

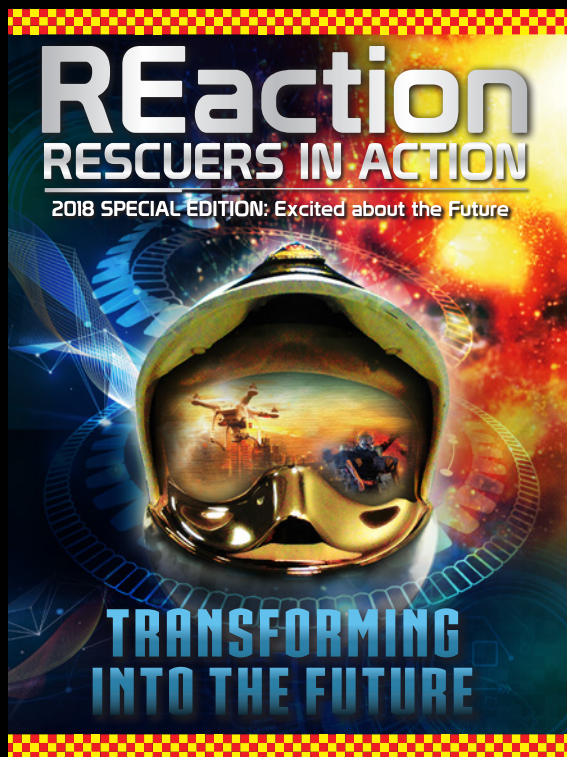
# REACTION

## RESCUERS IN ACTION

2018 SPECIAL EDITION: Excited about the Future



# TRANSFORMING INTO THE FUTURE



## **REaction**

Rescuers in action is the SCDF's annual technical publication. It aims to be a platform to stimulate critical thinking discussions and to share knowledge and new case studies.

This special edition aims to provide readers with insights to the SCDF Workplan Seminar 2018, integrating technology to both our academy and frontline operations.

By providing articles covering a myriad of subjects, we hope for REaction to continue being a repository of knowledge for both our academic and practicing readers.

We hope that you have gained new insights and found REaction beneficial to you.



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**TOGETHER**   
**A NATION OF LIFESAVERS**

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# COMMISSIONER'S FOREWORD

SCDF has the vision of building 'A Nation of Lifesavers' by 2025. Central to this transformation vision is the strong belief that everyone can be a lifesaver in an emergency situation. Tapping the potential of community involvement in emergency preparedness and response has become key to the transformation of the Force. There are three strategic outcomes underpinning our transformation efforts and these are the *'Sharpening of SCDF's Operational Edge'*, *'Enable and Empower the Community'* and *'Institutionalise Safety and Public Protection'*. In this special edition of REaction, we will be focusing on *'Sharpening of SCDF's Operational Edge'*.

Technological developments are changing the world and the way we work. At SCDF, we have been experimenting with robotics and technology to create a future ready force. Making the future requires plans and prototypes, creativity, innovation and experimentation, and most importantly, a vision to steer us towards our intended future. With that in mind, this special edition will provide a peek into our developments in the areas of Robotics, Data Analytics and Smart Solutions and Futuristic Training to sharpen our operational edge.

On this note, I would like to thank the various SCDF units for their article contributions to 'REaction 2018'. We hope that the articles will continue to inspire many lifesavers, generate interest, drive discussions, and catalyse new solutions or insights on issues which are relevant to the global fraternity of emergency responders and disaster managers.

**Eric Yap**

Commissioner  
Singapore Civil Defence Force

# EDITOR'S PREFACE

"The Future is unwritten".

I wanted to leave this page blank because the word "future", based on the online etymological dictionary, places its roots in the Latin "futura" meaning "going to be, yet to be". It's often said that the future is an unwritten book. We can't just look ahead to the future only to predict and react, but we have to make the future what we want.

In this short special edition of REaction, we hope to throw some light on the application of Robotics, Data Analytics, and Smart Solutions and Futuristic Training in Singapore Civil Defence Force (SCDF)'s operations. The main aim of this special edition is to excite the curious reader about the future, about how technology and humanity are converging. This REaction serves as a good reminder that the future does not just happen to us but rather, is created by us, every day, by the decisions we make, every moment.

The first article outlines some of the robotics used by SCDF to do things that once were the sole domain of firefighters and rescuers. These robots enhanced our operational capabilities & efficiency. The next article focuses on developments in UAV swarming technology where multiple UAVs could be autonomously tapped to identify the source of the HazMat incident. They can also execute monitoring tasks without risking our responders unnecessarily to hazardous environments.

With ambulance calls on the rise, it is timely to develop a novel system to integrate all healthcare systems with the purpose of effectively managing both routine and challenging medical cases in Singapore. The third article details Operational Medical Networks Informatics Integrator (OMNII) and its key features to complement Singapore's Prehospital Emergency Care (PEC) model, and develop strategies for improvement.

The publication will end with an article on the plan to transform the Civil Defence Academy (CDA) into a Smart Campus for future responders and to make the training more effective through a technologically enhanced learning environment, with data analytics to surface areas of both the trainee's strengths and weaknesses. Furthermore, CDA's Field Training Area (FTA) will be redeveloped to incorporate the latest developments of our high-density urban landscape with facilities like the Mixed-Use Premises (MUP). We hope that everyone will have an insightful reading experience. We welcome you to write your version of the future together with us!

Finally, I would like to thank the REaction editorial team - without their dedication and hard work, this publication would not be a success.

**AC Teong How Hwa**

Director

Singapore Civil Defence Academy

27 YEARS OF CHANGE AND INNOVATION

# 2025 A NATION OF LIFESAVERS

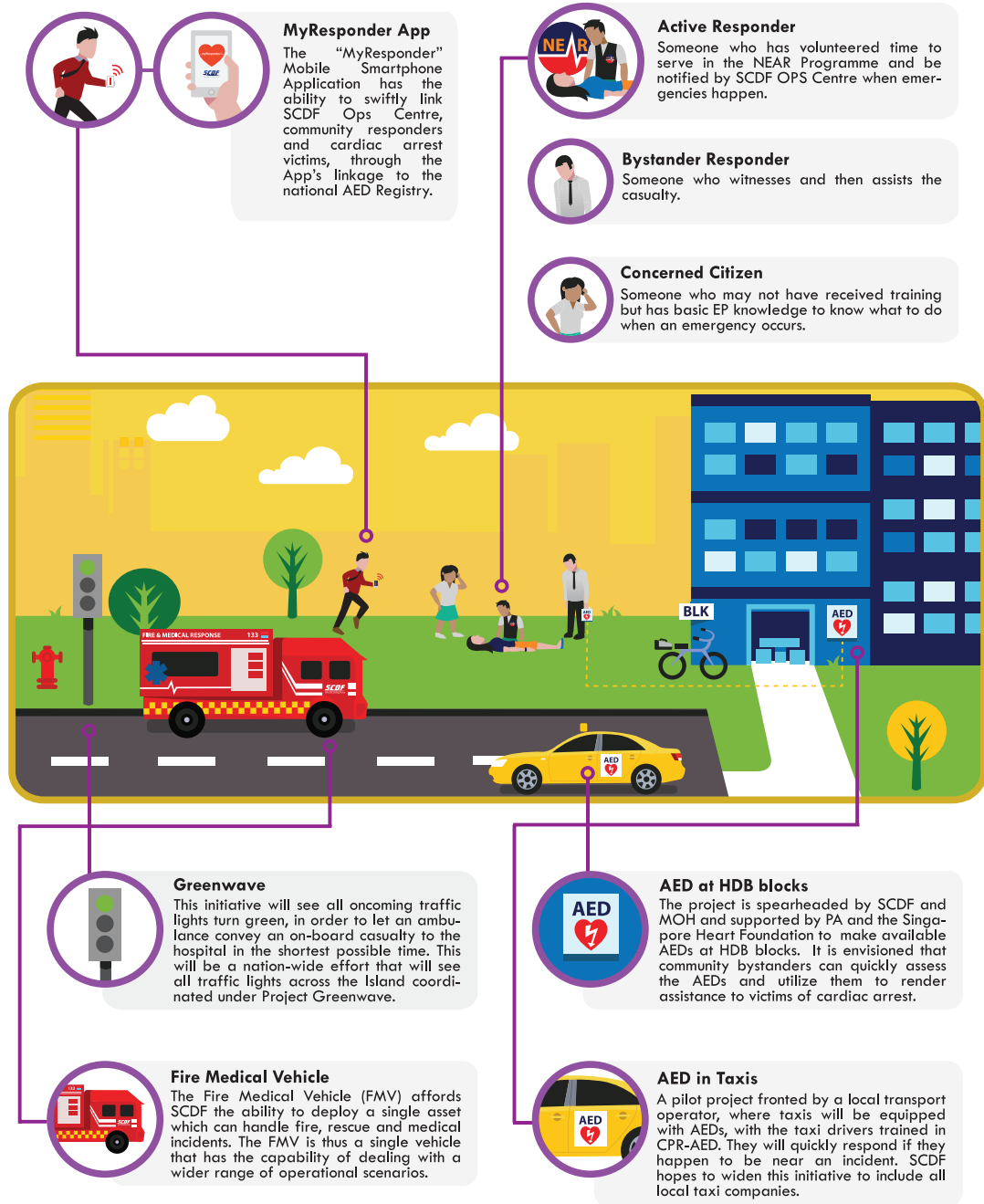
“A Nation of Lifesavers” is a bold vision statement that will propel SCDF to higher levels of service delivery, operational effectiveness, and service excellence. This visual serves to illustrate the types of operational response that SCDF will be able to field at the conclusion of the Force’s transformation efforts in 2025.

