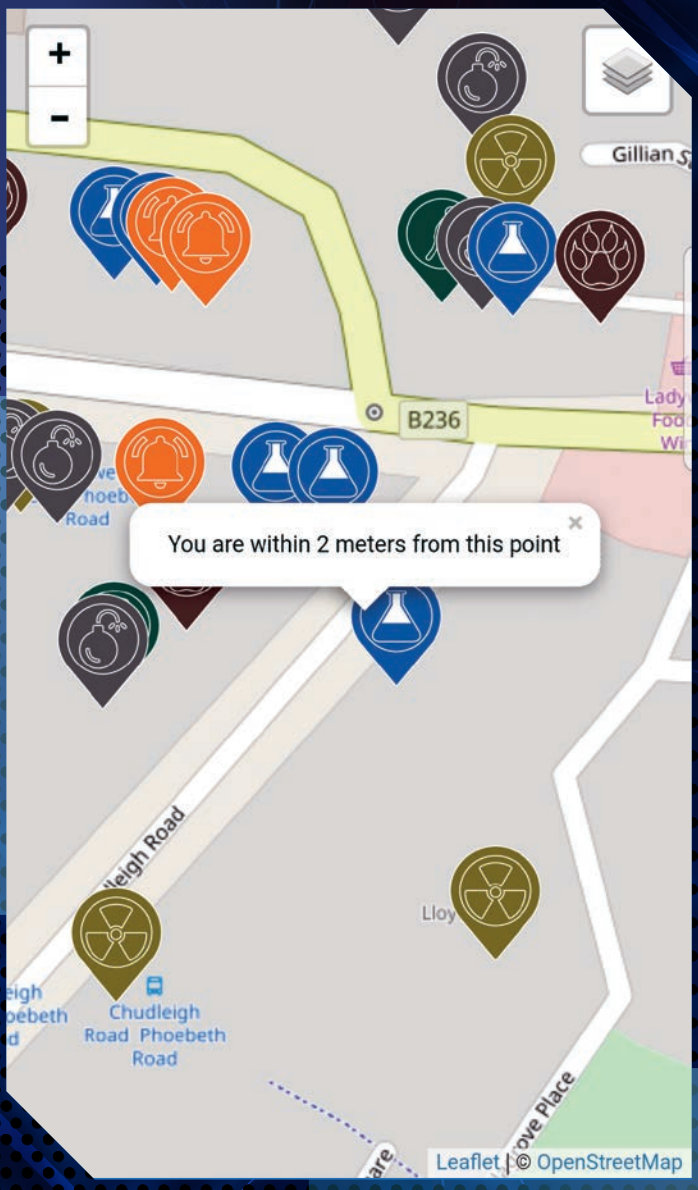
HOW AUGMENTED REALITY CAN ASSIST FIRE AND RESCUE SAFETY

Dinesh Thanigasalam
Commercial Director, Aligned Assets



Fire and rescue services need quick and easy access to intelligence about a location. Augmented reality technology can play a part in this. It is intuitive, visual and aware of its surroundings, making it an ideal tool for staff on the ground to rapidly understand the status of buildings and locations around them, helping safeguard both public and staff.

The emergency services have been called to a burning building. One floor is occupied by a wheelchair user; an adjacent building contains oxygen cylinders. These two pieces of crucial information are known within the fire service. Will all the firefighters on the ground be aware of them?



Traditional 2D map showing sample risks.

Technology is constantly changing the way we manage spatial data. This is as true for fire-and-rescue services as for any other organisation. They deal with spatial data on a daily basis, ranging from buildings and locations where an emergency call-out is required to when proactive management such as home fire-safety checks or fire-protection activities are carried out. Spatial boundaries such as floodplains are also important considerations when responding or planning.

The technical trend that has the biggest impact on the use of spatial data is the increasing use of mobile technology, especially apps on smartphones. Another emerging technology is the representation of spatial data in augmented reality. This article explores why and how these two technologies may be relevant to fire services.

The fire services hold a large amount of information about various locations, often obtained through fire-safety checks or during an emergency call-out. But fire crew will often only have access to limited information about the building they are sent to. Key intelligence tends to be restricted to departmental silos rather than shared more widely. For example, a commercial property could have been issued with an enforcement notice over stock restricting a fire exit or the presence of a combustible material, but the attending crew are unlikely to know about this or to think of requesting information from the relevant department. Yet is it often only the person on the ground who can judge what information is relevant.

Augmented Reality street view with sample risk data showing indicators for chemical hazards, explosives, dangerous animals and an alarm.

Fire crew already have access to site-specific information via mobile data terminals (MDTs), but this is usually limited to what has been preconfigured. In many cases, crew could be more effective if every member had access to all relevant information. This could include recorded hazards, vulnerable residents, enforcement and prohibition notices and risk ratings for the buildings, or the fact that a building is in a flood zone.

The other issue crew face on the ground is the same as we all encounter when trying to get our bearings using digital maps. While these are incredibly powerful and useful, they can still be confusing, especially when we are under time pressure. We have to read and interpret the virtual map and then project that information on to our real-life surroundings. This is where augmented reality can help.

Augmented reality superimposes a computer-generated image on to a view of the user's actual surroundings. It entered public consciousness in 2016 with the Pokemon Go craze, and so far has been mostly used for marketing and gaming. But it is also the ideal medium for delivering on-site information to fire-and-rescue services.

A digital 2D map can show the spatial information fire-crew members need, but augmented reality can project that information on to the user's actual surroundings. If information exists about a building, pointing the smartphone camera at it will reveal an augmented-reality image that represents the type of information held. As the user is viewing everything around the building in real-life, they can instantly gain an understanding of the implications on the

surrounding area and buildings. They may be attending an incident at one building, but another augmented-reality image of a nearby building can show them that this has immobile occupants. They can also see an augmented-reality image representing a hazardous material in a neighbouring building. This insight gives them the opportunity to take any necessary action to safeguard lives.

The augmented-reality image is seen by the user in a direct line of sight, unhindered by buildings or other structures that lie between them and the location of interest. The size of the image is proportional to the distance from the user, giving an instant understanding of proximity. A user can also see what is actually between them and the location. Brick walls and other obstructions do not show up in traditional 2D maps but may have a significant impact on a course of action.

Because the augmented-reality image is computer generated, the user can interact with it. They can, for example, delve into more detail about the location and intelligence on it, or filter what the app shows to reduce clutter and focus on the pertinent details.

A smartphone app is an ideal way of delivering this information. Smartphones are portable, familiar to almost everyone and relatively inexpensive, particularly when compared with a specialist kit such as an MDT. Smartphones can also be used for other purposes, increasing the return on investment, as the technology can be made available to most, if not all, staff, so everyone who might need to access this information can do so. Apps can be configured to store data for a specific area locally, and retrieve information in real time via 3 or 4G. Initiatives such as the Emergency Service Network (ESN) should make real-time access even more prevalent across the UK.

Many of the largest technology companies, including Google, Apple and Microsoft, are also investing heavily in smart glasses. These devices are likely to become a significant means of viewing augmented reality, possibly replacing smartphones in the future. Smart glasses can be combined with gesture technology whereby software is controlled by hand movements rather than tapping on a screen, with obvious advantages to fire crew. This is no longer sci-fi – the technology already exists. A helmet that projects augmented reality images onto a visor can be toggled to an infrared view when smoke prevents normal vision.

The features of augmented reality described here may not revolutionize the way fire- and-rescue services operate, but they can offer an extra set of tools for crew to have at their disposal. And sometimes this might make all the difference to the safety of both the general public and fire-and-rescue staff.

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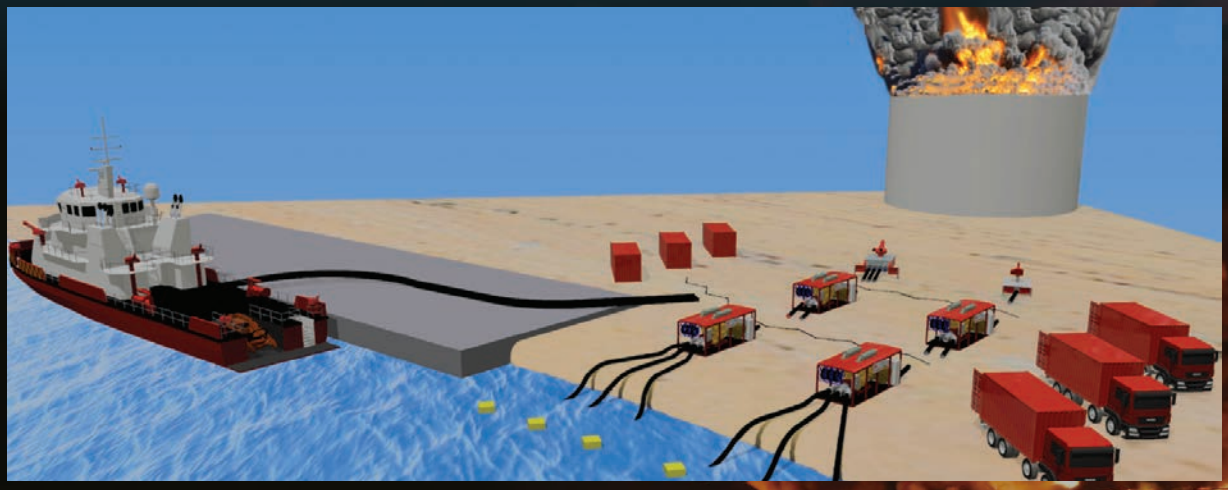
ENHANCING SCDF'S OIL TANK FIRE-FIGHTING CAPABILITIES – THE MODULAR OIL TANK FIRE-FIGHTING SYSTEM (MOTFS)

MAJ Clara Toh
Commander, Banyan Fire Station



Synopsis

Large storage tank fires are complex incidents that require significant resources and expertise to manage and mitigate. Failure to contain such incidents can have dire consequences from both the public health and economic perspectives. Though such incidents are not common, emergency authorities must be equipped to respond and mitigate such fires swiftly

The Modular Oil Tank Fire-Fighting System (MOTFS) enhances SCDF's capabilities for the mitigation of large storage tank fires. This article provides a brief historical perspective of storage tank fires in Singapore, as well as an overview of the new MOTFS's enhanced capabilities.

Storage Tank Fires in Singapore - A Historical Perspective

The Oil & Gas Industry is an integral part of Singapore's economy since 1891. As Singapore prides itself as a major oil and petroleum hub within the region, this naturally presents both economic benefits as well as accompanying risks – with one of the most significant risks being that of large storage tank fires.

Over the past three decades, Singapore has seen the occurrence of three major storage tank fire incidents. Since the 1988 Singapore Refining Company (SRC) refinery fire, the SCDF had significantly enhanced its large storage tank fire-fighting capabilities, which were subsequently put to test during the recent JAC oil tank fire and Pulau Busing oil tank fire incidents in 2016 and 2018 respectively. These capabilities include large monitors with a total combined output of 16,000 Gallons per Minute (GPM) and foam systems. The success of these two fire-fighting operations is testament to the importance of having appropriate equipment for mounting effective response against large storage tank fires.

As the SCDF continues to stay abreast of industrial developments and improvements to provide

enhanced and swift services for emergency response, it is hence timely to review the existing fleet of oil tank fire-fighting capabilities. Lessons drawn from the recent tank fires were also included in the review to ensure that the SCDF remains relevant against the backdrop of a rapidly evolving oil & gas industry.

Impetus for Review of Capabilities

As the SCDF continues to stay abreast of industrial developments, it is important for constant review of operational capabilities in order to ensure relevance against the backdrop of a rapidly evolving industry. Lessons drawn from past tank fires experience were incorporated and key factors that shaped the entire review are as follows:

i) Changes in Operating Terrain;

ii) Availability of New Technology; and

iii) Enhancing Capabilities and Streamlining Resources.

The abovementioned factors led to the development of the Modular Oil Tank Fire-Fighting System (MOTFS), which will replace the existing fleet of oil tank fire-fighting appliances upon its commissioning for operational deployment. While the new MOTFS capabilities will primarily be stationed on Jurong Island, which houses the majority of the petro-chemical and specialty chemical industries in Singapore, the MOTFS is a mobile system that can be transported rapidly to any site for deployment.

Changes in Operating Terrain

Over the years, Jurong Island had seen significant changes to its operating terrain as a result of industrial development, land reclamation and construction of coastal defences. Such changes have also indirectly imposed restrictions on the deployment of SCDF's existing large monitors and large pumps, thus constraining deployment options during fire-fighting operations. An example is the reduced accessibility to open water sources due to land reclamation, which has then practically rendered the option of water suction unviable, as the current system requires close proximity to the open source for suction capability.

In addition, with increased complexity and build-up of the infrastructure within these refinery premises, available deployment space within the tank farms area has also been reduced as a result, and this poses a logistical challenge with respect to the placement of multiple large monitors to obtain the desired flow rate during storage tank fire-fighting operations.

In view of these developments, a more versatile oil tank fire-fighting system needs to be introduced in order to suit the new operating terrain.

Availability of New Technology

The current large storage tank fire-fighting system in SCDF was first procured in 2000 and comprises the following components:

- 2 x 6,000 GPM Large Monitor Vehicle (LMV);
- 2 x 2,000 GPM Large Monitor Vehicle (LMV);
- 2 x 6,000 GPM Pump;
- 4 x 2,000 GPM Pump; and
- 2 x Hose Laying Truck (HLT).

With the development and maturation of technology, newer high-volume delivery monitors and systems have since emerged in the market, and hence it is apt for the SCDF to replace its current system with a more technologically advanced system that allows for increased precision and automation.

Enhancing Capabilities and Streamlining Resources

A typical large storage tank fire-fighting operation (i.e. full surface tank fire) requires specialised equipment and appliances to supply continuous fire-fighting foam at an adequate flow rate for mitigation. This usually involves prolonged hours of fire-fighting and entails the activation of multiple tiers of responders to the incident site. The tiered response framework is described as such:

i) Tier 1 – Response by Company Emergency Response Team[1] (CERT);

ii) Tier 2 – Response by Mutual Aid[2] Resources; and

[1] CERT – Company Emergency Response Team. In accordance to Singapore's Fire Safety Act (Chapter 109A), all premises with Fire Safety Managers (FSMs) are required to establish and maintain its own CERT for first response to incident(s) within their premises. Singapore's CERT framework is segregated into 3 tiers of proficiency and equipping; with Tier 1 CERT having the highest level of proficiency and equipping; and Tiers 2 and 3 CERT having gradually stepped-down levels of proficiency and equipping. All premises with storage of Petroleum and Flammable Materials (P&FM) in excess of 5 metric tons are required to have a Tier 1 CERT.

iii) Tier 3 – Response by SCDF Resources.

Considering the largest tank size present in Singapore, it will take an approximation of 26,000GPM flow rate to be sufficient for the required foaming operation. As such, combination with the equipment from the CERT and Mutual Aid resources is necessary to fulfil the flow rate demands for the largest tank and this will involve the deployment of multiple monitors and foam logistics areas, thus adding to the complexity of the operation.

As the Oil & Gas Industry progresses, new monitors with much higher throw capacity has been introduced into the market. Therefore, it is timely for SCDF to embark on the use of such new monitors in order to maintain our operational edge. The equipping of the new MOTFS also means that SCDF has the capability to deal with a much wider range of tank fire scenarios, for example either self-sufficient for a single largest tank scenario, or combined with CERT/Mutual Aid resources for a multiple tank fire scenario. Such enhanced capabilities are critical in providing assurance to businesses and investors in support of Singapore's economic growth in this industry.

