REaction

RESCUERS IN ACTION

TECHNICAL PUBLICATION FOR
SINGAPORE-GLOBAL FIREFIGHTERS & PARAMEDICS CHALLENGE

2015

TOGETHER
A NATION OF LIFESAVERS

REaction

Rescuers in action is the SCDF's annual technical publication that aims to be a platform to invoke thought provoking discussions and to share knowledge and case studies.

REaction will be issued yearly in conjunction with the Singapore-Global Firefighters and Paramedics Challenge (SGFPC).

By providing articles covering a myriad of subjects, we hope REaction will grow into a repository of knowledge for both academic and practicing readers in the emergency services fraternity. 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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FOREWORD

On behalf of the Singapore Civil Defence Force (SCDF), let me welcome all our guests and participants to the Singapore-Global Firefighters and Paramedics Challenge (SGFPC) 2015. It is heartening to see that the SGFPC has grown from strength to strength. Having begun as a platform for professional life savers in the Asia Pacific region and beyond to hone and share rescue and firefighting techniques, it has since developed into a global nodal point for the sharing of knowledge and building of networks. Your continued participation and support for SGFPC has allowed it to become a confluence of passion, ideas and skills for the life-saving fraternity.

This year's SGFPC takes place at a time of great significance for the SCDF – we have embarked on our transformational journey to build "A Nation of Lifesavers" by 2025, a bold vision based on the strong belief that everyone can be a life saver in an emergency situation. We will train and gear up the community to respond and deal with everyday emergencies as Community First Responder, and this will be seamlessly integrated with SCDF response as part of our quest to value-add to the global life-saving fraternity.

The SCDF's relentless pursuit of its vision and operational excellence has also been duly rewarded. Last month, the SCDF had been awarded the most prestigious business excellence award in Singapore, the Singapore Quality Award with Special Commendation (SQASC), in recognition of our sustained global leadership and strong innovative culture in the business of life-saving. We hope to share this vision of "A Nation of Lifesavers" with our partners. We are honoured to invite you to join us in this transformational journey, to allow this vision to transcend boundaries and build a global community of life savers.

The journey does not stop here. As we celebrate the SCDF's progress as an organisation, we remain committed to improving our practices and pursuing higher standards. Learning from the global life-saving fraternity is essential in achieving this. In this annual issue of 'REaction', we have put together a collection of articles which focus on the endeavour to create the ultimate real time and real experience training for our rescuers. With breakthroughs in simulation technology, the SCDF will continue to push the boundaries of creating ever more realistic scenarios in training, preparing us for complex operational challenges and leap frogging our mitigating prowess and capacity. On this note, I would like to express our sincere appreciation to our article contributors from DSO National Laboratories, XVR Simulation Pte Ltd, Hexcel Solutions Pte Ltd, Draeger Safety Asia Pte Ltd and China International Search and Rescue Team (CISAR) for your contribution to 'REaction'. We hope that the articles in 'REaction' will continue to inspire many life savers, generate interest, drive discussion, and catalyse new solutions or insights on issues which are relevant and current to the global fraternity of emergency responders and disaster managers.

I wish everyone an engaging read and a fulfilling SGFPC 2015!

Eric Yap
Commissioner
Singapore Civil Defence Force

SGFPC ORGANIZING CHAIRMAN'S PREFACE

The inaugural edition of ***'Reaction'*** – a technical publication discussing the best practices on skills and techniques, as well as topical issues that various services and departments are currently grappling with, has been launched in 2014. The second edition of this publication promises to be an even more exciting proposition as we have a strong lineup of contributors from SCDF and our partners from local and international arenas.

This year, we have again assembled a collection of related articles that we hope would benefit participants from the SGFPC fraternity. In 2014, the Exercise Urban Elite (EUE) was launched. We felt it would be useful to give everyone an overview of the EUE- why EUE was needed and what how the EUE envisions itself to further propagate the INSARAG guidelines to greater heights. Separately, we also thought it would be useful to share on the settings of the "RIP-IT-OFF" challenge and some observations gathered.

The SCDF has worked with our partners from Draeger Asia Safety Pte Ltd to pen an article on the makings of its new training facilities- the CDA@Mandai has been commissioned this year. XVR Simulation Pte Ltd will also be sharing an article on how Virtual Reality is now utilised in emergency service training throughout the world.

In this issue, we are also honoured to have an article from our local partners from DSO National Laboratories. This piece discussed about heat mitigation strategies aimed at reducing heat injuries for firefighters - a very real danger during prolonged firefighting and rescue operations.

The publication ends with two articles from the China International Search & Rescue (CISAR) and the SCDF, describing the 2 humanitarian relief operations that they conducted during the earthquake at Nepal in April 2015.

We wish everyone an insightful reading experience, and we welcome feedback at SCDF_CDA@SCDF.gov.sg on what you would like to see being covered here, or how we could improve as a publication.

Finally, I would like to thank the ***REaction*** editorial team for their hard work and dedication to the realisation of this edition.

COL Teong How Hwa
Organising Chairman
SGFPC 2015

BACKGROUND OF THE SGFPC LOGO

The Singapore-Global Firefighters and Paramedics Challenge (SGFPC) logo is composed of the images of a firefighter and a paramedic protectively overlooking the globe. The two figures signify the twin pillars of emergency response and their common life-saving mission anywhere in the world, while the colours reflect the passion (red) and dedication (blue) of these everyday heroes who lead extraordinary lives in a noble and sacrificial calling. The interlocking red and blue tiles in the globe represent the strong bonds of professional and personal friendship that the SCDF shares with the international fraternity of emergency responders.

RECAP OF SGFPC 2014

1

2

3

4

6

5

1. A RIP-IT-OFF contending team lays out the tools of their trade prior to the challenge 2. Braveheart champions exchange words of congratulations 3. Rescuers act in concert to fulfill the golden hour for casualty management 4. The Braveheart challenge comprises the handling of basic firefighting equipment, such as fire hoses 5. London Fire Brigade rescuers swiftly deploying the KED in a road traffic accident scenario 6. Executing physically demanding tasks while on a height element, a mainstay from the previous Braveheart challenge

7. Participants ready their equipment for the operation of the AED   8. Company Emergency Response Team (CERT) handling the confined space challenge with aplomb   9. Community first responders extricating the casualty prior to SCDF arrival   10. Young lifesavers deploying the extinguisher with practised confidence

» INNOVATION BEHIND SGFPC

MINI HEIGHT TOWER

Innovation is borne from having identified a need or a problem. The Mini Height Tower (MHT) is an innovation borne from SGFPC. SGFPC game props used to be bulky and considerably unstable. The props would wobble, for instance, in the heat of the competition when excited participants navigated through them. This proved to be a recurring safety concern throughout the previous runs of SGFPC games. In addition, to ensure a secure and safe game platform, the props party had to undergo test runs which were time-consuming and a waste of resources.

The MHT, in contrast, affords versatility by incorporating different skill elements into a singular, reliable prop structure. Such an amalgamation also reduces the time and effort needed to dismantle and assemble props for different game plays.

3

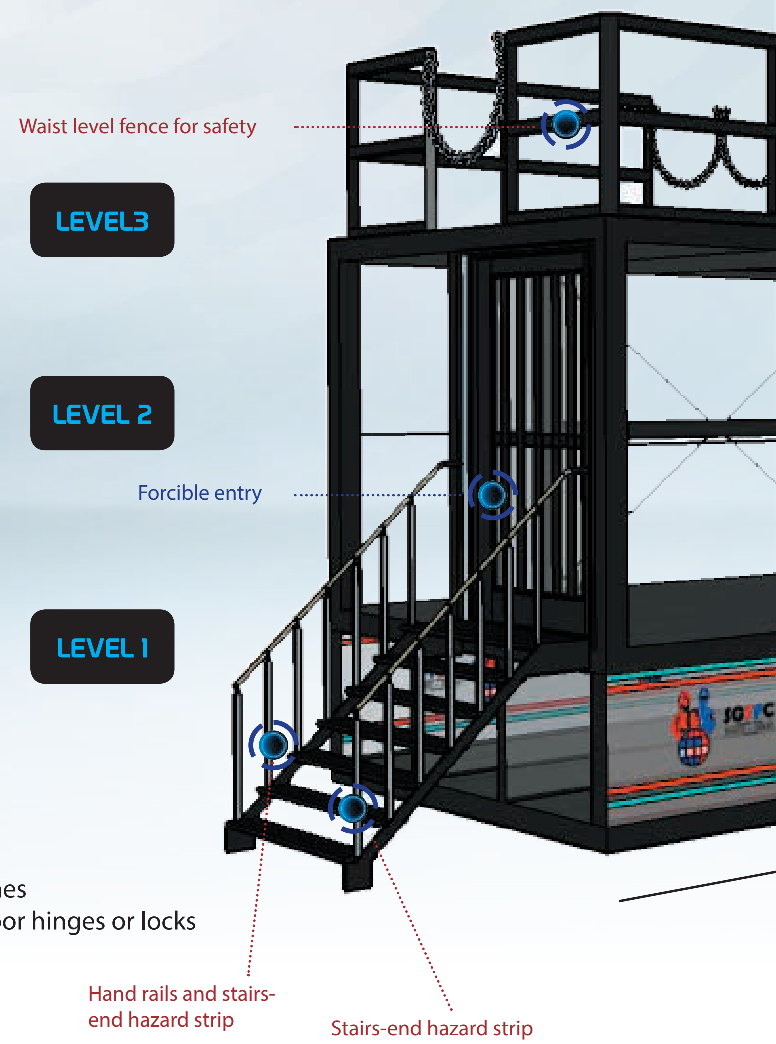
SCENARIO-BASED REALISM

- Gives sense of depth and scale to the competition arena
- Transfers realism into games by providing scenarios such as firefighting, confined space rescue, height rescue, HazMat mitigation and forcible entry

4

GAME TECHNICALITY

- Closely simulates real-life experience
  - Confined space of 1m x 1m
  - Real fire using fire wok
  - HazMat flange leak that is able to emit fumes
  - Forcible entry that requires breakage of door hinges or locks
  - Depth rescue using tripod
  - Height rescue using ladder hinge

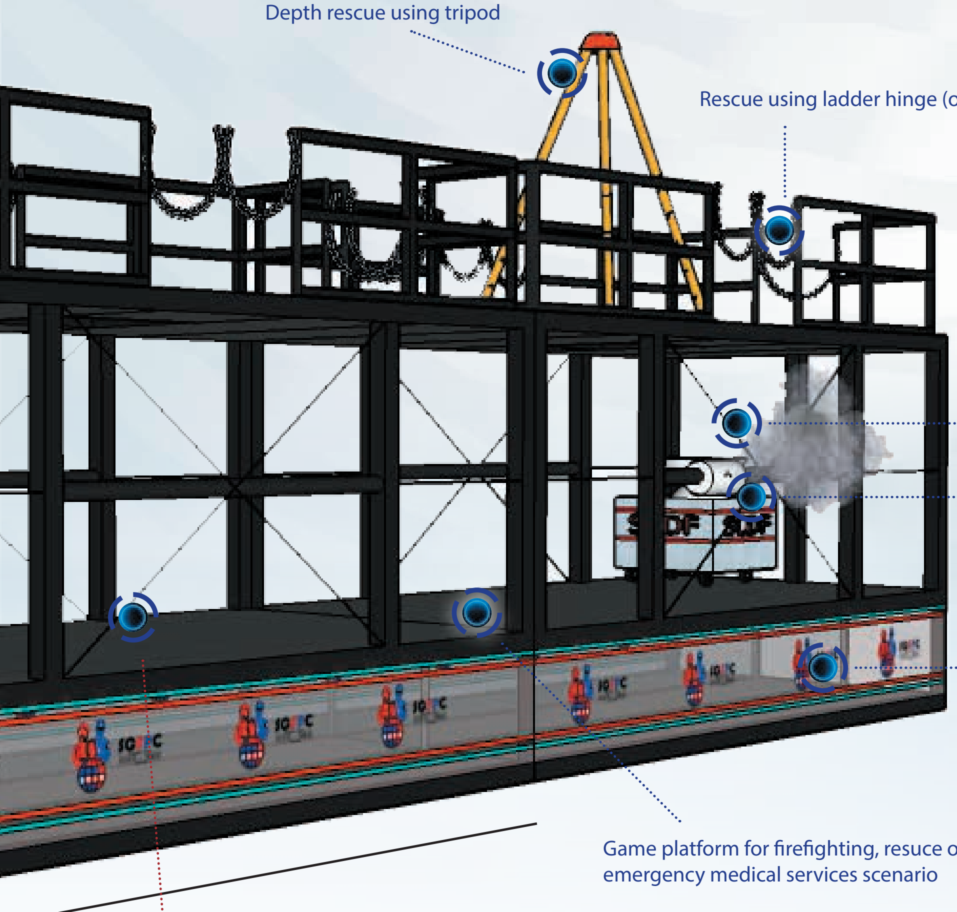


1 MULTI-FACETED DESIGN

- Level 1 - Confined Space Rescue
- Level 2 - Main Game Platform
- Level 3 - Height Elements

2 MODULAR-BASED CONCEPT

- Able to combine modules to form bigger game platform
- Allows flexibility and customisation according to game scenario
- Quick turn-around during competition



5 SAFETY FEATURES

- Carabiner hook on level 2 as barrier
- Waist level fence on level 3
- Hand rails along staircase
- Stairs-end hazard strip

EDITORIAL PREVIEW

SGFPC aims to be a platform for participating agencies and departments to share and advance collective skills and knowledge in the fields of firefighting, rescue, and pre-hospital emergency care.

First mooted, conceptualised and created in 2014 with the support of the United Nations (UN) Office for the Coordination of Humanitarian Affairs (OCHA) INSARAG, the first edition of the Exercise Urban Elite made its debut at the SGFPC 2014. The first Exercise Urban Elite (EUE) was a scenario-based exercise designed for UN INSARAG External Classification (IEC) certified teams or teams which are planning to be certified and are based on the UN INSARAG guidelines. The two-day exercise requires participating USAR teams to go through an actual deployment process and presents them with scenarios derived from the UN INSARAG Guidelines. Each edition of the EUE will be targeted at one of the 7 technical areas listed under the INSARAG guidelines.

This article describes in detail the rationale behind the creation of the EUE and the technical scenarios that were covered in the 2014 edition. An excerpt of the documented findings and observations for one of the technical scenarios is also shared.

Interested persons who want to obtain a detailed report on the documented findings and observations for all the technical scenarios conducted in EUE 2014 can contact the Editorial Board to register your interest.

PROMOTING INSARAG GUIDELINES AND SHARING OF BEST PRACTICES THROUGH EXERCISE URBAN ELITE

LTC Ow Yong Tuck Wah and
CPT Foo Yiing Kai,
Exercise Management Team,
Exercise Urban Elite 2014,
Singapore Civil Defence Force

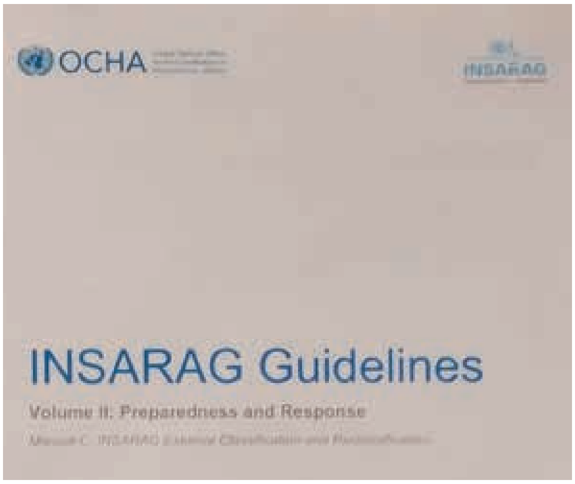


Figure 1: Cover of INSARAG Guidelines

Introduction

Disasters around the world have been occuring with increasing frequency and magnitude. The need for sophisticated Urban Search and Rescue (USAR) capabilities to render aid to affected nations or areas has greatly increased. To facilitate the United Nations International Search and Rescue Advisory Group's (UN INSARAG[1]) deployment of USAR teams in required sites according to their capabilities, there is a need to assess their capabilities and adopt standardised response and operations procedures.

The INSARAG External Classification

In 2005, the UN INSARAG implemented a system named as INSARAG External Classification (IEC) to classify international USAR teams according to their operational capabilities. This ensures that only qualified and appropriate international USAR resources are chosen and deployed to provide suitable assistance at suitable sites.

In February 2015, the UN INSARAG Steering Group also unanimously endorsed the new INSARAG Guidelines 2015 (See Figure 1).

The INSARAG Guidelines consist of 3 volumes, namely:

1. Volume I: Policy
2. Volume II: Preparedness and Response
    a. Manual A: Capacity Building
    b. Manual B: Operations
    c. Manual C: IEC/ Reclassification Guide
3. Volume III: Operational Field Guide

Volume II, Manual C aims to provide guidance to teams aiming to achieve IEC or teams aiming to renew their IEC through the INSARAG External Reclassification (IER) process. It is designed to classify USAR teams according to 3 main areas:

a. Preparedness, Mobilisation;

b. Arrival at affected countries; and

c. Required technical skills in USAR Operations.