The new vision will see the different communities (residential, commercial and industrial) taking greater and more sustainable ownership over their spheres of influence and surroundings to ensure the safety of their neighbourhood. The underlying premise of our vision is that while SCDF continues to provide the highest standards in our response, the community is still in the best position to respond to an incident. This bridges the critical interval between incident occurrence and SCDF’s arrival on-scene.



# A Joint Community - SCDF Response Model For Increased Survival Outcomes

The following scene shows different response elements with respect to a casualty in the community, and illustrates how different response avenues synergise to contribute towards a more effective and enhanced joint-response model.



# Technology As A Force-Multiplier For Higher Operational Effectiveness

This infographic depicts a Warehouse Fire and how the Force will deploy its myriad of capabilities to swiftly and decisively mitigate the incident. From next-generation appliances (HCV, LFAV) to robotics (UAVs, UFM), these new technologies illustrate SCDF's continued drive to leverage on new technologies to enhance its operational excellence, when dealing with incidents.



## Company Emergency Response Team (CERT)

CERT, a group of in-house first responders trained to prevent incident escalation, working hard to contain the incident, prior to SCDF's arrival.



## Unmanned Aerial Vehicle

Small drones, fitted with cameras, allow SCDF personnel to monitor the situation of the fire from the air. They will be deployed during large scale incidents.



## Fire And Smoke Telecamera (FAST) System at Warehouse Fire

Using video analytics and advanced image processing, it detects the presence of fire and smoke at its source within seconds. It then sends an immediate alert to the fire command centre for a quick response.



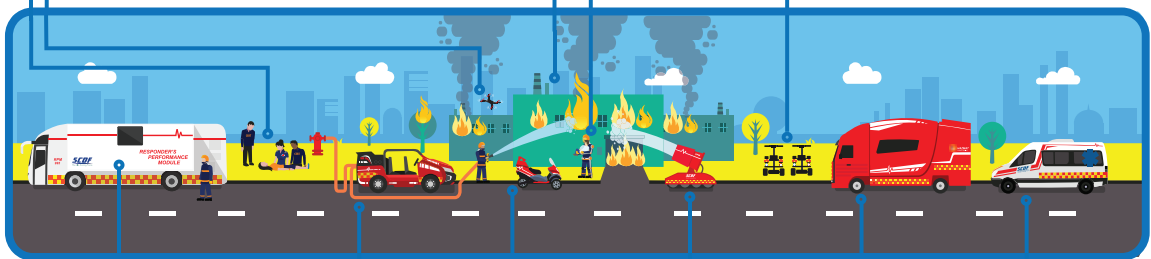
## FRS - EMT in Exoskeleton

Fire Response Specialists will be cross-trained to operate as Emergency Medical Technicians (EMTs) so that they are able to attend to victims of both fire and trauma incidents. In this instance, a FRS-EMT is wearing an exoskeleton, which aims to enhance operators' capacity to carry heavy loads by improving their physical endurance during fire-fighting operations.



## Mobile Transporter

A mobile electric vehicle to carry SCDF personnel and allows them to cover large areas quickly while also detecting toxicity levels in the air and sending back information to the control vehicle (HCV) wirelessly.



## Responders Performance Module (RPM)

Employing sports science to more efficiently combat fatigue and enhance heat recovery, the RPM will allow responders to recuperate quickly, so that they can be quickly re-deployed to combat a fire. This enhances SCDF's operational effectiveness.



## 5th Gen LFAV

First introduced in 2000, the Light Fire Attack Vehicle (LFAV), or affectionately known as the Red Rhino, has grown from strength to strength. The latest version is packed with more capabilities that allow it to respond to a variety of fire and rescue incidents more effectively.



## Firebike

Fire bikes are now equipped with the CAF Backpack which utilizes special technologies that extinguishes fire four times faster than water, while using 70% less water, thereby effectively minimizing water damage to properties during fire-fighting operation.



## UFM

The Unmanned Firefighting Machine (UFM) is a remote-controlled, versatile fire-fighting unit built to operate under extreme conditions as well as complex and hazardous environments. This reflects SCDF's use of technology and keeps SCDF responders away from highly-hazardous areas.



## Next-Gen HazMat Control Vehicle (HCV)

The HCV is deployed for the identification of hazardous substances, assessment of contamination and to determine the mitigation approach for the incident. With new detection technologies, communications equipment and vehicle-in-vehicle concept, it is highly capable.



## Ambulance

SCDF will develop a more robust response system to meet the growing demand for emergency medical services in order to improve overall patient outcomes and survival rates.

# Building A Strong SCDF Through Training Transformation

SCDF will establish a new training regime to ensure that staff are equipped with the competencies and capabilities that are needed to succeed in the evolving operating landscape. This will be done through various measures that include new training programmes, harnessing the latest training technologies, and partnering with institutions of higher learning.



## Chemical Hub Training Facility

A realistic replication of a petrochemical plant that is able to simulate jet fires, pool fires, pipe rack fires, gas cylinder fires, loading arm fires and various sealing and plugging operations for chemical leaks.



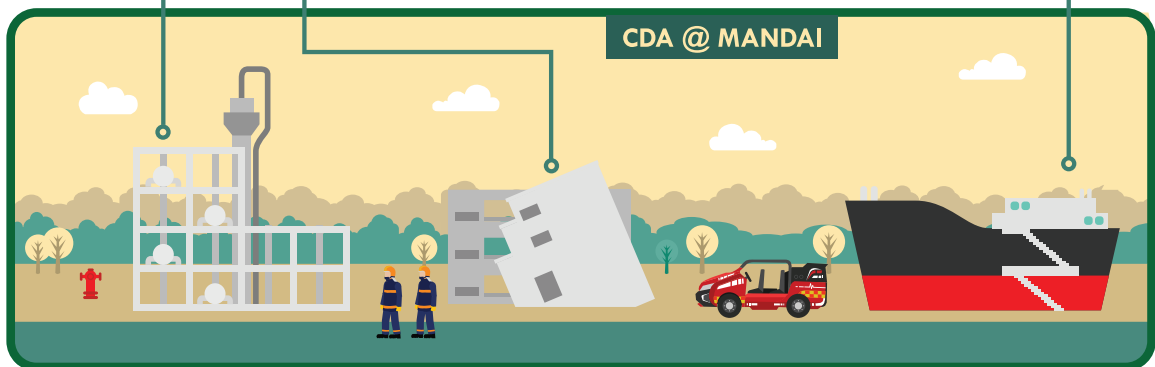
## Ship Fire Fighting And Rescue Training Facility

A realistic replication of ship internal structures that is able to simulate fuel spill fires, engine room fires, cargo hold fires and galley fires.



## Urban Search And Rescue Training Facility

A realistic replication of an urban settling collapsed structure that is able to simulate basement flooding and post-blast environment.





### Realistic Environment For Training

The creation of realistic environments and scenarios to allow for better training and learning outcomes for SCDF Trainees.