Another area of development is the transition to the use of 1x3% foam concentrate for fire-fighting operations. In recent years, market forces has driven the trend towards the use of 1x3% foam concentrate, as compared to the 3x6% foam in the past. Based on the current sensing conducted by the SCDF, a significant portion of the major industry partners in Singapore has already embarked on this change. The immediate benefits of this change is the reduced foam resources and logistical arrangements required to mount the same level of operational response for oil tank fire-fighting operations.

The impetus for the foam transition plan was also factored into this equipment review. As research studies and certification burn tests have shown that while the effectiveness of 1x3% foam is comparable to that of 3x5% foam, the former has a lower tolerance for marginal error in the foam proportioning rate, hence it is not compatible for use with SCDF's existing oil tank fire-fighting system. Therefore, there is a need to source for new equipment that is able to achieve the high precision required in proportioning 1% foam concentrate.

The Modular Oil Tank Fire-Fighting System (MOTFS)

Having explained the background and considerations to the review of SCDF's large storage tank fire-fighting capabilities, it is now apt to provide an overview of the new MOTFS and its capabilities and deployment concept. The MOTFS is a technologically advanced system that is built on an inter-changeable modular concept, thus allowing the flexibility of deployment on-site based on needs assessment by the Ground Commander. Given its multi-configuration design, the various components of the MOTFS are described as follows:

Pump Systems

- 2 x Submersible Pump Unit (SPU); and
- 2 x Booster Pump Unit (BPU)

Large Monitors

- 40,000 Litres per Minute (LPM) Monitor; and
- 80,000LPM Monitor.

Accessories

- 12" Hoses pre-flaked in 6 x Hose Pods (available in different lengths to facilitate flexibility of deployment)
- Collecting Manifolds (to bridge compatibility with existing Industrial Ring Mains)

Moving on from the broad overview of the MOTFS, the next segment of this article shall delve into the enhanced capabilities of the system. The key capabilities of the MOTFS can be summarised into four main features.

i) Increased Foam Delivery – up to 100,000LPM capacity;

ii) Increased Options for Water Supply;

iii) Increased Equipment Precision; and

iv) Reduced Equipment Footprint On-site.

[2] Mutual Aid Arrangement was introduced in October 1996, and spearheaded by members of the OPITSC (Oil & Petro-chemical Industries Technical Safety Committee). Intent is to implement a support framework whereby participating companies would commit to provide mutual aid in terms of supplying critical fire-fighting equipment and foam resources to support fire-fighting operations for any large-scale incidents that occur in the petro-chemical industry.

Submersible Pump Unit (SPU)

Booster Pump Unit (BPU)

Hose Pad

40,000 LPM Monitor

80,000 LPM Monitor

Figure 1: Components of the MOTFS

Increased Foam Delivery – up to 100,000LPM capacity

The MOTFS boasts one of the world's largest single fire-fighting monitor pegged at 80,000LPM. When deployed as a full system, the MOTFS is then able to deliver up to a full capacity of 100,000LPM. With this enhanced capability, it would now allow the SCDF to be better equipped to deal with fires involving larger tank sizes, as well as the ability to handle fires that involve multiple tanks in one scenario.

Figure 2: View of the water stream from both monitors at full capacity of 100,000 LPM

Increased Options for Water Supply

For any typical oil tank fire-fighting operations, water supply is often a major challenge and key factor to the success of the operation. The implementation of the MOTFS now brings about the benefits of having more options for water supply to a high-volume delivery system. Besides the existing primary means of water supply via Ring Mains, the added options now include i) open water source drafting via submersible pumps; and ii) sea-to-shore connection from SCDF's Heavy Fire-Fighting Vessel (HFV).

Increased Equipment Precision

Tapping on technological advancements, the MOTFS's pumps and monitors are built to a high degree of precision and can be controlled digitally. The highly precise foam proportioner in-built within the Booster Pump Unit helps to reduce errors in the foam proportioning ratio, thus rendering it compatible for use with 1x3% foam concentrate. Additional control and safety measures are also incorporated into the pump units to reduce the possibility of human errors simplify the operating procedures for the ground responders.

Reduced Equipment Footprint On-site

With the use of larger-volume monitors (i.e. 80,000 LPM monitor vis-à-vis current 6,000 GPM monitor), fewer monitors are then required to be deployed on-site for a given tank size. The transition from the use of 5" hoses to 12" hoses with this system also allows for a neater and more systematic hose-laying as a reduced number of hose lines are required to deliver the same water flow rate. This enhancement facilitates site management, which is important for such large-scale fire-fighting operations.

Roadmap Towards Operationalisation of MOTFS

The new MOTFS is targeted to be operational by mid-2020. Prior to operationalisation, various steps are taken to ensure adequate training and proficiency for the ground responders.

Conduct of Specialised Equipment Training

As with all other new fire-fighting equipment, proper training and familiarisation of equipment is essential for optimal effectiveness and results. Given the design complexity and various options of deployment for the MOTFS, it is thus even more necessary for the users to be confident in operating the system prior to deployment in actual operations. Moving forward, the lesson plans, Basic Task Manuals (BTMs) and doctrines will also be further refined to incorporate changes in deployment concepts arising from this new enhanced capability.

Figure 3: Deployment of submersible pumps from open water source

Preparedness through Contingency Planning and Exercises

Besides ensuring that SCDF's responders are familiar with the new MOTFS, it is also equally critical to allow key stakeholders and industry partners to be exposed to the system as well. Such familiarity will then help to facilitate mutual understanding and site coordination at the fireground, should there be a need to deploy the MOTFS. In addition, the SCDF also engages in contingency planning as part of its efforts towards emergency preparedness, hence it is important for these contingency plans to be updated to include considerations for deployment of the MOTFS. Validation of response plans and introduction of the new equipment to the industry can be achieved via the conduct of joint exercises, for example the Divisional-level exercise codenamed "Exercise Firestorm".

Conclusion

In conclusion, the SCDF has had many successes in dealing with large storage tank fires over the years. Operational readiness, in terms of having the appropriate resources and equipment, as well a robust and effective incident response framework was critical to the success of each of these fires.

While large storage tank fires continue to remain rare, ineffective management of such incidents can have very dire consequences. As such, it is timely for the SCDF to review and improve on its large storage tank fire-fighting capabilities. Experience garnered from recent tank fire incidents also provided the SCDF with first-hand understanding of the challenges of such operations, which were useful in helping the SCDF to draft the desired features and capabilities of the new MOTFS. Guided by the principle of constant learning and improvement, SCDF will continue to seek innovations for improved mitigation and management of large storage tank fires.

[3] Exercise Firestorm is a recurring exercise in SCDF's list of major exercises. This exercise is a large-scale storage tank fire-fighting deployment exercise and it practices the physical deployment of SCDF's foam and large monitor systems, as well as the coordinating arrangements and procedures jointly developed with related agencies such as the Singapore Police Force (SPF), Jurong Town Corporation (JTC) and the Petro-chemical Industry's Mutual Aid Arrangements.

DEVELOPMENT OF CHEMICAL & RADIOLOGICAL SENSOR GRID IN SINGAPORE

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With the increasing presence of chemical fixed installations in Singapore, it is important that local protection strategies are well designed to ensure that the occurrence of Hazardous Materials (HazMat) incidents are kept to a minimal for the safety and protection of the public. While these strategies would not serve to completely prevent such incidents, it would be operationally advantageous to be able to receive automated early warning alerts via a chemical sensor grid system linking multiple sensors across Singapore, should there be a leak at the onset of the incident. This will allow for the swift dispatch of resources to conduct investigation and perform downstream mitigation measures to contain the leak without further delay. In addition, early warning alerts could lead to appropriate public protective actions, such as the In-Place Protection (IPP), to be taken seriously and promptly; evacuation announcements can also be communicated quickly to the public as well.

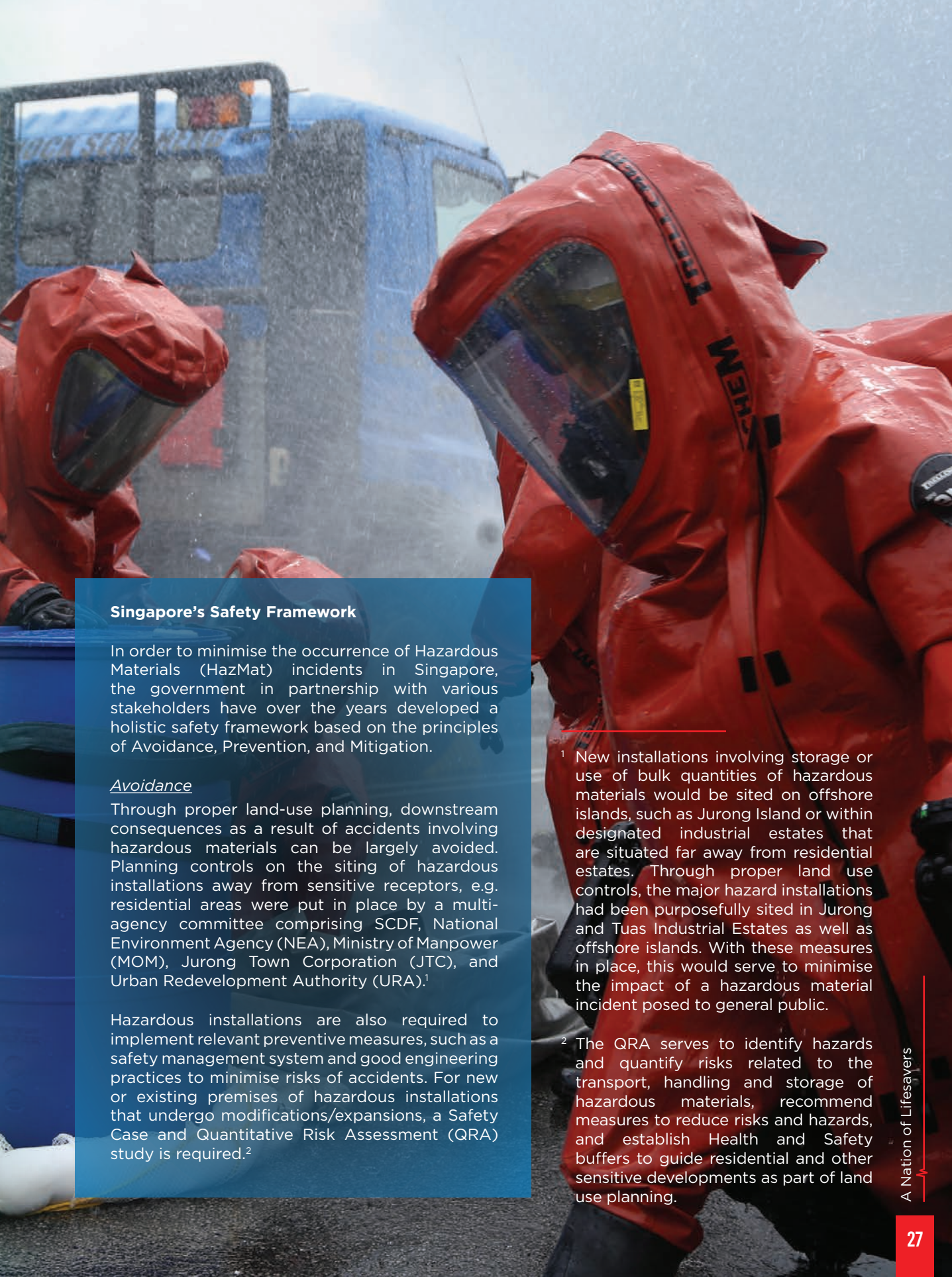
Introduction

Singapore is one of the world's leading chemical hubs, with over 100 chemical companies locating its major operations within the island. Singapore's position as a global chemical hub had greatly strengthened over the decades in tandem with the rapid development of Jurong Island, which is an integrated complex comprising the world's leading chemical and energy companies.

Besides chemical industries, Singapore has also seen exponential expansion in the pharmaceutical field, with the industry becoming increasingly important towards the nation's manufacturing sector. This is in-line with Singapore's long-term goal of being a leading centre in the development of innovative pharmaceutical products. In addition to the fixed chemical installations, the number of vehicles transporting hazardous materials on Singapore's roads has also increased two folds over the past decade.

With the huge volumes of chemicals present in Singapore, any accidental or deliberate release of these hazardous chemicals could potentially cause injury or even death to the population in the vicinity. In relation, the chemicals can also result in long-term damage to the surrounding infrastructure and environment. It is therefore important that strategies are implemented to ensure that such incidents are prevented where possible.

Further to the presence of chemicals in Singapore, it is noteworthy that there is an increasing prevalence of nuclear energy used as an alternative fuel in the world. Past incidents involving nuclear accidents in countries with Nuclear Powered Plants (NPP) such as Chernobyl and Fukushima had demonstrated the severity of downstream consequences, leading to people suffering from radiation illnesses and long-term environmental contamination. These incidents also highlight the possibility of transboundary incidents occurring elsewhere affecting Singapore.



Singapore's Safety Framework

In order to minimise the occurrence of Hazardous Materials (HazMat) incidents in Singapore, the government in partnership with various stakeholders have over the years developed a holistic safety framework based on the principles of Avoidance, Prevention, and Mitigation.

Avoidance

Through proper land-use planning, downstream consequences as a result of accidents involving hazardous materials can be largely avoided. Planning controls on the siting of hazardous installations away from sensitive receptors, e.g. residential areas were put in place by a multi-agency committee comprising SCDF, National Environment Agency (NEA), Ministry of Manpower (MOM), Jurong Town Corporation (JTC), and Urban Redevelopment Authority (URA).[1]

Hazardous installations are also required to implement relevant preventive measures, such as a safety management system and good engineering practices to minimise risks of accidents. For new or existing premises of hazardous installations that undergo modifications/expansions, a Safety Case and Quantitative Risk Assessment (QRA) study is required.[2]

[1] New installations involving storage or use of bulk quantities of hazardous materials would be sited on offshore islands, such as Jurong Island or within designated industrial estates that are situated far away from residential estates. Through proper land use controls, the major hazard installations had been purposefully sited in Jurong and Tuas Industrial Estates as well as offshore islands. With these measures in place, this would serve to minimise the impact of a hazardous material incident posed to general public.

[2] The QRA serves to identify hazards and quantify risks related to the transport, handling and storage of hazardous materials, recommend measures to reduce risks and hazards, and establish Health and Safety buffers to guide residential and other sensitive developments as part of land use planning.

In addition, HazMat Transport Vehicles carrying such hazardous materials within Singapore are remotely tracked and monitored via GPS tracking devices under real-time conditions. Should the HazMat Transport Vehicles violate transportation regulations such as plying non-permitted routes or travelling beyond the permitted transport hours, the vehicles could be immobilised immediately pending authorities' investigation.

Prevention

As part of prevention, licensing controls are in place to ensure that industries adopt the necessary technical and preventive measures to minimise risks that could arise from the handling, transportation, and storage of petroleum and flammable materials as well as hazardous substances. These licensing controls are implemented under SCDF's Fire Safety Regulations, as well as NEA's Environmental Protection and Management Act and the Environmental Protection and Management (Hazardous Substances) Regulations respectively.

