Air systems for emergency responders

Emergency Services Foundation Scholarship Scheme 2016-17

To explore the successful implementation of self contained breathing apparatus technology and innovation, specifically targeting enhancements to emergency responder safety in irrespirable atmospheres within complex environments.

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POSITION DETAILS

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1.0 EXECUTIVE SUMMARY

Air systems for emergency responders can be a simple solution, not only for enhancing, but ensuring emergency responder and public health and safety into our future.

Air systems for emergency responders are multi-dimensional; these systems will save lives, they will save time, they will save money, and all combining to ensure business as usual (BAU) activities can continue as normal as soon as possible. This benefits Victorian communities, our emergency management (EM) sector and the private sector. Such benefits that we can already see evidence from internationally.

Historically, within fire services across the globe, there has always been an acceptance to manually transport self-contained breathing apparatus (SCBA) cylinders to support air replenishment for firefighters. Whether this air replenishment requirement is up numerous flights of stairs through a multi storey building environment, or deep into structures, this is actually an inefficient approach to emergency response. Not only is there a requirement to transport this air in, but there is also the heavy resource reliance for carrying out empty SCBA cylinders for refilling.

This report provides evidence of investigation, research and study into the benefits of air systems for emergency responders. Funded through the Victorian Emergency Services Foundation (ESF) scholarship scheme, a collaborative approach was taken to produce this report from work conducted in Australia, North America and Europe.

2.0 INTRODUCTION

The protection and preservation of life is paramount; this includes the safety of emergency services personnel, and the safety of community members including vulnerable community members and visitors/tourists within the incident area.[1]

The modern world we live in is dynamic, progressive, innovative and exciting. Yet, our modern world can sometimes also be static, traditional, and resistant to change. Communities all over the world are constantly exposed to these two extremes.

So, in the Emergency Management (EM) world of 2019 and beyond, how can we ensure that we can all "work towards a sustainable and efficient emergency management system that reduces the likelihood, effect and consequences of emergencies – "We work as one".[2]

We also recognise the importance of integration and building effective and cooperative relationships with our emergency management partners. To achieve this we actively promote and strengthen capability, collaboration, interoperability and community connection as core building blocks of emergency management reform.[3]

The Victorian Government is investing $38 billion in major infrastructure and smart technology projects underway to build more capacity on existing networks - and a further $10 billion of upgrades and improvements across road, rail and port. Modern and reliable transport will be key to maintaining our prosperity and world famous liveability as our population continues to grow rapidly and the economy changes.[4]

There are currently many projects underway in Victoria, as well as some of Victoria's existing complex infrastructure, that present challenges to emergency responder safety. With respect to complex environments, attention can be targeted towards both the sub-surface (ie. tunnel infrastructure) and vertical (ie. multi storey buildings) environments.

This Emergency Services Foundation (ESF) scholarship has been to explore the successful implementation of SCBA technology and innovation, specifically targeting enhancements to emergency responder safety in irrespirable atmospheres within complex environments.

[1] https://www.emv.vic.gov.au/publications/fire-service-commissioner-victoria-state-controllers-intent, accessed 17/01/19.
[2] Emergency Management Victoria (2015), "Corporate Plan 2015-2018 Shared Vision – Safer and more resilient communities", Part 1: The Sector – Emergency Management in Victoria, p.6.
[3] Emergency Management Victoria (2015), "Corporate Plan 2015-2018 Shared Vision – Safer and more resilient communities", Part 1: The Sector – Emergency Management in Victoria, p.7.
[4] https://transport.vic.gov.au/our-transport-future/our-projects, accessed 17/01/19.

3.0 BACKGROUND

There are many hazards that Victorian emergency responders, and the Victorian community, could be exposed to. Some of these hazards will present major challenges to emergency service response. For example, there are many existing multi storey environments, large horizontal box constructions, sub-surface infrastructure and tunnel environments. Furthermore, there are other new complex infrastructure projects currently underway in Victoria that will present future complexity for emergency response.

Victorian State Control Priorities have a priority focus on the safety of emergency responders, where protection and preservation of life, health and safety is paramount. The complexity of major infrastructure presents challenges for Victorian emergency services, specifically with regard to SCBA response. There are currently many risks and hazards present across Victoria that could severely challenge our Victorian EM sector during an incident.

Current Victorian SCBA operations (ie. being a standard single cylinder configuration), is restricted to approximately 34 minutes total duration. This is based on a 300bar, 6.8 litre water capacity SCBA cylinder, at a nominal air consumption rate of 60 litres per minute (lpm). When an operator reaches approximately 100bar, a decision point is reached. This is when a theoretical 10 minutes remains, where an assessment should be made by that SCBA operator in relation to the dynamic risk assessment of their safety to either continue a task or to commence their exit into a clean, respirable atmosphere.

These summarised, theoretical calculations result in the notion that an SCBA operator has approximately 24 minutes duration of actual working time (ie. with the allowance of the theoretical 10 minutes preferred as allowance for safety and emergency procedures). It should be emphasized that these figures are notional, and actual SCBA operator durations will be influenced by a range of factors, including workload, fitness, health, stress levels, cylinder pressures, experience, etc.

It has been identified that there is complex infrastructure across Victoria will pose difficulty for such standard SCBA operations. For example, if access to an incident location requiring the use of SCBA takes approximately 8-10 minutes to reach, then there must be provision for at least a minimum of 8-10 minutes to exit from that same environment. With consideration for maintaining 100 bar (ie. theoretical 10 minutes for safety and emergency procedures), this will only provide a theoretical 4-8 minutes working duration.

In reality, this is probably not likely to be an accurate occurrence. In my opinion, the reality would be either longer access times to the actual incident site, and/or an SCBA operator's air consumption would be elevated above 60lpm (due to increased physical and mental workload). This would result in situations where no safe or efficient work could occur at the incident site itself, or it would place emergency responders at serious risk of running out of air due to miscalculation of, or ignorance to, exit times.

There does appear to be a real risk with any incident requiring emergency response into a sub-surface environment, especially if access to an incident within that sub-surface environment lacks adequate ventilation and results in a smoke filled atmosphere that presents an immediate danger to life and health (IDLH).

At this time of writing, Victoria is currently progressing with a new SCBA interoperability platform across parts of the emergency services sector. There is an opportunity to consider some options available to support the safety of emergency responders and the Victorian community during incidents within complex environments.

Some of the options were to explore different types of respiratory protection from other parts of the world; this required an emphasis on conducting research on air systems for emergency responders (eg. firefighter air replenishment systems, FARS), as well as personal protective equipment (PPC) based solutions (eg. extended duration breathing apparatus, EDBA or long duration breathing apparatus, LDBA).

This report aims to highlight the research completed and to provide recommendations for future capability development for Victoria, to enhance emergency responder safety.

4.0 AIM AND OBJECTIVES

Aim:
To explore the successful implementation of SCBA technologies and innovations, specifically targeting enhancements to emergency responder safety in irrespirable atmospheres within complex environments.
Objectives:
1. To explore the practicality of air systems for emergency responders within a Victorian context
2. To assess the differences and similarities between complex structures in Australia, Europe and North America, and the associated impacts that these have on emergency responders
3. To explore alternative options to air systems for emergency responders in complex environments

For any significant incident in a complex environment involving fire, generically speaking, success comes from the availability and efficiencies of key components such as resources, water and air. At this current time, there is an availability of resources, water and air. However, it's the access and quantity of such key components that can have a determining factor on successful combat, and this is a result of efficiency.

Using a tunnel fire or a multi storey fire as examples. In simple terms, there is the availability of resources (eg. people), and we can get more resources to a fire with response escalation. Obviously there are time and space considerations, but generically speaking if we need more people, we call for it, we get it.

In the case for the availability of water, once again it is there when required; whether the requirement is for a millcock hydrant in a tunnel, or inside a building, the availability of

sprinklers and boost points for internal fire suppression. Once again, if we need water, it is there when we need it. And the use of hoses allows water to be taken directly to an incident.

However, when it comes to air, we are not as fortunate. The availability of clean air is not always nearby, and a constant supply is limited. As outlined in the Background section, a limiting factor is the capacity of SCBA cylinders, the working duration and the safety/decision point time. This is where FARS becomes a very real option for consideration.

Without a FARS, fire crews must handle air replenishment in complex structures by manually transporting air cylinders up/down numerous flights of stairs or deep into a structure or ship to the crews engaged in fire attack and search and rescue, then shuttling the empty cylinders out of the structure to a mobile air unit for refilling. It is a labor-intensive process. In a complex structure fire, as many as half of the firefighters on the scene could be dedicated to this task; is this a misuse of highly trained professionals who could be more efficiently deployed for operations like fire attack, search and rescue and occupant evacuation?

The efficiencies gained with the use of FARS are:

- More efficient access to an incident;
- More efficient utilisation of resources;
- Reduction of logistical issues for complex infrastructure;
- Simplified command and control, supporting a non-linear approach to incident and EM;
- No major budgetary impacts on the EM sector, as the private sector will be responsible for its installation and maintenance;
- Support for interoperability in irrespirable atmospheres;
- Provides an opportunity for Victoria to demonstrate leading practise, both nationally and amongst Australasia

Progress in the fire service has often at times been impeded by the very traditions that we all embrace. Nevertheless, technological advances in the fire service do occur, sometimes with lightning speed and sometimes with painful slowness. Either way, every new technology has to be evaluated within our traditions and address the risks that we assume are part of our community's problems.[5]

If we consider just some of our governing state doctrine, we can see how important it is for Victoria to support enhancements to emergency responder and community safety. For example:

- Emergency Management Act 2013 – Objectives (Innovation, Commonality, Interoperability, Safety)
- Fire Services Review
- Victorian Strategic Control Priorities – State Controller's Intent: Priorities 1, 3, 4 and 5
- Risk management framework
- Hierarchy of risk management controls
- Occupational Health and Safety legislation

[5] RescueAir Systems Inc., "Firefighter Air Replenishment Systems (FARS) Training Manual", Microsoft Powerpoint presentation

5.0 ESF ITINERARY

The following tables detail the itinerary for my ESF scholarship travel, research and engagement.

To facilitate a balanced approach to research, my ESF scholarship was divided into two separate parts: Part 1 being travel to the United States (US) and Part 2 being travel to Europe.

These two parts were conducted at different times, with the US component being conducted in January 2017, and the European component being conducted in April/May 2017.