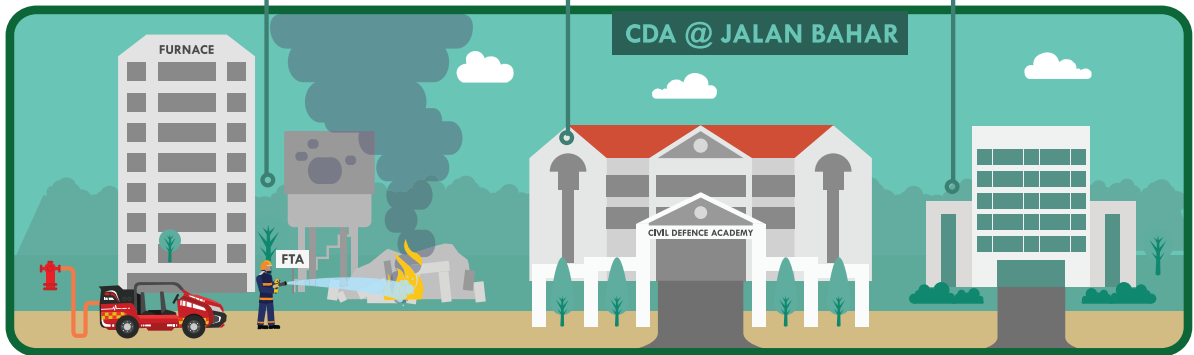
### Enhanced Training

Enhanced computers and simulation technology provides a more realistic and safe training environment that allows mistakes to be viewed as part of effective learning.



### Leadership Centre for Disaster Management Training in Asia Pacific

Through collaboration with a reputable tertiary institution, SCDF will be developing CDA into a centre of excellence for executive leadership level disaster management training in the Asia Pacific Region. This will place SCDF in the fore-front of the academic field of Emergency Management and Urban and Search Rescue knowledge. This is expected to enhance the development of SCDF Officers in disaster management.



# HARNESSING ROBOTICS TECHNOLOGY IN FIREFIGHTING

## Introduction

Robotics technology has progressed rapidly over the past 50 years and is seeing an ever increasing application in various fields. This is especially so in the manufacturing industry where the use of robots has become a key feature since as early as the 1980's. The use of industrial robots improves the quality of product output as well as reduces the manpower needed in the manufacturing process.

After the successful implementation of robots in the manufacturing industry, robotics technology subsequently moved into military and firefighting applications. It has been recognized early-on that robots can be used as a substitute for human presence in dangerous situations or in environments inhospitable for human survival. Robots can take on the role of dispensable assets; sent to carry out hazardous activities without risking human life. In the context of firefighting, robots are able to complement human firefighters not only as a tool for direct mitigation of a fire, but also as an aid to identify further hazards and to search for casualties within the scene.

**THE UFM CAN BE OPERATED BY REMOTE CONTROL FROM A DISTANCE OF UP TO 300 METRES. BUILT TO WITHSTAND TEMPERATURES OF UP TO 6000°C, THE UFM CAN BE DEPLOYED INTO HIGHLY HAZARDOUS FIRE SITUATIONS WITH THE EMERGENCY RESPONDERS OPERATING THE UFM FROM A SAFE DISTANCE.**

## Unmanned Firefighting Machine (UFM)

In April 2014, SCDF took a big step into the realm of firefighting robotics when it launched the Unmanned Firefighting Machine (UFM) during the annual SCDF Workplan Seminar. Designed for fire suppression and ventilation in large areas of operation, 4 of the acquired UFM's have since been deployed to Changi, Jurong, Jurong Island and Yishun fire stations. These fire stations were selected to house the UFM due to their proximity to high fire-risk industries as well as to provide a widespread distribution of the UFM to allow for the best coverage of the whole of Singapore.

The UFM can be operated by remote control from a distance of up to 300 metres. Built to withstand temperatures of up to 6000°C, the UFM can be deployed into highly hazardous fire situations with the emergency responders operating the UFM from a safe distance. Using a high output of water mist, water jet or foam, with a maximum flow of 400 litres per minute, the UFM is able to mitigate fires that may occur in high fire-load premises, such as industrial plants and large warehouses, containing large quantities of combustible materials.

With its high velocity fan, the UFM can be used to ventilate smoke-logged areas quickly and effectively. This clears away smoke, heat and other toxic gases, allowing emergency responders to enter the incident site safely for offensive firefighting as well as search and rescue operations.

Within the same month of its release, the UFM faced its first real challenge which came in the form of a fire at a waste chemical facility in Tuas. The fire involved petroleum based products in a warehouse, leading to several explosions and thick smoke enveloping the premises. Due to the fast spread of the fire, firefighters used foam jets to surround the warehouse. This was to contain the fire, preventing it from spreading to neighbouring premises. The intense heat of the fire prevented firefighters from operating up close to the blaze. Hence, the UFM was deployed to penetrate into the warehouse in order to apply a foam blanket over the seat of the fire. With the use of the UFM, the fire was effectively brought under control within two and a half hours.

**WITH ITS HIGH VELOCITY FAN, THE UFM CAN BE USED TO VENTILATE SMOKE-LOGGED AREAS QUICKLY AND EFFECTIVELY. THIS CLEARS AWAY SMOKE, HEAT AND OTHER TOXIC GASES, ALLOWING EMERGENCY RESPONDERS TO ENTER THE INCIDENT SITE SAFELY FOR OFFENSIVE FIREFIGHTING AS WELL AS SEARCH AND RESCUE OPERATIONS.**

**IN THE CONTEXT OF FIREFIGHTING, ROBOTS ARE ABLE TO COMPLEMENT HUMAN FIREFIGHTERS NOT ONLY AS A TOOL FOR DIRECT MITIGATION OF A FIRE, BUT ALSO AS AN AID TO IDENTIFY FURTHER HAZARDS AND TO SEARCH FOR CASUALTIES WITHIN THE SCENE.**

### **Pumper Firefighting Machine (PFM)**

Having witnessed the success of the UFM, SCDF made further inroads into robotics firefighting technology. In order to apply the capabilities of the UFM to a wider range of incidents, the idea of a Pump Ladder Robot (PFM) was born.

Similar to the UFM, the PFM can be controlled remotely and is able to withstand high temperatures; allowing for penetration into areas of intense heat for firefighting or ventilation operations.

**THE PFM IS DESIGNED TO OVERCOME THE UFM'S INABILITY TO OPERATE WITHIN THE MULTI-STOREY DEVELOPMENTS. IT IS ABLE TO TRAVERSE UP AND DOWN STAIRCASES AND ITS DIMENSIONS FALL WITHIN THE SIZE AND WEIGHT LIMIT OF A TYPICAL PASSENGER ELEVATOR IN SINGAPORE.**

The PFM is designed to overcome the UFM's inability to operate within the multi-storey developments. It is able to traverse up and down staircases and its dimensions fall within the size and weight limit of a typical passenger elevator in Singapore.

The PFM is also built to be water efficient, with a high pressure hose reel output of 25 litres per minute and a water mist output of 30 litres per minute. This water output is much lower in comparison to a typical firefighting nozzle which has an output of up to 550 litres per minute. The lower output reduces water damage caused by firefighting jets.



The first PFM prototype arrived in Singapore in December 2017. Functionality tests were conducted in the Civil Defence Academy where its ability to operate within the confines of a high-rise structure was put to the test. The PLR was able to use its water mist output to cool a test unit from 250°C to 60°C in under a minute with the use of less than 80 litres of water.

Currently undergoing further refining and streamlining, the PFM will be incorporated into future versions of the SCDF Pump Ladder and deployed to every fire station in Singapore..

### **Red Rhino Robot (3R)**

Faced with the challenge of increasing the efficiency and operational capabilities of a limited workforce, SCDF explored deeper into the integration of robots with frontline operations. A compact Red Rhino Robot (3R) was developed to work in tandem with the 6th Generation Light Fire Attack Vehicle (LFAV). This iteration of the LFAV is named the LF6G.

While the signature “Red Rhino” LFAV of SCDF is traditionally manned by a crew of 4, the LF6G is envisioned with a 3+1 concept consisting of 3 firefighters and a 3R. The 3R is designed to fit into the rear passenger compartment of the LF6G and its small size enables it to go deep into the incident site in order to go up close to the seat of the fire without risking the lives of responders. This robot is designed to conduct reconnaissance operations to locate the seat of fire through the use of thermal imaging and relay the information to the operator. The operator will then be able to initiate firefighting operations; with the robot effectively able to mitigate a fire within confines of approximately 15m<sup>2</sup>.

The concept and prototype of the LF6G and its accompanying robot will be unveiled in the SCDF Workplan Seminar 2018. Following which, the prototype will be put through trials to validate the performance of the LF6G and 3R. The 3R will not only augment SCDF’s firefighting capabilities, it also addresses the need to fulfil the ever increasing operational demands despite SCDF’s limited manpower.