Mitigation

Notwithstanding the controls and precautions taken, one cannot rule out the possibility of spillage and accidental releases of HazMat during handling, storage, and transportation. With well-drawn up emergency response plans and proper training, such release can be effectively contained, and the damage to the environment and lives minimised significantly. Premises that use, store or handle HazMat would come equipped with their own emergency response means and procedures to deal with such incidents, including a Company Emergency Response Team (CERT) for initial response. Emergency exercises involving the related agencies have been regularly conducted to ensure that all parties are prepared and well versed with the procedures to mitigate the impact of the incident.

Given that chemicals are also being transported into Singapore via its neighbouring country – Malaysia, it will be essential for response plans to be established for incidents that could possibly occur at the bordering checkpoints. Therefore, SCDF works closely with its Malaysia counterpart in the conduct of bilateral exercises.[3] Through these exercises, the responding agencies from both countries are able to gain familiarity with both response capabilities and the operating climate concerned.

[3] This would involve the deployment of SCDF, NEA as well as the Malaysian Fire and Rescue Department (Bomba) officers for scenarios involving hazardous chemical spills arising from an accidental collision of a HazMat Transport Vehicle at the causeway along Tuas 2nd Link.

Local Response – SCDF

In addition to measures taken to reduce the occurrence and severity of HazMat incidents, SCDF has strategically located its Fire Stations and Fire Posts throughout Singapore to provide adequate response outreach to incidents. In response to incidents of chemical leaks, SCDF will dispatch its fleet of appliances from the nearest Fire Stations/Posts. Mobile sensors will be deployed by responders for monitoring of chemicals to understand the extent of contamination and establish the hazard zones (cold, warm, and hot). Subsequently, downstream mitigation measures will be taken to contain the leak to ensure that the incident can be contained. If necessary, the public will be informed through the various public broadcast systems of the appropriate protective measures to be taken, such as In-Place Protection (IPP) or evacuation.[4]

Emergence of the Island-wide Sensor Grid

Despite the comprehensive measures set in place, the occurrence of HazMat incidents cannot be completely eliminated. With respect to the geographical characteristics and weather conditions of Singapore, it is expected that the movement of a chemical plume from a major HazMat incident will be extremely dynamic and spread from the affected area to another within a short period of time. This will prove challenging for SCDF's mobile response teams deployed with sensors to be able to travel fast enough to assess the moving plume. In addition, more often than not, SCDF would receive calls for assistance from either the affected premises or the public after the incident had already occurred. Therefore, this results in a delayed response of which there might be a higher number of affected people by reason of the chemical plume spreading beyond the affected premises.

Hence to overcome these challenges, there is an impetus to implement a sensor system that is capable of providing early warning should an incident occur. On this note, Singapore is currently developing an island-wide sensor grid, placing fixed chemical and radiological sensors across the country. Used in combination with mobile sensors, SCDF and other emergency response agencies will acquire the capability for a real-time live monitoring from multiple sensors linked to a single sensor network and therefore will be able to pick up incidents of HazMat leaks at the early onset.

[4] The public broadcast systems for broadcast of information on emergencies include systems such as the Public Warning System, SMS Public Alert System (SPAS), and SGSecure.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In addition, this will allow for better situational awareness of the incident as the positive detection by multiple sensors in the grid will enable SCDF to predict the spread and potential impact of the incident. This can be achieved via the method of triangulation of positive readings on a regional group of sensors to detect the source of release, through the multiple sensors linked to the sensor grid. This will be especially useful in a situation where there is limited information on the origin of the leakage at the onset of the incident, which could be due to acts of terrorism through deliberate release of HazMat sources. Further, it will also serve to relieve valuable manpower committed to monitoring the plume physically on-site.

Challenges & Considerations

The primary objective of the sensor grid is to provide early warning should an incident occur. This could allow operators to respond swiftly and decisively to dispatch resources for follow-up mitigation. Unfortunately, this also poses as a challenge due to an expected large amount of sensor information generated from a HazMat sensor grid in Singapore with the possibility of false alarms being activated.

Hence, to ensure quick response to any HazMat incident, automated data processing algorithms and artificial intelligence systems will be required to alleviate the load on operators manning such systems. In addition, artificial intelligence will sense-make the sensor measurements in real-time, eliminating false alarms.

Given that detection technologies are typically limited to detecting only a certain range due to the inherent characteristic of chemicals, a combination of sensors harnessing different technologies will have to be incorporated in order to cover the full spectrum of chemicals. An important consideration include the costs involved for both the set up and maintenance of sensors, which would have to be sufficiently affordable to sustain the system in the long run. Given that the sensors would be deployed for monitoring operations on a 24/7 basis, they will have to be ruggedised in order to withstand the local climate and humidity, and occupy a sufficiently small footprint to ensure an optimised land usage for the sensor grid.

Progress of Implementation

To date, NEA is close to completing the implementation of a network of radiological sensors in Singapore, which aims to detect elevated radiation levels in Singapore due to local or regional incidents.

To extend and build up the coverage for detection of chemicals, Singapore is building up a chemical sensor grid with a focus towards Major Hazard Installations (MHIs), and is also exploring the eventual scaling up of sensors to cover the entire country. This will be in conjunction with the nation's effort of developing a Smart Nation of sensors, where technology is harnessed for automation in monitoring without the need to physically deploy personnel to view the readings on a 24/7 basis.

Conclusion

The establishment of a sensor grid will allow SCDF as well as related agencies to achieve an early warning indication, should there be HazMat leaks from industrial premises. In addition, the sensor grid will provide a common situational awareness to allow a coordinated response to be achieved across the agencies. This will enhance the effectiveness of HazMat incident management in Singapore.

IMPROVING MEDICAL RESPONSE – SCDF'S TIERED-RESPONSE FRAMEWORK

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In today's aging population, it is of no doubt that medical calls are increasing in numbers. To address this major demographic shift and demand for pre-hospital emergency medical resources, SCDF conceptualised a tiered-response framework to manage the provision of resources, and ensure that patients in need of urgent intervention receive the intended medical attention in time. The framework is executed in phases, and serves to help SCDF improve medical response in Singapore.

The Need for Change

Two of the key strategic and operational challenges facing SCDF and Singapore at large, are an increasing population and ageing demographics. This has translated to a rising number of calls for Emergency Medical Services (EMS). Since 1998, the number of '995' medical calls has been increasing at an average of 5% annually. Last year, SCDF responded to 187,607 medical calls, or just over 500 calls daily. With the greying population, medical calls will continue to rise steeply and the annual load is expected to reach 290,000 by 2025.

Thus, SCDF is transforming the way our EMS functions. Since 2019, SCDF has been increasing its fleet of ambulances and training more EMS personnel to better cope with the increased call load. However, increasing resources alone is not sustainable, and against rising demand, there is a need to review the SCDF EMS framework to ensure that available resources can be best channelled to critical cases in dire need of immediate medical intervention. In this vein, SCDF adopted a shift in how it responded to EMS cases through the introduction of a tiered-response framework.

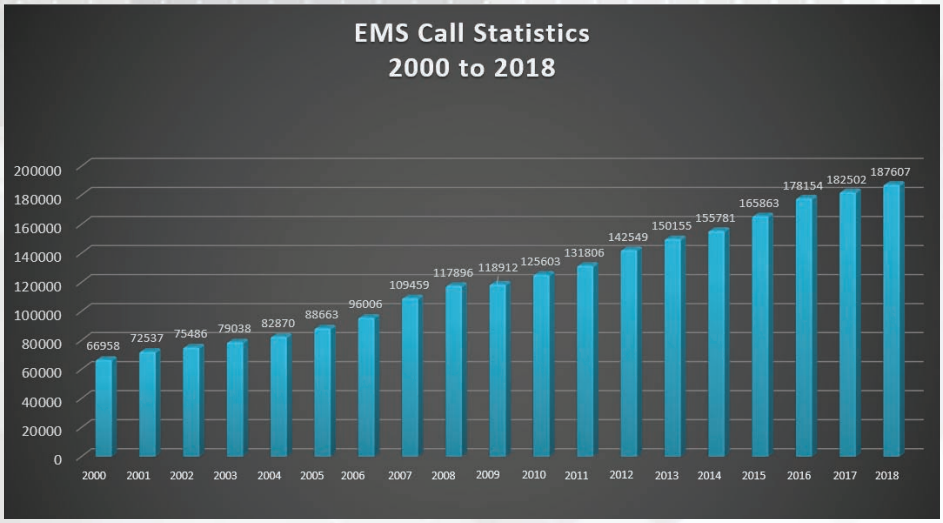


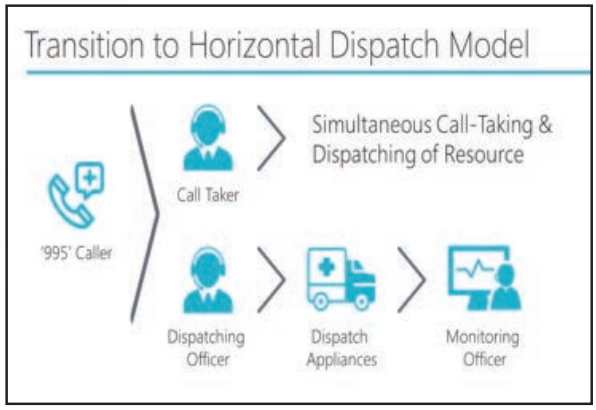
Figure 1: Increasing trend of EMS calls from 2000 to 2018

EMS Tiered-Response Framework (Phase 1)

Phase 1 of this framework was introduced in April 2017, and focused on differentiating '995' calls according to the severity of the patients' medical conditions. This is done through a system known as the Advanced Medical Protocol System (AMPS), which incorporates the triaging of patients' case acuity into the SCDF Operations Centre's call-taking function. Our call-takers, including SCDF Paramedics and MOH nurses, are automatically prompted to ask about the nature of the case in order for them to swiftly triage patients into the respective category of severity.

Figure 2: SCDF Operations Centre

This process generally takes 10 seconds to a minute, and once the SCDF call-taker has triaged and determined a life-threatening emergency, a dispatcher will concurrently activate the appropriate SCDF resources.[1] Meanwhile, the call-taker continues to engage the caller and where necessary, provides medical advice such as how to perform CPR on a cardiac arrest victim prior to the arrival of SCDF at the scene. This horizontal dispatch model is more efficient than the vertical model employed previously, where a single call taker manages the entire call taking and dispatch processes.



It is clear that not every emergency call is a time-sensitive life threatening situation. Thus, the scale of SCDF resources and speed of response must commensurate with case severity. For instance, utmost priority will be given to individuals suffering from highly time-sensitive life-threatening emergencies, as opposed to minor emergencies. As part of the Phase 1 implementation, Fast Response Bikes manned by fire-fighters cross-trained as Emergency Medical Technicians (EMTs) were deployed for life-threatening emergencies. Besides adding to the pool of deployable resources for such medical cases, the mobility of the bikes allowed for swift arrival at the scene ahead of ambulances, to stabilise and render immediate medical treatment to patients in life-threatening situations.

In addition, EMTs were deployed to operate the Fire Medical Vehicle (FMV). The customised FMV is a hybrid of a fire appliance and an ambulance for dual response to either fire-rescue or medical emergencies. The FMV is deployed for minor emergencies such as industrial and road traffic accidents, to stabilise and treat patients and, where necessary, convey them to hospital.

In 2018, EMTs on Fast Response Bikes responded to 16,897 life-threatening cases, while SCDF's fleet of six FMVs responded to 312 fire and rescue incidents. In the same period, SCDF was able to respond to 82% of life-threatening cases within eight minutes due to the quick arrival of the Fast Response Bike, as compared to 73.4% based on ambulance response time alone.

[1] In addition, Community First Responders (CFR) registered with SCDF's myResponder mobile application would be alerted to suspected cardiac arrest cases within a 400m radius of their location, and they would be able to view the location of the nearest available AEDs. Since the launch of myResponder, there have been 46,239 registered responders, and 2,870 responders who arrived at scene to render assistance (as of end-July 2019).

Figure 4: Deployment of Fast Response Bikes for medical cases

Figure 5: Fire Medical Vehicle (FMV)

EMS Tiered-Response Framework (Phase 2)

Phase 2 of the EMS Tiered-Response Plan has been progressively implemented from 1 April 2019. Pump Ladders (PLs), Light Fire Attack Vehicles (LFAVs) and the FMVs manned by fire-fighters cross-trained as EMTs, are deployed for life-threatening cardiac arrest cases to augment the response of Fast Response Bikes and ambulances through the provision of enhanced medical support and faster response.

Introduction of High-Performance Cardio-Pulmonary Resuscitation (CPR)

In line with efforts to provide enhanced medical support and faster response for critical and time-sensitive cases, SCDF also implemented High-Performance CPR[2] to further enhance treatment of cardiac arrest cases, and to improve patients' chances of survival.

SCDF NEWS CLIPPINGS
THE STRAITS TIMES
DATE: 30/03/19 PAGE: B2

The current four responders deployed to out-of-hospital cardiac arrests will be increased to eight – in ambulances, fire bikes, Red Rhino vehicles, fire engines or other fire medical vehicles. ST PHOTO: JASMINE CHOONG

How high-performance CPR is carried out

1st arrival: Fire bike
An emergency medical technician (EMT) arrives at the scene on a fire bike to perform CPR and deploy an automated external defibrillator (AED) that will provide live feedback on the chest compression quality.
This ensures that the chest compressions are done to the ideal depth, at an appropriate rate and with controlled ventilation.

2nd arrival: Either a fire engine, Red Rhino or fire medical vehicle
Four more SCDF officers arrive. They include two firefighters who will take turns every two minutes to perform chest compressions, a fire and rescue specialist who will deliver oxygen and ventilation to the patient using a device, as well as an additional EMT who will operate the AED.
The purpose of this team is to provide basic life support to the patient.

3rd arrival: Ambulance
The team, comprising a paramedic and two more EMTs, arrives last to provide advanced treatment to the patient.
The paramedic, who is the overall team leader, will operate the ambulance defibrillator.
One of the EMTs will help to set up an IV drip and administer drugs to the patient, while the other EMT will prepare equipment and drugs for the treatment procedures.

Figure 7: News clipping on High-Performance CPR

Figure 6: Additional fire appliances responding to cardiac arrest cases

[2] High-Performance CPR is practiced by EMS systems in Seattle & King County, which boasts world-leading Out-of-Hospital Cardiac Arrest (OHCA) survival rates of around 56%. In 2016, SCDF sent a team of officers to the Seattle Resuscitation Academy to learn the best practices and pilot the implementation of High-Performance CPR in Singapore.

High-Performance CPR is a team-based resuscitation method with the objectives of preserving blood flow to vital organs, most importantly to the brain, and converting fatal rhythms. The goal of High-Performance CPR is to improve the chances of patient survival, and for good functional recovery discharge from hospital. It is achieved through the administration of good quality manual CPR, which requires EMTs to work in precise unison with the ambulance EMS crew as a team.

High-Performance CPR focuses on the delivery of high quality manual chest compressions through the achievement of the following five areas:

I. Rate of chest compression between 100 and 120 beats per min

This is the rate that produces the highest survival probability, and is achieved by following the metronome audio cue from the AED. Beyond 120 beats per min, the survival probability drops significantly.