My itinerary was created through early engagement with industry professionals, and fire agencies contacts. The visits in the US were made according to access to credible resources and locations related to FARS and infrastructure complexities. The European visits were made according to access to major sub-surface/tunnel infrastructure, in conjunction with engagement with fire agencies.

A detailed description of this itinerary can be obtained from the photo album viewed at https://www.facebook.com/airsystemsforemergencyresponders/

5.1 Part 1 – United States:

Day	Date	Location	What	Who
Sun	Jan 15	Melb – Los Angeles (CA)	Transit - LAX International, Los Angeles	[redacted]
Mon	Jan 16	Los Angeles (CA) - Phoenix (AZ)	Transit - Sky Harbour International, Phoenix	
Mon	Jan 16	Chandler (AZ), Phoenix (AZ)	Inspection of FARS installation at Intel Fab (Chandler, AZ) and Phoenix Children's Hospital (Phoenix, AZ)	Jeff Allen (Rescue Air Technician)
Tues	Jan 17	Phoenix (AZ)	(AM) Inspection of FARS installation at Marina Heights and Talking Stick Resort (Scottsdale, AZ), (PM) Glendale Regional Public Safety Training Centre (GRPSTC) walkthrough (Glendale, AZ) and Hump Day Hangout preparation	Rescue Air, Chief Gary Morris (Pine-Strawberry FD), Chief Chuck Montgomery (GRPSTC), Bobby Halton (Fire Engineering)
Wed	Jan 18	Phoenix (AZ)	Hump Day Hangout broadcast with Fire Engineering (GRPSTC, Glendale, AZ) Phoenix Training Academy in PM	Rescue Air, Chief Gary Morris (Pine-Strawberry FD), Chief Chuck Montgomery (GRPSTC), Bobby Halton (Fire Engineering) Chief Chuck Montgomery (GRPSTC)
Thurs	Jan 19	Phoenix (AZ)	Phoenix Ride Along at Maryvale Fire Station	Phoenix Fire Department (arranged through Chief Morris PSFD)
Fri	Jan 20	Phoenix (AZ)	Phoenix Ride Along at Maryvale Fire Station	Phoenix Fire Department (arranged through Chief Morris PSFD)
Sat	Jan 21	Phoenix - Reno/Douglas County/South Lake Tahoe Airport to South Lake Tahoe	Transit - Reno Airport Transit to South Lake Tahoe	Chief (retired) Mario Trevino, Battalion Chief Richard Nalder (Tahoe Douglas FD)
Sun	Jan 22	Douglas County/South Lake Tahoe/Reno	Local alpine area and buildings with Tahoe Douglas FD Battalion Chief (South Lake Tahoe, NV)	Chief (retired) Mario Trevino, Battalion Chief Richard Nalder (Tahoe Douglas FD)
Mon	Jan 23	Douglas County/South Lake Tahoe/Reno	Meet Fire Chief of Tahoe Douglas FD to discuss the complex Alpine Environment (South Lake Tahoe, NV)	Chief (retired) Mario Trevino, Fire Chief Scott Baker and Battalion Chief Richard Nalder (Tahoe Douglas FD)

Day	Date	Location	What	Who
Tues	Jan 24	South Lake Tahoe	Rest Day	Rest Day
Wed	Jan 25	South Lake Tahoe - Sacramento Sacramento Sacramento - San Francisco	Inspection of FARS installations in Sacramento, and discussion about air management within the high rise environment (Sacramento, CA)	Chief Walter White and Fire Marshall staff (Sacramento FD)
Thurs	Jan 26	San Francisco	Inspection of FARS installations at Transbay & Infiniti Towers (San Francisco downtown, CA)	Jeff Allen (Rescue Air Technician)
Fri	Jan 27	San Francisco	Inspection of FARS installations at Four Seasons & Moffett Place (Bay Area Silicone Valley, CA)	Jeff Allen (Rescue Air Technician)
Sat	Jan 28	San Francisco	Oakland Ride Along at Fire Station #18	Oakland Fire Department (arranged through Captain Daryl Liggins (OFD)
Sun	Jan 29	San Francisco - Seattle Seattle	Transit - Seattle Tacoma Ride Along with Seattle FD (Northgate Fire Station), and discussions about air management in Seattle FD	Captain Mike Gagliano (Seattle FD)
Mon	Jan 30	Seattle Seattle – LAX LAX – Melb	Inspection of FARS installation at the Hilton Hotel Project in Renton (WA) Transit - LAX International Transit - LAX International	Captain Mike Gagliano (Seattle FD)
Tues	Jan 31	Transit	Transit	[redacted]
Wed	Feb 1	Arrive Melb	Melbourne Tullamarine	[redacted]

5.2 Part 2 – EUROPE:

Day	Date	Location	What	Who
Sat	Apr 15	Melb – Doha (UAE)	Transit – Doha	[redacted]
Sun	Apr 16	Doha (UAE) - Frankfurt (GER)	Transit – Frankfurt	
Sun	Apr 16	Frankfurt (GER)	Ride Along with Feuerwehr Frankfurt Au Main at Fire Station #1 in the Eckenheim District Induction into Station #1, Specialist Appliance information, Inspection of SCBA Maintenance Visit to Station #41 (Water Rescue) for research on marine respiratory protection, air management and complex infrastructure accessible from the water Introduction to the Frankfurt built environment, as well as the Frankfurt U-Bahn (the underground rail system) alarm monitoring system	Brandamtsrat Horst Hoffmeister, Head of the Protection Systems and Equipment Technology Department (Berufsfeuerwehr Frankfurt Au Main)
Mon	Apr 17	Frankfurt (GER)	Ride Along with Feuerwehr Frankfurt Au Main at Fire Station #1 in the Eckenheim District Inspection of standard appliances and respiratory protection, observing SCBA operating procedures	Frankfurt Feuerwehr 1 Dienstgruppe (Platoon #1)
Tues	Apr 18	Frankfurt (GER)	Inspection of Feuerwehr Rettungs Training Center (FRTC), to investigate training for complex infrastructure (eg. multi storey, tunnel), SCBA skills maintenance Inspection of the Frankfurt U-Bahn (the underground rail system), and research on air management principles for complex environments, and specialist appliances for ventilation/extraction of tunnel infrastructure Inspection at Taunus Turm; one of the newest high rise structures in downtown Frankfurt, to discuss high rise procedures and vertical air management	Brandamtsrat Horst Hoffmeister, Head of the Protection Systems and Equipment Technology Department (Berufsfeuerwehr Frankfurt Au Main)
Wed	Apr 19	Frankfurt (GER) – London (UK)	Meeting at London Fire Brigade (LFB) Headquarters with the LFB Operational Policy and Procedures Department Working with 'Red Watch' at LFB Old Kent Road Fire Station in Southwark Burrough, to discuss air management, SCBA equipment and procedures for multi storey complex structures	Tony Farrant, Technical Support Manager of Respiratory Protection Equipment and Hazmat PPE Team (LFB) Watch Manager Dave Topping, Chemical and Environment Section (LFB)
Thurs	Apr 20	London (UK)	Tour of London's complex built environment Inspection of the London Tube and the complex tunnel infrastructure Working with 'Green Watch' at LFB Euston Fire Station in the Camden Burrough, to discuss LFB sub surface procedures	Tony Farrant, Technical Support Manager of Respiratory Protection Equipment and Hazmat PPE Team (LFB) Watch Manager Dave Topping, Chemical and Environment Section (LFB)

Day	Date	Location	What	Who
Wed	Apr 21	London (UK)	Tour of London's complex built environment Discussion at LFB HQ on respiratory protection case studies	Tony Farrant, Technical Support Manager of Respiratory Protection Equipment and Hazmat PPE Team (LFB) Watch Manager Dave Topping, Chemical and Environment Section (LFB)
		London (UK) to Paris (FRA) to Modane (FRA)	Transit across from London (UK) to Modane (FRA)	
Mon	May 01	Arrive Modane (FRA)	(PM) Met by Commandant Frédéric Dutel, Le Service Departemental d'Incendie et de Secours de la Savoie (The Fire and Rescue Department of Savoie, SDIS 73), and settled into accommodation	Commandant Frédéric Dutel, (SDIS 73)
Tues	May 02	Modane (FRA)	Working with Commandant Frédéric Dutel	Commandant Frédéric Dutel, (SDIS 73)
Wed	May 03	Modane (FRA)	Working with Commandant Frederic Dutel Tour of French alpine villages and towns, and their associated multi storey complexities due to access and construction age Inspection of specialist appliances and equipment for complex tunnel and respiratory protection Discussion at Modane Fire Station on tunnel procedures and case studies Visit to the TELT (Tunnel Euralpin Lyon Turin) expo Meeting at one of the TELT construction sites (in Saint Martin de la Porta) to investigate tunnel construction emergency response and the TBM (tunnel boring machine) Meeting at the Frejus Tunnel (French entrance) to discuss training for complex tunnel infrastructure	Commandant Frederic Dutel, (SDIS 73)
		Arrive Melb	Melbourne Tullamarine	

6.0 ESF REMITTANCE

The following tables outline the expenditure during my ESF scholarship:

WONG USA ESF EXPENSES 2016/2017

Date Incurred	Expense to	Expense detail	Type	AUD $	USD $	Transaction	Reference	Receipt
19/12/2016	MTA Travel	Melb to USA (return)	Transport	$2,235.34		Credit Card	Invoice #414/75717C	Y
19/12/2016	MTA Travel	PHX to Reno	Transport	$211.70		Credit Card	Invoice #414/75717C	Y
19/12/2016	MTA Travel	SF to Seattle	Transport	$151.75		Credit Card	Invoice #414/75717C	Y
24/12/2016	MTA Travel	Dollar Rentals - SUV car hire	Transport	$315.00		Credit Card	Invoice #414/76035	Y
24/12/2016	AirBnB	Phoenix	Accommodation	$119.00		Credit Card	JKAMNA	Y
26/12/2016	AirBnB	Phoenix	Accommodation	$51.00		Credit Card	8TNHZ4	Y
27/12/2016	AirBnB	South Lake Tahoe	Accommodation	$522.00		Credit Card	MTSSNM	Y
1/01/2017	CFA	CFA merchandise from CFA SLC	Administration	$278.89		Online	758766	Y
4/01/2017	AirBnB	San Francisco	Accommodation	$108.00		Credit Card	9MN2PW	Y
5/01/2017	US Customs	US Visa Application	Transport	$20.15		Credit Card	25VS9T7K	Y
8/01/2017	Brudor Trophies	Appreciation Plaques	Administration	$180.00		Online	921843	Y
8/01/2017	Officeworks	Power Bank charging pack	Administration	$14.00		Cash	n/a	N
4/01/2017	AirBnB	Cancellation fee San Fran accom	Accommodation	$17.00		Credit Card	EA2QSR	Y
10/01/2017	AirBnB	San Francisco	Accommodation	$78.00		Credit Card	DPYAQR	Y
15/01/2017	Melb Airport	Parking fee	Transport	$29.70		Credit Card	Westpac Statement	Y
15/01/2017	Sky Harbour	Snacks	Meals		$7.00	Cash	n/a	N
15/01/2017	UBER	PHX: Sky Harbour Int. to accom	Transport	$18.81		Credit Card	Westpac Statement	Y
15/01/2017	UBER	PHX: Accomm to Piestewa Peak	Transport	$11.68		Credit Card	Westpac Statement	Y
15/01/2017	McDonalds	Dinner	Meals		$5.99	Cash	n/a	N