### **Merging of Humans and Technology**

Robotics technology is an effective force-multiplier in firefighting operations, as proven in the use of the UFM in a number of large-scale fire incidents since its launch in 2014. Despite this, the human element in firefighting must not be left behind. The dexterity of the human body and the decision making capability of the human mind are still key assets for an effective firefighting operation.

SCDF is also embarking on the development of an exoskeleton system to meld both the robotics and human elements into a cohesive firefighting asset. It is unlikely for robots of the near future to fully replicate the movements of a biological body. Human firefighters will still be necessary to handle delicate or complex tasks and equipment that a robot cannot be programmed to do. Hence the exoskeleton system can be used to enhance the capabilities of a human firefighter, allowing him to lift heavier loads and have a greater operational endurance.

Firefighters of the future will also be fitted with wearables which track their physical condition. This allows for effective management of fatigue and a better deployment of human resources at the fire ground.

SCDF will continue to invest into the development of robots to aid in firefighting and rescue operations. SCDF’s limited workforce, coupled with the increasing complexity of Multi-Use Premises (MUP) in Singapore, has made robotics a necessity in emergency response.

For effective implementation of present day robotics technology, both the human and robotics elements will have to work in tandem to apply their different strengths towards SCDF’s overarching goals of saving lives and property.

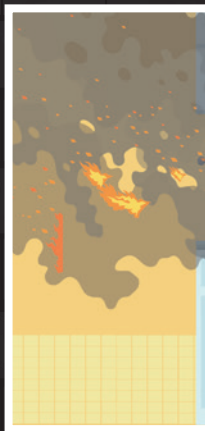


| DIMENSION    | UFM  | PFM   | 3R   |
|--------------|--|---|--|
| Width        | 2.33 m   | 0.74 m  | 0.46 m   |
| Length       | 1.35 m   | 1.2 m   | 0.46 m   |
| Height       | 1.98 m   | 1.55 m  | 0.8 m  |
| Capabilities | <ul style="list-style-type: none"> <li>• High flowrate of water mist, water jet or foam to tackle large industrial fires</li> <li>• High velocity fan to ventilate smoke-logged areas</li> </ul> | <ul style="list-style-type: none"> <li>• High water efficiency to reduce water damage within a factory</li> <li>• Designed within the dimensions and weight limit of passenger elevators</li> </ul> | <ul style="list-style-type: none"> <li>• Able to conduct reconnaissance operations with the use of thermal imaging</li> <li>• Designed to fit into the rear passenger compartment of the LF6G</li> </ul> |



# ROBOTS IN SCDF

Embracing robotics technology in firefighting, SCDF acquired the Unmanned Firefighting Machine (UFM) which has proven its worth in several major industrial fire incidents. SCDF is also developing 2 new robots, the Pumper Firefighting Machine (PFM) and the Red Rhino Robot (3R). The PFM is designed to be operated in factories while the 3R is a reconnaissance unit which is also capable of handling small fires. These new robots represent a big step by SCDF to further augment its frontline operations with robotics technology.





**UFM**

**INDUSTRIAL PLANTS**



**PFM**

**FACTORIES**



**3R**

**RESIDENTIAL UNITS**



# UAV DETECTION AND MONITORING IN HAZMAT INCIDENT RESPONSE



## Rise of the UAV

The term Unmanned Aerial Vehicle (UAV) has become mainstream among the general public in modern society with the widespread popularity of small and nimble UAVs. Often seen hovering over major events, these UAVs facilitate photography and video-taking from angles that are often impossible for the typical camera-toting photographer. Though many still perceive UAVs as toys for hobbyists, the wide-ranging applications for UAVs have not gone unnoticed by major companies and government organizations.

## Adopting the use of UAVs in SCDF HazMat incident operations

A key feature of Hazardous Material (HazMat) incident response is the need for quick detection and constant monitoring of the HazMat involved. The hazardous substance could be in the form of toxic industrial chemicals, chemical warfare agents or radiation. Detection and monitoring proves to be challenging for responders due to the level of danger posed by the HazMat, the large area of operations and the dynamic nature of a HazMat incident.

Exposure to high concentrations of chemicals or high doses of radiation can have a debilitating effect on responders and can even lead to death. Hence, responders entering the hazard zone to carry out detection and monitoring activities are exposing themselves to a high level of risk. HazMat detection equipment can be attached to UAVs which are then sent into the incident site to conduct detection and monitoring of HazMat. This reduces the need for a team of responders to risk their lives by entering an unknown environment to conduct an initial reconnaissance of the area.

A HazMat incident typically has a large area of operations. A chemical plume of a gaseous form can spread over a large area, carried by the wind. A liquid chemical spill is able to enter drainage systems and waterways, flowing over long distances. Radiation penetrates through structures, with gamma particles only blocked-off by thick concrete or lead. The aerial mobility of UAVs allow for fast movement over the terrain; unhindered by gates, fencing, rubble or any other obstacles that will slow down a ground-based response. In addition, the high speed of UAVs enables them to cover long distances rapidly.

HazMat incidents are also characterised by their dynamic nature. Fluctuations in wind condition or water flow causes changes in the HazMat plume, requiring adjustments to be made to hazard zoning and placement of SCDF appliances. Multiple UAVs will be able to scour a large area, monitoring the spread of HazMat more efficiently than with the use of personnel on the ground. They can also be programmed with a degree of autonomy to coordinate their positions and further optimise monitoring of the HazMat plume.

**THE AERIAL MOBILITY OF UAVS ALLOW FOR FAST MOVEMENT OVER THE TERRAIN; UNHINDERED BY GATES, FENCING, RUBBLE OR ANY OTHER OBSTACLES THAT WILL SLOW DOWN A GROUND-BASED RESPONSE. IN ADDITION, THE HIGH SPEED OF UAVS ENABLES THEM TO COVER LONG DISTANCES RAPIDLY.**

## Evolution of HazMat aerial monitoring in SCDF

The foresight to deploy aerial platforms for HazMat detection in SCDF began in 2008. SCDF embarked on a project to develop a proof-of-concept model for aerial HazMat detection, known as the Remote Aerial Detection and Surveillance System (RADASS). RADASS was an off-the-shelf hobbyist helicopter modified to carry a larger load and mounted with HazMat detectors. Trials were conducted for both radiological and chemical detection. Results showed that the aerial radiation readings measured by RADASS was comparable to the calculated expected readings. However, the chemical detection was severely affected by the downwash of the helicopter rotor system, resulting in inaccurate readings.

The project was discontinued due to the high level of competency needed to handle the remote-controlled helicopter effectively; experience and skill is needed in order for the operator to maintain the stability of the helicopter. Developing operator proficiency will require many hours of training time. The addition of various configurations of detectors to the helicopter also alters the centre of gravity of the helicopter, causing instability.

**TRIALS WERE CONDUCTED FOR BOTH RADIOLOGICAL AND CHEMICAL DETECTION. RESULTS SHOWED THAT THE AERIAL RADIATION READINGS MEASURED BY RADASS WAS COMPARABLE TO THE CALCULATED EXPECTED READINGS.**

**RECOGNISING THE BENEFITS OF DEPLOYING MODERN UAVS IN HAZMAT INCIDENTS, SCDF EMBARKED ON A STUDY RELATING TO THE USE OF UAVS TO CONDUCT SEARCH AND MONITORING OPERATIONS IN A RADIOLOGICAL INCIDENT.**

## Challenges of UAV usage in HazMat incident operations

As discovered in the RADASS project, aerial vehicles such as UAVs produce a strong downwash effect generated by their main rotors. Downwash refers to the deflection of air caused by the aerodynamics of the rotor system. This downwash induces mixing of air around the UAV hence distorting the concentration of chemicals detected by UAV mounted detection equipment. The downwash also has an undesired effect of spreading the chemical plume. A possible way to overcome this problem is to extend a downward tubing beyond the range of the downwash effect in order for a more accurate detection of chemicals.



UAV operational usage is limited by its flight time. A standard off-the-shelf UAV has an operating duration of approximately 15-30mins. This operating duration will be reduced when the UAV is loaded with HazMat detection equipment as well as surveillance cameras. Several UAV's must be used cooperatively to reduce the time needed to cover an area, hence avoiding battery exhaustion before their tasks are complete.

## Current plans by SCDF

UAV technology has matured significantly since the days of the remote-controlled helicopter used in the RADASS project. Present day UAVs are equipped with gyroscopic stabilisation, allowing for smooth and stable flight. Hence, minimal training and practice is required for proficient control of a UAV, making them very popular for recreational use.