[1]INSARAG is a global network of more than 80 countries and organisations under the United Nations umbrella. INSARAG deals with USAR related issues, aiming to establish minimum international standards for USAR teams and methodology for international coordination in earthquake 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

The technical areas examined under actual USAR Operations broadly cover the 7 listed operations shown in Figure 2.

USAR OPERATIONS						
Search	Canine Search	Cutting & Breaking	Lifting & Towing	Shoring & Stabilisation	Rope Work	Medical Care

Figure 2: 7 technical areas covered in UN INSARAG Classification

The IEC/IER is meant to evaluate a USAR team to ensure that it meets all the criteria required by the INSARAG Guidelines and that the current INSARAG Minimum Standard is achieved. In this sense, for tasks stipulated under the technical operations skills required, the teams are expected to be able to achieve the task objectives in safe conditions. However, there is no detail on the best practices or techniques of achieving the required task in the most efficient ways under the INSARAG Guidelines or INSARAG Field Guidance Notes.

Exercise Urban Elite

The overarching objective of the Singapore-Global Firefighters and Paramedics Challenge (SGFPC) is to provide a platform for participating agencies and departments to share and advance our collective skills and knowledge in the fields of firefighting, rescue, and pre-hospital emergency care. With the support of UN INSARAG, Exercise Urban Elite (EUE) was introduced as a special segment in the SGFPC 2014 edition. The purpose of this exercise is to propagate adoption of INSARAG Guidelines with a view to document the best practices that were observed by the exercise management team and other teams. It was also decided by the Exercise Simulation and Design Team to focus on one technical skill every year.

The Exercise Urban Elite 2014 was held from 10 to 11 September 2014 in a simulated disaster stricken area in Singapore. Six USAR teams (People's Republic of China, Malaysia, Qatar, Saudi Arabia, United Arab Emirates and Singapore) participated in the 2014 edition.

For the 2014 edition, the focus was on the 4 cutting and breaking operations depicted in Table 1 below.

Clause Number	Operations
13.3	Does the USAR team demonstrate the ability to cut, break and breach through steel reinforced concrete walls, floors, columns and beams, structural steel, reinforcing bars, timber and building contents? (according to the dimensions on the table below):
13.3.1	Penetrate 200 mm of steel rein-forced concrete vertically overhead to a void space.
13.3.2	Penetrate 200 mm of steel reinforced concrete laterally into a void space.
13.3.3	Penetrate 200 mm of steel reinforced concrete vertically below to a void space using a "dirty" technique.
13.3.4	Penetrate 200 mm of steel reinforced concrete vertically below to a void space using a "clean" technique.

Table 1: Cutting and Breaking operations extracted from INSARAG Guidelines, Manual C- IEC and R Clause Number 13.3

For each of the cutting operations, there were at least two USAR teams comprising a section of 4 to 5 rescuers, attempting the same scenario. The best practices observed and shared by the teams were documented. Such practices were then tried and validated by the SCDF Disaster Assistance and Rescue Team (DART). The most efficient practices would then be documented for future recommendations to INSARAG to adopt as a guide for best practices and standards. An excerpt of the documentation for a cutting operation (Clause 13.3.3: Penetrate 200 mm of steel reinforced concrete vertically below to a void space using a dirty technique) is described in the next segment of this article.

"Dirty" Technique

Dirty cut techniques are best used when the location of the casualty is not directly under the area of cut (See Figure 3). For reasons of efficiency, this would also be a preferred method over a clean cut technique which would be utilised when the casualty is very near to the area of cutting operations. Concrete is very strong in compression but weak in tension and shear. The shear and tensile strength of reinforced concrete is provided by the rebars embedded within the concrete. Powered saws are used to create relief cuts which take the concrete out of compression and remove the bond between the concrete and the rebar. The gap created by the relief cuts then allows one to attack the inherent weakness of concrete, and place it under shear or tension when applying breaker tools [1]. This methodology of breaching reinforced concrete utilises a combination of both powered saws and demolition hammers. The demolition hammer is then used to remove the concrete materials. Lastly, hydraulic cutting tools are used to cut the steel rebars.

The aforementioned has been proved to be the more time efficient method as compared to the conventional method of solely relying on a demolition hammer to breach reinforced concrete. 2 variations of the dirty cut that were utilised at EUE are compared in tables 2 and 3:

1. A conventional Square Grid Dirty Cut practiced by most teams; and

2. A Triangular Grid Dirty Cut which is deemed to be more efficient

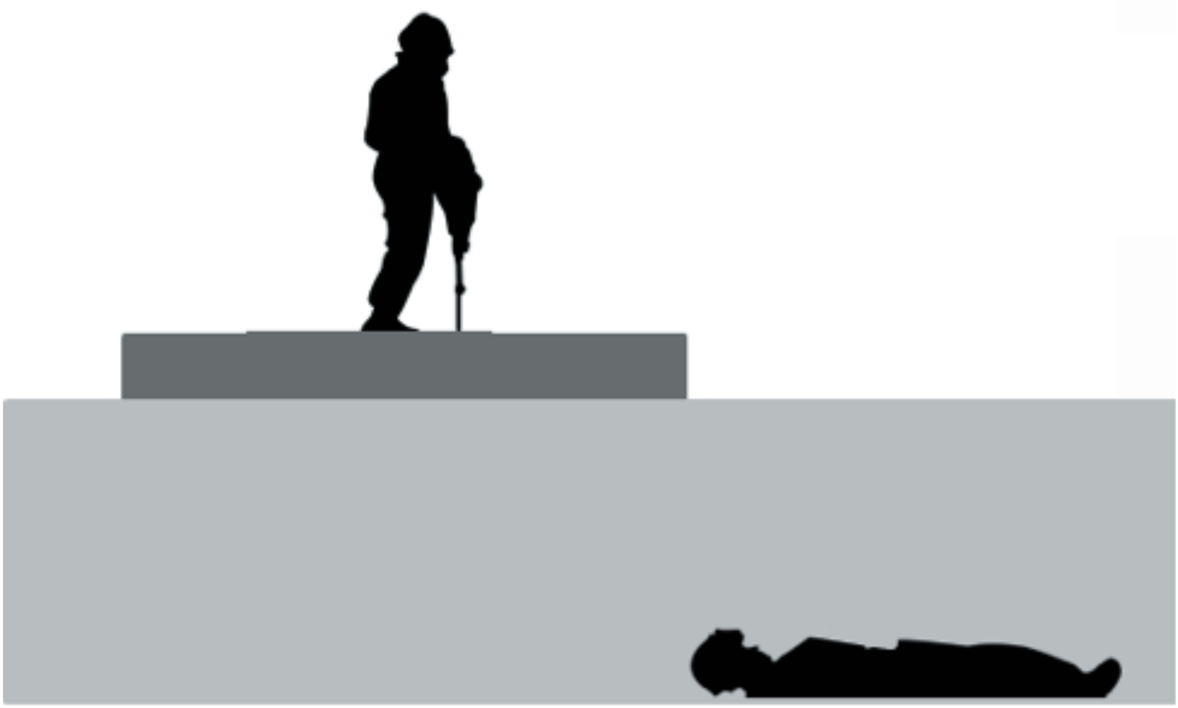


Figure 3: Pictorial diagram of a dirty cut technique employed to gain access to casualties

Table 2: Square Grid Dirty Cut

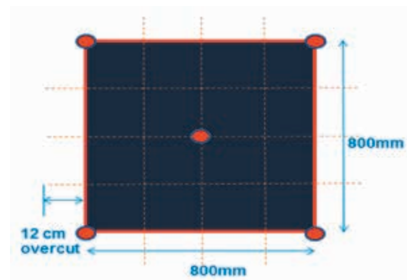
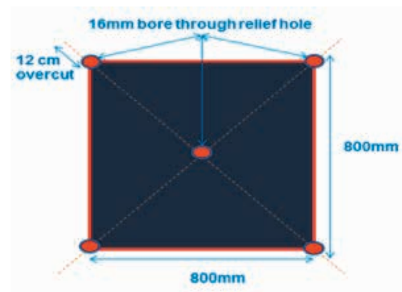
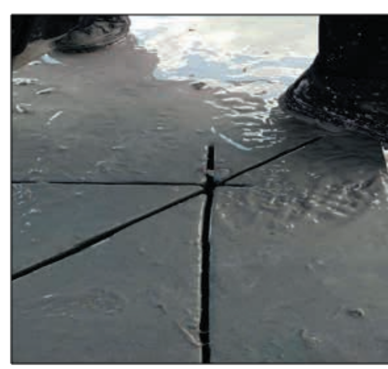
S/No	Steps	Diagram to illustrate
1	**Demarcation** To begin the cut, a square grid measuring 800mm by 800mm with 6 grid lines within is demarcated on the reinforced concrete. This would mark out 16 square grids with equal dimensions. To ensure that there is a complete cut on the concrete, it is a good practice to mark the 12cm over-cut on all of the grid lines.	
2	**Relief Cuts** With the grids marked out, a total of 10 relief cuts would be performed on the entire grid marking using a diamond blade gasoline powered saw. It will take approximately 20 minutes for all relief cuts to be effected and the 12cm overcut on all the grids need to be achieved to facilitate further breaking using a demolition hammer. *Note that during the cutting process, water must be applied to reduce the dust by-product. The dust by-product when mixed with water would form a layer of concrete sludge. Proper management of this sludge would entail copious applications of water.	 
3	**Concrete Removal** Upon completion of relief cuts, the removal of the concrete materials can now begin with the use of a demolition hammer. The minimal amount of concrete materials to remove would be 4 square grids. This would create a sufficient access for one rescuer to enter while the breaking crew continue to enlarge the opening. *Note that the 4 x 4 grid measures 400mm x 400mm. The reinforcing bars within the concrete slab can be removed using a bolt cutter or hydraulic cutter.	
	Total Breaking Time	**65 mins**

Table 3: Triangular Grid Dirty Cut

S/No	Steps	Diagram to illustrate
1	**Demarcation** To begin the cut, a square demarcation measuring 800mm by 800mm will be marked out with 2 diagonal lines across.	 
2	**Relief Cuts** With the grids marked out, a total of 6 relief cuts would be performed on the entire grid marking using a diamond blade gasoline driven powered saw. 5 additional 16mm diameter bore through relief holes will be made using a combination hammer. The 12cm overcut on all the grids need to be achieved to facilitate further breaking using a demolition hammer. *The 16mm bore through relief hole is achieved using a combination hammer equipped with a 16mm bore bit. *Note the completed relief cuts with the 12cm overcut. There will be a total of 4 triangular grids marking on the reinforced concrete slab. Total time taken for 6 relief cuts is approximately 12 minutes.	

S/No	Steps	Diagram to illustrate
3	**Concrete Removal** The removal of the concrete materials can now begin using the demolition hammer with a chisel tool bit. The initial amount of concrete materials to remove would be 1 triangular grid which would create sufficient access for one rescuer to enter while the breaking crew continue to enlarge the opening by working outwards. * The triangular grid has the same surface area as 4 square grids. *The rebars will be removed using a bolt cutter or hydraulic cutter. Total time taken for concrete removal of 1 triangular grid is approximately 30 minutes. The total time taken for Triangular Dirty cut is approximately 42 minutes.	  
	Total Breaking Time	**42 mins**

Discussion on the 2 "dirty" Techniques

The Triangular Grid Dirty Cut would be the more time efficient method as the total time of to execute a Square Grid Dirty Cut is 65 minutes while Triangular Grid Dirty cut is 42minutes. This is made possible with the introduction of relief cuts into conventional dirty cutting techniques which greatly reduces the tensile strength of reinforced concrete structures and allows for easier concrete removal.

Conclusion

All participating USAR teams found the Exercise Urban Elite very useful as they had the opportunity to work on honing their technical skills in cutting and breaking operations. The findings and lessons learnt have been shared during the exercise debrief and also documented in this article. The documented best practices will be recommended to INSARAG to adopt as a standard to follow or achieve in the Field Guidance Notes.

References

[1]U.S Department of Homeland Security, Federal Emergency Management Agency, National Urban Search & Rescue Response System, Structural Collapse Technician Module 3

Excercise Urban Elite 2014

EDITORIAL PREVIEW

In many modern urban cities, rapid car growth has made it convenient to travel around for the general population. On the flip side, it also contributes to an increasing number of road traffic accidents. Coupled with the increasingly myriad of complex technologies employed by car makers in the design and development of cars, it is becoming a challenge for fire and rescue agencies around the world to conduct effective and efficient road traffic accident rescues.

In 2013, the newly revamped Singapore-Global Firefighters and Paramedics Challenge (SGFPC) incorporated a new challenge, named "RIP-IT-OFF", for its annual skills challenge at the Singapore Expo Hall. "RIP-IT-OFF" is a road crash rescue challenge where rescue teams are challenged to conduct a series of actions to extricate casualties in simulated car crashes.

This article describes the competition settings of the "RIP-IT-OFF" Challenge, the team composition, equipment allocation and the safety aspects of the challenge. Observation and discussion of techniques employed by the different teams are also documented.

Interested persons who want to obtain a full detailed report on the documented observations and discussion for all the "RIP-IT-OFF" scenarios can contact the Editorial Board to register your interest.

EXPERIENTIAL LEARNINGS FROM "RIP-IT-OFF" CHALLENGE

MAJ Cheng Yaw Joo, Chief Umpire, Singapore-Global Firefighters and Paramedics Challenge, Singapore Civil Defence Force

Introduction

In 2013, a new segment named "RIP-IT-OFF" was introduced in the Singapore-Global Firefighters and Paramedics Challenge (SGFPC) for the purpose of sharing of technical knowledge and skills within a competitive setting. The "RIP-IT-OFF" challenge simulates a road traffic accident scenario where teams are ranked based on their scene assessment, vehicle stabilisation, extrication techniques, medical intervention, safe practices and the overall timing. The challenge in 2013 and 2014 drew international interest and attracted 29 teams from 13 countries to participate.

Teams need to find the right equilibrium between technical knowledge, teamwork, speed and safety. The challenge is not entirely about speed and covers other aspects such as safety and stabilisation of the vehicle before extrication. The fastest team to complete the challenge however may not be crowned the winning team. The SCDF team was the fastest completing team in the 2014 edition but eventually lost out due to point deductions as a result of safety infringements. Both challenges in 2013 and 2014 were won by the team from the Department of Fire and Emergency Services, Western Australia.

This article aims to provide insights and analysis on observed vehicle extrication techniques, as well as some common mistakes displayed by the teams during the past two editions. It is envisioned to serve as a resource to complement

Competition Settings

Due to the large number of participants, the teams are required to go through a round of qualifying heats. The 6 best qualifying teams from the Heats will then proceed into the Finals for another round of competition. There are a total of 4 designed scenarios and each scenario will only be made known before the commencement of the actual challenge. Each 'RIP-IT-OFF' scenario presents the teams with a live simulation of a trapped casualty at the driver's seat of a compact vehicle. The vehicles used are from the same make and model to provide uniformity for the challenge. The 4 designated scenarios are listed in Table 1 below:

Scenario	Vehicle alignment	Required objectives to achieve	
1	Vehicle upright on four wheels	Removal of 2 doors and the B-post on one side of the vehicle	
2	Vehicle upright on four wheels	Full removal of the vehicle roof	
3	Vehicle upright on four wheels	Forward roof flap	
4	Overturned vehicle on its roof	Removal of 2 doors and the B- post on one side of the car	

Table 1: List of scenarios available for RIP-IT-OFF Challenge

During the challenge, teams are required to size-up the scenario, stabilise the vehicle before gaining access and commence extrication of the casualty at the driver's seat. The teams are expected to simultaneously conduct medical stabilisation of the casualty and create an opening to bring out the casualty. To make the scenario more challenging, the teams are required to prescriptively create an opening before they are allowed to extricate the casualty. The casualty must be packaged with a Kendrick Extrication Device (KED) and placed firmly on a stretcher before he can be carried across the finishing line. The teams are allowed to adopt any technique using the standard equipment allocated.

Team Composition and allocated equipment

The team consists of four members, comprising one team leader, two rescuers and one paramedic. Each team is allocated identical standard rescue equipment for road accident rescue. Just before the competition begins, teams are given sufficient time to check the equipment and ensure its workability. The list of equipment provided is as such:

» Step Choke, Lock Block and Wedges
» Kendrick Extrication Device (KED)
» Battery Operated Ram
» Ram Support
» Reciprocating Saw
» Battery Operated Grinder
» Rabbit Too
» Crow Bar
» Bolt Cutter
» C-Collar
» 10 Ton Hydraulic Jack
» Glass Management Kit
» Spinal Board
» Oxygen Supply Kit
» Hydraulic Spreader
» Hydraulic Cutter
» Hard Protection Board
» Sharp Protection

Safety

To address safety concerns, side windows of all vehicles are removed and the car batteries are disconnected preceding the competition. Due to the risks of accidental activation of the airbag system being eliminated, it is not necessary to add in the additional element of exposing the posts and roof rails of vehicles before cutting. There are Equipment and Dump areas (See Figure 1) allocated for each team to place their rescue equipment and the wreckages of the vehicle respectively.