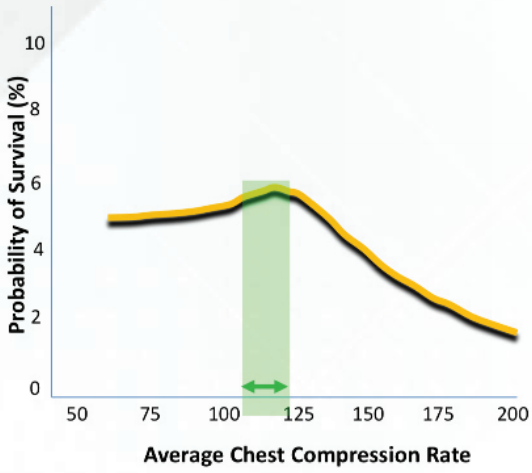


Figure 8: Optimal chest compression rate

II. Compression depth of 4 to 6 cm

This range of compression depth is proven to produce the highest survival to hospital discharge, and is achieved by monitoring the audio and/or visual feedback from the AED.

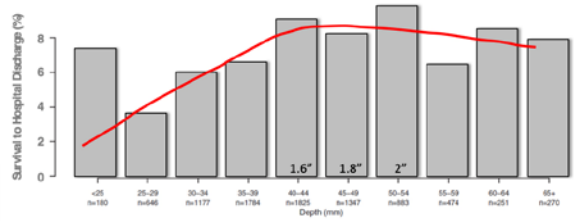


Figure 9: Optimal compression depth

III. Full recoil of patient's chest during release phase of CPR

Both the compression and decompression phase of CPR are equally important. The decompression (i.e. recoil) phase allows the heart to refill with blood for the next compression, and hence a full recoil is necessary to ensure that sufficient blood is pumped out in the next compression phase.

IV. Compression fraction of 80%

Compression fraction is the percentage of time a pulseless patient receives good chest compressions during resuscitation. It is achieved by good team coordination and chest compression discipline. Every interruption in chest compressions reduces compression fraction. It is critical to minimise interruptions to chest compressions, as it takes many compressions to build up the pressure in the aorta for blood to reach the brain, while it only takes 3 seconds of compression stoppage for this pressure to drop to almost zero.

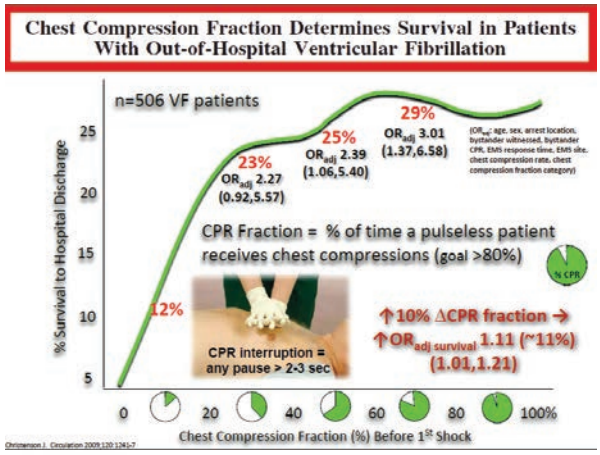


Figure 10: Optimal compression fraction

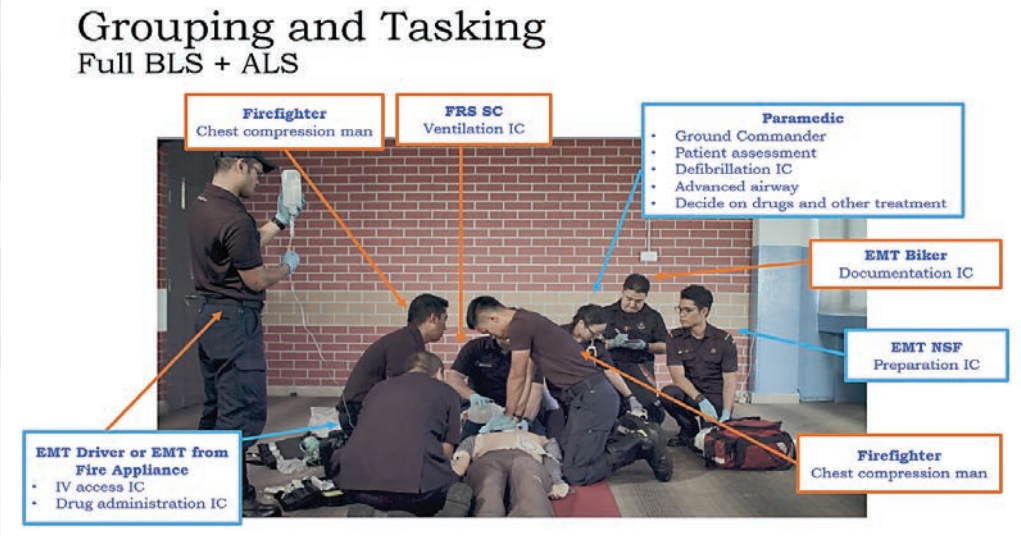
Figure 11: Use of Bag-Valve-Mask (BVM)

V. Prevent over-ventilation

Over-ventilation causes a build-up of pressure within the chest cavity, which in turn impedes blood return to the heart, and hence reducing the efficacy of chest compressions. Excessive oxygen levels also cause narrowing of blood vessels in the brain, reducing oxygen delivery to brain cells. Over-ventilation is prevented by depressing the Bag-Valve-Mask (BVM) only 1/3 of the way, just enough to provide 500ml of air to the patient; which is the amount of air in a normal breath.

The two main groups of responders carrying out High-Performance CPR are those from the fire appliances and ambulances, and their tasks are as follows:

Sequence*	1st Arrival	2nd Arrival	3rd Arrival
Emergency Vehicle	Fast Response Bike	Fire Engine or Red Rhino or Fire Medical Vehicle	Ambulance
Objective	Start CPR and deploy AED	Provide a well-coordinated team-based Basic Life Support	Provide advanced treatment (Advanced Life Support), integrated with Basic Life Support by FRS
Personnel and task	EMT Biker – single responder resuscitation	EMT – operates AED	Paramedic – overall team leader, operates the ambulance defibrillator, advanced treatment
		Fire and Rescue Specialist (FRS) – delivers oxygen and ventilation	EMT– assists in setting up IV drip and administering drugs
		Firefighter – chest compression (rotates)	EMT (NSF) – prepares equipment and drugs for procedures
		Firefighter – chest compression (rotates)	



Figures 12 & 13: Groupings & tasks of High-Performance CPR

As High-Performance CPR requires more in-depth medical skills, SCDF has started enhanced training for its EMTs, and full capability will be rolled out progressively to all fire stations over the next two years.

Minor & Non-Emergency Cases

Non-emergency cases do not require EMS assistance[3], and from 1 April 2019, SCDF has ceased to convey such cases to hospitals. These patients will be advised to seek treatment from their family doctor or general practitioner at nearby clinics. For those who insist on going to a hospital, they will be advised to make their own arrangements or call 1777 for a non-emergency ambulance at a fee.

Figures 14 & 15: Communication materials on non-conveyance policy

Minor emergencies, such as cuts with bleeding and minor accidents with bruises or swelling, are less time-sensitive, and the response time for such cases will be longer than for life-threatening cases.

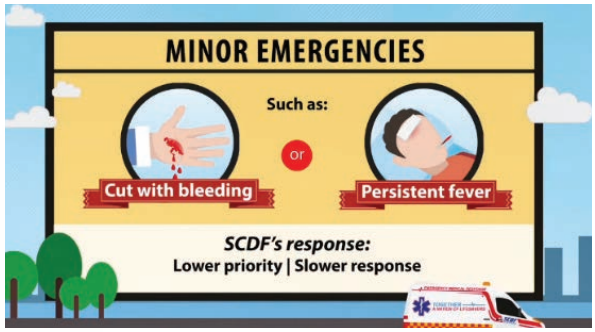


Figure 16: Communication material on SCDF's response to minor emergencies

Conclusion

The major demographic shift and aging population will continue to drive the increase in EMS call load, and SCDF will have to continue optimising resource utilisation and undertake measures to meet the changing emergency healthcare needs of a larger and older population. The EMS Tiered-Response Framework is an ambitious campaign that will positively transform SCDF's provision of pre-hospital emergency patient care services, as well as better optimise SCDF's fire appliances in support of the increasing EMS cases. Patients in need of urgent intervention will be attended to faster than before by a combination of appropriate fire and EMS resources. This in turn leads to better patient outcomes, and highlights SCDF's journey in improving medical response.

[3] For cases that are unclear, SCDF will still dispatch an ambulance to verify the patient's condition.

FROM MARINE COMMAND TO MARINE DIVISION – THE FULL OPERATIONALISATION OF SCDF'S MARINE RESOURCES

CPT Keave Soh Cheng Wei
Navigational and Training Officer, Marine Division

SCDF commissioned three new vessels on 20 August 2019, witnessed by Mr K Shanmugam, Minister of Home Affairs & Law. The addition of these new vessels marked the 7th year in SCDF's 10-Year Maritime Transformation. Since SCDF took over marine firefighting operations from Maritime and Port Authority of Singapore (MPA) in April 2012, the SCDF Marine Division has been expanding its marine operation capabilities, through the training of marine fire fighters, and the expansion of the fleet of vessels. In only seven years, the SCDF Marine Command has grown from a single marine fire station with two firefighting vessels to become SCDF Marine Division. Under the command of Assistant Commissioner (AC) Derek Tan, Commander Marine Division, the unit currently operates two fire stations and one marine fire post, namely Brani Marine Fire Station, West Coast Marine Fire Station, and Loyang Marine Fire post, with a fleet of eight vessels.

Introduction

Against the backdrop of global terrorism, a joint consultancy study by the Ministry of Home Affairs (MHA) and the Ministry of Trade & Industry (MOT) on national capabilities to deal with security threats in the maritime domain concluded that MHA should take over the marine firefighting function to enhance consequence management of maritime security related incidents. To safeguard Singapore's position as one of the world's busiest maritime hub ports, SCDF took over the marine firefighting and rescue function from the Marine Port Authority of Singapore (MPA) in 2012. Since the SCDF Marine Division was formed, it has developed from a basic response outfit to a modern fleet equipped with highly automated features, helmed by highly trained professionals who are equipped to mitigate a range of maritime emergencies from fire to complex Chemical, Biological, and Radiological (CBR) scenarios.

The existing fleet of the Division includes the Marine Fire Vessel (MFV), which was transferred from MPA in 2012, and the Rapid Response Fire Vessel (RFV). Commissioned on 23 March 2017, the RFV was the first purposefully designed fire boat by SCDF to improve maritime response within Singapore's port limit. The RFV has a top speed of 40 knots and is equipped with two water monitors for firefighting. With the speed of the RFV, the response time to offshore incidents is greatly reduced. Additionally, by reason of its relative small size, the RFV has the capability to reach more places such as marinas and jetties that has tight spaces and shallow waters, which previously restricted access of larger vessels such as the MFV. In 2019, three new vessels, each designed and built for various scenarios were commissioned, further enhancing SCDF's marine capabilities.

MARINE RESCUE VESSEL – RED DOLPHIN

The first of the three new vessels delivered, named Red Dolphin, is the Marine Rescue Vessel (MRV), which was designed to meet the demand for a multi-role maritime response to firefighting, rescue, and Chemical, Biological and Radiological (CBR) incidents. The FIFI 1 class vessel is equipped for firefighting operations with three fire monitors which can deliver up to 88, 000 litres of water per minute and is accompanied by a protected citadel that can be pressurised to protect against the outside environment; automated decontamination shower and CBR detectors. The vessel is designed to accommodate up to 30 passengers in the rescue room, a number that coincides with the average crew size of a commercial vessel. A first aid room is also incorporated into the vessel to cater to casualties requiring medical attention.

Similar to the other new heavy vessels, a Rigid Hull Inflatable Boat (RHIB) is placed on board which can be deployed for shallow water operations such as 'Man Over Board' incidents. With a top speed of 30 Knots, the vessel is able to provide an effective response to a range of maritime incidents. The MRV was officially delivered on 23 November 2018, the first of the three heavy vessels to be berthed at Brani Marine Fire Station.

Figure 1: SCDF's MRV – Red Dolphin

HEAVY RESCUE VESSEL – RED MANTA

The second of the three new vessels, named Red Manta, is SCDF's latest Heavy Rescue Vessel (HRV). The launching ceremony on 7 November 2019 was officiated by SCDF Commissioner Eric Yap, alongside Assistant Commissioner (AC) Derek Tan, Commander of the SCDF Marine Division. In his speech, AC Tan highlighted the vessel's strength from both the operational and engineering perspectives. The vessel has a passenger capacity of 300 and is equipped with automated showers for mass decontamination. The vessel is also installed with a lift system that allow casualties to be brought from the main deck to the heli-winch pad where they can be airlifted to hospitals, if necessary.

Efforts to understand and include SCDF's operational needs were apparent in the HRV's design. In contrast to the usual mono-hull vessels that SCDF operates, the HRV is the first catamaran (twin-hulled) vessel, and offers higher stability during vessel-to-vessel transfer operations. The design team took into account the need to have the HRV carry a large number of casualties. In addition, the catamaran hull form provides a larger deck space and allows the vessel to travel at high speeds.

Special attention was paid to the command room as well. To ensure that it could serve as an effective command post during incidents or emergencies, the design team incorporated a video wall to allow the display of different types of information at the same time to facilitate decision-making. The video

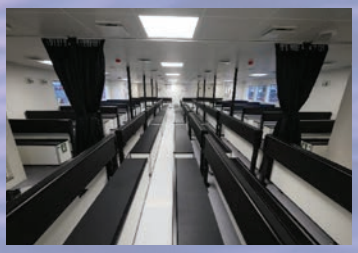
Figure 2: SCDF's HRV – Red Manta

wall can be connected to various equipment such as the on-board Seaborne Electro-Optics Camera and Electronic Chart Display to provide situational awareness of the vessel's surrounding. It can also be connected to different electronic devices that facilitate the sharing of information on the go.

Design considerations were also apparent in the rescue room on board the HRV, which SCDF required to accommodate up to 300 passengers. The design team conceptualised the room to be re-configurable, such as having removable benches which can be adjusted for sitting or lying casualties based on situational needs, and medical treatment tables that can be set up if required. The flexibility of the rescue room supports the dynamic operational requirements of SCDF for emergencies.

Command Room

Bridge



Rescue Room

Decontamination Room

Figure 3: Photographs showing the Command Room, Bridge, Rescue Room, & Decontamination Room on board the Red Manta

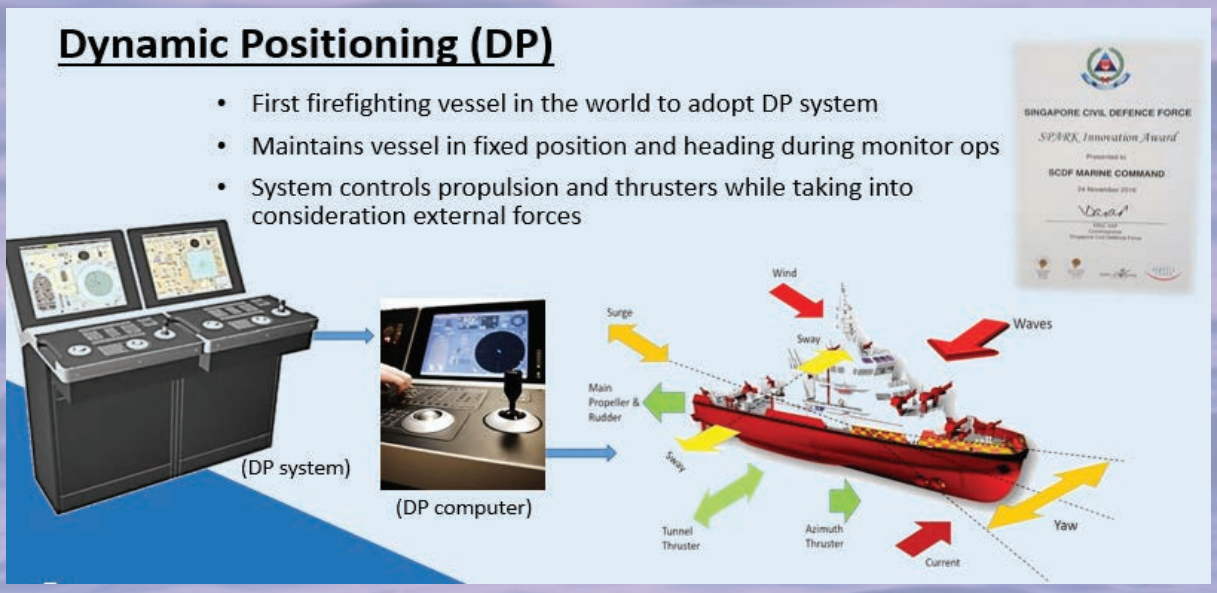
HEAVY FIRE VESSEL – RED SAILFISH

The most powerful of the three new vessels, named Red Sailfish is SCDF's new Heavy Fire Vessel (HFV). The vessel was delivered in March 2019, marking a significant milestone in the development of marine capabilities.