Recognising the benefits of deploying modern UAVs in HazMat incidents, SCDF embarked on a study relating to the use of UAVs to conduct search and monitoring operations in a radiological incidents. Focus was put towards radiation detection as radiation readings are not affected by the downwash effect that was experienced in the RADASS project. Radiation detection trials with UAVs is scheduled to start in the 3rd quarter of 2018. Successful trials will lead to the implementation of UAVs for the detection of radiation during HazMat operations.

The UAV trials will eventually be expanded to also look into the possibility of chemical detection with the use of UAVs. This segment of the study will explore the means of incorporating chemical detection equipment into a UAV such that the downwash effects of the UAV can be minimized, hence improving the accuracy of the readings.

**USING WHAT IS KNOWN AS SWARM OPTIMISATION, MULTIPLE UAVS CAN BE PROGRAMMED TO AUTONOMOUSLY POSITION THEMSELVES AT CALCULATED POSITIONS AND ORIENTATIONS FROM ONE ANOTHER SUCH THAT THEY ARE ABLE TO SCOUR A LARGE AREA QUICKLY AND LOCATE THE SOURCE OF THE HAZMAT INCIDENT.**

## Future of UAV detection

Much of the focus of the implementation of UAVs in HazMat incidents is directed towards the ability of a single UAV to perform its detection and monitoring tasks effectively under operational conditions. In order to fully utilise UAV technology, SCDF will have to be able to apply multiple UAVs to function cooperatively at the incident site.

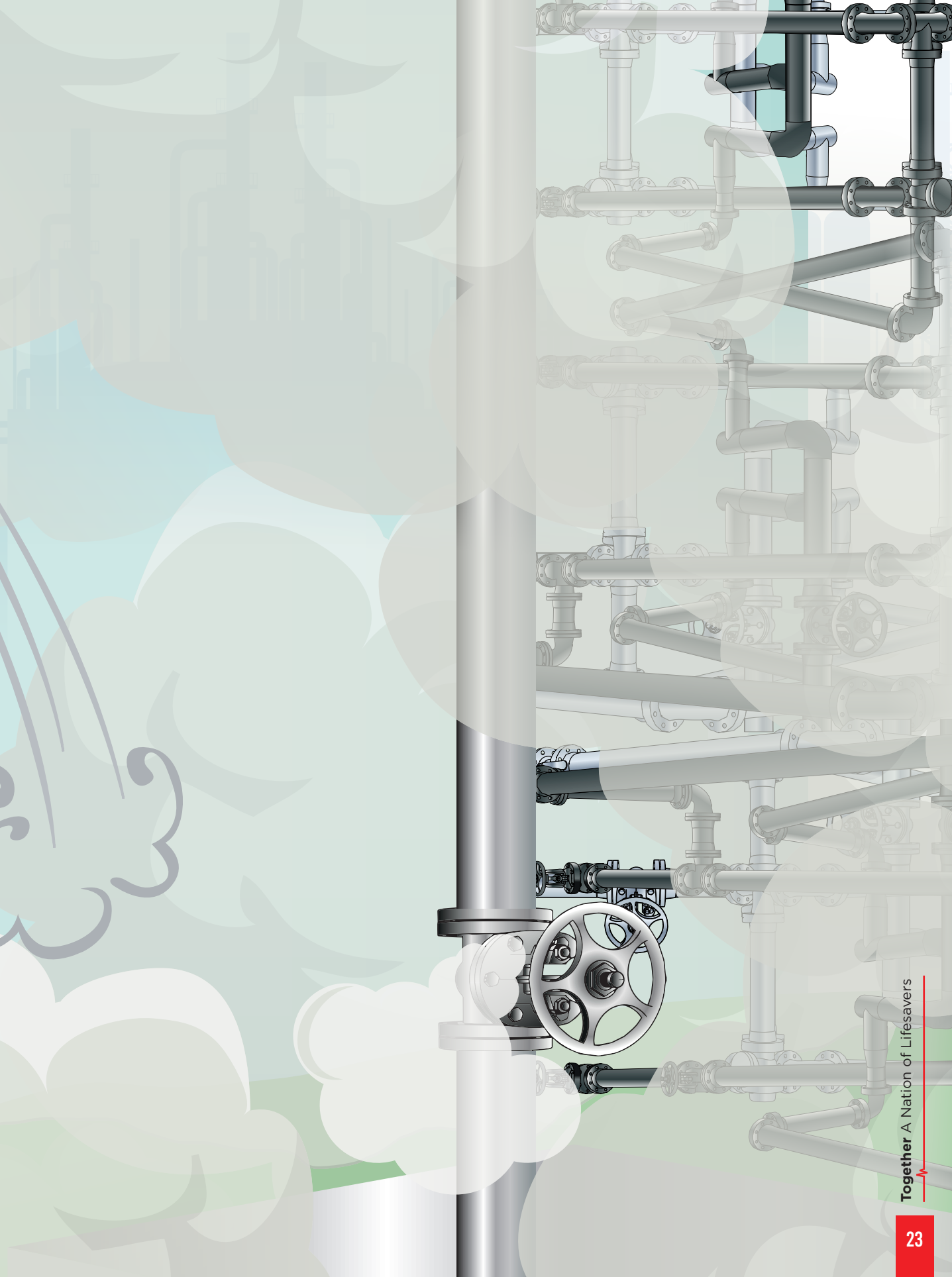
Using what is known as swarm optimisation, multiple UAVs can be programmed to autonomously position themselves at calculated positions and orientations from one another such that they are able to scour a large area quickly and locate the source of the HazMat incident. This maximises detection coverage of the incident site, enabling responders to gather information on the nature of the incident swiftly, facilitating decision-making. An autonomous swarm of UAVs also helps to reduce manpower deployment as a single operator will be able to monitor and observe a large incident site.

With the continuing improvements in technology, UAVs will become more manoeuvrable, with a longer operating time and larger load carrying capacity. Advanced programming of UAVs will also lead to a high degree of autonomy, allowing for multiple UAVs to operate effectively in a swarm. A positive result from SCDF's trial on the use of UAVs for HazMat detection will open up a world of possibilities, not just for HazMat incident response but also for SCDF operations as a whole.

## DETECTION OF CHEMICALS USING UAVS

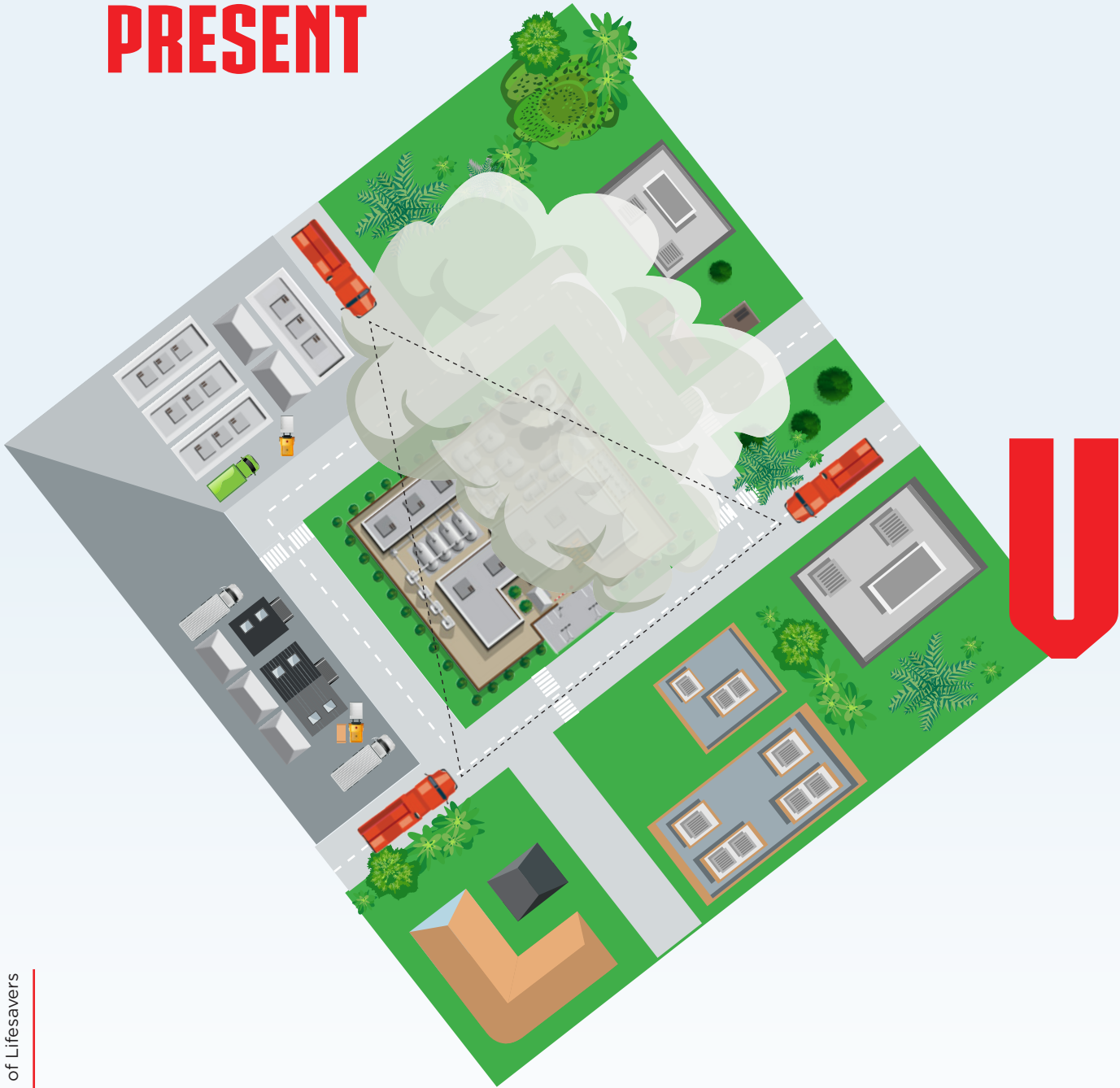
A challenge of using UAVs for chemical detection is the downwash effect from the UAV rotor system. This effect is due to the aerodynamic movement of air caused by the spinning propeller blades. Downwash causes mixing of air around the UAV, making readings of chemical concentration levels inaccurate. SCDF will be conducting trials on the means to overcome this effect, allowing for chemical detection using UAVs.