15/01/2017	Bus Company	Bus back to accom	Transport		$2.00	Cash	n/a	N
16/01/2017	Ace Parking Lot	Carparking downtown PHX	Transport		$10.00	Debit Card	Travelex Statement	Y
16/01/2017	Street vendor	Dinner	Transport		$14.00	Cash	n/a	N
16/01/2017	Street vendor	Evening	Meals		$5.00	Cash	n/a	N
17/01/2017	Circle K	Fuel for rental car	Transport		$10.00	Debit Card	Travelex Statement	Y
17/01/2017	Australia Post	Travel SIM card top up	Administration	$25.00		Credit Card	Westpac Statement	Y
17/01/2017	Renaissance Hotel	Hotel WiFi fee	Administration	$19.05		Credit Card	Westpac Statement	Y
20/01/2017	PFD#25	Lunch	Meals		$6.00	Cash	n/a	N
20/01/2017	UBER	PHX: PFD#25 to accomm	Transport	$15.10		Credit Card	Westpac Statement	Y
21/01/2017	UBER	PHX: accomm to Sky Harbour Int.	Transport	$18.80		Credit Card	Westpac Statement	Y
21/01/2017	American Airlines	PHX to Reno flight baggage fee	Transport		$60.00	Debit Card	Travelex Statement	Y
21/01/2017	Gunbarrel	Lunch	Meals		$31.40	Debit Card	Travelex Statement	Y
21/01/2017	Fire & Ice	Dinner	Meals		$35.20	Debit Card	Travelex Statement	Y
23/01/2017	Beef Jerky shop	Morning tea	Meals		$4.29	Cash	n/a	N
23/01/2017	Ace High S'House	Lunch	Meals		$35.58	Debit Card	Travelex Statement	Y
23/01/2017	Reno Fuel Station	Fuel for rental car	Transport		$20.00	Cash	n/a	N
25/01/2017	Oakland Bridge	Oakland-SF bridge toll	Transport		$6.00	Cash	n/a	N
25/01/2017	Pao Alto Fuel St.	Fuel for rental car	Transport		$8.00	Cash	n/a	N
26/01/2017	SF Parking	Fisherman's Wharf metered parking	Transport		$1.00	Cash	n/a	N
26/01/2017	San Mateo Bridge	San Mateo-SF bridge toll	Transport		$1.00	Cash	n/a	N
26/01/2017	Nola	Dinner	Meals		$50.42	Cash	n/a	N
27/01/2017	Four Seasons	Rental car parking	Transport		$12.00	Cash	n/a	N
27/01/2017	Redwood Fuel St.	Fuel for rental car	Transport		$20.00	Cash	n/a	N
27/01/2017	SF Restaurant	Dinner	Meals		$25.00	Cash	n/a	N
28/01/2017	Oakland Bridge	Oakland-SF bridge toll	Transport		$5.00	Cash	n/a	N
28/01/2017	Dollar Rentals	Rental car fuel fee	Transport	$128.19		Credit Card	Westpac Statement	Y
29/01/2017	Delta Airlines	SFO to Seattle flilght baggage fee	Transport		$60.00	Cash	n/a	N
29/01/2017	SFO Airport	Breakfast	Meals		$10.00	Cash	n/a	N
29/01/2017	UBER	WA: Seattle Airport to SFD#31	Transport	$62.42		Credit Card	Westpac Statement	Y

30/01/2017	Northgate Diner	Breakfast	Meals		$39.26	Cash	n/a	N
30/01/2017	Burger King	Lunch	Meals		$8.86	Cash	n/a	N
30/01/2017	LAX Airport	Arvo tea	Meals		$5.46	Cash	n/a	N
30/01/2017	Melb Airport	Parking fee	Transport	$29.70		Credit Card	Westpac Statement	Y

KEY	
	Transport
	Accommodation
	Meals
	Administration

			$498.46	
		$4,660.28	$699.24	(USD-AUD conversion rate as of 07/02/19)
USA Total (AUD)	**$5,359.52**			

WONG EUROPE ESF EXPENSES

Date Incurred	Expense to	Expense detail	Type	AUD $	Euro € Pound £	Transaction	Reference	Receipt
15/04/2017	Melb Airport	Parking fee	Transport	$11.50		Credit Card	Westpac Statement	Y
13/04/2017	MTA Travel	Melb to Europe (return)	Transport	$1,911.94		Credit Card	Invoice #414/85189	Y
13/04/2017	MTA Travel	Eurail Select Pass	Transport	$350.75		Credit Card	Invoice #414/85198	Y
13/04/2017	MTA Travel	EasyJet flight	Transport	$89.63		Credit Card	Invoice #414/85198	Y
15/04/2017	Frankfurt Airport	Breakfast	Meals		10.00 €	Cash	n/a	N
15/04/2017	Taxi	Taxi	Transport		18.00 €	Cash	n/a	N
15/04/2017	Frankfurt	Groceries	Meals		22.00 €	Cash	n/a	N
15/04/2017	Frankfurt Feuerwehr	Lunch on station	Meals		6.50 €	Cash	n/a	N
15/04/2017	McDonalds	Dinner	Meals		21.00 €	Cash	n/a	N
16/04/2017	Frankfurt Feuerwehr	Breakfast on station	Meals		8.00 €	Cash	n/a	N
16/04/2017	Frankfurt	Lunch	Meals		18.00 €	Cash	n/a	N
16/04/2017	Frankfurt	Dinner	Meals		25.00 €	Cash	n/a	N
17/04/2017	Frankfurt Feuerwehr	Breakfast on station	Meals		6.50 €	Cash	n/a	N

17/04/2017	Frankfurt Feuerwehr	Lunch on station	Meals		6.50 €	Cash	n/a	N
17/04/2017	Frankfurt	Groceries	Meals		28.40 €	Cash	n/a	N
16/04/2017	Frankfurt	Dinner	Meals		27.00 €	Cash	n/a	N
18/04/2017	Australia Post	Travel SIM card top up	Administration	$25.00		Credit Card	Westpac Statement	Y
19/04/2017	Frankfurt Airport	Breakfast	Meals		8.00 €	Cash	n/a	N
19/04/2017	Heathrow Airport	Breakfast	Meals		£15.00	Cash	n/a	N
19/04/2017	Heathrow Airport	London Underground	Transport		£6.00	Cash	n/a	N
19/04/2017	London FB HQ	Lunch	Meals		£25.00	Cash	n/a	N
19/04/2017	London	Groceries	Meals		£22.00	Cash	n/a	N
19/04/2017	London	Dinner	Meals		£35.00	Cash	n/a	N
20/04/2017	Australia Post	Travel SIM card top up	Administration	$25.00		Credit Card	Westpac Statement	Y
20/04/2017	London	Breakfast	Meals		£14.00	Cash	n/a	N
20/04/2017	London	Lunch	Meals		£16.50	Cash	n/a	N
20/04/2017	London	Dinner	Meals		£31.00	Cash	n/a	N
20/04/2017	London	Evening	Meals		£9.00	Cash	n/a	N
21/04/2017	London	Breakfast	Meals		£10.00	Cash	n/a	N
21/04/2017	London FB HQ	Lunch	Meals		£18.00	Cash	n/a	N
21/04/2017	London	Groceries	Meals		£21.00	Cash	n/a	N
21/04/2017	London	Dinner	Meals		£32.00	Cash	n/a	N
25/04/2017	AirBnB	Paris	Accommodation	$453.68		Credit Card	HPKNB5	Y
27/04/2017	UBER	Paris	Transport	$9.02		Credit Card	Westpac Statement	Y
27/04/2017	UBER	Paris	Transport	$16.70		Credit Card	Westpac Statement	Y
27/04/2017	UBER	Paris	Transport	$11.57		Credit Card	Westpac Statement	Y
28/04/2017	Santorini	Lunch	Meals	$72.64		Credit Card	Westpac Statement	Y
28/04/2017	Franprix	Groceries	Meals	$36.99		Credit Card	Westpac Statement	Y
29/04/2017	MTA Travel	Serris, France	Accommodation	$575.92		Credit Card	414/85189+H66	Y
1/05/2017	UBER	Paris	Transport	$12.24		Credit Card	Westpac Statement	Y
1/05/2017	Modane	Breakfast	Meals		16.00 €	Cash	n/a	N
1/05/2017	Franprix	Map	Administration		6.25 €	Cash	n/a	N

1/05/2017	Modane	Lunch	Meals		22.55 €	Cash	n/a	N
2/05/2017	Modane	Lunch	Meals		25.00 €	Cash	n/a	N
2/05/2017	Modane	Dinner	Meals		30.00 €	Cash	n/a	N
3/05/2017	Hotel De La Gar	Lunch	Meals	$56.86		Credit Card	Westpac Statement	Y
3/05/2017	Franprix	Groceries	Meals	$29.94		Credit Card	Westpac Statement	Y
					304.70 €			
					£254.50			
					$486.39	(€ to AUD conversion rate as of 07/02/19)		
					$462.73	(£ to AUD conversion rate as of 07/02/19)		
				$3,689.38	$949.12	(TOTAL converted AUD as of 07/02/19)		

KEY	
	Transport
	Accommodation
	Meals
	Administration

EUR Total (AUD)	**$4,638.50**

TOTAL (AUD)	**$9,998.02**

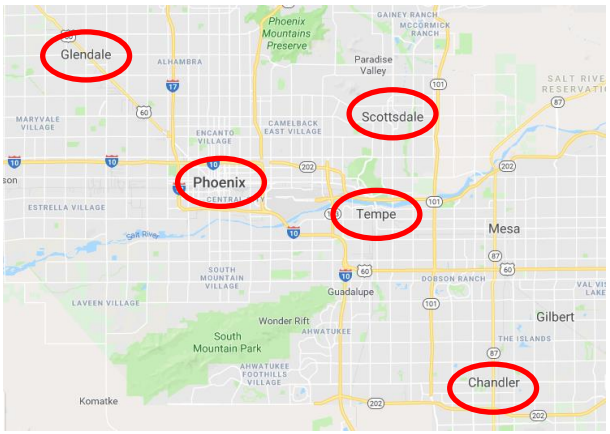
NOTE: The total budget applied for in my ESF submission was $9980.00

7.0 FINDINGS

In the months leading up to commencing my international research trip, I initiated and maintained detailed engagement with Rescue Air Systems Inc. (Rescue Air), to form the primary focus of this study. The relationship with Rescue Air was strengthened by the links shared by Captain Mike Gagliano (Retired) from Seattle Fire Department (SFD), who is a credible mentor and advocate for air management within the fire services.