Designed and developed locally, the HFV is the first purpose-built FIFI 3 class firefighting vessel in the world that is integrated with a Dynamic Positioning (DP) system. The DP system allows the vessel to maintain its position as if she is moored while the fire monitors are in operation, which enables the ship crew to focus on the operation, reducing the work load of maintaining the vessel's position and heading during firefighting. Equipped with an unparalleled pump capacity of 240,000 litres per minute and its ability to station keep, the HFV is well positioned for any marine fire incidents.

The HFV is also built to mitigate CBR capabilities. The HFV is equipped with a CBR protection system similar to that of the MRV, which allows SCDF to respond to marine Hazardous Material (HazMat) incidents that entail mitigation, monitoring, and rescue operations. The vessel introduced airlocks and gas tight doors to protect the vessel's boundaries and guard the crew from any contaminated external environment. Military grade filters are also applied to cleanse any air channelled into the accommodation areas. To mitigate the accidental entry of contaminants, the

Figure 4: SCDF's HFV – Red Sailfish



protected area is pressurised and sensors are provided to monitor environmental conditions around the vessel.

The design team also successfully integrated the complex external firefighting system and rescue equipment within the limited space of the 50-metre-HFV. This was achieved through the use of 3D modelling tools to plan and optimise space allocation for the complex network of large pipes (up to 600mm in diameter) required for the external firefighting system, and de-conflict the space required for other infrastructure such as cables and air-conditioning ducts.

To provide internet connectivity on board the HFV for accessing control systems, the design team installed the mobile cellular 3G/4G network instead of the traditional means of installing satellite communications, common among the marine industry. This alternative is more cost-effective, and while only local network coverage is provided, it is sufficient for SCDF's operations in Singapore's territorial waters. SCDF had also procured a 4G booster and video streaming system for sending video footage from the vessel's electro-optics system.

SCDF's Maritime Journey

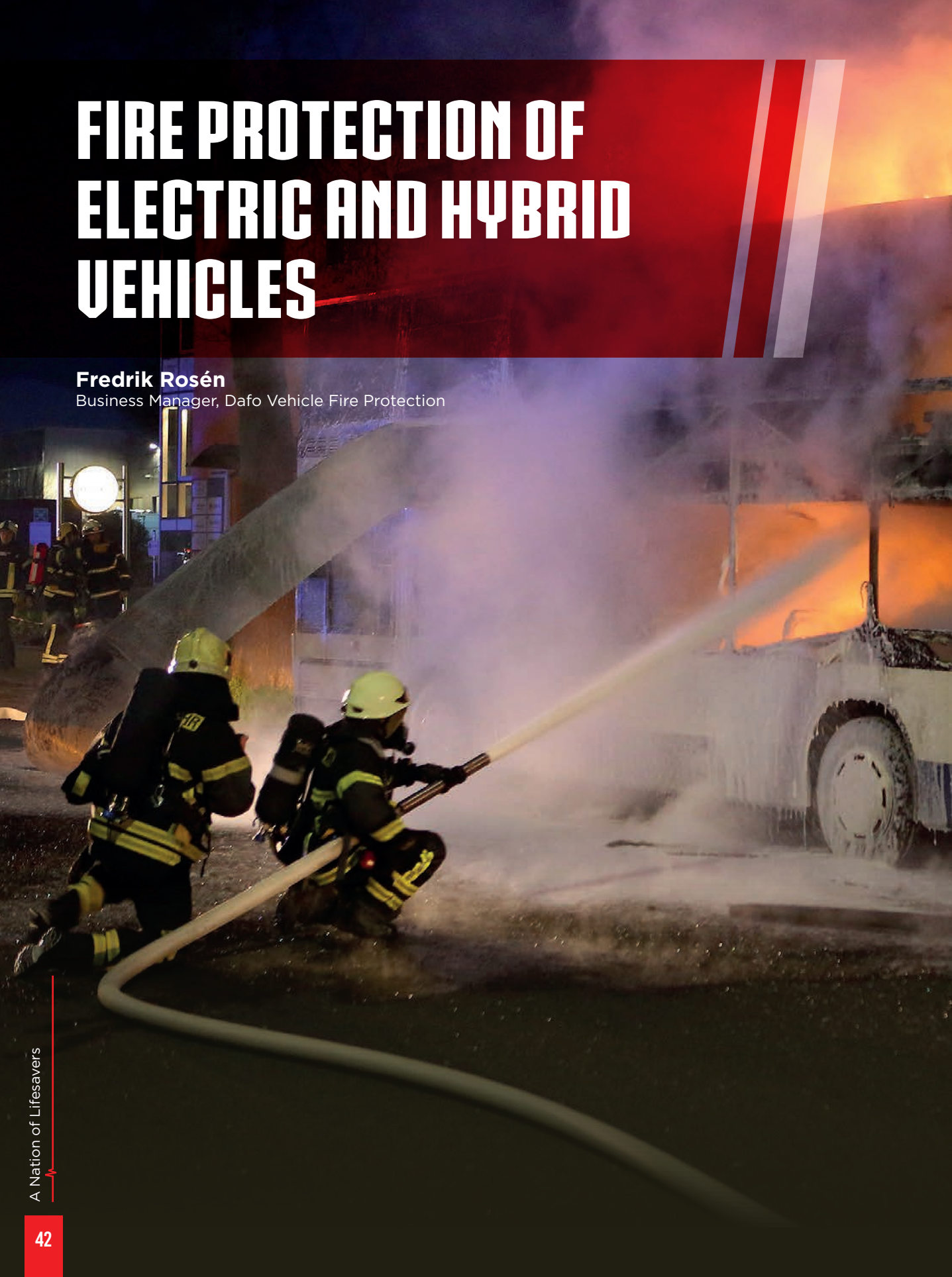
Training for the crew to helm the three heavy vessels began as early as January 2018. A common user interface was developed to be applied for the systems on board the three heavy vessels. While the three vessels are of different shapes and sizes, establishing a common user interface for their systems was needed to improve interoperability and reduce SCDF's training load. This was crucial in supporting the Force's operational model where staff can be deployed to any of the vessels whenever the need arises.

Figure 6: Photograph taken on 16 July 2018 during a fire incident on board container vessel, Salam Mesra, where the fire started from the ship Master's cabin and affected accommodation spaces

Since the development of the SCDF Marine Division, it had responded to numerous shipboard fires ranging from small vessels such as pleasure crafts and launch boats to big ships such as container vessels and tankers. The Division was also called to attend to medical incidents for ship crew suffering from injuries or particular medical conditions. To better respond to offshore medical incidents, selected Marine Specialists are required to undergo Emergency Medical Technician (EMT) training. In addition, the Division was also involved in major Search and Rescue operations led by MPA for missing personnel at sea or Man Over Board incidents. One notable incident led by MPA with SCDF, Republic of Singapore Navy (RSN) and Police Coast Guard (PCG), was a joint search operation for missing crew members after a dredger collided with a tanker in Singapore waters on 13 September 2017. With the addition of three new heavy vessels, SCDF Marine Division is well poised to respond to any marine incidents within the Singapore port limit.

FIRE PROTECTION OF ELECTRIC AND HYBRID VEHICLES

Fredrik Rosén
Business Manager, Dafo Vehicle Fire Protection



More and more vehicles on our roads are electric or hybrid vehicles (EV and HEV) as there is a global transition to renewable fuels. Knowledge is limited about fire risks with vehicles having these new energy sources. Consequences connected to risks of Li-ion batteries in case of a malfunction may imply serious outcomes, for example, if the driver is affected by gas emissions or by fire/explosion. Therefore, more research in this area is needed.

Storing large amounts of energy, whether it is in large batteries used in energy-storage applications or batteries used in electric vehicles can be inherently dangerous as energy stored in a confined space tries to escape, sometimes violently. As a result, Li-ion batteries are susceptible to spontaneous ignition and subsequent explosion due to overheating. Overheating may be caused by electrical shorting, rapid discharge, overcharging, manufacturing defects, poor design, or mechanical damage, among many other causes. This might cause thermal runaway and the release of a flammable electrolyte. A thermal runaway produced enough heat to cause adjacent battery cells to ignite thus producing a fire that repeatedly flares up at each cell. Li-ion fires have different characteristics and spread quickly in comparison to normal fires which makes extinguishing very difficult.

Risk perspectives and risk management

The difference between vehicles with combustion engines and EV/HEV in a risk perspective is the location and the character of the potential fire sources. In vehicles with combustion engines, the location of most fire sources is concentrated in the area of the engine compartment. In EV/HEV vehicles, the potential fire sources can be located in different sections of the vehicle; in other words, more protection zones have to be considered and often together with a combination of different extinguishing agents due to the sensitivity of electrical components and the type of fire that might occur.

Prior to any installation of fire-suppression systems, a fire-risk analysis must be conducted in order to identify potential fire hazards. The severity and probability are then assessed in order to design the optimal fire-protection solution for the vehicle. SP method 5289 – Fire Risk Management procedure for vehicles – issued by RISE Research Institutes of Sweden, is used as a basis for conducting fire-risk assessments. A fire-risk management process includes the following steps:

1. HAZARD IDENTIFICATION
2. RISK ESTIMATION
3. RISK EVALUATION
4. RISK REDUCTION

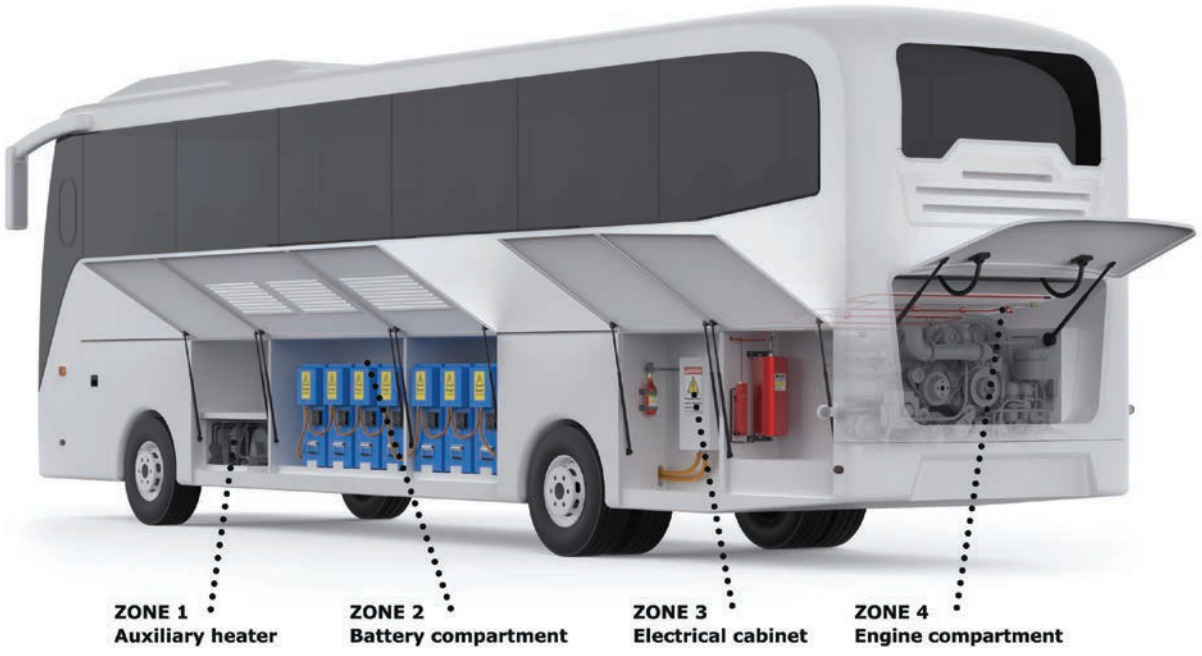
A fire hazard exists where there is a possible interaction between fuel, ignition sources and oxygen. The hazard identification process aims to answer where this could happen, when it could happen, how it could happen and why it could happen.

Following the hazard identification, risks shall be quantified by a risk-estimation method. The objective is to quantify the risks such that they can be sorted with respect to priority and actions needed. A method often used in the vehicle industry is Failure Mode and Effects Analysis (FMEA). This method can also be applied for quantification of the vehicle fire risks. The identified hazards (failure modes) are given risk priority numbers based on quantifications of probability of occurrence, severity and probability of detection failure. Each of the quantifications is made on a relative scale where a higher rating contributes to a higher estimated risk priority number. Fire severity can be quantified by estimating the potential consequences for the vehicle, the driver and any passengers, as well as to the surrounding environment.

When the fire risks have been quantified, they shall be sorted to provide an overview of the risk image. The risk evaluation, which is done based on the fire-risk assessment matrix, aims to provide this overview and separate risks that need to be addressed from risks that are more acceptable.

Following the risk-evaluation process, an action plan for each identified fire risk must be laid out. Risk-reduction measures can be arranged in a hierarchic structure where measures at each level should be considered.

1. **RISK ELIMINATION OR MINIMISATION BY DESIGN**
2. **PASSIVE AND ACTIVE FIRE-PROTECTION SYSTEMS**
3. **IMPROVED MAINTENANCE AND CLEANING PROCEDURES**
4. **IMPROVED TRAINING AND QUALITY PROCEDURES**



The main risk scenarios are divided into four protection zones on an EV and HEV bus.

Currently there is no comprehensive solution for fire mitigation available on the market. However, Dafo Vehicle Fire Protection (Dafo VFP) has developed a full-coverage interim multi-zone fire-protection solution in response to the urgent need. The Dafo FORREX liquid-based extinguishing agent, which is non-corrosive, is used as one part of the complex system solution, and it provides effective cooling capacity to slow the fire development, allowing safe evacuation of passengers.

Upcoming mandatory installation of fire suppression systems in buses and coaches having an internal combustion engine. Future research will aim to implicate the development of future standards and regulations such as UNECE Regulation 100 and UNECE GTR 20.

In order to cover all risk areas in an EV or HEV bus, the main risk scenarios are divided into four protection zones:

- Zone 1 Auxiliary heater and AC – protection for potential fires due to leakage of flammable fuels sprayed on hot surfaces etc.
- Zone 2 Battery compartment – protection of batteries from outside fire, fire containment at battery fire/thermal runaway.
- Zone 3 Electrical cabinet – protection for electrical-related fires due to short circuits, arcs etc.
- Zone 4 Engine compartment – protection installed for combustion engine (HEVs) and compartment with electrical components (EVs) for potential fires due to leakage of flammable fuels sprayed on hot surfaces etc.