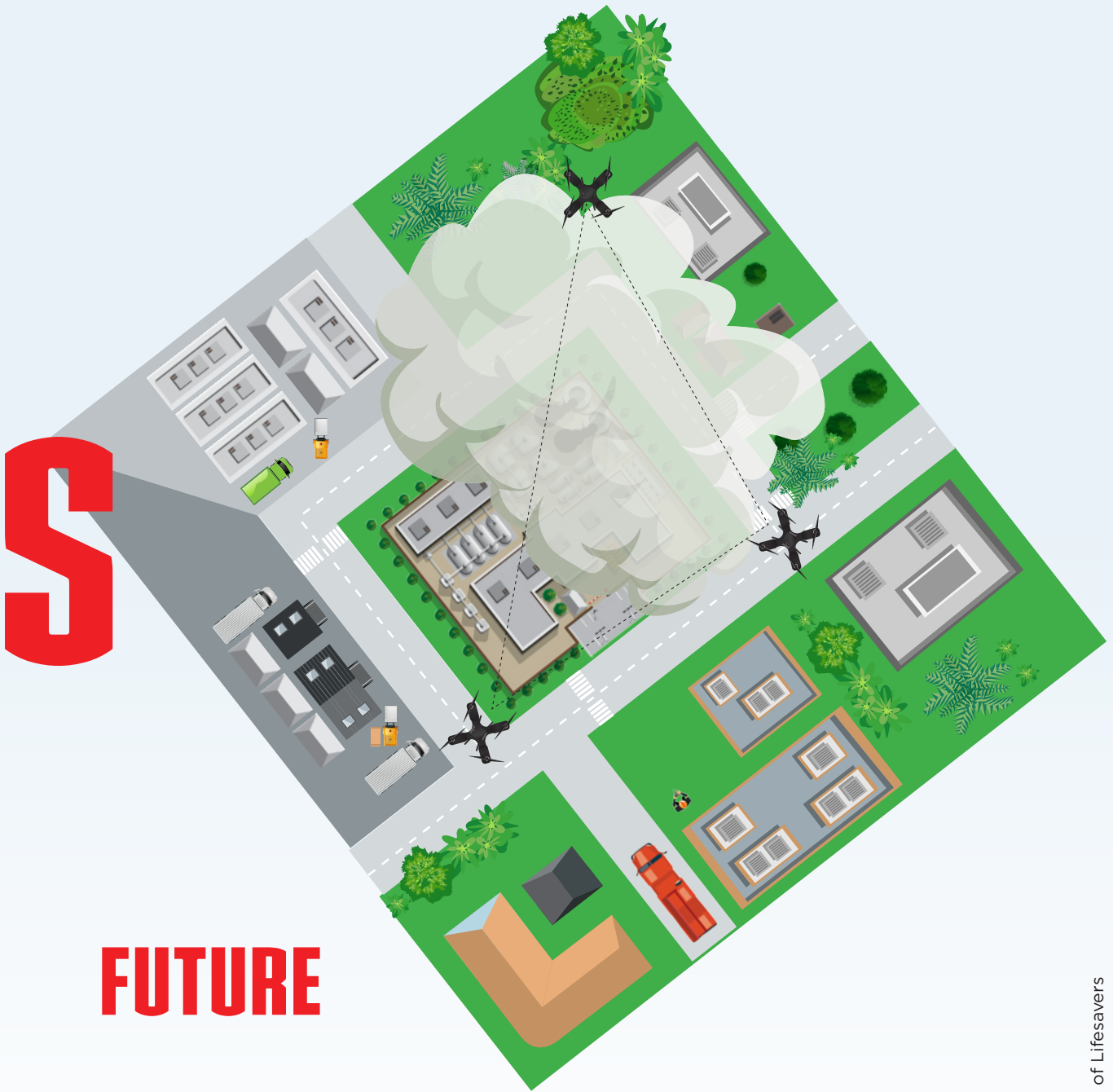


# PRESENT



At present, multiple teams will have to spread out around a HazMat incident in order to monitor the spread of a chemical plume. These teams will be able to compare the chemical concentration readings and observe for any increase, decrease or spread of the chemical levels. This approach requires multiple monitoring resources and proper coordination between the teams.

With the use of UAV swarming, multiple autonomous UAVs can be programmed to position themselves at optimal positions to maximise monitoring coverage of the incident site. A high level of UAV autonomy will allow for operation by a single responder. As compared to the present deployment of land-based resources, the aerial mobility of the UAVs enables easy relocation to react to changes in incident conditions.



# FUTURE

**Legends:**



Industrial Premises



UAV



HazMat Control Vehicle



Chemical Plume



Fireman





# PARAMEDICS OF THE FUTURE: OMNII

*\*Operational Medical Networks  
Informatics Integrator*

## INTRODUCTION

Prehospital Emergency Care (PEC), as the phrase construes, refers to the initial medical care given to an ill or injured patient from an emergency medical service before the transportation and arrival at the hospital's Emergency Department (ED). The PEC provider in Singapore has been under the wing of Singapore Civil Defence Force (SCDF) and is commonly known as Emergency Medical Services (EMS) anchored by paramedics and emergency medical technicians.

PEC and ED all come under the umbrella of healthcare services. In the past 20 years, healthcare in Singapore has changed dramatically with urban development and demographic transition. In 2017, SCDF responded to a total of 182,502 medical calls – this accounts for a 2.4% increase as compared to 2016. Of the total medical calls received in 2017, 89.6% were emergency calls. 75% of these were medical-related such as chest pain, breathlessness, unconsciousness and cardiac arrest. The remaining 25% of the emergency calls were trauma-related or involving road traffic accidents.

Singapore's ageing population places an increasing load on SCDF's PEC. Assuming the demand continues to increase at 5% annually, this could result in a doubling of the number of medical calls in 15 years.

To deal with these challenges, SCDF has been identifying its services' gaps and developing strategies for improvement. A data-driven concept to PEC led to the development of the Operational Medical Networks Informatics Integrator, also known as the OMNII.

The article will share the concept behind OMNII and its key features. Secondly, the article will identify the improvement to Singapore's PEC model with the aid of OMNII. The vision is to possess a world-class PEC system – readily accessible to all, and providing excellent patient outcomes.

## **Operational Medical Networks Informatics Integrator (OMNII)**

OMNII is the solution to address the increasing challenges in PEC. SCDF will be able to leverage on information technology to access and manage the high volume of information between PEC and ED. OMNII allows SCDF to receive, process and transmit key information from all systems in both SCDF and ED even before they meet the patient. In addition, the integration of data across the different channels and stakeholders will be able to enhance the services provided by all healthcare providers. The key is to reduce the lead-time for decision making while responding to medical calls and allow the seamless transfer of patients to ED at the hospital.