Figure 1- Typical Equipment and Dump Area for each team

Observed Extrication Technique

The various extrication techniques adopted by the different teams for each scenario were observed by the judging teams and documented. Different methods of extrication were then compared for their efficiency and the issues associated with each technique are discussed. An example of the documented findings from Scenario 1(the removal of 2 doors and B-posts in an upright vehicle) observed during the challenge is highlighted below:

Removal of 2 doors and B-Post

The purpose of removing the side doors and the B-Post is to create a larger opening at the side of the vehicle that can be used for casualty care or immediate release as appropriate.

There are generally two methods of removing the two doors and the B-Post that are highlighted in many vehicle extrication guidebooks:

1. The traditional method; and

2. B-post rip

The traditional method involves removing the 2 side doors first and then cutting the B-post using a hydraulic cutter and/or reciprocal saw. Most teams employed the traditional method while 4 teams whom adopted the 'B-Post Rip' achieved faster average timings as compared to those who employed the traditional method.

There is another method that can be improvised from a 'side fold-down' method [1], but was not displayed by any team that participated in the competitions. Table 2 compares the three techniques in terms of speed and difficulty level. Each of these techniques has its own advantages and disadvantages that have to be evaluated which will be best in any given situation.

	TRADITIONAL METHOD	B POST RIP	SIDE FOLD-DOWN
DIFFICULTY	Easy	Moderate	Moderate
AVERAGE TIME TAKEN (MINUTES)	12	6	8*
REMARKS	Most commonly practised method; more time-consuming due to the need to expose and cut more hinges and latches. The thick base of B- Post also requires more time to cut.	Rip the base of B- Post using hydraulic spreader, but such a technique requires proper techniques and know-how compared to cutting only	Ease of cutting due to lesser space restriction for cutting the bottom post of B-Post. However, there may be a risk of destabilising the car while executing the fold-down

Table 2: Comparison of B-Post Removal Techniques

**based on trial by SCDF to test the method. The timings of the traditional and B-post rip methods are obtained from the "RIP-IT-OFF" Challenge*

Side Fold-Down

As the lower part of the B-Post is usually wide and made of very tough materials, rescuers may face difficulties using a traditional method or 'B-Post Rip'. By folding down the entire side of the vehicle, only the latch of the rear door, the upper part of the B-Post (See Figure 2) and the hinges of the front door need to be severed. Relief cuts should be made on the lower part of the B-Post where applicable (See Figure 3) to facilitate the folding down (See Figures 4 and 5). After folding down, the fully exposed B-Post allows for cutting to be expedited. This technique is found to be relatively faster than the traditional method.

Figure 2 – Cut the top of B Post

Figure 3 – Cut relief cuts at the bottom of B Post

Figure 4– Bend the B Post and two doors downward

Figure 5 – Fully exposed B-Post makes cutting easy

However, it is important to note that the results from the 3 techniques may vary, depending on the vehicle model and the composition of high-strength, low-alloy steel in the B-Post which constitutes a greater challenge and requires more time [2].

Common Safety Violations and Mistakes observed

While it may seem intuitive to hasten in the extrication process to win the challenge, teams also need to be mindful of the safety aspects as safety is one important component of the challenge. Many teams were penalised for safety violations which are listed below:

1. <u>Forcing out of Vehicle Parts by human strength</u>

   One common safety violation observed was the usage of brute human strength in their attempts to rock and force the door out. Such acts introduce excessive movement to the vehicle which can cause further injuries to the casualty or even members of their own team (See Figure 6).

Figure 6 – A participant using his leg to manually force open the door

2. Wrong Positioning of Equipment

   There were situations when the operators of equipment got themselves into situations where they were 'sandwiched' between the equipment and the vehicle components during cutting operations. One cannot prevent the natural movement of the tool during operation and may result in the rescuer being wedged between the equipment and the vehicle component if they are not careful. The rescuer needs to stop and reposition the equipment before parts of the body become trapped against the vehicle component (See Figure 7) [3]. In the rush against time, some teams overlooked this important aspect and were stopped by the umpire for rectification before they could continue, hence slowing down their extrication process.

Figure 7 – A participant from SCDF demonstrating the correct positioning to ensure a rescuer is not positioned in between the equipment and the vehicle component

3. Falling Vehicle Parts

   When cutting an unsupported or hanging end of an object, such as the B-Post, care should be taken to prevent team members from getting injured. It is advisable to hold the free end piece of the hanging object, to prevent excessive dislodgement while the rescuer is making the final cut (See Figure 8) [4].

Figure 8 – A participant correctly supporting the B-post to prevent excessive dislodgement

4. Poor Site Management

   It is a requirement for tools not actively being used to be placed at the tool staging areas for safety reasons [5]. Trip hazards are dangerous to both the rescuers and the casualty but this aspect was often disregarded (See Figure 9).

Figure 9– The hydraulic cutter which is not being used while other equipment is employed creates tripping hazards

5. <u>Covering of Sharps</u>

All sharps must be covered to prevent injuries. In most instances, sharps were covered promptly. However, after cutting the top of the B-Post, some teams immediately proceeded to bend downward to cut the bottom of the without covering the sharps at the top. The members could have easily be injured especially when they were immersed in cutting the base and forgot about the hazard on top in the heat of their rescue (See Figure 10).

Figure 10 – Participant from London Fire Brigade covering the sharp at the top of B-Post before cutting the base

Conclusion

A road traffic accident in which one or more people are trapped is a demanding situation from both the technical and medical points of view. The condition of casualties must not be made worse by the extrication process, and the medical treatment must not be delayed. The survivability of the casualty will largely depend on the level of skills, knowledge and importantly, the team coordination of the rescuers. Being aware of the good practices and common errors committed through the nerve wracking experiences in the challenges will put the teams in better stead to prepare for future 'Rip It Off' challenges and also real road crash rescue operations. Through continual learning and reflection on key lessons learnt will raise the bar of any rescue team.

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EDITORIAL PREVIEW

Fires around the world have been declining from a peak of 4.5 million fires in the early 2000s to a low of 2.5 million in 2013 [1] (CTIF Report Number 20). Such low numbers may lull members of public into a false sense of security. The importance of fire safety cannot be understated and one of the ways of highlighting fire safety is to give people first hand experience of a fire situation in a safe manner.

This article describes the facilities of the Furnace at the Civil Defence Academy (CDA), and also shares on an innovation, the Mobile Fire Trainer to deliver the facilities of the Furnace to remote locations for firefighting training or exhibitions of fire safety.

Interested persons who want to learn more about the Furnace @ CDA or the Mobile Fire Trainer can contact the Editorial Board to register your interest.

MOVING THE FURNACE- THE MOBILE FIRE TRAINER

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The SCDF embraces realistic fire training environments for its trainees to practise their skills on. Such training has been conducted within the Furnace @ the Civil Defence Academy (CDA) (See Figure 1) , a 10-storey training facility located at CDA@Jalan Bahar, since 1999.

There are a total of 14 fire simulators (See Table 1 for a list of fire simulators) in the Furnace and they are modelled after actual objects and settings that could happen in a day to day setting.

Figure 1: The Furnace @ CDA

S/No	Fire Setting and Storey Level	Description	
1	Sump Fire @ Basement	The Sump Fire simulator challenges trainees to descend into a smoke-filled basement with a charged hose. To reach that fire, the trainees must ensure that the hose length is sufficient. They must also exercise proper procedures to comb the basement for casualties in near-zero visibility	
2 (a) and (b)	Ship Engine @ Level 3 Ship Bunker @ Level 4	These 2 simulators are used for training SCDF marine firefighters, personnel of the Republic of Singapore navy and sailors from various maritime businesses. Trainees learn to locate and open the hatches, extract heat and smoke from the engine room, before descending into it with a charged hose to apply foam on the heated oil from the engine.	 
3	High Bay Storage @ Level 4	This warehouse-like simulator presents trainees with a challenging scenario where industrial chemicals stored in high storage racks are on fire. It can simulate falling hazards and the effects of applying the wrong extinguishing medium. For e.g a fireball ensues if water is applied on water-reactive chemicals	
4	Flat Unit @ Level 5	This residential unit simulator focuses on electrical fires and fires within a residential setting. Trainees can practice their forcible entry techniques, manage hazards associated with gas leaks and experience the rollover effect	

S/No	Fire Setting and Storey Level	Description	
5	Unit Window @ Level 6	This simulator presents the challenges of responding to a well-developed residential unit fire, where the fire has filled the room and emerged from crevices in the window sills, threatening to spread to the upper floors. Aerial appliances such as the combined platform ladder are employed for trainees to practise high rise firefighting procedures	
6	HazMat Storage @ Level 7	Similar to the High Bay Storage Fire Simulator, this simulator emphasises the importance of applying the correct extinguishing medium when hazardous materials are involved. Trainees must identify the various hazardous chemical signages and apply corresponding techniques and safety measures.	
7	Packing Room @ Level 7	The Packing Room simulates an industrial setting with emphasis on electrical hazards such as switch boards and conveyor belts, the latter of which can accelerate the spread of fire in the room. Trainees approach the scene with electrical detectors, use electric nozzles and de-energise electrical appliances.	
8	Bartop @ Level 8	This simulator resembles an entertainment outlet where bottles of alcoholic drinks are abundant, posing both fire and falling hazards. Trainees must not direct water jets at bottles to prevent breaking them and causing further fire spread, which can be simulated using the purpose-built bar top.	
9	Karaoke Lounge @ Level 8	Alongside the Bar Top, this simulator challenges trainees to perform deep penetration into a smoke-logged environment while faced with drunken patrons and combustible materials. As the fire develops, trainees must “push back” the rollover effect and apply cooling measures.	

S/No	Fire Setting and Storey Level	Description	
10	Deep Fryer @ Level 8	The purpose of the Deep Fryer is to simulate challenges faced when dealing with fires in restaurants, involving super-heated oil. If trainees were to apply water as the extinguishing medium, the simulator mimics the "slopover" effect, which occurs when water comes into contact with hot oil.	
11	Corridor and Hotel Rooms @ Level 9	The four Hotel Rooms 902-905 are where trainees learn advanced search and rescue procedures. As they comb each room for casualties and trapped victims, trainees practise the laying of guidelines and room tags. The trainees are briefed on their individual roles within their sections, and are expected to perform standard casualty management techniques	
12	Mini Mart @ Level 9	In the Mini Mart, trainees come across narrow passageways lined with shelves full of combustible materials. In a smoke-logged and dark environment, trainees mitigate the effects of falling objects as well as explosions resulting from the combustion of pressurised aerosol cans	
13	Laundry Room @ Level 9	The Laundry Room is less about laundry than the effects of a fire within an enclosed area. It simulates the effects of suddenly introducing oxygen into such an area (commonly known as the backdraft effect). To avoid dangers associated with the backdraft effect, trainees learn about how to feel the heat on doors before entry	

Table 1: List of Scenarios available in the Furnace at CDA@ Jalan Bahar

The Mobile Fire Trainer

The CDA has received many requests for firefighters from external agencies and members of public to visit to feel the experience of fires up close. Due to constraints and availability of resources, the Furnace training slots are usually catered for SCDF personnel to train. In order to bring the experience of practical fire scenarios to a wider audience, the vision of the project team was to have a condensed package which is mobile, small enough to be transported and yet still encapsulates the required sensory experience! The SCDF has worked with a local engineering solutions provider, Hexcel Solutions Pte Ltd to design such a package that can be deployed anywhere to conduct training for firefighters or conduct exhibitions for members of public to feel the heat in a real fire situation.

The end result is the Mobile Fire Trainer (MFT) which was commissioned in 2014 (See Figure 2). This is a 12m purpose built fire-rescue simulator on-the-wheels, deployable easily and customised to user-specified fire scene settings for realistic and safe fire-rescue training.

Figure 2: The Mobile Fire Trainer

Figure 3: A Kitchen Scene Prop configured on the MFT

Figure 4: Storage Rack Scene Prop configured on the MFT

The MFT is versatile in providing for contextual fire-rescue training at remote locations without any disruption to daily operations or imposing undue onsite risks during training. The interchangeable scene-settings enable scenario-based training to be optimised with the graduated fire-points using modular scene-props. These modular scene-props (See Figures 3 and 4 for Kitchen stove and storage rack modular scene props) can be re-configured with ease and are listed below:

1. Kitchen Stove
2. Storage Rack
3. TV and Hi-Fi Console
4. Bedroom
5. Living Room
6. Process Pipelines/Reactor
7. Plant Room
8. Confined Spaces

Safety

The MFT is designed with state-of-the-art computer-controlled, water-bath technology that enables the fire-points to be controlled at the finger-tips of the instructor. The operations of MFT are safe, simple and reliable. Piloting, firing and re-firing the fire-points can be controlled by one instructor using wired or wireless handheld pendant controllers. Similar to the Furnace, the MFT is also designed with training safety in mind. It is equipped with a comprehensive safety system which includes liquefied petroleum gas detectors, thermal couple temperature sensors, ventilation and exhaust systems, emergency shutdown, manual override, etc.

Conclusion

The delivery of realistic and safe training cannot be understated. Aided by rapidly developing technology and know-how, the development of the MFT will aid in delivering the experience of real fires to both external firefighters and members of public.

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EDITORIAL PREVIEW

The opening of the Home Team Tactical Centre (HTTC) is a significant milestone in the development of training simulation in the Home Team, bringing the training facilites of the Singapore Police Force and the Singapore Civil Defence Force together into an integrated complex. Technological features are used to replicate actual operational environments, allowing officers to train in a safe and controlled environment to build up mental resilience and hone their judgement.

The SCDF's Civil Defence Academy at Mandai (CDA@Mandai) is located within this HTTC and comprises of 3 distinct facilities designed to replicate fire and rescue scenarios that can happen at chemical plants, ships and collapsed structures. This article shares the design and capabilities of the facilities within CDA@Mandai. Design standards and safety aspects of the CDA@Mandai are also discussed within the article.

Interested persons who want to obtain a detailed report on the CDA@Mandai can contact the Editorial Board to register your interest.

THE CDA@MANDAI: CREATING HIGHLY REALISTIC, LARGE SCALE TRAINING SCENARIOS

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Introduction

The Civil Defence Academy (CDA) is the premier training institution of the Singapore Civil Defence Force (SCDF). Established in 1999, it conducts all professional and specialised trainings in the field of civil defence for SCDF and its partners. The Academy started with an 11-hectare site at Jalan Bahar in the west of Singapore, and is equipped with state-of-the-art simulators such as the Oil Tank and Chemical Plant fire simulators (See Figure 1) amongst many others to conduct realistic training scenarios. These simulators are controlled by sophisticated computer systems which allow various scenarios to be pre-programmed to add realism in training.

Fig 1: Oil Tank Simulator and Chemical Plant training simulator at CDA@Jalan Bahar

Since the inception of CDA in 1999, the global security climate has evolved tremendously. Responders have to be better prepared to face large scale crises, in terms of the magnitude of the consequences. This requires them to stretch their imaginations in projecting how scenarios may unfold. To sharpen operational response, CDA must provide participants with the environment to act out their response in a highly realistic scenario set up, over and over again, so that participants can react better, less nervous or stressed, and with the right skills and knowledge. As the saying goes, "If you have to work with fear, you need to train with fear." Realistic training is therefore an important conduit for responders to confront their fears head-on, and build up their capabilities to deal the unknowns of a major catastrophe.

Based on these considerations, SCDF set out to develop a brand new training complex. The project entailed a comprehensive review of ways to test, refine and maintain the skills of SCDF personnel based on current needs, as well as a projection of the future operational and training requirements of the SCDF. After more than 10 years of hard work in conceptualising, planning, consultation, design, and construction, this new training complex that prepares SCDF for the future was commissioned in October 2015. Located at Mandai, in the northern part of Singapore, it was aptly named as CDA@ Mandai (See Figure 2).

Figure 2: CDA campuses in Singapore. CDA@Jalan Bahar is the main campus where most local and international courses are conducted; CDA@Ubi is a city campus located next to SCDF HQ, catered for working adults; and CDA@Mandai is the latest addition where high impact and technical trainings are conducted.

CDA@Mandai is part of the Home Team Tactical Centre (HTTC), which also houses the practical training complexes of another member of the Singapore's Home Team - Singapore Police Force (SPF). The co-located SCDF and SPF training complexes can be utilised for combined exercises between the two Home Team agencies to improve interoperability and operational synergy. CDA@ Mandai occupies 8 hectares of HTTC (See Figure 3 and 4), and it houses 3 key training complexes for large scale tactical training as well as scenario exercises.

Figure 3: Artist Impression of CDA@Mandai

Figure 4: The view of CDA@Mandai from Diamond

The first impression of anyone who steps into CDA@Mandai is the realism of its structures. At the centre of the complex stands a cluster of simulated collapsed structures, built to re-create possible scenarios in Urban Search and Rescue (USAR). Parts of the building are deliberately sloped at an angle of 18°, while other parts deliberately come with an absence of walls, floors and roof. Another eye-catching facility looks like an actual ship, except that it is grounded and is adjoined to a deep pool. This is named 'Orca', after apex predators in the sea. The name was chosen to signify the apex of ship fire-fighting training. A third training complex could be mistaken from far to be an actual petrochemical facility, complete with a distillation tower. It is named 'Diamond', in reference to the diamond shape symbol used for the identification of hazards under NFPA 704. 'Diamond' has been designed to conduct elaborate training on pressurised industrial firefighting, HazMat response and mitigation.