With the great support from Rescue Air CEO Anthony Turiello and Captain Gagliano (ret), this provided the opportunity for a comprehensive and collaborative schedule to be created (*refer to 5.0 ESF Itinerary*).

7.1 Arizona State



My visit to Arizona (AZ) included Phoenix, Chandler, Tempe, Scottsdale and Glendale. My majority of my time in AZ was spent with Rescue Air.

Work conducted in AZ included:

- obtaining direct learnings and construction/installation insights with a FARS technician, Jeff Allen;
- visiting and inspecting FARS installations (different in relation to occupancy risks and construction);
- visiting and inspecting the Glendale Regional Public Safety Training Centre (GRPSTC)
- being involved in the setup and conduct of a Fire Engineering Humpday Hangout live webcast and presentation of FARS; and
- direct engagement with Phoenix Fire Department (PFD)

Chandler –

A visit to the Intel Fabrication Plant (Ocotillo Campus) provided my first opportunity to conduct a building inspection of a commissioned FARS installation. This Intel location focuses primarily in high-volume microprocessor manufacturing at state-of-the-art facilities, situated across many large buildings with large occupancies. The site has a range of older and newer FARS installations, which provided an early opportunity to directly compare how FARS systems have evolved over time. (Note: due to high security levels, photos were not permitted).

Tempe –

A visit to the State Farm Credit Union Complex (Marina Heights Branch) was to see a FARS recently installed into a large commercial office complex under construction. This provided a good opportunity to see all the different key components of a current generation FARS installation; including the external mobile air connection (EMAC), air monitoring equipment, emergency refill panels, and air storage.

Scottsdale –

Talking Stick Casino, one of AZ's more reputable entertainment destinations, includes entertainment, casino, accommodation, dining and retail; resulting in a complex mix of occupancy and risk. From a FARS perspective, I was able to inspect one of the largest FARS installations to date. This included a detailed look at the basement bypass control panel, which housed a cascade system of air onsite and air storage.

Glendale –

The primary focus of my visit to Glendale was to participate in a Fire Engineering Humpday Hangout live demonstration webcast and presentation on FARS. I was invited to be involved in the setup, alongside Anthony Turiello and Debra Hall (Rescue Air), Bobby Halton and (Fire Engineering) and Fire Chief Gary Morris (Pine Strawberry Fire Department, and former PFD Fire Chief). In addition, a detailed tour of the GRPSTC facility was provided by Deputy Fire Chief and GRPSTC Director Chuck Montgomery. This provided a great insight into how FARS can be incorporated into the training environment, to support training for complex incidents, as well as discussion on emergency and air management.

The Fire Engineering Humpday Hangout live demonstration webcast and presentation on FARS can be viewed at the following link on You Tube:
https://www.youtube.com/watch?v=1BNNLLUj_zw

Whilst staying in Glendale, I was accommodated at the Renaissance Hotel and Spa; accommodation being part of the Marriot and Renaissance Hotel chains. This stay provided an opportunity to see one of AZ's first FARS installations. With many older system components (eg. non-concealed stainless steel high pressure air lines), it was still provided visual proof of how useful these systems would be during a fire.

Phoenix –

Whilst in the capital city of AZ, Phoenix involved an inspection of a FARS installation in the Phoenix Children's Hospital. This demonstrated the versatility of FARS for various occupancies presenting different complex risks for emergency responders. The focus of this FARS installation was its's application to a taller multi storey building.

My time in Phoenix was also accommodated by Phoenix FD (PFD), and with the support of Chief Morris, I was able to spend two days working at PFD Station #25 (Maryvale A & B shifts) in the West District. A tour was provided by FF Marcus Goodrich, which included visiting the Resources Division and Air Management Department.

Whilst working on station, discussions occurred around PFD air management policies and other supporting procedures, for example rapid intervention teams (RIT). I also had the

opportunity to visit PFD Station #09 in the Central District to be shown over Utility 10, which is PFD's Mobile Air Unit. This is the vehicle that is responded to connect into an EMAC to supply continuous external air to a FARS.

AZ Summary –

As multiple FARS installations were inspected (with each one being different in terms of age, construction and occupancy), I found it evident that FARS would definitely enhance emergency responder safety in complex environments.

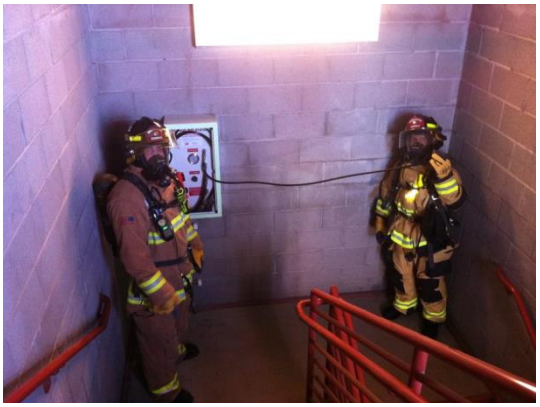
The presence and FARS knowledge of Jeff Allen (Rescue Air technician), as well as a detailed explanation of all the key system components on site, demonstrated the wide spread protection that FARS can provide. This extends emergency responder safety, not only in multi storey environments, but also sub surface environments (eg. underground car parks, transport tunnels) and large horizontal warehouses.

The simplicity of FARS (ie. from installation to construction to operation to maintenance), low construction costs, ability to incorporate specific training into training centres, and the safety design features should be assessed for suitability in Victorian complex environments.

I believe that FARS would definitely provide enhanced emergency responder safety, as well as more efficient emergency response (therefore providing enhancement to community and infrastructure safety, and supporting the Victorian Strategic Control Priorities and the State Controller's Intent (refer to https://www.emv.vic.gov.au/publications/fire-service-commissioner-victoria-state-controllers-intent).

James Wong, Senior Station Officer, Country Fire Authority, Victoria
"Air systems for emergency responders", June 2019

Selected images from AZ:



Humpday Hangout - 1/18/2017: Live Demo of FARS from the GRPST in Glendale, AZ
1,962 views

7.2 Nevada State

My visit to Nevada (NV) included Reno, Douglas County and South Lake Tahoe. My time in NV was accompanied by Mario Trevino (retired Chief of San Francisco FD), who is also a credible advocate for FARS and air management.

Work conducted in NV included:

- direct engagement with Reno Fire Department (RFD)
- direct engagement with Tahoe Douglas Fire Protection District (TDFPD) on the NV side

Reno –

A visit to the RFD headquarters in Downtown Reno at the Reno City Hall Building, provided an opportunity to discuss air management and SCBA procedures with RFD Fire Chief David Cochrane and one of his Division Commanders.

Douglas County and South Lake Tahoe –

Direct engagement with TDFPD provided the opportunity to discuss air management and respiratory equipment in the complex alpine environment. TDFPD serves the stateline between Nevada and California; from South Lake Tahoe and Zephyr Cove to Glenbrook. The town of South Lake Tahoe is at the base of Heavenly Valley Ski Resort;

Tahoe's largest ski area is the fifth biggest in North America, straddling the state line between California and Nevada. With almost 100 slopes, 28 chairlifts, 3,500 lift-served vertical feet (unmatched on the West Coast) and a 10,067 feet of elevation (the highest in Lake Tahoe) it's good on some other stats too.[6]

I had the opportunity to work directly with both Battalion Chief (BC) Richard Nalder (retired 05/01/2018) and Captain Chris Peterson. BC Nalder conducted a tour of the alpine complexities surrounding the TDFPD, from alpine access/egress, snow conditions, snow loading/shedding, multi storey (up and down) operations, and the risks around surging

[6] https://blog.liftopia.com/2017s-top-10-biggest-ski-areas-north-america/, accessed on 29/01/19

populations. At the time of my visit, this region of CA was receiving a large amount of snowfall, with January 2017 being "a record breaking month of snowfall."[7]

With a tour of each TDFPD fire station, this engagement allowed the alpine air management discussions to continue, encompassing rapid intervention teams and equipment. This provided some key insights into the complexities of enhancing emergency responder safety in alpine resort and town areas.

NV Summary –

As multiple complexities were discussed and witnessed, the focus on air management in alpine environments highlighted some key areas. The limited access and egress, influenced by snow conditions, and the different physical stresses encountered whilst operating in the snow, requires alpine firefighting to be met with specific attention. That is, attention to detail for air management, personal protective clothing and equipment (PPC & E), and the working with limited resources. Victoria has more to learn with specifics around alpine firefighting and air management.

To support enhancing emergency responder safety in alpine environments, I believe that options like FARS in larger buildings in Victoria's alpine areas (eg. in Les Chalet Apartments at Falls Creek, Arlberg Apartments at Mt Hotham, multi storey environment of Mt Buller), could provide some key efficiencies for protecting life and property.