The following are the key features of OMNII:

### **Empowering Paramedics On-The-Move**

Every paramedic in each of the SCDF's ambulances will be issued with a wireless mobile device supported by OMNII. Paramedics will be able to retrieve the patient's information from the National Emergency Healthcare Record (NEHR), shared by all public hospitals. In addition, the paramedics will be able to enter additional information such as treatment administered on-the-move. OMNII has also designed in built tools which synthesise clinical information as to provide treatment advice and evacuation decisions for the paramedics. The mobile devices will also include features such as integrated video, voice and data communication tools to support telemedicine, when necessary.

### **Incident Case Record (ICR)**

The ICR system will provide near real-time data sharing with the destination hospital so that the hospital can activate additional resources should there be a need to provide life-saving treatment. From a strategic position, the management is provided with an overview of incident and near real-time information updates, further improving decision-making at management level too.

### **The Digital Ambulance**

The future ambulances will be equipped with digitised medical equipment that will seamlessly transfer the medical data into OMNII. Mobile hotspots will be installed in ambulances to support the data integration. In addition, OMNII will be able to enhance the PEC through improved situational awareness - with real-time traffic updates, real-time hospital's information and also automatic sharing of information to all stakeholders.

### **Quality Assurance and Analytics**

The increase in volume and accuracy of data collection through a network of interconnected equipment and systems will provide detailed operational and clinical performance for analysis, audit and quality assurance of SCDF's PEC. Quality assurance is further enhanced through a sophisticated data analysis report for the paramedics' performance review.



THE FUTURE AMBULANCES WILL BE EQUIPPED WITH DIGITISED MEDICAL EQUIPMENT THAT WILL SEAMLESSLY TRANSFER THE MEDICAL DATA INTO OMNII. MOBILE HOTSPOTS WILL BE INSTALLED IN AMBULANCES TO SUPPORT THE DATA INTEGRATION.

## EMERGENCY CALL AND DISPATCH



### Moving Towards a Patient-Centric PEC Model

#### Emergency Call and Dispatch

Upon receiving a 995 call, SCDF's call operator from operation centre will seek critical information such as the signs and symptoms as well as the patient's identification card number. The operator will dispatch an ambulance once the case is established. The call operator can access the patient's information through the NEHR and update the responding paramedics accordingly.

With the OMNII mobile device, the paramedic assigned will be able to retrieve NEHR information on the patient's medical history instantaneously while responding. In addition, OMNII also include records from SCDF should the patient had engaged SCDF's ambulance services previously. OMNII improves the current PEC model as the patient's medical history will be more accurate than information given verbally by families and friends – such information is sometimes even non-existent.

#### Treatment

The paramedic, upon arrival at incident location, will be able to confirm the patient's identity through scanning of the patient's identification card number or biometrics authentication. This will avoid the inconvenience in the original PEC model where the family's members or callers might not have access to the patient's identity.

The paramedics will conduct a verbal check on the patient's medical history and also a preliminary physical examination – the OMNII mobile device will be able to capture all the verbal information through the in-built microphone. Paramedics can also take photographs at scene with the mobile device, which will be transferred to a centralised database accessible by all stakeholders.

## TREATMENT



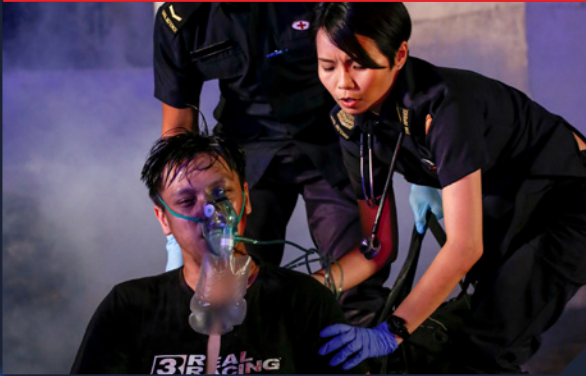
**OMNII IS CAPABLE OF ANALYSING THE MULTI-LAYERS OF DATA IN THE SYSTEM TO GENERATE ALERTS AND RECOMMENDATION TO SUPPORT THE PARAMEDIC RESPONDING.**

The OMNII mobile device is also wireless-enabled and can transfer all the information collated to the medical equipment on the ambulance and vice versa. OMNII is capable of analysing the multi-layers of data in the system to generate alerts and recommendation to support the paramedic responding. The recommendation from the system is based on the latest assessment input by the paramedics on top of the pre-existing records.

There are also complex incidents which require more in-depth expertise from ED's physician. In the original PEC model, paramedics would conduct a teleconference with the ED's physician at scene. The details exchanged through the teleconference would need to be updated to SCDF operation centre at the end of treatment. However, the OMNII mobile device allows the paramedic to conduct either a voice or video call, with the full recording of said call automatically captured and subsequently uploaded into SCDF operation centre's database.

**WITH THE OMNII MOBILE DEVICE, THE PARAMEDIC ASSIGNED WILL BE ABLE TO RETRIEVE NEHR INFORMATION ON THE PATIENT'S MEDICAL HISTORY INSTANTANEOUSLY WHILE RESPONDING.**

## CONVEYANCE



### Conveyance

The existing PEC model will identify the nearest public hospital to the incident location for conveyance. However, the nearest public hospital might have a longer waiting time depending on the patient's traffic. Ministry of Health (MOH) has a real-time informatics system on the availability of hospital ED, hospital ED's waiting time, availability of ward bed and special treatment facilities. The OMNII mobile device will be able to integrate this system and recommend the nearest appropriate hospital for conveyance based on a more diverse range of factors.

The paramedic will update the conveyance destination on the OMNII mobile device - allowing the receiving ED to retrieve the case for preparation. During conveyance, the ED will be able to receive real-time updates of ambulance location, estimated time of arrival, the patient's vital signs, and interventions carried out.

**OMNII PROVIDES AN ADMINISTRATIVE BRIDGE BETWEEN MANAGEMENT AND OPERATIONAL STAFF, MAINLY IN TERMS OF COMMUNICATION AND SCHEDULING.**

### Transition and Return to Service

OMNII will be able to identify high-value cases and auto-generate analysis report for future references. The report will be sent back to the paramedic as a performance review to enhance future services. In addition, data can be easily retrieved for case studies sharing at training.

## TRANSITION AND RETURN TO SERVICE



The feedback will also be sent to the ED physicians to educate the paramedics on optimising care for similar patients in the future. Besides the brief interaction at the hospital, ED physicians and paramedics are provided with more opportunities for post-incident collaboration and learning.

OMNII provides an administrative bridge between management and operational staff, mainly in terms of communication and scheduling. An example will be the function to upload new protocols for immediate dissemination to and acknowledgement by all medical crews. It is especially critical for SCDF to manage dynamic situations such as epidemic-level outbreaks of disease and mass-casualty events,

Last but not least, OMNII also has a feature to detect repeated cases of similar signs and symptoms - allowing early monitoring, intervention and warning surveillance for unusual occurrence of disease and even bioterrorism.

### CONCLUSION

OMNII will further digitise and elevate the service quality of SCDF's PEC - empowering the paramedics to perform their tasks more efficiently for their patients. Moving away from the traditional PEC model, OMNII will seamlessly integrate all the healthcare systems and effectively manage both routine and challenging emergency medical cases across Singapore. OMNII will be the future of Singapore's world-class PEC system - readily accessible to all, and providing excellent patient outcomes.





# TRAINING TRANSFORMED: CDA

## INTRODUCTION

The Civil Defence Academy (CDA) opened its doors in 1999 to equip SCDF officers in various vocations and specialist units with the knowledge and skills to fulfil SCDF's mission – to protect and save lives for a safe and secure Singapore. Today, the operating environment has changed. Mixed-Use Premises (MUP) are becoming increasingly common (compared to single-use buildings). Technology has also advanced in almost every frontier. The learning environment has changed. People are comfortable with high levels of technology and a wide array of information is readily available in the palm of your hand as and when desired. This is also known as “Borderless Learning”.

To ensure that SCDF remains relevant, training transformation is essential to enhance its responders' learning through the introduction of modern and realistic training infrastructure. This will be achieved through the redevelopment of CDA's Field Training Area (FTA). To make training more effective, the learning environment will be technologically enhanced to facilitate self-directed learning and where applicable, data analytics would be employed to surface areas of improvement, as well as pinpoint precise aspects of underperformance.

This article details the enhancements to the training of SCDF's future emergency responders. This includes the transformation of CDA into a Smart Campus, the integration of advanced virtual reality simulation and wearable technologies, as well as the redevelopment of the FTA.