Leaning Tower

The Leaning Tower was chosen for the name of this training simulator as it highlights the true essence of what it was built for: to conduct training on USAR. It serves to refine and improve the USAR skills of rescuers, by providing them with realistic and challenging conditions. These conditions were created with the input and experiences of SCDF rescuers, drawn from their various overseas and local missions. By re-creating the challenging conditions that rescuers have had to face previously, participants of CDA courses who train at the facility would gain a better appreciation of the operational considerations and limitations behind their chosen methods and courses of action.

Figure 5: Leaning Tower

The Leaning Tower (See Figure 5 and 6) features a partial or total collapsed structure with the capability to inject water to simulate basement flooding. To provide realism in training, smoke and scent machines are installed to simulate post-blast scenarios, which also include cars trapped in collapsed buildings and even simulated smell of corpses. In addition, there is a room designed at an angle of 18° to simulate disorientated spatial awareness of rescuers when they encounter such rescue spaces. This affects the rescuers' sense of balance and coordination as their vision does not give them the accurate information to cognitively assess their surroundings and adapt.

Figure 6: Another view of the Leaning Tower

A 125 m network of tunnels called Catacomb (See Figure 7) is integrated to the Leaning Tower, allowing versatile and complex scenario trainings. The Catacomb is a confined space measuring 1m x 1m which includes a sloping tunnel, concrete or wooden panels installed in the tunnels to warrant cutting or breaking operations to gain access to trapped victims. This tunnel network serves to train basic canine skills, use of audio and optical search devices, stabilisation of structures as well as depth rescue operations.

Figure 7: View of Catacomb from the Leaning Tower

To facilitate height rescue training for suicide scenarios in Singapore where high-rise buildings are aplenty, Vista (See Figure 8) is designed to replicate features of Singapore's residential building landscape. This allows rescuers to practice their skills in anticipating various scenarios that can develop from a suicide situation at various levels of a building. There is also a facility within this area, named Cube (See Figure 8) which is designed to simulate an industrial building with multiple hazards including leaking chemicals and gases, electrical hazards and working at height scenarios.

Figure 8: View of Vista and Cube from the Leaning Tower

Orca

Looking very out of place and less than 100 meters away from the Leaning Tower, Orca (See Figure 9) – as it is officially named – stands tall at 16 m tall. Built like a cargo ship, the simulator measures 38m by 10m and consists of four decks with eight separate compartments for firefighting and rescue training. The internal of the ship has been designed to follow the conventional design of a large ship and comprises 4 decks including a simulated cargo hold, engine room, bunks and galleys. A 9-metre deep pool is placed on the right side (starboard side) of the simulator, to provide an additional dimension and complexity to training scenarios. Due to the different varieties of hatches and doors available in different commercial vessels, this has also been taken into consideration in the design of the Orca. Various compartments are fitted with different kinds of doors and hatches to ensure that trainees can learn to differentiate and familiarise themselves.

Fig 9: Orca co-locating with the 9-metre deep pool

The Orca is able to simulate 15 fire scenarios, involving bunk/sleeping areas, galley, lounge/resting areas, marine engine, cargo hold, electrical panels and hallway fires, as well as a large spill fire on the deck. The fire simulators have been designed to allow the instructors to create the most realistic emergency response scenarios using simple controls systems that can escalate and de-escalate the size of the fire with the touch of a button. Each of the scenarios may be escalated to 3 different levels of fire sizes and intensity. The thermal power for the 15 scenarios ranges from a minimum of 50 KW (small fire in the bunk) to a maximum of 5.7 MW (fuel spill fire). Flame heights can also be increased with each escalation level to provide a visual cue in addition to the additional heat flux that participants will feel from the escalated fires. This allows for an evaluation of the performance of the participants to achieve certain targets within specified periods of times, failing which the incident may escalate to a bigger incident.

Besides creating fire scenarios, the Orca also adds realism by creating the confined spaces and heights that are reminiscent of an actual ship. Listing training of the ship and flooding of the cargo hold to simulate the sinking of a ship can also be conducted within the Orca. Confidence jumps to instill water confidence in trainees, anchoring points for casualty evacuation training can all be conducted on board the Orca. (See Figures 10 to 13)

Orca: Bottom Deck - Fire Simulation

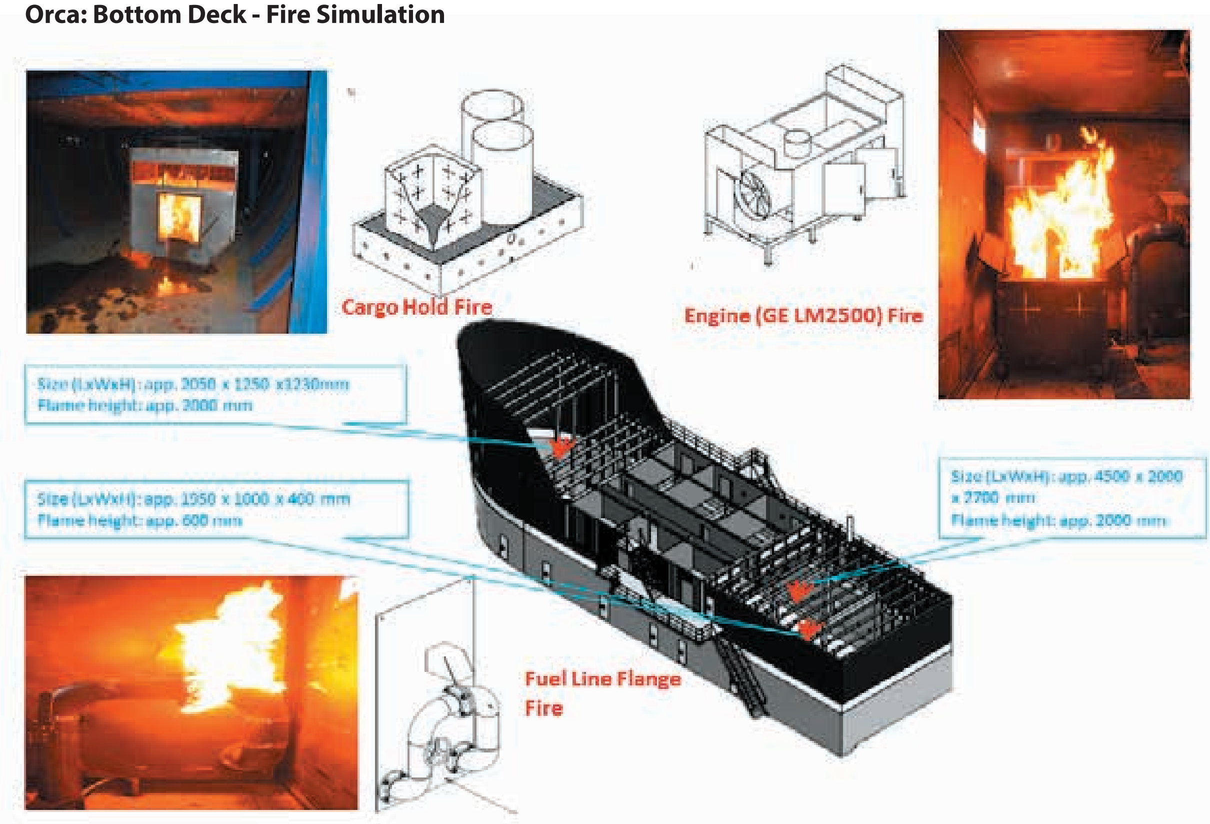


Figure 10: Schematic layout of the fire scenarios at ORCA bottom deck

Orca: Lower Deck - Fire Simulation

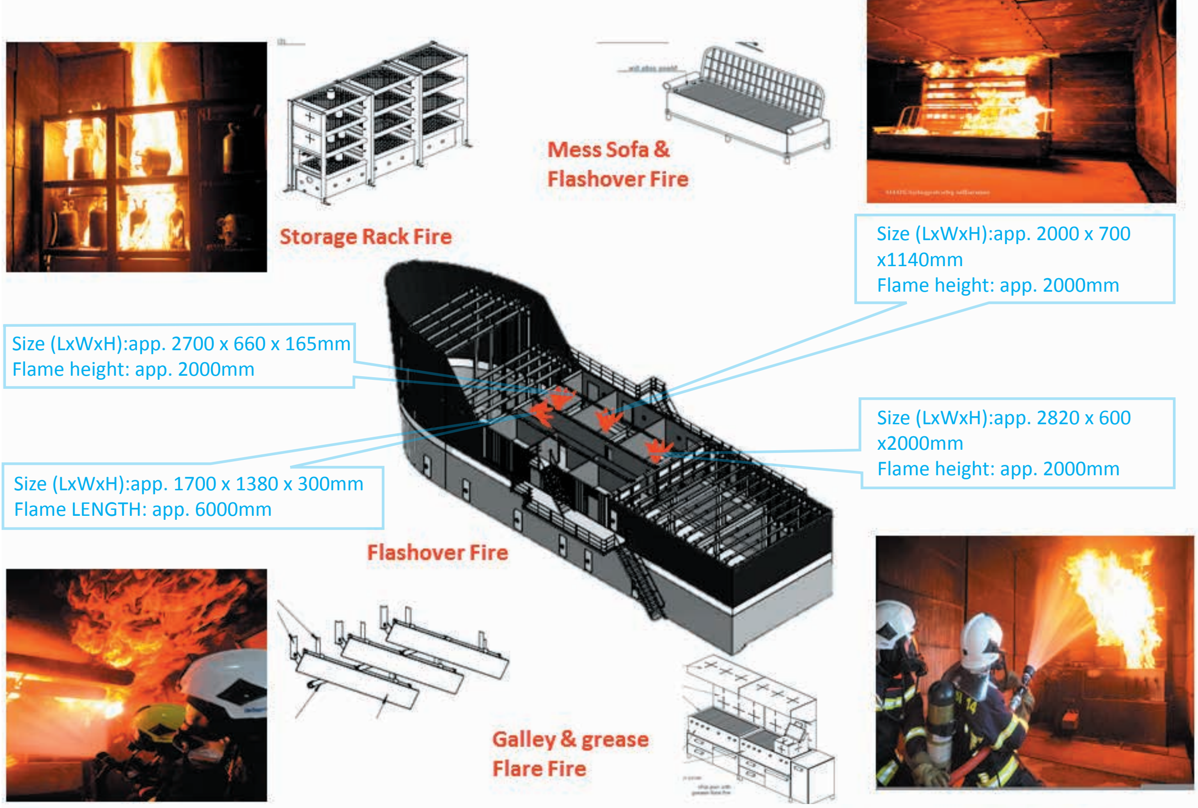


Figure 11: Schematic layout of the fire scenarios at ORCA lower deck (starboard side)

Orca: Lower Deck - Fire Simulation

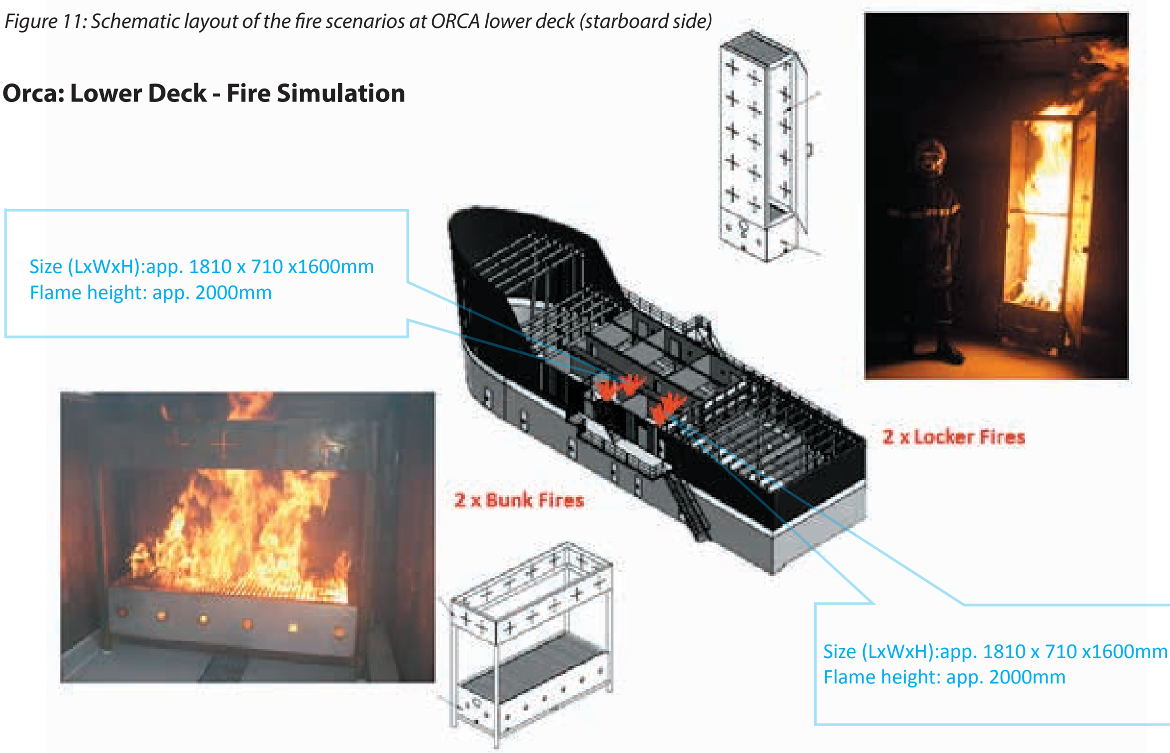


Figure 12: Schematic layout of the fire scenarios at ORCA lower deck (port side)

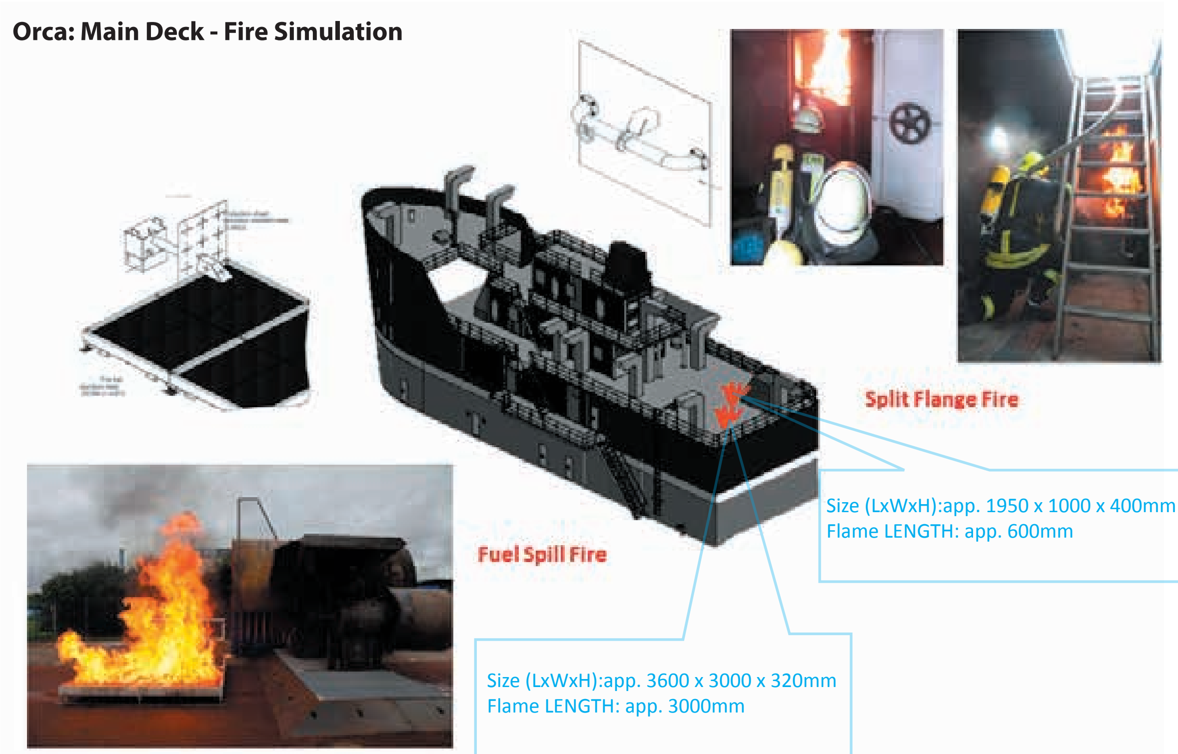


Figure 13: Schematic layout of the fire scenarios at ORCA main deck

Diamond

Diamond (See Figure 14) simulates a complex industrial site that could be found in any industrial area across the world. This petrochemical refinery hub simulator is built to provide advanced industrial firefighting, HazMat response and mitigation under one roof. This 5-storey infrastructure with roof-top viewing gallery measures 60 metres in length, 40 metres in width and 25 metres in height.

Fig 14: The Diamond is a massive training complex where 15 training simulation scenarios are built across this 5-storey building.

The Diamond is able to produce 12 fire scenarios (See Figures 15 to 18) that can be employed at different locations and decks of the facility all at once or at different stages of the training exercises. The scenarios include flash fires, jet fires, pool fires, pipe rack fires, storage cylinder fires, loading arm fires, pressure valve fires, underground trench pipeline fires, heat exchanger fires and a vertical distillation column fire. The thermal power for the 12 scenarios ranges from a minimum of 50 KW (small fire at a broken pipe) to a maximum of 10 MW (Reactor fire).