The different zones are then protected in various ways by robust detection and suppression systems – both liquid- and gas-based solutions.

Mandatory installation of fire suppression systems in buses and coaches

In 2016 the documents Addendum 106 – UNECE Regulation No. 107 – Revision 6 – Amendments 3 and 5 were published. The documents included a fire-testing procedure for fire-suppression systems for engine compartments of buses and coaches with four tests extracted from SP method 4912.

Since 11 July 2018, it has been mandatory to install fire-suppression systems in new vehicle types of single-deck, double-deck, rigid or articulated vehicles of category M2 or M3 and specifically vehicles having a capacity exceeding 22 passengers in addition to the driver – 'Class III'. Class III vehicles are constructed exclusively for the carriage of seated passengers, more commonly referred to as 'coaches'. As of 11 July 2019, this will apply to all new Class III vehicles.

As of 1 September 2020, it will be mandatory to install fire-suppression systems in new vehicle types of single-deck, double-deck, rigid or articulated vehicles of category M2 or M3 and specifically vehicles having a capacity exceeding 22 passengers in addition to the driver – 'Class I and Class II'. Class I vehicles are constructed with areas for standing passengers, to allow frequent passenger movement, and Class II vehicles are constructed principally for the carriage of seated passengers and are designed to allow the carriage of standing passengers in the gangway and/or in an area which does not exceed the space provided for two double seats. They are more commonly referred as 'city buses and inter-city buses'. As of 1 September 2021, this will apply to all new Class I and Class II vehicles.

The requirement for installation of fire-suppression systems applies to the vehicle. The fire-suppression system manufacturer's UNECE approval (fire-suppression system as component with regard to UNECE Regulation No. 107) will be used as a part of the bus manufacturer's vehicle approval for UNECE Regulation No. 107.

The requirement applies in the case of vehicles having an internal combustion engine or a combustion heater located to the rear of the driver's compartment. Consequently, EV and HEV buses and coaches are currently excluded from this requirement.

Li-ion battery fire safety research

Li-ion batteries are still a relatively new technology and Li-ion battery safety is a recent research area. Regulations and standards are to some extent lagging behind. Dafo VFP is at the forefront of the research, and participates in several projects dealing with fire hazards of Li-ion batteries in vehicles, in order to provide solutions for reducing the risks and consequences of a thermal incident in, or in connection with Li-ion batteries in heavy commercial HEVs and EVs, such as buses and trucks. Dafo VFP is leading one of the most advanced research projects called Li-Ion Fire® funded by the EU Framework Program for Research and Innovation – H2020 – under the SME Funding Scheme.

The ongoing research will lead to future safety solutions, including system design, battery placement, monitoring and analysing existing data through the Battery Management System (BMS) to achieve early detection of battery malfunction in order to shut the battery down before a full thermal runaway occurs. Furthermore, the objective is to investigate the extent to which fire-suppression systems can be applied to vehicles powered by Li-ion batteries in an optimised way, including refining the formulation of extinguishing agents and possible integration within the Li-ion batteries. In addition, investigations will be conducted on the possible use of sensitive smoke sensors with control systems integrated into the vehicle's CAN-bus control system.

The main objective is to implicate the development of future standards and regulations such as UNECE Regulation 100 and UNECE GTR 20.

Fires in Li-ion batteries are rare but severe and very difficult to suppress once they are fully developed. Therefore, early detection will be key in any upcoming solution.

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PROTECTING THE PROTECTORS: ENSURING FIREFIGHTER SAFETY WITH LIVE VIDEO

Neil Hendry
Vice President, Digital Barriers

A new law, the Assaults on Emergency Workers (Offences) Bill, is currently passing in the UK that will increase sentences for those who assault crucial emergency workers up to six months and/or a fine in a magistrates' court and up to 12 months in a Crown Court. This will look to protect police constables, prison officers, custody officers, paramedics, nurses, firefighters, A&E consultants, lifeboat officers, A&E porters, ambulance drivers, and mine rescue officers.

Times are already challenging for the fire services, with Britain suffering a crisis in some regions after eight years of cuts – around 40 stations have closed due to low staffing levels. This, amongst other factors, has resulted in a rise in fire-related deaths across the country in the last year. Firefighters need all the help they can get to respond to this crisis, in order to save lives and minimise their own risk. The law will help deter people from attacking first responders, but technology can also prove invaluable in these situations. Of course, firefighters already rely on a whole host of technologies, which enable them to fight fires more effectively, from thermal cameras to drones for situational awareness. In order to help protect firefighters and all first responders from assault, live-streaming video can prove to be an invaluable tool. This article will assess the current threat to first responders, and fire crews in particular, before explain how live-video-streaming technology works and how it can help keep firefighters safe, whilst delivering real-time situational awareness to aid rapid decision-making.


REC
ONLINE

The rise of attacks against fire crews

It's shocking that a law is required in the first place to discourage members of the public from assaulting first responders, but the Assaults on Emergency Workers (Offences) Bill comes in response to a recent spate of both physical and verbal attacks against these critical workers in our society. For example, in the UK during Storm Emma in early 2018, a paramedic was attacked whilst helping a woman with chest pain simply because their ambulance was temporarily parked parallel to the attacker's car.

Fire crews also frequently suffer from abuse at the hands of the general public. From 2014 to 2016 alone, crews came under attack 1,063 times according to a Freedom Of Information (FOI) request – equalling an assault more than ten times a week on average. These attacks included 370 instances of crews being attacked by people throwing objects at them, as well as 71 cases of physical violence – other cases included verbal attacks and harassment. Two firefighters in Northern Ireland reported that when they were dealing with a car fire in North Belfast a gang of men attacked them with a baseball bat and threw objects at them, including an iron bar. One of the firefighters had to take eight weeks off work after the attack, having suffered from broken ribs and bruising on her arm. As well as this, both firefighters have been affected psychologically by the attack. In areas that have the highest frequencies of assaults against firefighters, authorities also reported people throwing fireworks and bricks at crews and shining red and green lasers into their faces and eyes. It appears that incidents like these are not a UK-only phenomenon, with two firefighters being shot and one tragically being killed in one attack in Long Beach, California in June 2018.

Live video for the right response

Reports suggest that attacks against firefighters have increased since budget cuts have reduced their ability to engage with the local community. Communication and understanding between the community and firefighters would foster respect and most definitely help to reduce these attacks, but crews must also be prepared to call for the right protection if they encounter violent people. Many incidents when reported over 999 may not seem to warrant an urgent law-enforcement presence but may then turn out to be dangerous for the firefighters once they arrive on the scene, particularly if they are called with a malicious goal in mind. The aforementioned incident in Long Beach took place after an elderly man, Thomas Kim, lured firefighters to his retirement home by calling emergency services and reporting an explosion. When firefighters arrived on the scene, some windows were blown out, sprinklers were activated and there was a fire, which they were able to extinguish. When they began to search the building itself, Kim fired shots at the firefighters – the reason for his aggression was later determined to have stemmed from a feud with a neighbour.

Live-video streaming from a dash-cam on the fire engine, and even on sufficiently ruggedized cameras worn by the crew, can provide a very high level of situational awareness for command teams. Ultimately, this is because live video gives commanders a much more immediate view of the scene than a vocal report ever could. This means that command centres can assess the scene in seconds in order to advise crews on the best course of action and send out additional tools or crews immediately if required. It also gives commanders the ability to quickly identify if something 'isn't quite right' so that other emergency services, such as law enforcement or paramedics, can be urgently dispatched to the scene.

Live video streaming gives commanders an immediate view of the scene, allowing for them to assess the situation and give out appropriate commands in seconds.

The immediacy of live video enables it to save lives, both of firefighters and of the public, in the incidence of a fire as well as if firefighters face a violent threat. However, if a video is recorded as well, it can be used as evidence to allocate liability according to facts in a court of law. Furthermore, other video analytics such as facial recognition can be applied to recorded video by law enforcement agencies in order to identify if any criminals not arrested at the scene are on police watch lists so that they can be apprehended. Facial recognition can be applied to live-streaming video, but this application is of more use to police officers whose duty is to apprehend known criminals – firefighters ultimately are protectors of the public and lifesavers, not enforcers of law.

Live video technology not only helps crews to respond quicker, but also allows for greater coordination of firefighters in protecting both the public and themselves.

The technology

Many of the incidents that firefighters have to attend are in either very remote or very congested areas that lack available 4G signal for anything but the bare minimum of vocal reporting. However, live video is only useful to help protect firefighters and members of the public if it really is live. Even the slightest delay could result in an inaccurate reading of the scene or a reaction that comes too late. The technology must be secure, affordable for an already overstretched sector, and reliable to the nth degree.

As said before, streaming video over 4G can be a challenge not only because it can already be constrained or limited but also because video consumes a very large amount of data. Networks can be particularly constrained during larger incidents, as during a fire people automatically reach for their phones, either to call loved ones or to live stream the incident themselves over social networks such as Instagram or Snapchat. Luckily, there is more than one way to egress video over cellular. It is possible to utilise a specialist codec (encoding and decoding algorithm) to stream secure and reliable video over an ultra-low bandwidth even when networks become constrained or are limited for some other reason. Technology can also be used to create a local wireless 'bubble' at the scene, and then by using Wi-Fi or mesh radio systems transmit high-bandwidth communications. Control teams can then view, command and protect teams on the ground with situational awareness that is streamed instantly to them using cellular or even satellite communications.

The deployment of live-video streaming may seem like a hefty infrastructural challenge for fire services, but in fact equipping a fire engine with fixed cameras or dash cams is very simple.

Furthermore, if firefighters are already using body-worn cameras, live-streaming video can be applied to these devices at a very similar cost to the deployment of traditional record-only body-worn cameras. Then, infrastructure required to support live streaming back at the command centre can be standalone initially and later integrated into existing command-and-control systems. If looking to expand situational awareness further, the technology can even be deployed on drones to get a wider picture of an incident.

Ultimately, the root cause of this problem stems from the fact that due to reduced resources and personnel the firefighting sector in the UK is less able to engage with local communities. This means that many communities may have less of an understanding of firefighters' exact responsibilities, how important they are and how many lives they save on a daily basis. It is critical that government funding goes into reinvigorating these community schemes. However, technology can also help to protect teams on the ground against violence by providing commanders with instant situational awareness that enables them to respond effectively and straight away and give command the best possible chance to keep their teams safe.

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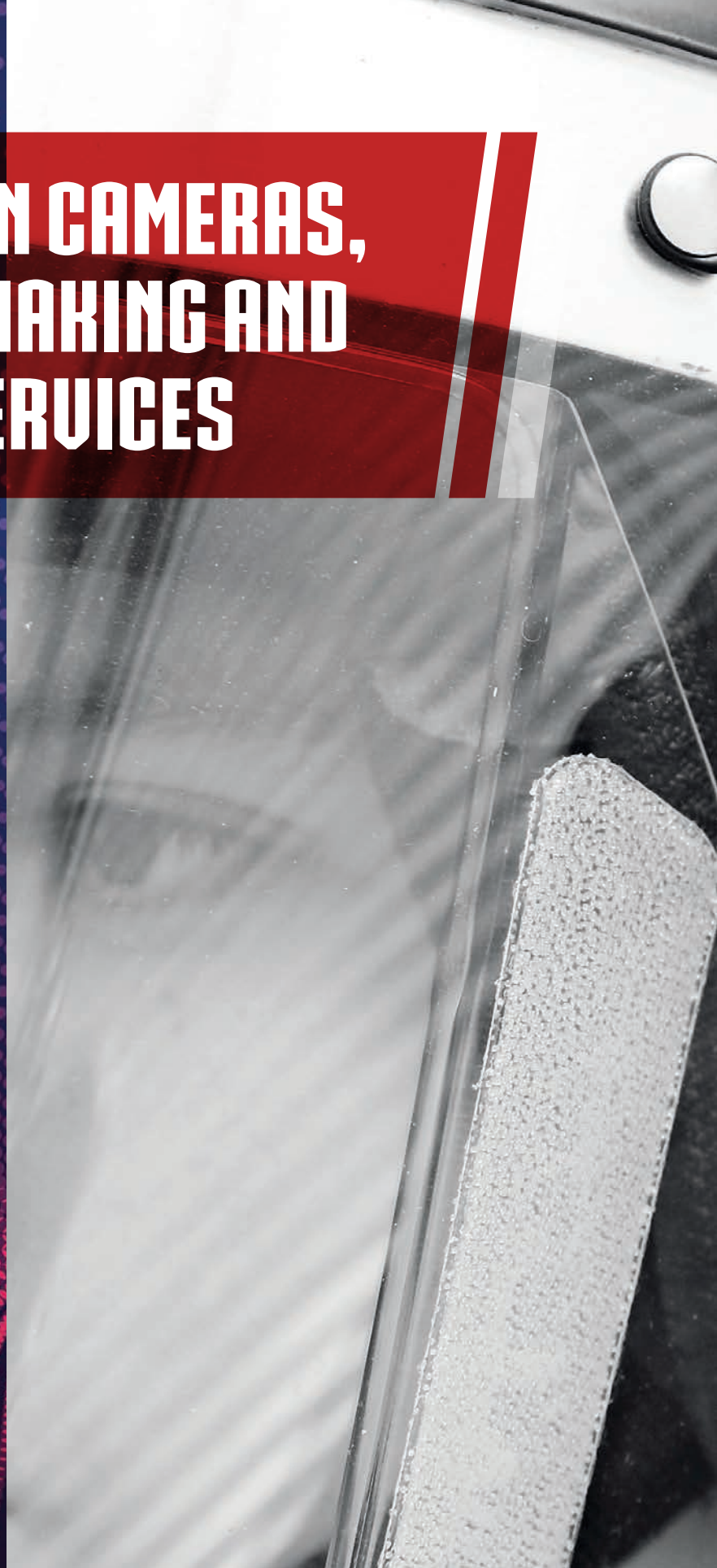
BODY-WORN CAMERAS, DECISION-MAKING AND OUR FIRE SERVICES

Richie McBride
CEO and Co-Founder, Edesix Ltd



As the use of wearable cameras grows within the emergency services industry, Edesix provides an insight into how these devices benefit the fire service today and future technology developments designed to improve processes and protect the community.

The influence of police body-worn cameras

Police-issue body-worn cameras, in recent years, have become an accepted and beneficial piece of equipment, used to gather unbiased evidence, protect officers and the public, as well as act as a deterrent to antisocial and aggressive behaviour. With such trials and subsequent force-wide roll-outs of wearable cameras deemed a success, it is no surprise that we're now seeing interest in these devices trickling into other emergency services such as first responders and the fire service.

With devices available that can record for up to 14 hours, offer streaming and text alerts when activated, provide full audit trails of recorded data and the ability to securely redact, crop and share footage, these body-worn devices are ideal for those working on the front line.

However, the use case for such technology within the fire service, so far, has differed from that of police and security enforcement. Where police officers see wearable cameras as a mode for capturing evidence for prosecution, both first responders and the fire service are currently using them from a training and best-practice perspective.

The Edesix VB-300 body-worn camera is currently used by many UK Fire Services.