### Smart Campus

Over the 19 years of its operation, CDA has leveraged on technology to enhance its Training and Learning environment. Technology enhanced learning has evolved from E-Learning<sup>1</sup> to Mobile Learning<sup>2</sup> to U-Learning<sup>3</sup> and, at present, to Smart Learning<sup>4</sup>. To further improve its daily operations, the academy will create a Smart Learning Environment (SLE). An SLE in an environment that features the use of innovative technologies and elements that allow greater flexibility, effectiveness, adaptation, engagement, motivation and feedback for the learner.

The SLE will encompass software elements such as the Home Team Learning Management System (HTLMS), Virtual Reality Training and Wearable Technology. While the hardware element, the FTA will also undergo a redevelopment so as to incorporate and synergise the various software elements into its daily operations.

**TO MAKE TRAINING MORE EFFECTIVE, THE LEARNING ENVIRONMENT WILL BE TECHNOLOGICALLY ENHANCED TO FACILITATE SELF-DIRECTED LEARNING AND WHERE APPLICABLE, DATA ANALYTICS WILL BE EMPLOYED TO SURFACE AREAS FOR IMPROVEMENT, AS WELL AS PINPOINT PRECISE ASPECTS OF UNDERPERFORMANCES.**

<sup>1</sup> E Learning – Computer Networks

<sup>2</sup> Mobile Learning – Mobile Devices & Wireless Communication

<sup>3</sup> U-Learning – Sensor Technologies, Mobile Devices & Wireless Communication

<sup>4</sup> Smart Learning – Social Technologies, Sensor Technologies, Mobile Devices & Wireless Communication

## Online Learning

The HTLMS will serve as a centralised learning platform serving all Home Team Departments to support Home Team Training & Learning. It will also allow for the standardisation of training methods. With the introduction of the HTLMS, all SCDF personnel are able to monitor their continuous learning needs.



Figure 1: An overview of the HTLMS dashboard

**THE VLC WILL ALSO EMBARK ON INCORPORATING ARTIFICIAL INTELLIGENCE (AI) INTO TRAINING AND LEARNING. THE “AI INSTRUCTOR” WILL FOCUS ON GUIDING AND HONING TRAINEES’ SKILLS AND KNOWLEDGE IN THE VARIOUS AREAS OF OPERATIONS INCLUDING: FIREFIGHTING, HAZARDOUS MATERIALS AND MEDICAL AID.**

## Virtual Reality Training

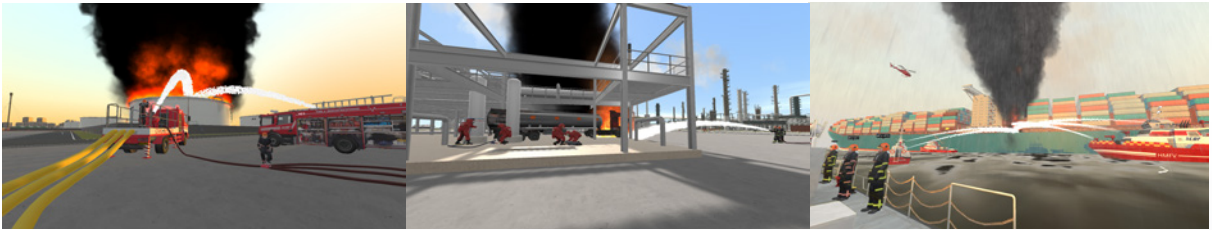


Figure 2: From left to right: Oil storage tank fire, Hazardous Materials incident and offshore vessel fire incident are some of the many scenarios that can be created in ACTS2 to test our trainees on their command and control during the simulation exercises.

Currently the academy uses one of the most advanced training simulator as part of daily training: The Advanced Command Training System (Version 2) also known as ACTS 2. The ACTS 2 is a simulation training system designed to hone the command and control skills of frontline commanders. However, as technology constantly pushes the boundaries of imagination, the academy must continue to review its approach to Training and Learning.

The next phase of development at the academy will focus on a haptically<sup>5</sup> enabled firefighting training system.

With the rapid advancement in technology we are now able to interact with the virtual environment:

- A fire jacket and legging (firefighting gear) that heats up as you get close to a heat source
- Feedback from equipment: Pulling the lever of the nozzle would create a “pull back” effect to create a realistic sense of water pressure
- Smoke/Sound effects to create realistic training environment

<sup>5</sup> Haptically – By means of or as regards the sense of touch; in a manner involving or depending primarily upon tactile and related kinesthetic sensations.

As part of the multi-million dollar upgrade to the academy's training facilities, a Virtual Learning Centre (VLC) will be developed to oversee the virtual training capabilities in the academy.

The VLC will also embark on incorporating artificial intelligence (AI) into Training and Learning. The "AI instructor" will focus on guiding and honing trainees' skills and knowledge in the various areas of operations including: Firefighting, Hazardous Materials and Medical Aid.

### **Wearable Technology**

The training in CDA exposes the future emergency responders to a plethora of training regimes where they are pushed beyond their limits in order to improve their physical capabilities and mental resilience.

By exploring the physiological, psychological and behavioural aspects of training and using evidence-based findings, training methodology could be reviewed to enhance training efficacy. Profiling and identification of individual responder based on quantifiable data will accommodate directed training, ensuring improved productivity and prevent the onset of injuries, especially relating to heat and muscle.

Wearable technology can be used to monitor physical fitness and enhance training returns. Indeed, wearable activity trackers have emerged as an increasingly popular method for users to assess their daily physical activity and energy expenditure. These wearables commonly measure and convert physiological data, e.g. heart rate variability, into actionable information needed by the user to monitor or change daily workout intensity in order to attain a fitness target more rapidly, push performance envelopes or reduce the likelihood of injuries.

The presence and advancement in technology have offered the academy great and exciting opportunities to develop new environments. The Smart Campus will be a ground breaking concept reaffirming the academy's position as a world leading institution.

### **Physical Infrastructure Redevelopment - CDA's FTA**



*Figure 3: The present FTA provides a wide range of training courses to both our local trainees and overseas participants.*

**PROFILING AND IDENTIFICATION OF INDIVIDUAL RESPONDERS WILL BE BASED ON QUANTIFIABLE DATA WILL ACCOMMODATE DIRECTED TRAINING, ENSURING IMPROVED PRODUCTIVITY AND PREVENT THE ONSET OF INJURIES, ESPECIALLY RELATING TO HEAT AND MUSCLE.**



*Figure 4: An immersive environment is envisaged to be used for multi-modal profiling of our firefighters. A holistic evaluation through a 360° fully immersive dome operational environment will be conducted on firefighters to collect vital data for analysis.*

The new FTA design concept will replicate the various unique features of Singapore’s architecture to create a comprehensive range of realistic training scenarios. These facilities within the FTA are specifically designed to reflect Singapore’s dense urban surroundings. This allows future SCDF officers the essential knowledge, skills sets and confidence to perform in any emergency.

To mirror a high density urban fabric, MUP, a 4-storey facility, will be carefully designed to simulate a variety of firefighting and rescue scenarios. It will include a mock-up bus interchange, MRT Shelter, food court, supermarket, library, and single and multi-story residential units. These training environments will be equipped with smoke and fire simulators to instil realism.

Besides the training needs, the academy will carry out research and development to optimise firefighters’ performance and prevent injury in both physically and mentally demanding emergency situations. Emergency Responders Fitness and Conditioning Lab (EXCEL) is, hence, developed to address to this aspect through the use of current sports science and rehabilitation. This facility comprises of a strength training room, a Breathing Apparatus (BA) Maze as well as an Environmental Chambers. Its research components will include performance training such as endurance and acclimatisation, nutrition plans on pre- and post-training needs, and physical therapy programmes tailored for firefighters’ injury recovery.



*Figure 5: Concept Rooms (left) are planned to be integrated in the new redevelopment to conduct assessment with simulations. A&E Facility (right) serves as a platform to facilitate joint exercises among the related agencies.*

## CONCLUSION

Over the next three years, Training and Learning in SCDF will be transformed. By leveraging on technology, the academy will be able to adapt to the needs of its people and place, unlocking its potential.

The Emergency Medical Services (EMS) will serve to equip our paramedics with the necessary medical skills. This facility serves to provide areas such as Skill Mastery Lab and Concept Rooms for skills competency training. To synergise amongst the Ministries in Singapore, a mock up Accident and Emergency (A&E) facility is also included to validate contingency plans through joint exercises with the related agencies such as Ministry of Health (MOH).

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