Other than fire scenarios, 3 gaseous and liquid leakages simulators are built within this complex. They are able to simulate cylinder liquid leaks, gas cylinder vapour leaks and flange liquid leaks to allow participants to practice their HazMat mitigation and containment skills.

Diamond: 1st Floor

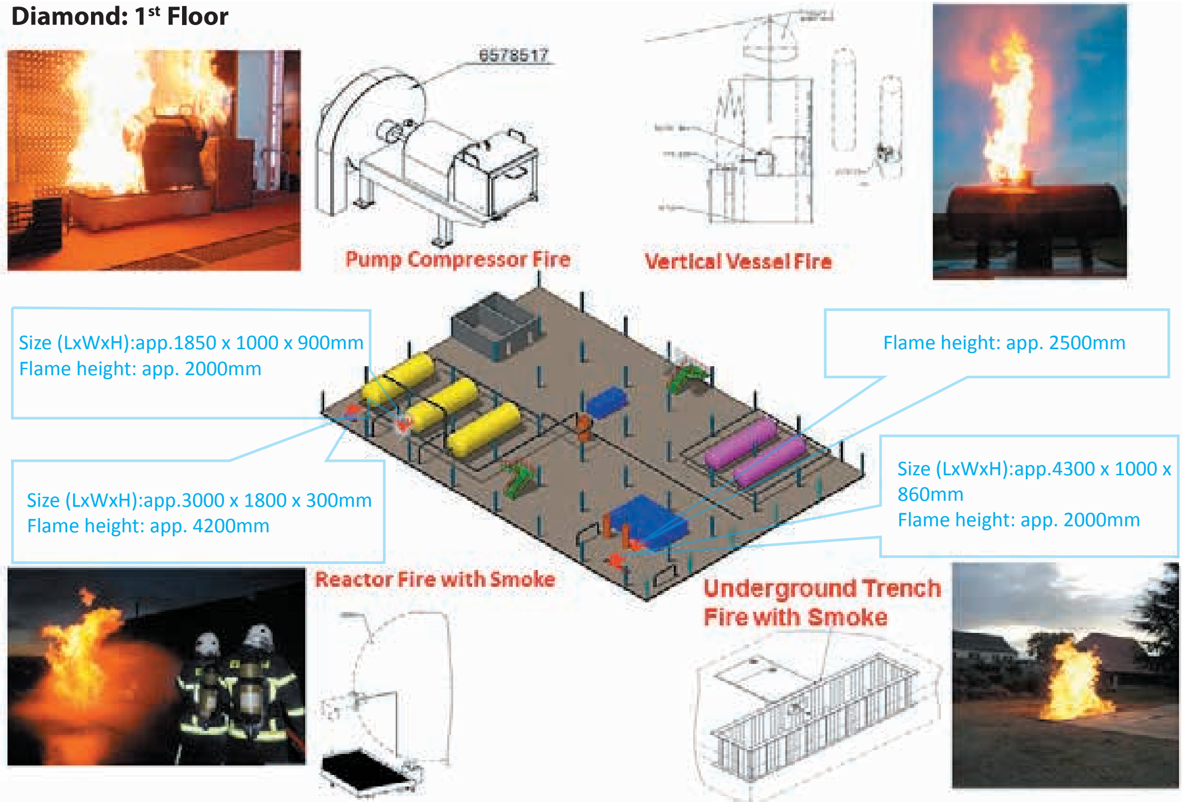


Figure 15: Schematic layout of the scenarios at Diamond 1st floor

Diamond: 2nd Floor

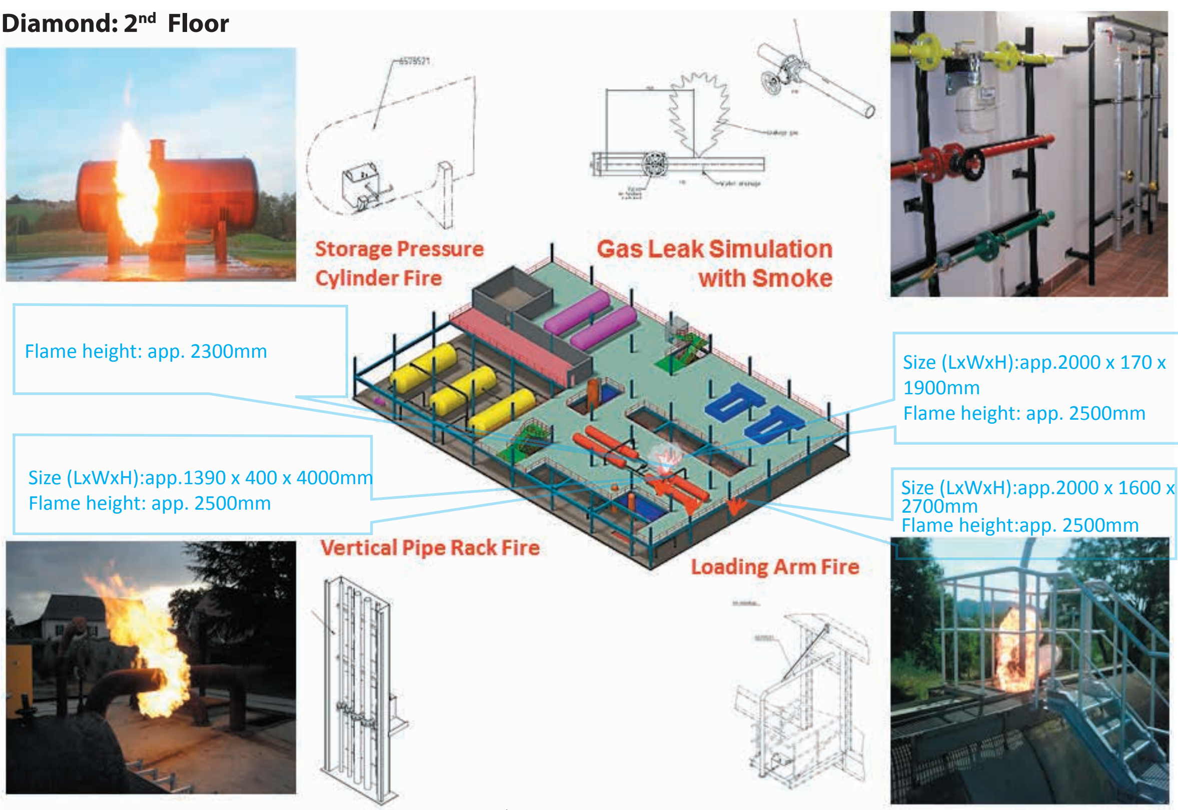


Figure 16: Schematic layout of the scenarios at Diamond 2nd floor

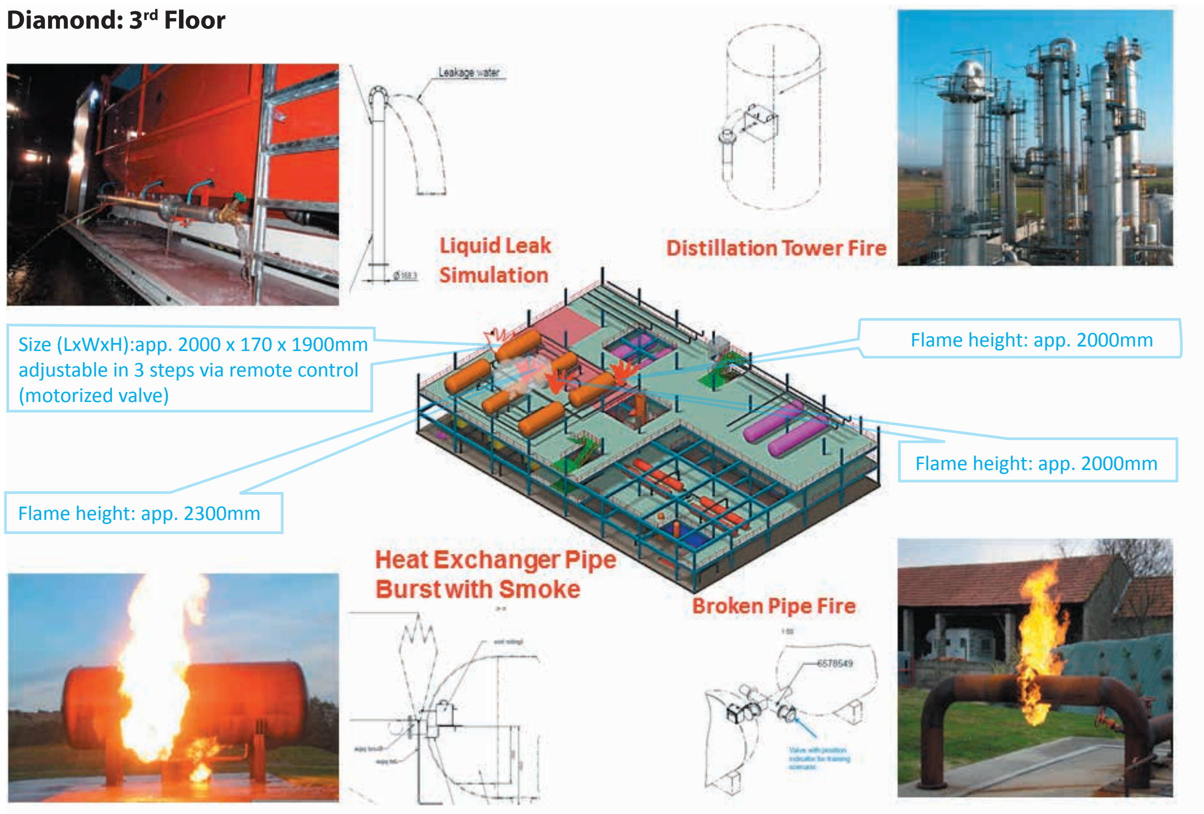


Figure 17: Schematic layout of the scenarios at Diamond 3rd floor

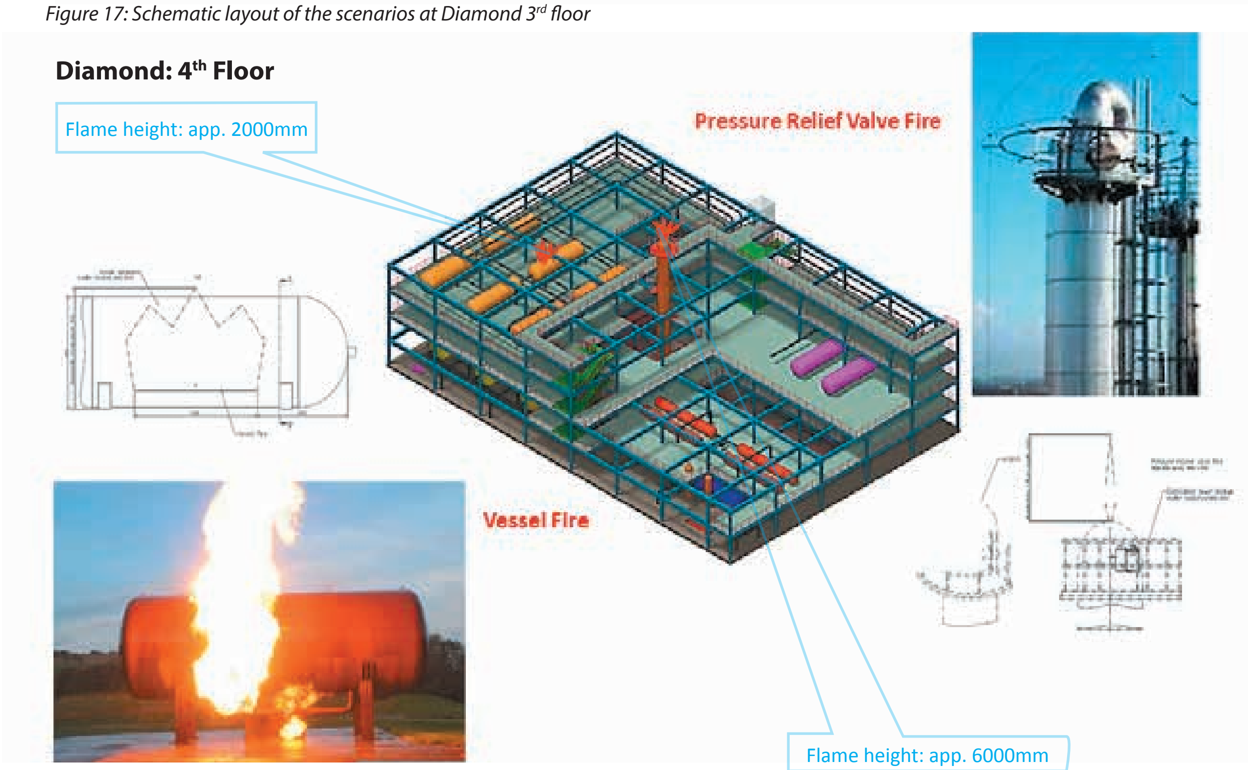


Figure 18: Schematic layout of the scenarios at Diamond 4th floor

Safety

Each of the three facilities have their own Control Rooms to control all operations within their boundaries. Each Control Room receives information from sensors on the fire training props while Infra-Red and Thermal Imaging Cameras provide images real time on monitor screens in the control room. Working with the on-site instructors, the Control Room Operators can have an overall view of which training facilities are active, as well as shut down any simulator in the event of an accident. (See Figure19) The on-site instructors supervising each individual exercise has control over the height of the flames and smoke using a radio linked remote control.

Other safety features in CDA@Mandai's training facilities include temperature probes, which monitor ambient temperature within compartments (the Orca) and emergency stop buttons in the event of any emergency. Upon activation, the fire simulation point will be turned off immediately and mechanical ventilation will kick in.

Liquefied Petroleum Gas (LPG) has been chosen to power the fire training simulators in both the Orca and the Diamond as it produces a controllable flame that responds quickly to request but is also able to withstand the force of the water from firefighters' hose lines. This allows the 'same' training scenario (predictable fire pattern) and yet provides for flexibility in manipulating the intensity of scenarios by adjusting the intensity of fire or combining other training simulators.

The Build

The design of this training area was a collaborated effort by SCDF and Draeger. Both the Orca and the Diamond had been designed to exceed the requirements of EN 14097 Fire Fighter Training Facilities Part 1 and Part 2. This European Standard ensures that the facilities that are planned and built for firefighting training are safe, whilst keeping the environment realistic and challenging. The training simulator systems had been designed with the user in mind while ensuring that these standards are addressed providing safety for the instructors and students.

Conclusion

Professional and prospective rescuers require a place that allows them to apply their new skills and test themselves to their limits. CDA@ Mandai provides them with such an environment, where their mistakes can be corrected, and their situational awareness and adaptability can be built up. However, no structure is built to have a fire burn repeatedly so it also needs protection to ensure its longevity. The SCDF has worked with its partners to design this facility to provide a Realistic, Repeatable, Reliable, and Safe training environment for participants of training exercises. This will give the participants greater confidence when called upon to actual incidents to rely on the training that they have gone through in the SCDF.