In 2016, West Midlands Fire Service was the first service to adopt body-worn cameras, after a successful trial across ten of its fire stations using Edesix VideoBadge cameras, distributing them in early 2017 to their incident commanders.

With an outstanding response rate for emergencies in which people or buildings are in danger, West Midlands Fire Service has been praised for its operations. In order to maintain and improve upon this success, body-worn cameras have been implemented to allow detailed accounts of incidents and emergencies to be recorded, in turn providing real-life learned techniques for training both new and experienced firefighters.

Councillor John Edwards, Chair of West Midlands Fire and Rescue Authority, publicly said: "We're proud to be at the forefront of rolling out this technology. The cameras will help us to maintain excellent levels of service to the West Midlands. They will provide a valuable video resource to support learning and development and, ultimately, firefighter and public safety."

West Midlands Fire Service deployed VideoBadge cameras for Incident Commanders.

Body-worn camera features

As with the police, both first responders and the fire service have been faced with challenges around privacy. How and when the cameras are used, as well as how footage is reviewed, stored and deleted are all key to ensuring an effective body-worn camera roll-out. Such policies and compliance are partly facilitated by the camera provider's own software, using secure role-based login and access, automatic deletion policies, and two-factor authentication to ensure that services are equipped to create user policies that adhere to their organisation's approach to data protection.

With features such as live-streaming, HD recording, voice recording, incident bookmarking and a suite of accessories ensuring the device is secure and accessible for the wearer, body-worn cameras are ideal for capturing real-time footage of firefighters attending incidents. This footage can then be offloaded post-event, and reviewed for discussion around best practices and process improvements when required.

In 2017, the Staffordshire Fire and Rescue Service (SFRS) embarked on a trial of body-worn cameras also aimed at best practice and training facilitation. Neil Gordon, leading the project for SFRS, said: "Staffordshire Fire and Rescue Service's vision of the benefits for body-worn video is to overtly capture video and voice data during the course of their duty such as at operational incidents, exercises and other appropriate operational training events. The introduction of body-worn video is solely for the development of our service, enhancing our already high-standard incident decision-making to protect life and property."

The future of wearable cameras in the fire service

As trials progress, and with further fire services adopting the technology, it can be assumed that the spectrum of use cases will grow. We are already seeing services such as Durham and Darlington trialling body-worn cameras as a deterrent to violence against firefighters. With statistics reported that firefighters are attacked more than ten times a week in the UK, the evidence captured and instant response that wearable cameras enable, not to mention the mere deterrent of wearing a recording device, cannot be ignored.

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CONTINUED ASSISTANCE FOR REGIONAL DISASTERS – INSARAG HEAVY USAR TEAM RECLASSIFICATION

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SCDF's humanitarian efforts in the form of Urban Search and Rescue (USAR) dated back to 1990 when a maiden contingent was sent to Baguio City, Philippines to assist with rescue efforts in the earthquake-stricken country. This was before the inception of International Search and Rescue Advisory Group (INSARAG)[1] which comes under the United Nation Office for Coordination of Humanitarian Affairs (UN OCHA)[2] established in 1991.

SCDF joined INSARAG in 1999, contributing to international efforts in rendering humanitarian assistance and disaster relief. One of the key mechanisms SCDF has put in place is a team of specialists capable of providing USAR assistance to countries affected by disasters. Codenamed 'Operation Lionheart' when activated, the Operations Lionheart Contingent (OLHC) can be mobilised and deployed for overseas missions within short notice.

In January 2008, SCDF OLHC became the first team in Asia-Pacific to successfully undergo the INSARAG External Classification (IEC) and attained the Heavy USAR Team classification. It is the highest accolade given to a USAR team in recognition of its professionalism, adhering to international standards set by the INSARAG. To ensure the classified team maintains and remain ready for deployment according to the INSARAG Guidelines[3], all classified teams are required to undergo a re-classifier every five years. In September 2018, the SCDF OLHC underwent its second IER and successfully retained its Heavy USAR team status.

The Asia-Pacific region is one of the most disaster-prone regions in the world that SCDF had responded on numerous occasions to render assistance. The first overseas mission SCDF Operations Lionheart Contingent (OLHC) responded to was in Baguio City, Philippines in July 1990 in the aftermath of an earthquake. The latest mission to date was in July 2018, following the collapse of an under-construction dam causing massive flooding in the south-east region of Laos. In all, SCDF OLHC has been deployed to 18 overseas missions.

[1] INSARAG was formed in 1991 following the aftermath of the 1985 Mexican earthquake and the Armenian earthquake in 1988. It was deeming there was a need for better coordination and understanding among international USAR teams responding to such disasters.

[2] OCHA was formed to strengthen the UN's Response to complex emergencies and natural disasters. OCHA is the part of the UN Secretariat responsible to ensure a coherent response to emergencies through a framework within which each actor can contribute to the overall response effort.

[3] INSARAG Guideline consists of 3 Volumes, describing the methodology of INSARAG. Please visit INSARAG.ORG for the full Volumes of the INSARAG Guidelines.

The International Search and Rescue Advisory Group (INSARAG) was established in 1991 and remains a global network of more than 90 countries and organisations under the United Nations (UN) umbrella. INSARAG deals with Urban Search and Rescue (USAR) related issues, aiming to establish minimum international standards for USAR teams and methodology for international coordination in disaster response based on the INSARAG Guidelines endorsed by the United Nations General Assembly Resolution 57/150 of 2002, on "Strengthening the Effectiveness and Coordination of International Urban Search and Rescue Assistance".

Figure 1: SCDF Operations Lionheart Contingent during deployment in Laos

Prior to the introduction of the INSARAG classification system, USAR teams conducts self-assessment and submits the report to the INSARAG Secretariat for recording into the Directory of International USAR Teams. INSARAG strongly recommends Member States to establish national USAR team classification processes as an initial step.

In 2005, the INSARAG network supported the establishment of independently verifiable, operational standards for international USAR teams through the INSARAG External Classification (IEC) process, and encourages all Member States with USAR teams to be classified so that international teams are deployed in accordance to the INSARAG methodology following the IEC process.

The INSARAG Guidelines defines USAR teams according to their capacity to provide the key components of USAR. The five key components are management, search, rescue, medical and logistics. USAR teams can be classified under three categories namely Light, Medium, or Heavy USAR teams. The key differences are shown in the figure below.

Category	Suggested Number of Personnel	Self-Sufficiency	Operations Capacity	Search Capability	RDC/UCC
Light	17-20	Up to 5 days	Single Worksite 12-hour ASR 3	Search Dog and/ or Technical Search	Ability to deploy one personnel to support RDC/UCC
Medium	Minimum of 40	Up to 7 days	Single Worksite 24-hour ASR 3/4	Search Dog And Technical Search	Full set-up and running of RDC/ UCC
Heavy	Minimum of 58	Up to 10 days	Dual Worksites 24-hour ASR 3/4	Search Dog And Technical Search	Full set-up and running of RDC/ UCC

Table 1: Key differences between Light, Medium, and Heavy Teams

Figure 2: Members from the contingent receiving the INSARAG patch upon successful reclassification

Overview of Reclassification Process

In September 2018, the SCDF OLHC underwent its second INSARAG External Reclassification (IER) and once again successfully retained its Heavy USAR team status. The reclassification process can be divided into three main phases: Preparation, Actual Assessment, and Results.

Preparation

To prepare for IER 2018, a Steering Committee was established to spearhead the preparatory activities needed for IER. Key considerations set by the Steering Committee was to deliver standards beyond minimum requirement and to invite other classified USAR teams to be part of our IER.

Undertaking an IER is a resource-intensive commitment and requires coordination among key staff departments and units. Preparation activities include review of the OLH SOPs, setting aside funds, developing exercise plans, preparation of training facilities, procurement and equipping, among others. This being SCDF's second IER, options for a scaled-down assessment programme were also explored with the mentor and Emergency Response Support Branch (ERSB) of the UN Office for the Coordination of Humanitarian Affairs (UN OCHA).

According to the INSARAG Guidelines, USAR teams undergoing IEC/R shall adhere to a 24-month preparatory timeline. This timeline ensures that all IER milestones are met and that gaps arising from the previous IEC/IER are identified and resolved. Upon the submission of SCDF's IER application together with the Abbreviated Portfolio of Evidence (A-POE)[4], a provisional IER date was set and that marks the start of the 24-month preparatory phase. After the A-POE have been submitted, a Comprehensive Portfolio of Evidence (C-POE)[5] is to be submitted to the INSARAG Secretariat at the 12-month point of the two-year timeline. Prior to its submission it must be reviewed and endorsed by the team Mentor.

[4] A-POE is a compilation of documented evidence that demonstrates the USAR team has been developed in accordance with the INSARAG Guidelines and has adopted the INSARAG methodology.

[5] C-POE is a detailed follow-up of the A-POE documenting the progress of the team during the 24-month preparatory phase. It may include documents such as Exercise Plan and Scenario, USAR Team Personnel Manifest, Shippers Declaration of Dangerous Goods.

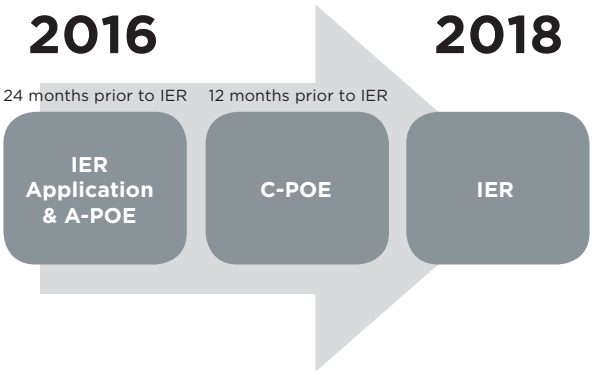

Figure 3: Infographic showing the timeline of submission of A-POE/C-POE leading up to the IER

In the beginning stage of preparation, the OLHC have to go through a Pre-IER screening to ensure the team has fulfilled the obligations expected of an INSARAG classified team since its last classification. A Pre-IER Self-Assessment Checklist with supporting documents including the Mentor's Assessment Report[6] is to be submitted to ERSB for pre-screening purposes. Under the checklist there are three main categories namely "Preparedness", "Follow Up" and "Deployment".

The "Preparedness" category determines if the classified team has undertaken sufficient measures to ensure the operational readiness level of the USAR Team from its last IEC/R is maintained and/or improved. This segment also includes the USAR Team's participation in INSARAG activities during the five-year period.

The "Follow Up" category ascertains if the classified team has implemented measures to act on the "yellow" items arising from the previous IER. This segment also considers if the classified team has improved its operational readiness via the introduction of new equipment, workflows and best practices.

The "Deployment" segment ascertains if the classified team has deployed in the capacity in which it has been classified.

The preparatory work started early in conjunction with the most updated INSARAG Guideline endorsed in 2015.[7] The preparatory works includes the following items:

- Refresher workshops for contingent on standby
- Deployment exercises for contingent on standby
- INSARAG Guidelines Induction Workshops for key appointment holders and officers performing support functions
- Sending personnel for USAR Coordination Cell (UCC) course
- New staff aids aligning to the latest guidelines were implemented
- Revision of Search Platoon's operational deployment procedures to align with the standards of International Rescue Dog Organisation (IRO)
- Key appointment individuals i.e. EXCON members, Contingent Commanders and Steering Committee Secretariats participating in other Team's IER as observers and classifiers

Figure 4: Quarterly deployment exercise conducted for contingent on standby

Figure 5: Component training for key appointment holders and officers performing support-functions

[6] Mentor's Assessment Report will include Mentor's contact and engagement with the USAR team to date, a snap-shot of the USAR team's current state of preparedness, findings as well as recommendations.

[7] INSARAG Guidelines are reviewed every 5 years with the current review to be conducted in 2020.

Day	Full IER Programme	Scaled-down IER Programme
Day 1	• Key Note Address and Opening IER • Presentation on OLHC Capabilities • Visit to exercise sites	• Key Note Address and Opening IER • Presentation on OLHC Capabilities • Visit to exercise sites • Audit checks on documentation (scaled-down)
Day 2	• Audit checks on documentation	• 36-hour ground exercise • Audit checks on documentation
Day 3	• 36-hour ground exercise	
Day 4		• Preliminary results announcement • Closing
Day 5	• Preliminary results announcement • Closing	

Table 2: IER Assessment Programme

Figure 6: Keynote address & opening by INSARAG Secretariat Mr Winston Chang

Figure 7: Mobilisation phase of the 36-hours ground deployment exercise

Results

A month after the IER exercise, SCDF received the full IER 2018 report by the classifying team. Due to the extensive preparatory work, the OLHC had surpassed INSARAG's requirements for reclassification during IER 2018. There were a total of 17 best practices identified by the classifying team, and these will be shared to the wider INSARAG community through appropriate INSARAG forums.[8]

Figure 8: A rescue specialist performing a lateral concrete breech while suspended in mid-air

Best Practices

This segment highlights a few key initiatives that were incorporated in the Ops Lionheart SOP, which were identified by the classifiers as best practices:

a. Pre-Deployment Phase (Mobilisation Support Group). The use of the Ops Lionheart Electronic Management System (OEMS) for administration of the contingent's personal particulars and details, training records and medical triaging was commended by the classifiers for helping to enhance the efficiency and effectiveness of the mobilisation process. They also commended that the veterinary medical screenings of the canines were conducted in a comprehensive manner.

b. SCDF's Psychological Support. The inclusion of two psychologists on the team to provide psychological support and to ensure the mental well-being of the contingent during deployment was commended by the medical classifier.

c. Base of Operations (BoO). The logistics classifier praised the contingent's usage of SCDF's own innovation project, "BoO layout magnetic board", which allowed the BoO manager to better plan the BoO layout based on the available ground and provides contingent member with a clear reference of the BoO layout during the setting up of the BoO. The clear demarcation of clean and dirty areas within the BoO between the decontamination area and the administrative area were also captured as best practices by the classifying team.

d. IER Exercise Control. The exercise control team was commended by the classifying team leader and deputy team leader as exercise simulations were real and scenarios are appropriately executed. This is the result of a well-designed exercise plan and a strong set up of an exercise control command post. With reality simulation and timely coordinated injects, the OLHC were able to display skill sets well above the standards ordinarily expected of an IER exercise.

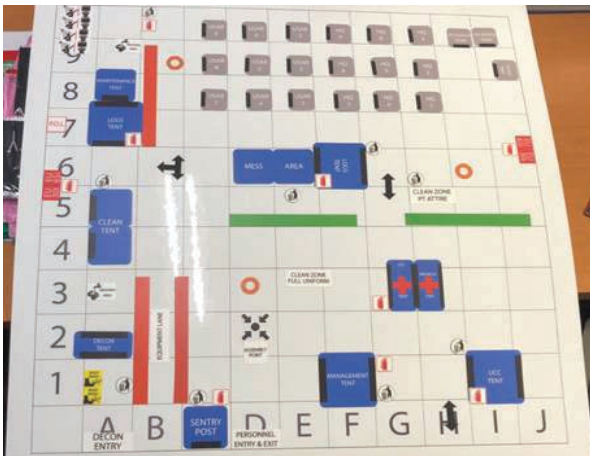

Figure 9: SCDF's innovation project – "BoO layout magnetic board"

Recommendations for IER 2023 Preparations

The robust and comprehensive preparations prior to the conduct of IER 2018 ensured the smooth execution of the 36-hour exercise, verification of documents as well as hospitality support for the INSARAG classifiers and other foreign guests. The efforts invested in reclassification must go hand in hand with SCDF's continuous engagements with INSARAG to lay the foundation for our next IER, scheduled for 2023. An internal AAR was held in October 2018 following the IER. The key recommendations in preparation for IER 2023 are as follows:

a. Involvement in INSARAG Working Groups. SCDF is currently involved in the Guidelines Review Group (GRG)[9] and Information Management Working Group (IMWG). It is imperative to tap SCDF's involvement in the current INSARAG GRG to enhance collaborations between SCDF and the INSARAG fraternity, thereby maintaining SCDF's international profile in the disaster management community and staying up to date with the review of INSARAG guidelines for 2020[10] and new initiatives.