[7] https://sf.curbed.com/2017/1/25/14384962/california-snow-lake-tahoe-ski, accessed 30/01/19

Selected images from NV:

7.3 California State

My visit to California (CA) included South Lake Tahoe, Sacramento, Downtown San Francisco, San Francisco Bay Area (Pao Alto) and Oakland. My time in CA was accompanied by Mario Trevino (retired Chief of San Francisco FD) from South Lake Tahoe to Sacramento, and then again with Jeff Allen (Rescue Air technician).

Work conducted in CA included:

- direct engagement with TDFPD, on the CA side
- direct engagement with Sacramento Fire Department
- obtaining direct learnings and construction/installation insights with a FARS technician, Jeff Allen;
- visiting and inspecting FARS installations (different in relation to occupancy risks and construction);
- direct engagement with Oakland Fire Department (OFD)

South Lake Tahoe –

The Grand Residences by Marriott, a luxury resort, is one of only a handful of alpine ski area locations that contain a FARS. The complexities of the alpine environment, limited resourcing, diverse alpine conditions and the large internal building spaces, is a clear reason why FARS has been implemented here. Whilst in South Lake Tahoe, I was able to see scale of infrastructure in this alpine town, and to draw comparisons to Victorian alpine snow areas.

With an altitude of 1,901m above sea level at South Lake Tahoe, this CA resort city already sits at an altitude that is higher than the highest lifted points at each of Victoria's main snow resorts; being 1,845m at Mt Hotham (Summit Chair), 1,780m at Falls Creek (Summit Chair) and 1,780m at Mt Buller (Grimus Chairlift). These lifted points are all higher than the ski villages of Hotham Heights, Falls Creek and Mt Buller.

The small area of Kingsbury, although technically in NV, is also within the TDFPD boundary. With Kingsbury sitting at an altitude of Kingsbury 2,201m, this is almost equal to the highest point in Australia, being Mt Kosciuszko at 2,228m.

Working at these altitudes definitely has an effect on air consumption compared to equal tasks at sea level, or anywhere in between.

Sacramento –

My visit to Sacramento was hoted by Fire Chief Walt W White (retired March 2018). We commenced our discussions on air management at the City of Sacremento Public Safety Centre, where the Sacramento FD Headquarters is located. This allowed me to gain an insight into the City of Sacramento FD's air management procedures, which included the support for FARS implementation into multi storey buildings throughout Downtown Sacramento.

A tour was conducted to two Sacramento multi storey buildings with office occupancy (the 2020 East El Camino building) and a residential and entertainment occupancy (the Kay Street High Rise building). This tour was led by Sacramento FD Fire Marshall Jason Lee, which highlighted Sacramento's emphasis on air management. This was evident by the implementation of FARS, the use of rupture containment stations, and supplemented by multi storey firefighting equipment caches to more effectively resource complex high rise fires.

Downtown San Francisco –

The visit to downtown San Francisco was to investigate large, major city multi storey buildings containing FARS. Some of these buildings were constructed with FARS, whereas many others also contain retro fitted FARS installations. The San Francisco Fire Department (SFFD) was one of the first fire departments to adopt FARS in their jurisdiction. My time in downtown San Francisco was hosted by Rescue Air FARS technician, Jeff Allen.

The main inspection we conducted was at the Infiniti Towers. The Infinity or 300 Spear Street is a mixed-use residential condominium development in the Rincon Hill neighbourhood of San Francisco, California consisting of 2 high-rise towers and 2 low-rise buildings. The four buildings contain 650 residential units. The complex is the first phase of a massive residential development encompassing two city blocks.[8]

The work in downtown San Francisco also provided the opportunity to directly see more complex infrastructure, which included many historical sites, as well as the Bay Area Rapid Transit (BART) transportation system.

San Francisco Bay Area –

After downtown San Francisco, I travelled south to the Bay Area. Still being hosted by Rescue Air, the Bay Area inspections were targeted at large commercial building structures of the renown 'Silicone Valley'. Some of these buildings in this large industrial/commercial precinct where part of Moffett Place; a precinct under construction and renovation for Google's new headquarters.

Another inspection was to The Pullman Hotel, in Redwood City. This is a premise housing the first ever installed Firefighter Air Replenishment System. It was beneficial to see how FARS innovation has evolved, yet to also see how it still maintains the simplistic operational design.

Oakland –

[8] https://en.wikipedia.org/wiki/The_Infinity, accessed 13/03/19

I then spent some time in Oakland, which was accommodated by Oakland FD (OFD) and through the support of Captain Daryl Liggins. I was able to spend two days working at OFD Station #18 (Melrose B shift) with Engine #18 and Truck #6.

Whilst working with OFD, I was hosted by Battallion Chief #4 James Bowron and was able to have a tour of Station #1 in Uptown to see the technical rescue appliance including airline equipment for remote respiratory protection, as well as visiting Station #19 in Rockridge. Here I was able to see OFD's Mobile Air Unit (MAU). This OFD station is the closest OFD station to the The Caldecott Tunnel; which is a four-bore highway tunnel through the Berkeley Hills between Oakland, California and Orinda, California. The OFD MAU actually provides a mobile solution to air management, in the form of a high pressure airline for rapid refill.

Whilst working at OFD Station #18, I was also able to have discussion with OFD firefighters about air management procedures and BART emergency response. The rapid transit public transportation system serves the San Francisco Bay Area in California. The heavy rail elevated and subway system connects San Francisco and Oakland with urban and suburban areas in Alameda, Contra Costa, and San Mateo counties.

There are currently no FARS installations in Oakland. However, it was important to note that for any major multi-jurisdictional incident, the potential exists for OFD firefighters to perhaps need to use FARS during joint operations. Although at the time of discussions, and with some of the OFD firefighters not very aware of FARS, it did raise some interest in the benefits of such innovation.

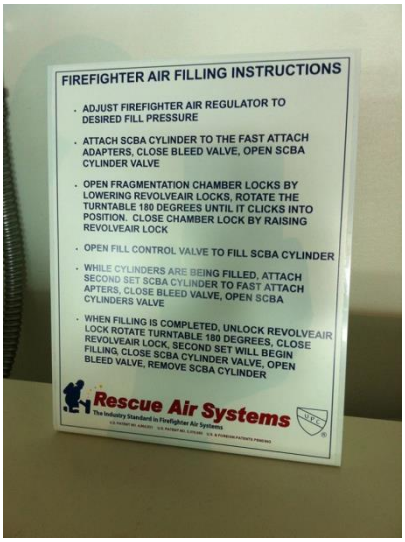
CA Summary –

The time spent in CA provided some really diverse experiences of FARS installations in various complex environments and infrastructure. From the high alpine, to the Financial District of downtown San Francisco, to major Bay Area hotels, to the large industrial/commercial precincts of the Silicone Valley; each different premise having different risks but with the same enhanced safety for firefighters.

The diverse nature of each respective area visited in CA also provided some great insight into the relevance of air management. At altitude, firefighters need to work harder to obtain the same amount of air intake than at sea level. So naturally, this increase in air consumption will require different considerations for air replenishment. In the high density multi storey environment of downtown San Francisco, air replenishment considerations relate to increased workload due to the logistics to resource upper levels. This is particularly evident if responding crews must transport themselves through irrespirable atmospheres due to smoke and potential stack effects (both positive and negative) that may present in buildings during structure fires.

The CA visits also provided the opportunity to compare different FARS installations; from the very early stages of FARS adoption, right up to modern multi-faceted installations that incorporate functional design (eg. installation isolation points, backup power, air monitoring). The various FARS installations designs demonstrate how FARS has evolved over the years, but also the fact of how simplistic the FARS concept is in providing a real solution to enhance emergency responder safety in complex environments.

Selected images from CA:



7.4 Washington State

My visit to Washington (WA) included Seattle and Renton. My time in WA was hosted by Captain Mike Gagliano (retired) from Seattle FD (SFD), who is a credible expert and advocate for air management and FARS (refer to Air Management for the Fire Service, by Gagliano, Phillips, Bernocco, Jose, and Fire Engineering Books, 2008).

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Work conducted in WA included:

- direct engagement with SFD;
- obtaining direct learnings and discussion on adopting better air management approaches from SFD;
- discussion on opportunities to introduce FARS to Victoria

Seattle –

My time in Seattle was predominantly spent working with Captain Gagliano and the crew from Engine 31 and Ladder 5, located at SFD Station #31 in Northgate. Targeted discussion were focussed on standard air management procedures on the fireground, such as RIT and multi storey procedures.

I also had the opportunity to travel with Battalion Chief Ben Haskell (BC06) to SFD Station #5, a temporary station that moored two SFD fireboats; Fireboat 2 and Fireboat 4 (aka M/V Leschi). Seattle has a complex water environment.

Located on a narrow isthmus between Puget Sound on the west and Lake Washington on the east, water comprises approximately 41% of the total area of the city of Seattle.[9] This raises further complexity of air management on the water environment.

M/V Leschi is SFD Fireboat 4, as is set up to be self-sufficient when away from land on the many lakes, or at sea. There is facility to refill SCBA cylinders on board. Interestingly, FARS can also be installed on large vessels, and this would create huge efficiencies for firefighting

[9] https://en.wikipedia.org/wiki/Bodies_of_water_of_Seattle, accessed 31/01/19

and air management on water. There is currently no case of FARS being installed on a vessel.

Renton –

The visit to Renton (south of Seattle) was to conduct a FARS inspection with Captain Gagliano at a new Hilton Hotel under construction. This was a great opportunity, as it will be the first FARS installation in the state of WA. This experience provided a direct look at the construction phase of FARS, the simplicity of installation and how all the key components come together based on regulatory requirements.

WA Summary –

The visit to WA highlighted examples of another major US city's emphasis and attention to detail on air management. WA seems to have embraced the benefits of FARS, with the addition of the first FARS installation at the new Hilton Hotel in Renton.

I was also made aware of another proposed FARS project in Bellevue (east of Seattle on the other side of Lake Washington); the East Link Bellevue Tunnel. Eventually, light rail trails will carry passengers to from Seattle to Bellevue and Redmond through the tunnel.[10] There has been some discussion from Rescue Air Systems about the possibility of a FARS installation being considered for the new light rail tunnel. This would support the fact that FARS is equally a critical component in supporting emergency responder safety and air management in the sub surface environment.