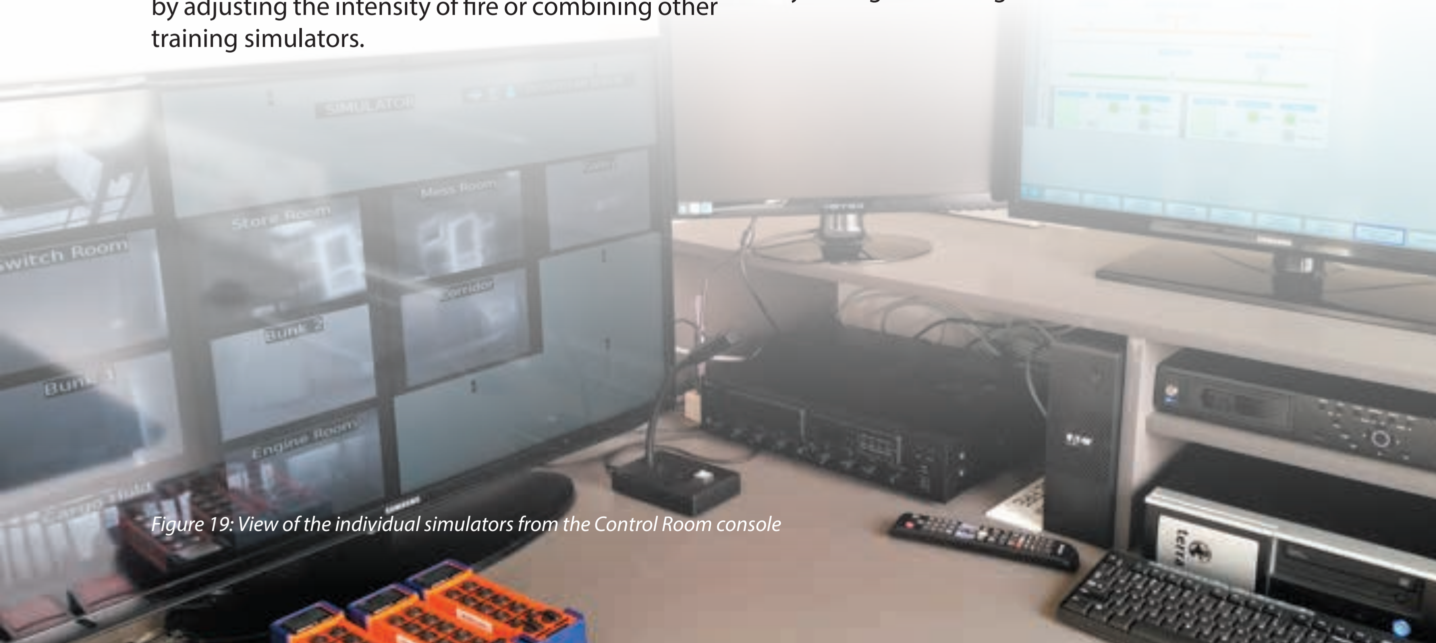


Figure 19: View of the individual simulators from the Control Room console

Summary of Training Facilities of CDA@Mandai

Urban Search & Rescue Training Facility

	USAR		
Description	A realistic replication of urban setting collapsed structure		
Dimension	100m x 100m		
Structure concept	One central ruins (40m x 40m) and 5 training buildings (10m x 10m) each		
Simulation Points	-		

	Location	Types of Simulators	Training Scenario
Breakdown	The Leaning Tower	• Smoke • Scent • Water • Gas Leak • Light • Sound	• Lift shaft rescue • High angle rescue • Flooded basement training • Cutting and Breaking training • Shoring
	The Catacomb	• Smoke • Water • Gas Leak	• Rescue operation in confined spaces • Water rescue in tunnel • Breaking and Cutting • K9 Search and Rescue • Optical Devices • DELSAR
	The Vista	• Sound	• Entry and Access Training • Forcible entry for gates, windows, metal grille • Height Training (Suicide Rescue)
	The Cube	• Smoke • Water • Gas Leak • Light • Sound	• Height Training, i.e. cable car • Gas leak
	Basic Training Area	• Nil	• Heavy Cutting and Breaking • Shoring

Ship FireFighting Training Facility

	Marine
Description	A realistic replication of ship internal structures
Dimension	38m (L), 9.8m (W), 16m (H)
Structure concept	4 decks with 8 fire compartments - Bottom Deck - Lower Deck - Main Deck - Wheelhouse Deck
Simulation Points	15 fire simulation points

	Location	Types of Simulators	Training Scenario
Breakdown	Engine room (Bottom Deck)	Engine block fire	Different types of access, Firefighting (FF) & rescue
	Engine room (Bottom Deck)	Flange fire	Different types of access, FF & rescue
	Cargo hold (Bottom Deck)	Cargo fire	Different types of access, FF & Depth Rescue
	Corridor (Lower Deck)	Flashover	Flashover
	Switch Room (Lower Deck)	Switchboard fire	Entry procedure, FF & Rescue
	Galley (Lower Deck)	Galley fire	Entry procedure, FF & Rescue
	Mess (Lower Deck)	Sofa fire	Entry procedure, FF & Rescue
	Mess (Lower Deck)	Flashover fire	Entry procedure, FF & Rescue
	Store room (Lower Deck)	Storage rack fire	Entry procedure, FF & Rescue
	(Lower Deck)	Locker fire x2	Entry procedure, FF & Rescue
		Bunk fire x2	
	Main deck	Flange fire	Spill & flange FF & Rescue
	Main deck	Spill fire	Spill & flange FF & Rescue

Chemical Hub Training Facility

	HazMat
Description	A realistic replication of petrochemical plant
Dimension	60m (L), 40m (W), 25m (H)
Structure concept	5-storey infrastructure - 4 storey + 1 roof top viewing gallery
Simulation Points	12 fire simulation points 3 non fire simulation points

	Type of Simulators	Level	Training Scenario
Breakdown	• Pump Compressor Fire • Reactor Vessel Fire • Trench Pipeline Fire • Vertical Column Fire • Cylinder Liquid Leak	Level 1	• Firefighting (flash fire) • Firefighting in smoke-logged condition (spill/ pool fire) • Fire fighting in smoke-logged condition (flash fire) • Fire fighting (flash fire) • HazMat Mitigation (liquid leak)
	• Gas Cylinder Fire Pipe Rack Fire • Loading Arm Fire • Gas Cylinder Vapor Leak	Level 2	• Firefighting (jet fire) • Firefighting (jet fire) • Firefighting (jet fire) • HazMat mitigation in smoke-logged condition (gas leak)
	• Heat Exchanger Fire • Broken Pipe Fire • Distillation Column Fire • Flange Liquid Leak	Level 3	• Firefighting in confined space (flash fire) • Firefighting in confined space (flash fire) • Fire fighting (flash fire) • HazMat mitigation (liquid leak
	Storage Cylinder Fire	Level 4	• Firefighting (flash fire)
	Pressure Valve Fire	Level 5 (Top Deck)	• Firefighting and/or Height Rescue (casualty search & rescue)
	Confined Space Hatch	Levels 1, 2 & 3	• Casualty Search & Rescue

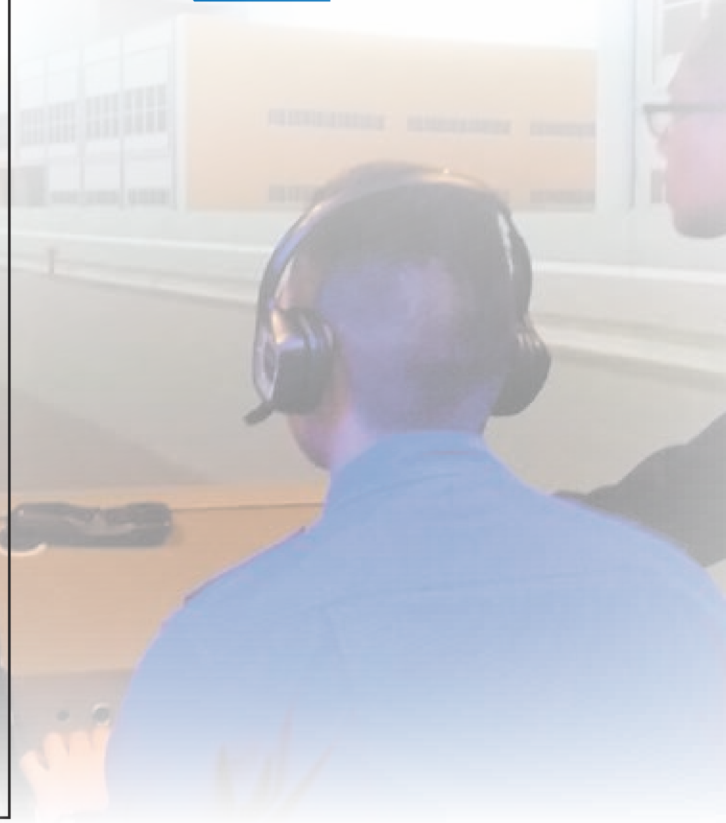
1. The thermal power for the Diamond ranges from a minimum of 50 KW (small fire at a broken pipe) to a maximum of 10 MW (Reactor room fire) 2. Fire at distillation column 3. Other than fire scenarios, there are also 3 HazMat gaseous and liquid leakages simulators 4. Concrete slabs 5. Different types of collapsed structure was designed to simulate various rescue scenarios 6. Building C was designed to simulate SCDF training for threaten to jump incidents, which is common in SCDF's working environment 7. Large fuel spill fire at ship deck 8. The internal of ship has been designed to follow the conventional design of a large ship

EDITORIAL PREVIEW

As a leader in the emergency services, the SCDF places a high emphasis on the development of its personnel. The consequences of people development issues have a high incubation period, and if not addressed at an early stage, have the potential to cripple the organisation. As such, the SCDF is constantly reviewing potential issues of the future and addressing them today. One such issue is the training of current and future Ground Commanders (GCs).

Traditionally, GCs had the luxury of learning in the academy, then being exposed to a variety of real incidents in their first few months on the job while under the guidance of their seniors. However, due to manpower constraints and the trend of decreasing number of incidents, the learning opportunities for new and future GCs is likely to continue decreasing. As part of its people development programme, the SCDF has gone to great lengths to ensure the operational readiness of its GCs by investing in technology and training methods that can recreate these experiences, allowing the GCs to hone their skills incident management at the fire ground. The usage of technology to recreate such experiences is discussed in the article.

Interested persons who want to learn more about the methods and systems employed by SCDF in the training of its personnel can contact the Editorial Board to register your interest.



XVR SIMULATION-BASED TRAINING: UNPARALLELED REALISM IN RECREATING THE FIRE GROUND

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Introduction

The operational landscape and responsibilities of Fire Services throughout the world have changed dramatically over the last 15 years, with terrorist attacks, extreme weather events and complex fire prevention strategies significantly affecting the scope, severity and most importantly the numbers of incidents attended. This dynamic operating landscape requires Fire Services around the world to constantly change, adapt and innovate in order to stay relevant and up to date. Due to dwindling resources, a shift of focus towards efficiency savings, and additional non-operational responsibilities, there is a demand for efficient and effective operational training to allow the personnel to train for the 'unexpected'. This article investigates how three very different International Fire Services utilise simulation based training to tackle this problem from three very distinct demographics, namely Singapore, the United Kingdom and New Zealand.

The Decreasing Opportunities for Experiential Learning

Over the last decade the number of operational incidents responded to by the UK Fire and Rescue Service alone has diminished by 40% (Knight, 2013). The reduction in incident number and the consequential reduction in experiential learning opportunities have resulted in a deterioration of incident evaluation skills by the Fire Service Commanders. With this reduction in incident numbers mirrored around the world and the consequential reduction in experiential learning opportunities, Fire Services have increasingly turned to simulation and virtual reality (VR) as realistic and cost effective ways to build and maintain operational command and control skills in officers.

Fire Service training methods have traditionally incorporated large amounts of lecture or classroom-based tuition. The individuals then use this technical knowledge and develop operational competence, through practical application, utilising traditional drill sessions and incidents. More recently, many Fire Services are turning to simulation as an alternative training tool to provide this essential application-based, incident or scenario exposure.

Training for Operational Competency

Competence or expert knowledge can be differentiated into two distinct groups, explicit knowledge and tacit knowledge. Explicit knowledge is factually based, and traditionally taught in the classroom, but is proven of little use in generating effective skill-based training. An individual can learn the technical aspects of fire behaviour, including flashover or backdraught conditions, but it is unlikely that they would generate any practical competence from this form of training.

On the other hand, tacit knowledge involves a detailed understanding of how a whole system operates. It is the use of the explicit technical knowledge through practical application that translates it to tacit knowledge and subsequently, operational competence. Individuals need to see, hear and feel during practical training sessions, simulation-based scenarios or actual incidents, before the technical knowledge they have learned in the classroom begins to make sense. The harmony of explicit (technical) and tacit (practical ability) knowledge allows these two key pieces of the training puzzle to fit together, resulting in a state of operational competence in the individual (Figure 1).

Figure 1 –Diagram illustrating the important interaction between Explicit and Tacit knowledge during training to attain the desired state of operational competence

Advantages of Simulation

Simulation (Physical and VR)can be used to replicate the pressure of the incident ground with none of the associated incident ground risk. The individual is immersed through high quality graphics, realistic and believable environments, and most importantly reactive scenarios that change according to the actions detailed by the officers or crews. Role players are also a vital component of both simulation and VR scenarios, as they provide key information to assist the officer with prioritisation and decision making.

Extreme Virtual Reality (XVR) simulation software is currently used (or will be implemented in the near future) by all three services studied, as a flexible training and competence assessment tool. XVR software is used by over 200 emergency services worldwide and its versatility supports a variety of uses within the training domain. This enables the instructors to create scenarios that are unique to their geographical or topographical area, recreate specific incidents for training reviews or debriefs and to develop an array of different incident types and training tools.

XVR enables the individual or a group of individuals to operate within the scenario, assigned with a specific role or as a command team (Figure 2). They can also request actions to occur during the resolution of the incident; these actions are then completed dynamically by the instructor. These features of the software aid the individual's immersion into the scenario. The quality and accuracy of the graphics enable the individual to make operational decisions about the use of the equipment and resources they see on the screen. Also available, is ability to change the weather, the wind direction, and the time of day of the scenario. This level of detail draws the individual into the scenario and provides the most realistic environment available, enabling them to demonstrate their competence and ability to make appropriate dynamic decisions as an alternative to incident exposure.

Figure 2 – Simulation in use during training

Implementation of Extreme Virtual Reality Technology

Singapore is preparing to utilise XVR in their second generation Advanced Command Training System (ACTS2) to improve the of Singapore Civil Defence Force's (SCDF) frontline commanders during incident command and control. The current ACTS system helps to bridge training gaps between classroom and in-field training, in particular the limitations posed by table-top and field exercises. Table-top exercises lack realism whereas realistic field exercises are not entirely practical in Singapore due to the lack of space, ability to obtain resources (motor vehicles, for example, are at a premium in Singapore and difficult to obtain for RTA training) and safety constraints. Training scenarios that are complex or difficult to simulate with conventional training facilities can be created using the ACTS with ease. ACTS is a more cost effective method to simulate realistic incidents of differing scale and complexity and can incorporate realistic challenges commanders face on the incident ground such as firefighter fatigue and unreliable or over run water supplies. ACTS2 (See Figure 3 for a screenshot) is a further enhancement of ACTS providing a greater range of scenarios, using improved graphics and the greater features that XVR provides.

Figure 3: Screenshot of a VR Scenario

In the United Kingdom, XVR simulation software is generally used during critical decision making training and the assessment of command competence, with many services using the Introspect Assessment Model (Lamb et al., 2014). XVR provides a reactive visual stimulus that can be manipulated by the instructors to reflect the actions and decisions detailed by the commander. The Introspect Model investigates the rationale that sits behind these command decisions, and gives confidence to individuals who have successfully transferred their explicit incident command knowledge to tacit knowledge, and ultimately operational competence, all within the safe environment of simulation.

New Zealand has been using simulation and VR training for a number of years, and has traditionally focussed on the outcome of scenarios rather than the process of incident management. The team trainer platform has been popular where several sector commanders operate and report to the incident controller. Traditionally this involved a limited number of fixed scenarios, however, the recent shift to XVR enables the creation and use of dynamic training scenarios which provide the individuals the opportunity to practise critical decision making under pressure. New Zealand has started a process of including local risks incorporated with simulated fire conditions in order to train and assess commanders on their information gathering, risk assessment and initial action decision making. The intention is to use XVR and its range of functionality to take these training principles further, include all incident management skills and classroom based team training and to demonstrate best practise or procedure.

Conclusion

The 21st century Fire Service utilises a combination of tools from the 'training toolkit' recognising each for its merits and limitations. Real life practical training and virtual reality simulation like XVR will continue to be used either in parallel, or integrated during hybrid training of fire officers and other incident responders. They are complementary disciplines, each offering distinct benefits for training specific skills and capabilities. XVR delivers the flexibility for the instructor to design, provide and implement varied, realistic and most importantly, reactive training scenarios. These advantages have been recognised in Singapore, New Zealand and the United Kingdom, who utilise this state–of-the-art training tool to provide their commanders limitless opportunities to transfer their explicit knowledge into tacit knowledge, and ultimately competence.

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EDITORIAL PREVIEW

The SCDF is cognisant of the tremendous heat and physical stresses faced by firefighters during an emergency response. Such stresses may lead to heat cramps, heat exhaustion and even heat strokes. To ensure that our emergency responders are well equipped to handle such stresses, SCDF has collaborated with research bodies and companies to research on heat mitigation strategies for firefighters. The SCDF has also adopted various measures and designed its own Rehabilitation Framework to minimize injuries due to heat accumulation.

In this article, researchers from the DSO National Laboratories, National University of Singapore and Nanyang Technological University will share their insights on heat mitigation strategies for firefighters.

Interested persons who want to find out more details about SCDF's various measures in combating heat stresses can contact the Editorial Board to register your interest.

HEAT MITIGATION STRATEGIES FOR FIREFIGHTERS

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Introduction

Firefighters are often faced with high environmental temperatures when performing fire suppression tasks. To protect against heat injury, personal protective equipment (PPE) are donned during training and operations. The PPE however traps the internal body heat produced while the firefighters are working, subjecting them to excessive heat strain.

Heat exchange between a human and the environment occurs through four avenues: conduction, convection, radiation and evaporation. Of these four avenues, the greatest contribution to heat loss during exercise is through the evaporation of sweat, provided that the environment permits evaporation (Gisolfi and Wenger, 1984). The PPE donned by firefighters however creates a microenvironment that is saturated with water vapour and therefore impedes heat loss through evaporation (Montain et al, 1994). During fire suppression tasks, the accumulative build-up of body heat within the PPE places firefighters under uncompensable heat stress. This results in an elevation of body core temperature (Sawka et al., 1992). There is evidence of firefighters reaching body core temperatures above 40^{o}C while performing simulated fire suppression tasks (Van Gelder et al., 2008). This places them at an increased risk of developing exertional heat stroke, a condition characterised by an elevated body core temperature (>40°C) with central nervous system dysfunction (Armstrong et al., 2007). It is therefore important that firefighters incorporate heat mitigation strategies before and during their operational tasks, to reduce the risk of exertional heat stroke and augment work performance.