[8] These forums include the INSARAG Working Group Meeting, USAR Team Leaders Meeting, Guidelines Review Group Meeting and AP Regional Meeting. For instance, SCDF has already shared the OLHC USAR Coordination Cell set up during the USAR Team Leaders Meeting in Romania October 2018.

[9] Singapore (SCDF) and Switzerland (Swiss Agency for Development and Cooperation) were appointed as the co-chairs of the new GRG by the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA).

[10] The INSARAG Guidelines is reviewed every five years

b. Continuous participation in the INSARAG Community. SCDF will continue to support and participate actively in all INSARAG activities, and maintain its close ties with the community. These include hosting of events, being represented in INSARAG meetings and participating in related exercises.

Figure 10: 4th GRG meeting 12-14 Jun 2019, Singapore

c. Engagement of other International USAR teams. The involvement of China International Search and Rescue (CISAR) and Special Malaysia Assistance and Rescue Team (SMART) for IER 2018 facilitated the close sharing of experiences and USAR methodologies between SCDF and the foreign teams. It is recommended for SCDF to continue the invitation of foreign USAR teams to participate in subsequent IERs so as to enhance SCDF's learning.

Figure 11: Team Leader meeting during IER 2018 involving counterparts from SMART

Figure 12: Rescuer from CISAR in action during IER 2018

d. Enhancement of Training. SCDF sends its officers for USAR Coordination Cell (UCC) courses periodically. SCDF also has officers appointed as trainers for Indonesia (Jakarta), Australia and the New Zealand UCC. It is recommended for SCDF to train its own pool of IEC/R classifiers in specialised areas such as USAR, medical, and logistics. With the experience of other international USAR teams' IEC/R, these classifiers will return and contribute to the training and preparatory of the SCDF OLHC's IER 2023.

e. Knowledge Management. All materials prepared for IER 2018 were compiled and archived in the electronic registry. This collation will aid relevant staff departments' preparation for IER 2023. All materials will subsequently migrate to SCDF's common document management and storage system. The email notification function on the system will also be used to send automatic alerts to trigger our preparatory activities to meet key milestones for IER 2023.

f. Review of IER Steering Committee Structure. Whereas the previous IER was largely DART-led, the IER 2018 Steering Committee was structured to drive planning and execution of the IER through various HQ Staff Department-led functional clusters. It was recognised that experience was thin and the learning curve was steep, but the structure does have its merits and it is important to review how it should be further strengthened to support the efforts in IER 2023.

g. Continual Capabilities Development. In-line with leveraging on technologies to enhance operational capabilities, it is recommended that relevant stakeholders continue to look out for equipment and technology that can aid USAR. Innovations and work improvement should also be extended, not only in operations, but also for training, administrative workflows, data collection and analytics etc.

Conclusion

With the successful completion of IER 2018, it is important to consolidate the experiences and lessons learnt for the preparation of the next IER in 2023. Learning from experience, it is vital for SCDF to commence preparations early. This includes the procurement of equipment, pre-greening procedures, establishing a steering committee, planning component trainings and equipment familiarisation, and review of the Ops Lionheart SOP. SCDF must strive to continually improve and enhance the readiness of its Ops Lionheart system to provide quality and effective humanitarian assistance whenever disasters occur in the region.

INCREASING DIVERSITY THROUGH RECRUITMENT

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Introduction

Creating a diverse and highly skilled workforce is a key aim for Fire and Emergency New Zealand. As the makeup of our communities' change, we acknowledge that our current workforce does not reflect the populations we serve. Recruitment plays a critical role in moving to a diverse and inclusive workforce and we have used three pieces of research, commissioned by Fire and Emergency, to provide an evidence-based approach for improving our recruitment processes. We are also developing a recruitment strategy to introduce and sustain new and enhanced ways of attracting and recruiting personnel to ensure we have the right people, with the right skills, at the right time.

Research project one: *Young people's perceptions of firefighting*

The purpose of this research was to explore young people's perceptions of the firefighter role. It looked at their understanding of the role and the skills needed to be a firefighter, and identified the sources of information that contributed to these perceptions.

The research involved ten focus groups with 38 young people, aged 18 to 22 years, who were in the 'explorer phase' of their career. This career phase sees young people transition from their educational institute into their first careers and are considering future potential career options.

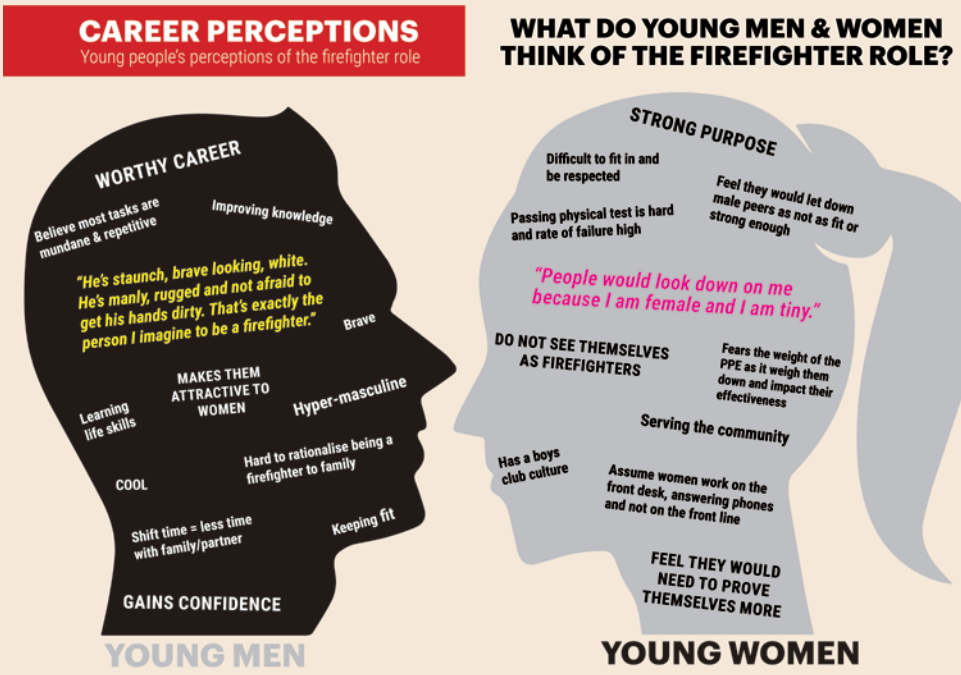
Mini-group focus groups	Women	Men
Pākehā (NZ European)	4	4
Māori	4	4
Pasifika	4	3
Asian	4	4
Rainbow community (LGBTQI)	2	2
Disabled people	1	2
Number of young people	**19**	**19**

Within the focus groups, participants were given magazines and asked to make visual montages from pictures in the magazine of what a firefighter might look and feel like.

Results: The results from this research showed that young people were not aware of the extensive emergency role that Fire and Emergency operational personnel undertake. There was almost no awareness that Fire and Emergency personnel conduct medical co-response (attending life-threatening events at the request of ambulance personnel).

Some young people felt that the firefighting role would be limiting and would not offer the opportunities available in other emergency responder organisations, like Police, Navy and the Air Force.

Young men felt that the firefighter role would establish strong friendships, help to maintain physical fitness and allow them to support their communities. Most young women assumed that women in the fire service work at a desk answering telephones and not on the front line. Young people described a firefighter as 'big, white, strong and male and was associated with being an outdoors type, good at problem solving and not afraid to get their hands dirty.'

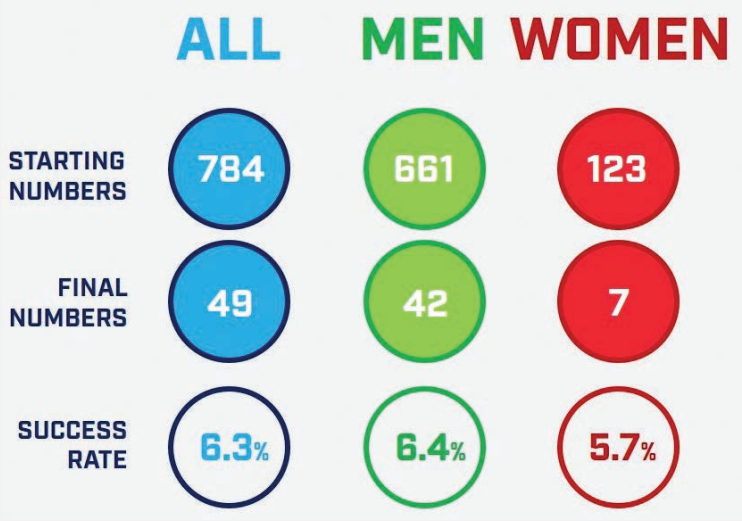


Research project two: *Becoming a career firefighter*

This research focused on identifying and understanding the variety of ways Fire and Emergency, fire stations and individual watches/crews, shape and influence new recruits' attitudes and behaviours. It covers the firefighter journey from their application to their training to their transition onto station. As part of this project, researchers observed and interviewed applicants as they undertook elements of the recruitment process. The recruitment process involves a number of stages with each section requiring completion before moving onto the next.

Recruitment stage	Description
1. Information and Practice day	Applicants are asked to attend a non-compulsory but recommended information and practice day. Session includes overview of process and opportunity to practice Physical Pre-entry Test (PPT).
2. Online application and shortlisting	Applicants complete an Expression of Interest (EOI)
3. Cognitive Testing and Psychometric Assessment	Candidates are invited to complete two online assessments and if successful, are invited to complete an additional three tests.
4. Physical Testing	Candidates required to pass the PPT.
5. Practical Assessment Centre (PAC)	The PAC is used to assess core competencies required for our firefighters (team work, problem solving etc.)
6. Formal interview	Successful candidates will be invited to have a behavioural and situational-based interview
7. Background checks	Medical check, police vetting etc.
8. Final acceptance and 12-week course	Successful candidates are now recruits and are invited to attend a 12-week live-in recruit course at the National Training Centre.

In our September 2018 recruitment round, Fire and Emergency had the largest proportion of diverse applicants. Despite this diversity in applicants, we found that the ethnicity of recruits was similar to previous years. An analysis of the applicant data showed that the Cognitive Testing stage resulted in significant reductions in our Pasifika and Asian applicants. The Physical Testing stage saw a large drop in female applicants.



	PĀKEHĀ	MĀORI	PASIFIKA	ASIAN	NON-NZ EURO & OTHER
STARTING NUMBERS	416	97	107	41	123
FINAL NUMBERS	34	7	4	0	4
SUCCESS RATE	8.2%	7.2%	3.7%	0%	3.3%

Results: Interviews and observations indicated that applicants weren't always clear about the purpose of the cognitive testing and how it contributed to the recruitment process. Additionally, there was an expectation that the physical testing was the most important part of the process and people needed to be strong and fit to pass it. While our trainers and assessors were supportive and encouraging, it was clear that there would be no exceptions. Women were very conscious of this and felt, "as a woman you have to prepare more. You can't just expect to show up and get it."

Research project three: *Diversity in recruitment evidence review*

This evidence review combined a review of recent research literature and fire agency documents along with interviews with emergency service professionals. Documents and web-based information was retrieved from a wide-range of fire agencies from Australia, the United Kingdom, Canada and United States. Interviews were held with individuals from agencies such as Los Angeles Fire Department, Fire and Rescue New South Wales, Metropolitan Fire Brigade, Queensland Fire and Emergency Services and New Zealand Police. Analysing this information provided Fire and Emergency with a summary of 'good practice' for the design and implementation of interventions to increase diversity in applications and recruitment.

Results: Initiatives to increase diverse recruitment are relatively recent, therefore long term results may not be seen for some time. This is especially true for programmes that focus on young people where the time it takes to go from implementation of a programme to potential recruitment of participants may be several years. Despite the increasing number of strategies and programmes being developed and implemented, very little has been published specifically about the impact of diversity recruitment for fire services.

Making the change – How we are using the evidence

Across all three research projects, the Fire and Emergency Research team worked alongside the National Recruitment Manager to analyse the data and find ways to potentially improve the recruitment process. As a result of the Young people's research, Fire and Emergency has instilled a change to the recruitment practice by:

- having marketing attraction campaigns target women and other ethnic groups by increasing diversity in photos

• developing short video series providing the viewer with insights of the recruitment process which aims to answer any concerns they may have; and

• improving information on our website and holding information and practice sessions.

Following the *Becoming a career firefighter* research, the recruitment team have changed the cognitive testing which now incorporates a set of five (short) assessments which are a closer match to what is expected of a firefighter. Additionally, pilot 'firefit' boot camps were held in 2019 for previous applicants who were unsuccessful at the Physical Pre-entry test (PPT). This involved targeting women and small framed men to support them through the PPT. The boot camps received positive feedback from participants and trainers with people feeling better prepared. As a result of the latest boot camp, five females have progressed to the interview stage.

The Diversity in recruitment results helped the recruitment team understand that recruitment is only part of the picture. "It is not enough to simply recruit more diverse team members, that simply gets more 'difference' in the door," (McLeod & Herrington, 2017). As a need to support diverse recruits so they feel welcomed and supported, recruitment initiatives need to be part of a multi-faceted Diversity and Inclusion strategy.

The way forward – developing our Recruitment Strategy

Looking towards the future, all the evidence from our research is being utilised to develop our recruitment strategy.

The aim for our recruitment strategy will:

• develop an attraction and recruitment 'brand' for Fire and Emergency which clearly articulates who we are as an organisation, what we stand for, and the benefits of working and volunteering with our organisation.

• identify opportunities to build on, and shift, public perceptions regarding the range of opportunities to volunteer and/or build a career with Fire and Emergency NZ, and understand who is a good fit for those opportunities.

• drive enhanced attraction and recruitment practices and processes across our recruitment streams.

• inform our recruitment investment plan (i.e. the resourcing requirements to deliver on the strategic intent).

The strategy development is still ongoing however having the evidence at our fingerprints is helping to guide how we put everything together.

Conclusion

Utilising the three pieces of research has been valuable in guiding Fire and Emergency to identify how to attract and engage with a wider range of people. What the research also demonstrates is the importance of evidence-based practice and how it is effectively contributing to one of our strategic priorities of being an evidence-based and intelligence-led organisation. The research has also contributed to effective decision making as we have seen with the changes made to our recruitment process, our marketing approaches and the engagement with our communities. As we develop our recruitment strategy we will continue to focus on how we can build Fire and Emergency to be a leading service in creating a diverse and highly skilled workforce.

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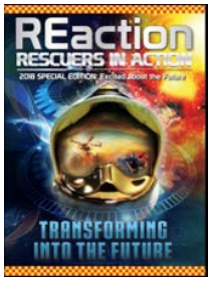

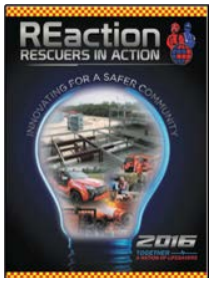

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