[10] https://seattle.curbed.com/2018/7/13/17570496/east-link-bellevue-tunnel-status, accessed 31/01/19

Selected images from WA:





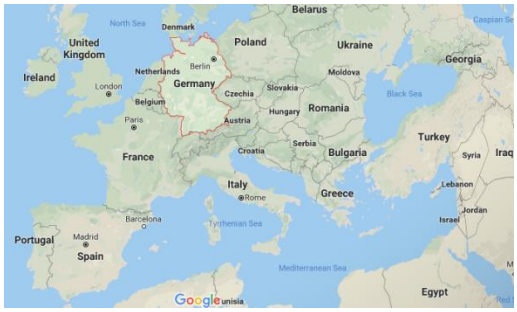








7.5 Germany



My visit to Germany had the sole focus of visiting Frankfurt, to work directly with Feuerwehr Frankfurt au Main and to gather information about their approach to air management in complex environments. I had the honour of being hosted by The Late Horst Hoffmeister (Brandamtsrat), Head of the Protection Systems and Equipment Technology Department (Berufsfeuerwehr Frankfurt Au Main).

Work conducted in Frankfurt included:

- direct engagement with Berufsfeuerwehr Frankfurt Au Main;
- obtaining direct learnings and discussion on adopting better air management; approaches from Berufsfeuerwehr Frankfurt Au Main;
- discussion on response approach to Frankfurt's U-Bahn (underground rail system);
- investigation of SCBA skills maintenance procedures;
- investigation of training simulation for complex environments.

Frankfurt –

As a major European financial hub, known as the business and finance capital of Germany, Frankfurt was the starting point for my ESF scholarship work to continue with obtaining a balanced approach to researching ways in which to enhance emergency responder safety in complex environments.

Direct engagement with The Late Horst Hoffmeister, a well-respected and credible professional firefighter, commenced well before I arrived in Frankfurt. And from the time I arrived, there was a detailed schedule, including:

- working at Fire Station #01 in the Eckenheim District, where specialist appliances and SCBA maintenance was located
- visit to Station #41 (Water Rescue) to look at air management in the marine environment and complex infrastructure from the water
- inspection of the Feuerwehr Rettungs Training Center (FRTC), to investigate training for complex infrastructure (eg. multi storey, tunnel), and SCBA skills maintenance procedures
- inspection of the Frankfurt U-Bahn (underground rail system),
- research on air management principles for complex environments, and specialist appliances for ventilation/extraction of tunnel infrastructure
- Inspection at Taunus Turm; one of the newest high rise structures in downtown Frankfurt, to discuss high rise procedures and vertical air management

Frankfurt Summary –

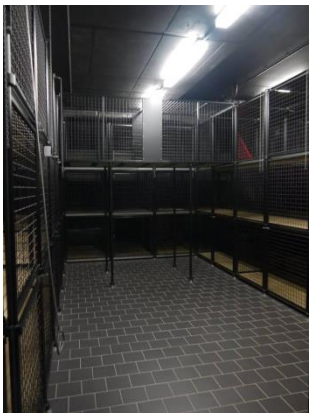
The importance obtained from my Frankfurt trip highlighted a need for promoting a culture of air management from the top down; the importance of annual SCBA skills maintenance and having realistic training environments in line with real risks.

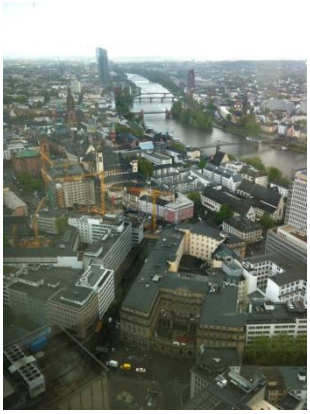
Feuerwehr Frankfurt au Main have an exceptional SCBA Maintenance Department, and their FRTC is second to none. Additionally, specialist equipment (such as the remote controlled track vehicle, LUF 1 and the large ventilation appliance) and long duration SCBA, supports their approach to air management in complex environments and provides enhanced operational capability.

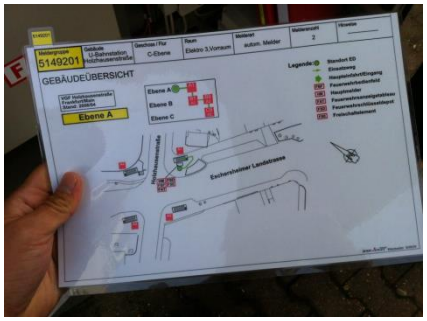
The response to the U Bahn also deserves a mention. The availability of detailed tunnel mapping of every piece of fire service infrastructure based on detector points and hydrants locations and directions, with corresponding egress/exit identification (eg. A1, B1, etc.), and main ventilation/extraction ports (to use in conjunction with their large ventilation appliance). Additionally, supporting all tunnel exit paths, the exit signage and directions are all located down at knee height for clearer visibility in the effect of heavy smoke logging and reduce visibility.

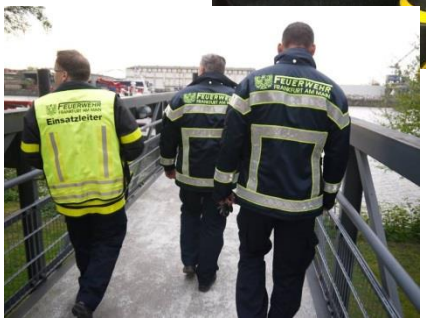
These design features support enhancing efficiency for emergency response within a complex environment.

Selected images from FRANKFURT:

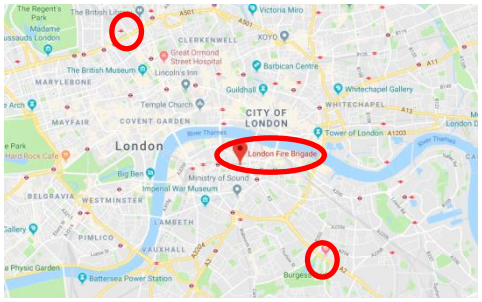








7.6 England



My visit to England had the sole focus of visiting London, to work directly with London Fire Brigade (LFB) and to gather information about their approach to air management in complex environments. This was to focus on London's underground (The Tube), as well as their multi storey environment. I was hosted by Tony Farrant, Technical Support Manager of Respiratory Protection Equipment and Hazmat PPE Team and Dave Topping, Watch Manager Chemical and Environment Section.

Work conducted in London included:

- direct engagement with LFB;
- obtaining direct learnings and discussion on adopting better air management approaches from LFB;
- gathering case studies related to BA 'line of duty deaths', injuries and near misses;
- discussion on response approach to London's complex infrastructure (underground rail system and multi storey;
- investigation of other respiratory protection equipment (ie. extended duration BA and long duration BA) and ancillary equipment (ie. high rise packs, BA control, Telemetry that can also be used for response to complex environments

London –

As a major international city, London is also 'a 21st-century city with history stretching back to Roman times. At its centre stand the imposing Houses of Parliament, the iconic 'Big Ben' clock tower and Westminster Abbey, site of British monarch coronations. Across the Thames River, the London Eye observation wheel provides panoramic views of the South Bank cultural complex, and the entire city.'[11]

During my time working with LFB, my detailed LFB schedule included:

- discussion with LFB Operational Policy and Procedures Department, to further discussions about air management culture and case studies on BA emergencies and firefighter LODD's. There was also an opportunity to link in with another senior manager related to response and procedures for The Tube and transport tunnels;
- a tour of parts of London to get a visual impression of the complex infrastructure (encompassing the vertical, sub-surface, historical);
- working at LFB Old Kent Road Fire Station, in the Southwark Burrough. This is one of LFB's most newly built stations, of which a large proportion of London's multi

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https://www.google.com/search?q=london&oq=london&aqs=chrome..69i57j69i60j0l2j69i60j69i61.2462j0j4&sourceid=chrome&ie=UTF-8, accessed 06/02/19

storey infrastructure are located within Old Kent's response area. Information obtained here related to BA operational and training procedures, records and logging, multistorey equipment (eg. high rise packs) and procedures, BA equipment, BA control and telemetry

- working at LFB Euston Fire Station, in the Camden Burrough. This is one of LFB's older stations, of which has a rescue appliance that responds to complex incidents, such as the London Underground. We had discussion on LFB sub surface procedures and EDBA equipment.

London Summary –

My experiences gained from working in London highlighted traditional focus on air management with the continued emphasis and existence of BA control procedures. Evidence of this focus can be seen from the LFB operational database system that records the daily roles and assignments for the current shift, noting the specific designation of a breathing apparatus entry control officer (BAECO).

Clear visual color distinction between different respiratory protection equipment; with standard BA identified by yellow cylinder safety covers and BA tally tags and EDBA identified by red cylinder safety covers and BA tally tags. Additionally, corresponding air consumption figures on BA control boards are also colored accordingly.

Ancillary equipment for BA, specifically the cylinder protective covers with safety straps, implemented to reduce the possibility of firefighter entanglement between BA cylinder and backplate. The protective cover also protects the SCBA cylinder integrity.

LFB's approach to air management was clearly supported by the use of various types of respiratory protection, with the need to have this specialist equipment readily available and having firefighters specifically trained in their operations.

Other valuable points to highlight was enhanced safety signage in complex environments, such as the London Underground. Within "The Tube", the stairways of the London Underground were marked with the quantity of steps at the top of each stairway. This is useful for emergency crews and public for access and egress purpose.

London has a rich history in firefighting. This has been supported in modern times by the use of specific respiratory protection to assist LFB in protecting life and property throughout London's complex infrastructure. However this approach was tested 2 years ago.

On 14 June 2017, a fire broke out in the 24-storey Grenfell Tower block of flats in North Kensington, West London …, it caused 72 deaths, including those of two victims who later died in hospital. More than 70 others were injured and 223 people escaped. It was the deadliest structural fire in the United Kingdom since the 1988 Piper Alpha disaster and the worst UK residential fire since the Second World War. The fire is under public inquiry, police investigations and coroner's inquests.[12]

Reports have noted that LFB firefighters (amongst other fire brigade resources) "said inside the building they lacked sufficient 'extended duration' breathing apparatus… [and] a London Fire Brigade spokesman said, "The commissioner has made clear her intention to fully review the brigade's resources and seek funding for any additional requirements."[13]

Could FARS have been a workable solution in minimising lives lost in the Grenfell Tower?

[12] https://en.wikipedia.org/wiki/Grenfell_Tower_fire, accessed 19/03/19.
[13] https://en.wikipedia.org/wiki/Grenfell_Tower_fire, accessed 19/03/19.