There are five main heat mitigation strategies that firefighters can adopt: (1) work-rest cycles, (2) aerobic fitness conditioning, (3) heat acclimatisation, (4) pre-exercise cooling and (5) fluid replacement. These strategies attenuate the accumulation of body heat storage in three ways: reducing the start state, attenuating the rate of rise and extending the limit. The end-goal in mind with the adoption of these strategies is to extend endurance time by improving heat tolerance when working under heat stress.

Work-Rest Cycle (WRC)

Prolonged periods of physical activity result in an accumulative build-up of body heat, and high environmental temperatures can precipitate this. The aim of implementing work-rest cycles (WRC) is to introduce intermittent rest periods in between work to limit excessive heat storage (McLellan, 1994; Figure 1). The rest periods limit heat production and promotes heat dissipation (especially when firefighters remove their PPE), as well as the recovery of heart rate due to lower cardiovascular demands. This results in a decrease in the overall 2 physiological strain. The design of WRCs depends on the intensity of exercise and the environmental conditions. Under conditions of uncompensable heat stress, shorter work periods and longer rest periods may be required due to a greater rate of body heat accumulation.

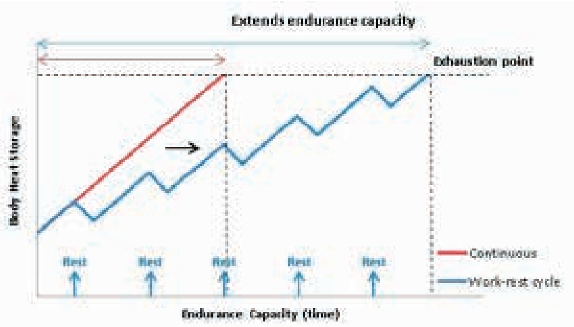

Figure 1: Work-rest cycles during physical tasks limit excessive heat storage (black arrow), thus extending endurance capacity.

During rest periods, various cooling aids can also be employed to further reduce heat storage. The use of cooling fans, air-conditioning and immersion of arms in cold water are useful cooling aids to consider.

Aerobic Fitness Conditioning

Aerobic training induces physiological adaptations that not only improve fitness, but also enhance thermoregulation. Efficiency of the cardiovascular system is improved through increased blood and stroke volume following a period of aerobic conditioning, allowing more blood to the muscles and skin during exercise (Convertino, 1991). In addition to increased skin blood flow, training improves sweating responses during exercise as well, hence enhancing heat dissipation (Roberts et al., 1977). Taken together, these adaptations attenuate the rate of rise in body heat storage and therefore increase the heat tolerance of individuals (Cheung and McLellan, 1998; Figure 2).

A lowering of baseline body core temperature (and therefore body heat storage) is also seen following a period of aerobic training (Shvartz et al., 1974). Furthermore, aerobically trained individuals have been shown to possess higher body heat storage limit before reaching their exhaustion point (Mora-Rodriguez et al., 2010). These attributes derived from aerobic training allows one to last longer during exercise in the heat and decreases one's susceptibility to heat injury. It is therefore important that firefighters maintain a high level of fitness to deal with the physically demanding fire suppression tasks and reduce heat strain during the course of their work.

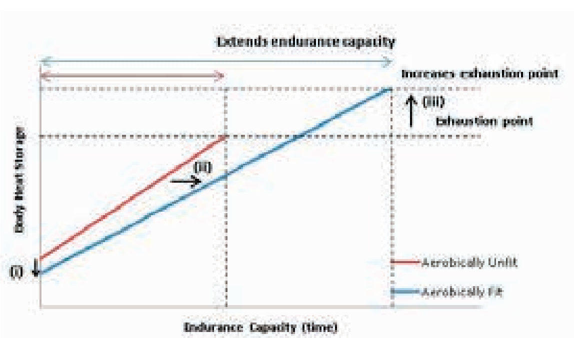

Figure 2: Aerobically fit individuals with (i) lower body heat storage, (ii) attenuated rate of rise in body heat storage during exercise and (iii) increased point of exhaustion. All these adaptations extend the endurance capacity of an individual who is aerobically fit.

Heat Acclimatisation (HA)

Heat acclimatisation (HA) is a process of repeated exposure to heat over several days, which induces physiological adaptations favourable for thermoregulation during exercise in the heat. These adaptations result in a lowering of baseline body heat storage and attenuation in the accumulation of heat strain during exercise. Taken together, the window for body heat storage to rise before reaching exhaustion point is extended (Figure 3). Heat acclimatisation protocols are often combined with aerobic exercise. The adaptations gained are similar to those induced via aerobic training: an expanded blood volume which improves cardiovascular function during exercise in the heat, and an enhanced skin blood flow and sweat response to promote greater heat dissipation during exercise. Nonetheless, research has shown that highly trained individuals can still acquire additional beneficial adaptations after undergoing HA programmes (Nielsen et al., 1993; Lorenzo et al., 1985).

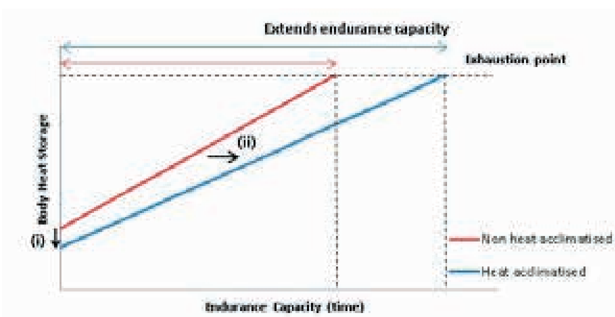

Figure 3: Heat acclimatised individuals with (i) lowered body heat storage and (ii) attenuated rate of rise in body heat storage during exercise. All these adaptations extend the endurance capacity of a heat acclimatised individual.

Similar to aerobic conditioning, the extent of adaptation from HA is dependent on the level of thermal load imposed on an individual, which is influenced by the environmental conditions as well as the exercise intensity and duration. The aim of HA is to induce thermal stress for corresponding thermoregulatory adaptations to develop. Therefore, individuals should aim to attain a body core temperature of 38 to 38.5^{0}C during each HA session.

Two common adaptations of HA are an increased production of sweat and a lower body core temperature required to trigger its onset. Usually these adaptations will be advantageous in an environment where sweat is allowed to evaporate freely, but the PPE that firefighters wear creates an uncompensable heat stress environment. Since the PPE has limited permeability to the evaporation of sweat, the increased production of sweat has limited benefit on evaporative heat loss. On the contrary this could lead to increased fluid loss and therefore dehydration if fluid replacement is inadequate (Nunneley, 1989). The importance of adequate fluid replacement will be addressed in the last section. Although an increased sweat rate and an earlier onset of sweating may not be advantageous to firefighters, other adaptations (decreased baseline body heat storage, increased blood volume and cardiovascular functions) are still beneficial when working under uncompensable heat stress. In addition, while these adaptations are similar to those derived from aerobic training, heat acclimatisation does not enhance the body heat storage limit at exhaustion point (Figure 3). Heat acclimatisation should be done when an individual is already aerobically fit, to serve as a further enhancement to heat tolerance following aerobic conditioning.

Pre-exercise Cooling

Pre-exercise cooling is a common technique to reduce heat storage prior to a physical task. There are various types of pre-exercise cooling interventions, which can be broadly characterised into two categories: 1) external cooling via immersion in cold water, cold jackets or application of ice packs on the body, and 2) internal cooling via ingestion of cold/ice beverage. The main underlying principle behind all the precooling techniques is to create a heat sink (lowered baseline body heat storage) before the start of an exercise bout, allowing a greater heat storage capacity and prolonging one's endurance during exercise (Figure 4). By starting at a lower body heat storage point, firefighters can last longer in the heat before reaching their exhaustion point.

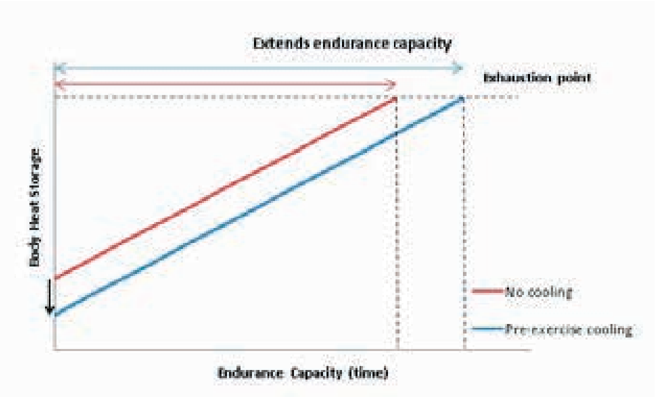

Figure 4: Pre-exercise cooling lowers the baseline body heat storage prior to the start of exercise (black arrow), thus extending endurance capacity.

External cooling techniques remove body heat mainly via conduction and/or convection, thus lowering the body core temperature prior to exercise. Cold water immersion involves submerging parts or the whole body in water with temperature below the human thermoneutral zone (Jones et al., 2012). Cold jackets and ice packs work in similar manner as cold water immersion, although the body surface area in contact with the cold material is typically smaller. It should be noted that some individuals may display uncomfortable sensations of coldness and shivering with exposure to external cooling techniques such as cold water immersion. Internal cooling offers additional ergogenic and sensory benefits (Lee et al, 2013) associated with ingestion of cold/ice beverage, especially when there are salts and carbohydrate infused in the beverage. Ingestion of cold/ice beverage also provides hydration, which will be discussed in the next section. Between cold and ice beverages, the latter can facilitate greater transfer of internal heat due to the additional latent heat of fusion required for phase change from ice to water (Siegel et al., 2010). Internal cooling via Bingestion of cold/ice beverage is simple and practical to implement, thus it may be a better cooling technique for firefighters to adopt.

Fluid Replacement

During exercise in the heat, sweat production leads to a state of hypohydration (net loss of body water) if there is insufficient replacement of fluid. In a hypohydrated state, blood volume is reduced, impairing the cardiovascular and thermoregulatory systems. This in turn results in a greater rate of rise in body heat storage (Figure 5), which reduces endurance capacity and increases the risk of heat injury. Studies have shown that hypohydration increased the rate of body heat storage accumulation and decreased tolerance time during exercise in the heat (Buono and Wall, 2000; Cheung and McLellan, 1998). In contrast, fluid replacement during exercise under uncompensable heat stress increased tolerance time due to attenuation in the rate of rise in body heat storage (McLellan and Cheung, 2000).

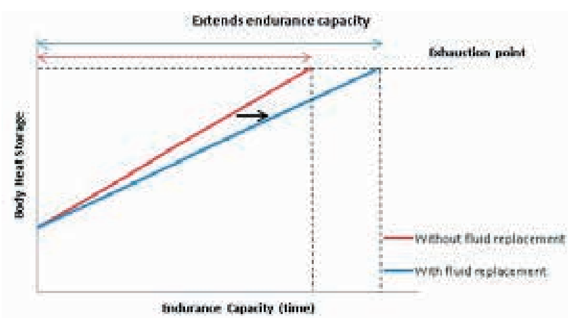

Figure 5: Fluid replacement attenuates the rate of rise in body heat storage during exercise (black arrow), thus extending endurance capacity.

There are a number of factors that will affect the effectiveness of fluid replacement, like the volume and temperature of fluid ingested and the rate of fluid absorption. Firefighters should drink an amount (depending on work intensity and environment) sufficient to prevent excessive dehydration (body mass loss greater than 2%) (Sawka et al., 2007). On the contrary, firefighters should not overcompensate by drinking excessively large volumes of fluid. Overdrinking can lead to the dilution of blood and possibly hyponatremia (Lee et al.,2011), a syndrome associated with low blood sodium and which has detrimental effects on performance and physiological function (Von Duvillard et al., 2004). Contents of the fluid replaced should include salts and carbohydrates to replace body salt lost via sweat and improve gastric absorption of fluid respectively. The temperature of fluid should ideally be cold, to aid in internal cooling of the body (as described above).

Conclusion

Each of the above heat mitigation strategies reduces thermal strain in their own unique way, and they can be used in combination to elicit greater thermoregulatory and performance benefits for firefighters during their fire suppression operations. Adopting these strategies will not only help to improve firefighters' performance in the heat, but will also reduce the risk of sustaining heat injury.

With various heat mitigation measures and a Rehabilitation Framework, heat injuries can be prevented during fire fighting operations as well as during training at the Civil Defence Academy.

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EDITORIAL PREVIEW

China International Search and Rescue (CISAR) Team was deployed rapidly after the Nepal earthquake occurred. This was the first international relief operation after CISAR attained INSARAG External Reclassification (IER) and was recognised as a Heavy USAR Team in August 2014. Two live victims were successfully rescued by CISAR during the mission. The second victim took a total of 34 hours to extricate from the collapsed building.

In this article, the process of the rescue operation for the second victim, including reconnaissance, assessment, search, rescue and medical treatment is summarised and discussed. The important factors influencing the operation are analysed as well, which aims to provide reference for the efficient implementation of Urban Search and Rescue (USAR) operations during collapsed buildings in future.

ANALYSIS ON URBAN SEARCH AND RESCUE OPERATIONS IN COLLAPSED BUILDINGS DURING NEPAL EARTHQUAKE

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Introduction

An earthquake with magnitude 8.1 occurred in Nepal at 11:56 on 25 April, 2015, which resulted in large numbers of casualties and numerous building collapses. Based on the disaster situation, a CISAR team of 62 members (Fig.1) carrying 6 canines and 17 tons of rescue equipment and relief supplies, was quickly assembled and deployed to the earthquake-stricken areas of Nepal, to carry out humanitarian relief operations. 22 hours after the earthquake, CISAR arrived at the Kathmandu Tribhuvan International Airport on 26 April 2015.

Under the guidance and support from the Embassy of People's Republic of China in Nepal and the Nepal military, CISAR deployed an advance team comprising 10 members to the northeast area in Kathmandu, which was one of the most affected areas during the earthquake, to carry out assessment, search and rescue operations. When the advance team reported that they had found live victims under the debris, the main rescue team was deployed to support them. Two live victims were successfully rescued respectively: one at 1523 hrs on 26 April, while another at 0200 hrs on 28 April. The rescue process of the second survivor lasted 34 hours. Based on currently available research on the rescue operations in collapsed buildings[1-4], and according to the relevant provisions of INSARAG Guidelines[5], this article focuses on this second rescue process and analyses the operational process in order to provide reference for future rescue operations.

Fig.1 CISAR team depart from Beijing

Area of Operations

The collapsed building, in which the second survivor was rescued, was located in the northeast area of Kathmandu, north to the Ring Road and behind roadside buildings, at the coordinates N27.7355º, E85.3095º. The building was a 7-storey (1 floor basement) hotel, steel reinforced concrete frame structure, named New Star Guest House. After the earthquake, the building collapsed because of the destruction of vertical structural members, wherein one to four stories appeared to have suffered a pancake collapse, while the fifth and sixth stories were substantially intact. The southwest side of the debris was the main entrance of the hotel, which appeared to have sustained severe damage and piled up with lots of rubbles (Fig.2). The collapsed building was abutted by adjacent buildings from three sides, sandwiched in a narrow triangular area, resulting in a limited workspace. The adjacent building in the southwest side was also tilted towards the collapsed hotel, adding to the dangers of a secondary collapse.

Fig.2 Collapsed entrance of a 7-storey hotel (New Star Guest House)

Reconnaissance and assessment on site

CISAR was carrying out the rescue of the first survivor at the worksite, while a small group of 10 members was deployed to carry out reconnaissance and search operations in the surrounding buildings. Upon arrival at the collapsed building, CISAR observed that the local people were digging and moving debris using their hands. Upon gathering intelligence from the locals, it was noted that there were possibilities of victims trapped in the collapsed building. One victim was still buried under the debris but had sent out an audible distress signal, shouting for help. CISAR immediately organised another group of rescue team members and coordinated with the local armed police and military on site to cordon off and evacuate members of public (Fig.3). Following that, CISAR conducted reconnaissance, assessment and search work at the site (Fig.4). The location of the trapped victim was located preliminarily by both physical search and canine search. With the help of the local military, CISAR managed to locate the owner of the hotel to collect detailed information about the floor plans of the collapsed building, such as the layout of the hotel rooms (Fig.5), and the number of persons estimated to be in the building. With the information collected, the floor plan was sketched out to give rescuers an indication of the possible void spaces and areas they could penetrate. Based on the information collated and the approximate location of the victim, it was estimated that the victim was trapped in the first floor and near a stairway access.

Fig.3 Cordoning off and evacuation of the masses

Fig.4 Reconnaissance and assessment

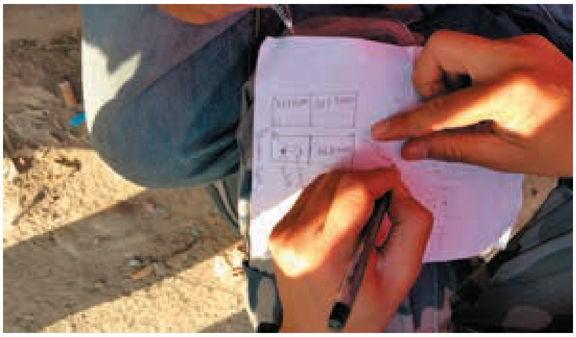

Fig.5 Sketching the layout of hotel rooms within the hotel

Commence of Rescue operations on site

Based on the reconnaissance and assessment at the scene, CISAR developed two courses of action plans: the first plan was to break and breach three steel reinforced concrete floors vertically down near the position of the survivor and then set up a short horizontal access to reach the victim (see Fig.6 upper left corner); the second plan was to break and breach one floor of the basement, then set up a long horizontal access by breaking the wall in the basement and penetrate the floor overhead to reach the victim (see Fig. 6 bottom right corner).

In order to improve the efficiency of the rescue operation and extricate the victim as soon as possible, CISAR rescue team members on site were divided into two groups to carry out the rescue operation using the two different plans simultaneously. In addition, CISAR also coordinated with the local military to find and deploy an excavator to clear the ruins in the southeast area near the collapsed building to assist in the rescue operations (Fig.7). The access to the collapsed building was cleared up and the working area was expanded for the second course of action.

For the first plan, the working area was still confined and the environment was dangerous due to the probability of secondary collapse in the adjacent building, hence rescuers could only use drills, hammers, and hydraulic combination tools to break, remove and clear the debris. It was a laborious effort and needed an extended amount of time to penetrate 4 stories. For the second plan, it was easier to penetrate to reach the floor at the basement. However, the rescuers encountered a setback when they found that water had accumulated in the basement. A pump had to be used to drain out the water before further efforts could be undertaken. This process also took a long time. Later on, in the evening of 26 April, it started raining, which increased the difficulty of the rescue operations. However, the two rescue teams, noting the urgency required of the rescue operations insisted on carrying out operations throughout the night.

Fig.6 Two plans of action carried out simultaneously

Fig.7 Clearance of the ruins around by excavator

At 0800 hrs on 27 April, both plans of action had made progress. Rescuers had created a 60cm diameter hole for the first plan and still needed to break more floors and remove more debris; while for the second plan, rescuers had drained all the water in the basement but still needed to break walls to set up a horizontal access (Fig.8). At 1200 hrs, utilising the first plan, rescuers had created a vertical access attaining 2.5m in depth. However upon entering, they discovered that the horizontal access was blocked with stair handrails, doors, tiles and other debris (Fig.9).

Fig.8 Access and shoring carried out for the second plan

Fig.9 (a) and (b) Vertical and horizontal accesses created in the first plan

The live victim was assessed to be trapped about 3m away with his right leg trapped under debris while the upper part of the body could move freely in a very small space. At this juncture, utilising the second plan, rescuers had ventured into the basement and found the underground structure to be more complicated than expected. It was also ascertained that a load bearing component of the structure had to be breached to set up a horizontal access which would probably affect the stability of the structure. After evaluating that the horizontal access was too lengthy to clear out and the situation behind the wall was not clear, rescuers exercised caution in carrying out further efforts for this course of action. At 1330 hrs, a Turkish team named GEA SAR arrived at the worksite and requested to join the CISAR team to carry out rescue efforts. The commander of CISAR team agreed with the joint rescue. Both teams then discussed the plans of actions together and decided to carry on with the first course of action and abandon the second course. The CISAR team and GEA SAR team worked together (Fig.10) and rotated on a periodic basis, using cutting pliers, multi-sawing and drilling kits to clear the horizontal access. After 4 hours, the debris in the horizontal access was cleared and the live victim was reached. However, due to the very limited and confined space created for access, only one rescuer could enter the horizontal access under the collapsed building to break, breach and remove the remaining debris, which buried the right leg of the victim. One rescuer was stationed outside to assist with the action and this crew was rotated periodically. At 1800hrs in the evening, only three slabs still remained on the right leg of the survivor. One rescuer then went to the rear of the victim and broke the slabs by sawing using SOS combination tools, while another three rescuers stayed in the horizontal and vertical accesses to remove the debris by buckets and ropes in a bid to further widen the access for victim extrication. Finally, at 0135 hrs on 28 April, the victim was rescued successfully and extricated using a roll stretcher after 34 hours!

Medical treatment on site

In the afternoon of 26 April, after the live victim was located, the medical team members provided simple psychological comfort for him and monitored his health via verbal communication (Fig.11). At 1300 hrs on 27 April, after a rescue access was created, rescuers provided some drinking water and food for the victim with the permission of the medical team. At this time, it was noted that the vital statistics of the victim had deteriorated and he was unresponsive to attempts to engage him in conversation. Hence, a medical team member proceeded into the access space to check on the injury of the victim and provided glucose and saline at 1605 hrs on 27 April for him to maintain his vitality. Later on, rescuers provided drinking water to the victim respectively at 1705 hrs and 2005 hrs on 27 April. At 0100hrs on 28 April, upon successful clearance of debris around the victim's right leg, the medical team member provided emergency medical treatment for the victim's right leg which included hemostasis, fixation and dressing, to prevent crush syndrome. The wound on his forehead was disinfected as well, resulting in the stabilizing of the condition of the victim.

Summary and analysis of rescue operation

CISAR was faced with adverse effects of aftershocks, high temperatures recorded in the day, and continuous working through the night, rainfall, confined spaces and narrow accesses for 34 hours. The survivor, a 21 years old male, with good vital signs was handed over to the local ambulance and rushed to Nepal Army Hospital with his right leg crushed (Fig.12). Based on the above summary and description of the rescue process, the following factors were very important to the successful operation carried out in the collapsed building:

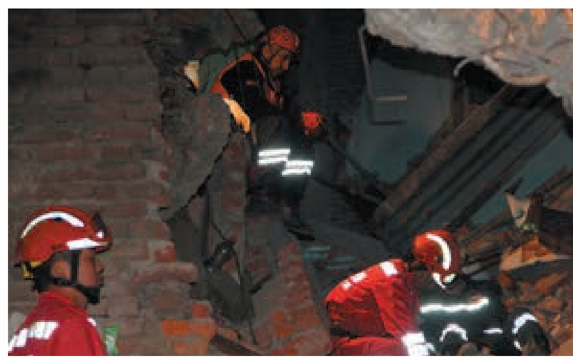

Fig.10 CISAR working with GEA SAR during night operations

Fig.11 Medical member of CISAR at the worksite

Fig.12 Extrication of the live victim

(1) Command and coordination on site

When CISAR arrived at the worksite, a field command post was established in a safe area not far away from the collapsed building. The command post made a reasonable allocation of personnel to carry out reconnaissance, assessment, search, rescue and medical operations, and developed two courses of action to be carried out simultaneously in order to ensure rapid rescue of survivors. During the whole operation, the command post discussed and adjusted the plans periodically in tandem with the rescue progress to carry out actions safely. In addition, the command post kept close contact with the management part of CISAR in the base of operation (BoO), coordinated the timely provision of supporting rescue equipment, and also communicated and coordinated actively with local armed police, military, hospital and other rescue teams to provide support and assitance for the operation. The efficient and effective command and coordination played a part in ensuring a successful rescue mission.

(2) Information communication

Upon arrival of CISAR at the worksite, reconnaissance was first carried out at the scene to collect related information from the locals. When queried on the possible position of the trapped victim, there was a misunderstanding between the terms of "first floor" and the "ground floor" due to the different naming convention for the building floors in Nepal and China. It was subsequently confirmed that the survivor was trapped in the ground floor of the hotel. Besides this, when asked about the numbers of missing and trapped, the owner of the hotel had said that there were 7 persons in the building present before the earthquake but the situation was not clear after the quake. This was further echoed by the local people who mentioned that there were probably several persons trapped in the ruins. However, there was only 1 person trapped in the collapsed building. In addition, during the whole rescue operation, communication was maintained closely among the rescuers on site, between the field command post and the headquarters in BoO, which played an important role to ensure the smooth implementation of the rescue operation.

(3) Local support on site

During the entire rescue operation, the assistance provided by the local armed police and military cannot be understated. The local militia assisted to evacuate the public cordon off the rescue area, and coordinated heavy plant support to assist in breaking and removing debris. In addition, they also gave a lot of support for the transportation, safety and security of CISAR. Local citizens also supported with a interpreter and guide to aid CISAR's rescue operation by providing intelligence about the collapsed building and trapped victims. The timely coordination of the local ambulance provided by the local health department, which transferred the survivor quickly to the local army hospital for specialised treatment were also key elements which contributed to a successful and effective rescue operation.

(4) Joint operations with other teams

During this rescue operation, the local armed police and the Turkish rescue team were also actively involved in offering help for the actions carried out by CISAR. All the members from different teams interacted and cooperated with one another closely, which greatly improved the efficiency of the rescue operation. During the joint operations, different teams brought their own resources and knowledge into full play. The rescue work was assigned reasonably to all the members on site who were rotated periodically, and the plans of action were discussed together and optimised. In addition, all the teams involved maintained communication with one another, which facilitated information and equipment sharing. This allowed the rescue operation to be completed even though the ruins were complicated, the space was confined and the rescue conditions were difficult.

(5) Safety first principle

Safety first is always the operational concept of CISAR. During this rescue operation, CISAR was faced with the potential dangers and hazards, such as secondary collapse of the worksite building and adjacent buildings, aftershocks, rain, continuous work through the night work and hot conditions during the day. Therefore, several safety officers were assigned to closely monitor the rescue operation process from different angles. Meanwhile, CISAR took several measures to ensure safety in the rescue operation, such as placing an inverted bottle of drinking water on the ruins to monitor signs of shaking, hanging of a vertical rope on the wall to monitor the displacement of the structure. In addition, CISAR also developed a plan of personnel rotation, disseminated the emergency evacuation routes and signals to all rescue team members, and ensured that all members wore their personal protective equipment when any entrance to the worksite was required. All these measures were very important in safety in the rescue operation.

Conclusion

This case study documents a successful operation mounted by CISAR, which attained unanimous recognition and praise of the local government and local citizens in Nepal. The comprehensive collation of details of this rescue operation, analysis of the problems in depth, is envisioned to provide guidance and reference for other USAR teams for future earthquake rescue operations. It would be beneficial for the USAR community to document case studies, and provide similar analysis so that future USAR teams can apply the learnings and develop better rescue models and operations in future.

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EDITORIAL PREVIEW

The Asia-Pacific region experiences over 70% of the world's natural disasters, with increasing frequency and magnitude. This emplaces SCDF in a position to contribute internationally, by rendering swift assistance to many disaster-stricken sites. When called upon by our neighbours and international friends, the SCDF stands ready to deploy its United Nations' INSARAG certified Heavy Urban Search and Rescue contingent, codenamed Operation Lionheart, to aid disaster stricken countries in humanitarian assistance and disaster relief efforts.

This article shares on SCDF's Operation Lionheart composition, the training and certification of the contingent and also a summary of its recent deployment together with the Singapore Police Force - a first joint deployment for humanitarian assistance for the 2 agencies from the Home Team.

Interested persons who want to find out more about the Operation Lionheart and its various deployments can contact the Editorial Board to register your interest.

LIFE SAVING, BEYOND BORDERS

MAJ WILFRED LIM AND CPT LEE HENG
SINGAPORE CIVIL DEFENCE FORCE

Introduction

The SCDF maintains a 24/7 Operation Lionheart Contingent (OLC) – a 76-man task force to provide USAR assistance to countries that are struck by disasters such as earthquakes or tsunamis. The OLC can also be reconfigured to assist countries facing incidents involving flooding, forest fires, and other requests for international aid. Its maiden deployment was to Baguio City, the Philippines, on 16 July 1990 after the city was devastated by a powerful earthquake measuring 7.8 on the Richter scale. Since then, Operation Lionheart has seen a total of 16 missions (See Table 1), including the most recent deployment to Nepal in April 2015.

Disaster	Location	Year
Baguio City Earthquake	Baguio City, Philippines	Jul 1990
Highland Towers Collapse	Kuala Lumpur, Malaysia	Dec 1993
Tai Chung County Earthquake	Taichung County, Taiwan	Sep 1999
Asian Tsunami Disaster	Aceh, Indonesia	Dec 2004
Asian Tsunami Disaster	Khao Lak, Thailand	Dec 2004
Sumatra Earthquake	Nias Island, Indonesia	Mar 2005
Rokan Hilir Bush Fires	Sumatra, Indonesia	Aug 2005
South Asian Earthquake	Muzaffarabad, Pakistan	Oct 2005
Central Java Earthquake	Central Java, Indonesia	May 2006
Sichuan Earthquake	Sichuan, China	May 2008
Padang City Earthquake	Sumatra, Indonesia	Oct 2009
Christchurch Earthquake	Christchurch, New Zealand	Feb 2011
Japan Tōhoku Earthquake	Fukushima, Japan	Mar 2011
Malaysian Floods	Kelantan, Malaysia	Dec 2014
Thailand Bush Fires	Chiang Mai, Thailand	Mar 2015
Nepal Earthquake	Gorkha and Lalitpur, Nepal	Apr 2015

Table 1: Operation Lionheart Deployment History

[1]In addition to the Operation Lionheart contingent, SCDF also works with various United Nations (UN) and Association of Southeast Asian Nations (ASEAN) disaster response organisations to build critical capabilities that are needed in humanitarian operations, as well as provide highly trained officers on 24/7 standby to assist affected countries in specialised capacities as part of disaster response coordination. As a founding member of the Asia-Pacific Humanitarian Partnership (APHP), SCDF also provides Info-communications Technology support to UN Disaster Assistance and Coordination Teams (UNDAC) under the auspices of the UN Office for the Coordination of Humanitarian Affairs (UNOCHA) at disaster sites to facilitate the establishment of the On Site Operations Coordination Centre (OSOCC). SCDF also contributes officers to the ASEAN Emergency Response and Assessment Teams (ERAT) and the UNDAC teams to conduct assessment and coordination for the rescue teams that come forward to render help for disaster stricken areas.

Training and Preparation

The OLC must ensure that it is constantly prepared to conduct search and rescue under the most challenging circumstances. To this end, a robust framework had been put in place to validate the contingent's activation, equipping and deployment procedures. One important platform that facilitated this was the reclassification exercise performed by the contingent in 2013. Having first attained the Heavy USAR Team classification – the highest level of recognition accorded to USAR Teams by the United Nations (UN) – in 2008, the Operation Lionheart Contingent was required to undergo reclassification once every 5 years.

The 2013 reclassification exercise, which took place over 36 hours, provided an extremely realistic simulation of the activation, equipping and deployment procedures for Operation Lionheart, complete with a send-off by SCDF's Deputy Commissioner Jackson Lim. Officers were then tested on their technical competencies, when they had to search and rescue victims trapped under collapsed buildings using different techniques such as cutting and lifting, tunnelling and using life detectors and search dogs.

The OLC was successfully reclassified as a Heavy USAR Team, a testimony to SCDF's capability to carry out difficult and complex technical search and rescue operations, as well as the robust system put in place to facilitate Operation Lionheart. The experience garnered through the exercise would also prove invaluable for further mission deployments.

Operationally Ready National Servicemen (ORNSmen) are part of SCDF's strategic plans to bolster the regular force significantly during times of major national emergencies. To further bolster the SCDF strength during local incidents of Urban Search and Rescue, SCDF has embarked on plans to raise the competency level of new Rescue Battalions and train them to the required UN INSARAG Medium standard. This will enable and train a larger pool of competent rescuers beyond SCDF's own regular forces, in its push towards attaining a nation of life savers.

Summary of Latest Deployment in Nepal

On 26 April 2015, an SCDF OLC of 60 officers was deployed to Nepal to render humanitarian assistance to the victims of an earthquake which struck the nation on 25 April 2015. The OLC team was later joined by 70 officers from the Singapore Police Force's (SPF) UN Peacekeeping Force who provided relief supplies, humanitarian aid and also Disaster Victim Identification (DVI) services.

This was the first time that the Home Team (HT) had sent a joint Humanitarian Assistance Mission Team. During this mission, the team successfully retrieved the body of one victim in Lalitpur District together with members from Malaysia's SMART and Thailand Rescue Team, while the SPF assisted in the DVI processing of the body. The SCDF and SPF also rendered medical aid to 22 villagers and assisted in the heli-evacuation of seven casualties. The team also donated humanitarian aid as well as medical supplies towards the ongoing relief efforts in Nepal.

Conclusion

The SCDF OLC has made unprecedented progress in this mission, marking a milestone also for the first HT overseas joint mission. The SCDF's successful partnership with SPF, fortitude in overcoming the challenges of the mountainous terrain and large distances, and courage in braving several aftershocks at the risk of their own safety show the commitment and dedication of the servicemen to provide assistance to those in need!

Partially collapsed building where rescuers retrieved the body of one victim

A hydraulic strut is used to support an overhanging slab of concrete stairs. Beneath it, rescuers break away concrete with an electric tool to gain access to the body

Officers from the SPF assisting in the DVI processing of the body

Rescuers from the SCDF, SMART and Thailand rescue team bringing the body out from the building

SCDF OLC Contingent Commander LTC Alvin Tan speaking to the villagers of Laprak after distributing medical aid during his conduct of humanitarian needs assessment

Home Team officers going through the list of donated medical supplies with the Singapore Red Cross team operating in Nepal

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The Life Saving Force