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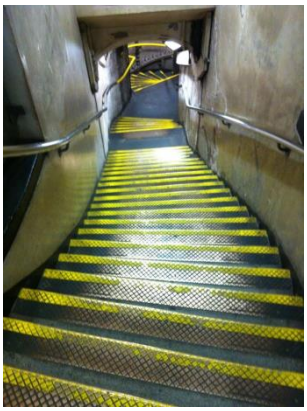

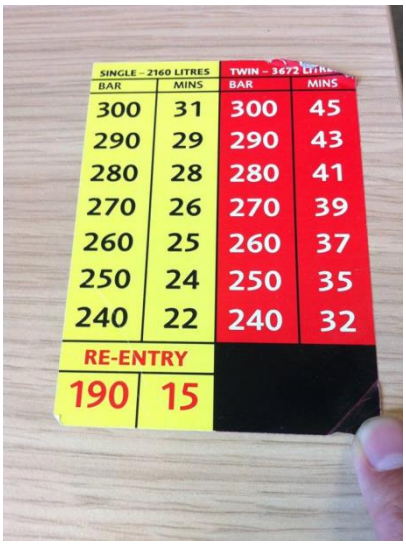

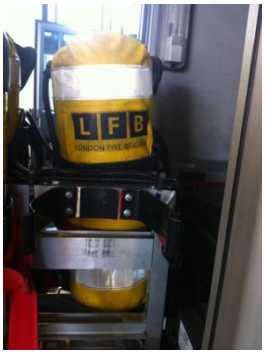

7.7 France

My visit to France had the sole focus of visiting Modane, to work directly with Commandant Frédéric Dutel, from Le Service Departemental d'Incendie et de Secours de la Savoie (The Fire and Rescue Department of Savoie, SDIS 73). Frédéric is an experienced firefighter and tunnel specialist in the French Alps. He was also responsible for managing the response planning for SDIS73 in conjunction with the construction of the Tunnel Euralpin Lyon Turin (TELT).

Work conducted in Modance included:

- direct engagement with SDIS73;
- obtaining direct learnings and discussion on adopting better air management approaches from Commandant Frédéric Dutel and SDIS73;
- discussion on response approach to complex environments such as Tunnel Du Fréjus
- investigation of SCBA skills maintenance procedures for tunnel response
- investigation of training simulation for complex environments, such as tunnels

Modane –

Modane is a commune in the Savoie department in the Auvergne-Rhône-Alpes region in southeastern France. The commune is in the Maurienne Valley, and it also belongs to the Vanoise National Park.

This is a very popular destination for the snow industry, and also for the Tour De France. Modane is a French Alps border town, close to Italy. Although being a mountain town, situated at an altitude of over 1000 metres, Modane is surrounded by many complex environments; with road, rail and climatic.

Direct engagement with Commandant Frédéric Dutel commenced the day I arrived in Modane. The detailed schedule, included:

- visit to Sapeurs Pompiers (SDIS 73) Modane Fire Stationater Rescue) to look at the wide range specialist appliances and equipment, in particular the gear required for complex tunnel response;
- discussion on tunnel air management in the mountainous alpine environment;
- inspection of the Fréjus Tunnel training simulator, to investigate training for complex infrastructure (ie. road tunnel), and SCBA skills maintenance procedures;
- inspection of the TELT (TELT - Tunnel Euralpin Lyon Turin) construction site in Saint-Martin-de-la-Porta, and research on air management during Tunnel Boring Machine (TBM) operations within these complex construction sites.

The Fréjus Road Tunnel is a road tunnel of 12.87 km, connecting France and Italy. It runs under Col du Fréjus in the Cottian Alps between Modane in France and Bardonecchia in Italy. It is one of the major trans-Alpine transport routes between France and Italy being used for 80% of the commercial road traffic.

The Fréjus Rail Tunnel (also called Mont Cenis Tunnel) is a rail tunnel of 13.7 km (8.5 mi) length in the European Alps, carrying the Turin–Modane railway through Mont Cenis to an end-on connection with the Culoz–Modane railway and
linking Bardonecchia in Italy to Modane in France. Its mean altitude is 1,123 m and it passes beneath the Pointe du Fréjus (2,932 m) and the Col du Fréjus (2,542 m).

The Fréjus tunnel remains an important link in the connection between Rome and Paris, via Turin and Chambéry. Following the development of car and truck transportation, the Fréjus Road Tunnel was built along the same path from 1974 to 1980. A future high-speed rail tunnel to improve transit capacity between France and Italy is being planned at a much lower elevation as part of the Turin–Lyon high-speed railway project.[14]

Summary –

The information gathered from my trip to Modane demonstrates how specialist equipment can be used to combat complex infrastructure response. Supported by specialist procedures and interoperability with private industry emergency response, ensures a collaborative approach across borders and jurisdictions.

Seeing the planning put in place for emergency training and response to the TELT construction zones, as well as the specific Fréjus Tunnel training simulation, further demonstrated the emphasis on preparedness to complex infrastructure.

Having an understanding of the FARS innovation, it raised some questions about the possibility of how such a concept could definitely enhance emergency responder safety when operating deep inside tunnel infrastructure. There is a heavy reliance in Modane on self-sufficient respiratory protection provided on two specifically designed tunnel rail response appliances funded by the rail company (Réseau Ferré De France); being the Grande Capacite Rail (GCR 73) and Cellule Lutte Intervention Chimique (CLIC 73). The air supplies are housed and plumbed directly into the appliance cabin, hence providing self-sufficiency for a period of time (based on the capacity of air in the cylinders on board the appliance, which could be for several hours). This design could be supplemented by fixed air on demand through a FARS installation retro-fit within the tunnel network.

Furthermore, with Modane being an alpine town sitting at altitudes between 1,054m and 3,560m above sea level (with an average altitude of 2,307m[15]), the effects of altitude on air consumption and air management are heightened with less oxygen with the more altitude gained.

These experiences of Modane highlighted that serious complex infrastructure needs solutions, as often learnings from previous experiences contribute to those solutions. Victoria has an opportunity for proactivity rather than reactivity, to ensure that the implementation of solutions to complex environments can continue to enhance emergency responder safety.

[14] https://en.wikipedia.org/wiki/Fr%C3%A9jus_Rail_Tunnel, accessed 14/02/19
[15] http://www.map-france.com/Modane-73500/, accessed 19/03/19

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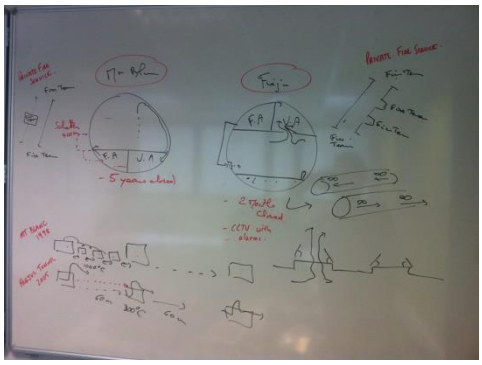
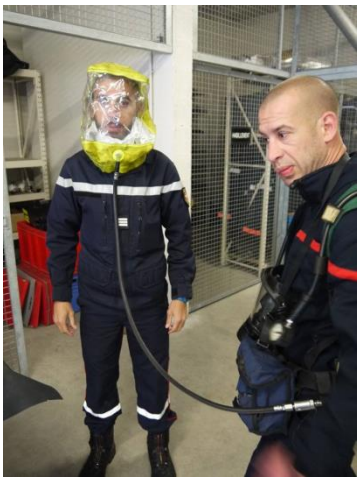
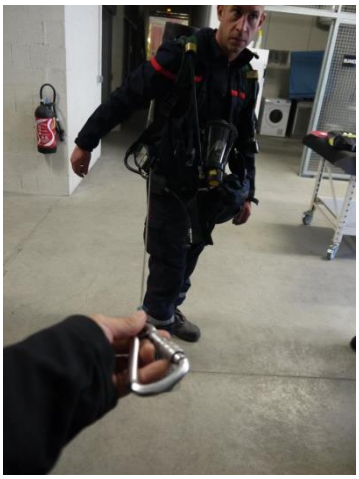
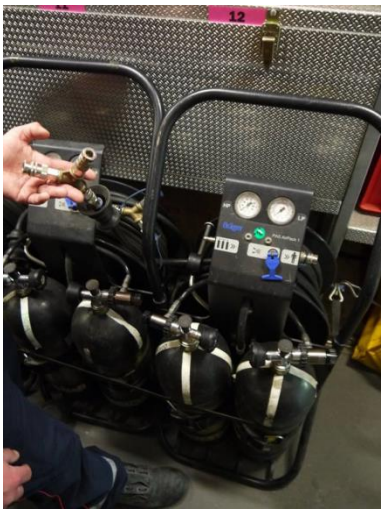
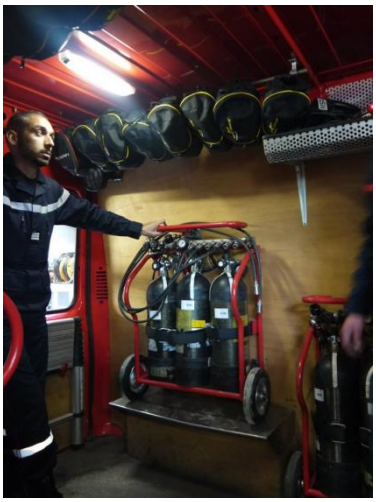










7.8 Australia

Since the completion of my ESF scholarship research travel, I have sought out opportunities in which to further progress the awareness and concepts for enhanced air management, and to support the benefits of inclusion of air systems for emergency responders in complex environments.

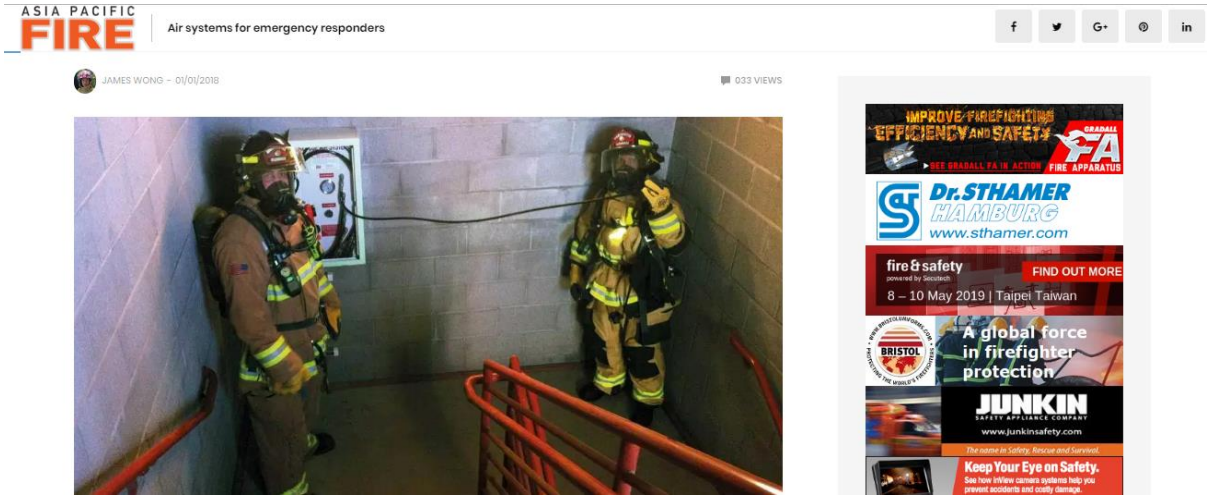
Conducting research into the complex environments within Victoria, this has led me to promote further awareness for FARS and the benefits of the enhance air management opportunities. The focus is primarily on the sub surface tunnel environment, of which will require strong advocacy for further support.

I have had the opportunity to further develop working relationships with Melbourne Fire Brigade (MFB), to engage and be part of some discussion involving the concept of FARS for some of Melbourne's complex tunnel infrastructure, both existing and future (eg. MURL, Metro Tunnel). At the time of writing, I would like to acknowledge the engagement with MFB Assistant Chief Fire Officer (ACFO) Gary Mann and MFB Breathing Apparatus Officer (BAO) Station Officer (SO) Mike Howard AFSM, for their collective support towards advocating for FARS in Melbourne.

I have linked CFA into these complex environment discussions, by developing FARS awareness alongside SO Howard AFSM in a joint 2017 presentation to the CFA Service Delivery Leadership Team (SDLT), as well as briefing both CFA Chief Officer (CO) Steven Warrington and CFA Deputy Chief Officer, DCO (Urban) Gavin Freeman with a separate presentation.

During 2017, further awareness presentations of FARS also occurred with (former) Emergency Management Victoria (EMV) Emergency Management Commissioner (EMC) Craig Lapsley, to other MFB personnel (ACFO Barry Gray) and representatives of the United Firefighters Union (UFU) Victorian Branch.

Through the ESF and Chairman Neil Bibby, I was invited to produce an article for the Asia Pacific Fire Magazine, on the topic of air systems for emergency responders. This article can be located at **https://apfmag.mdmpublishing.com/air-systems-for-emergency-responders/**



During 2018, I was further supported by DCO (Urban) Freeman to present on the national level, and have since conducted separate presentations on FARS to the Australasian Fire Authorities Council (AFAC) Urban Operations Group and the AFAC Built Environment Technical Group, in July and October respectively.

There are more opportunities to create awareness and to ultimately strengthen the advocacy for FARS across Victoria. Other opportunities remain with private industry, to promote the benefits of FARS and focus on air management; having the enhanced focus on safety for employees and emergency responders within tunnel environments (eg. mining and water industries)

Looking at existing complex tunnel infrastructure across Victoria, such as the Melbourne Underground Rail Loop (MURL), Melbourne Water tunnels, and two current tunnel projects (ie. The Metro Tunnel and the Westgate Tunnel), these environments do present significant challenges to emergency responder and public safety. The opportunity for collective advocacy and collaboration across the emergency management sector and Victorian State Government, could assist to allow a concept such as FARS become a real solution to enhancing emergency responder and public safety.

8.0 RECOMMENDATIONS

Based on the work, research and study conducted, as well as my findings, I make the following recommendations:

1. Continue to disseminate awareness of air systems for emergency responders (such as FARS) across Victoria (and Australia); to support an all agencies approach to emergency response and emergency management to enhance emergency responder safety in complex environments;
2. Continue to promote the benefits of air systems for emergency responders (eg. FARS), and to gather collective advocacy for this solution to a complex gap;
3. Evaluation of future opportunities for quick fill capacity of SCBA cylinders across Victoria
4. Investigate further the balanced approach of supplementing the concept of air systems for emergency responders with the use of specialist respiratory personal protective equipment (eg. extended duration breathing apparatus) and other specialist firefighting appliances (eg. mobile air units, ventilation appliances, tracked vehicles for ventilation and fire suppression);
5. Investigate the appetite for private industry to adopt air system innovation for efficiencies gained in minimising privately owned infrastructure and property dollar value loss in relation to equipment and/or business continuity;
6. With emergency management sector advocacy, continued engagement with private industry and building industry to also support the air system concept and potential for inclusion of life saving innovation to significant Victorian infrastructure, with a focus on the sub surface tunnel environments;
7. Victoria maintains a focus on the potential introduction of FARS, specifically into the new construction of the Metro Tunnel and other tunnel infrastructure;
8. CFA and MFB continue to build fire agency advocacy collectively, to influence the key stakeholders of industry and the AFAC audience to support air systems for emergency responders (eg. FARS);
9. Maintain relationship between Rescue Air Systems and Victoria, to further opportunities and insights into the FARS innovation;
10. Victoria continues to support further research and study into enhancing emergency responder safety in complex environments.

9.0 CONCLUSION

Progress in the fire service has often at times been impeded by the very traditions that we all embrace. Nevertheless, technological advances in the fire service do occur, sometimes with lightning speed and sometimes with painful slowness. Either way, every new technology has to be evaluated within our traditions and address the risks that we assume are part of our community's problems.[16]

I have conducted extensive research into FARS. Air systems appear to be a real option to lead the way in what may prove to be the most revolutionary innovation to hit the fire services in decades, can reduce the amount of staffing necessary for the labour-intensive task of maintaining an adequate supply of SCBA at high-rise fires, underground tunnels, and other all-hazard threats that may afflict a structure and put more demands on our management needs.[17]

Air systems for emergency responders are multi-dimensional; these systems will save lives, they will save time, they will save money, and all combining to ensure BAU activities can continue as normal as soon as possible. This benefits Victorian communities, our EM sector and the private sector. Such benefits that we can already see evidence from internationally.

The investigation and analysis of different methodologies and approaches across Europe, North America and Australia, has provided a balanced approach with respect to emergency response in irrespirable atmospheres within complex environments. Having a focus on major community and infrastructure risk of high consequence, I have been able to look at comparisons and differences between Melbourne and other major international cities. This has provided intelligence into what solutions are realistic to benefit Melbourne, and Victoria abroad.

The FARS innovation has quickly gained momentum within North America, and continues to spread throughout the country today. More than 500 buildings in 10 states are now equipped with these systems, and they are required in more than 80 jurisdictions across the country. And more cities are adding this requirement to their fire codes every year.[18]

Air systems for emergency responders can be a simple solution, not only for enhancing, but ensuring emergency responder and public health and safety into our future.

[16] RescueAir Systems Inc., "Firefighter Air Replenishment Systems (FARS) Training Manual", Microsoft Powerpoint presentation
[17] Rush III, Joseph D. (April 2012), "The Case for Interior High-Rise Breathing Air Systems", Fire Engineering: Training Digest
[18] http://rescueair.com/, accessed 19/03/19

10.0 ACKNOWLEDGEMENTS

In completing this ESF report, I would like to acknowledge the efforts of many people. As there are too many people to list down who assisted me in some form or another, I would like to make an overall acknowledgement to you all.

Thank you to the Emergency Services Foundation for providing the opportunity and for continuing to motivate Victorian emergency services personnel through the scholarship scheme. Many thanks to Jenny Davis, ESF Executive Officer for all her assistance in the lead up to, and post, my scholarship work.

To CFA, thank you for supporting me to represent the agency in this space and for the ability to undertake this scholarship study and research.

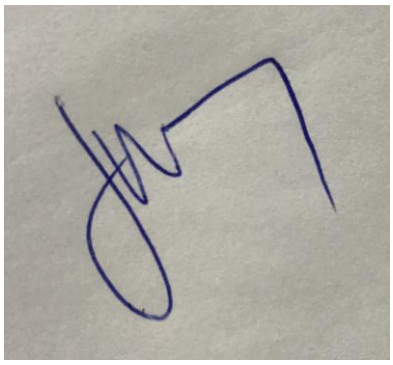
There are some specific people who I would like to thank (and not in any particular order) for making this ESF scholarship possible for me:

- Chief Officer, Steven Warrington AFSM, CFA
- Deputy Chief Officer Gavin Freeman AFSM, CFA
- Deputy Chief Officer Alen Slijepcevic, CFA
- Executive Director Volunteers and Strategy John Hayes, CFA
- Operations Manager Stephen Walls, CFA
- Operations Manager Rick Owen AFSM, CFA
- Operations Manager Graham Lay, CFA
- Operations Officer Glenn Jennings AFSM, CFA
- Pat Hunter, Project Manager – Performance Improvement, CFA
- Assistant Chief Fire Officer Gary Mann, MFB
- Station Officer Mike Howard AFSM, MFB
- Station Officer Louise Cannon, MFB

- Captain Mike Gagliano (Retired), Seattle FD
- Anthony Turiello, CEO Rescue Air Systems
- Jeff Allen, FARS Technician, Rescue Air Systems
- Fire Chief Mario Trevino (Retired), San Francisco FD, Las Vegas FD
- Fire Chief Gary Morris, Pine Strawberry FD
- Fire Chief Scott Baker, Tahoe Douglas Fire Protection District
- Battalion Chief Rich Nalder (Retired), Tahoe Douglas Fire Protection District
- Fire Chief Walt W White (Retired), Sacramento FD
- The Late Horst Hofmeister (Brandamtsrat), from Feuerwehr Frankfurt au Main
- Tony Farrant, Technical Support Manager RPE & Hazmat PPE, London Fire Brigade
- Commandant Frédéric Dutel, Le Service Departemental d'Incendie et de Secours de la Savoie (The Fire and Rescue Department of Savoie, SDIS 73)
- Sebastien Lahaye,

Lastly, I would like to thank and acknowledge my wife and children. The support from Freya, Jasper and Ruby, towards me to undertake this ESF scholarship is greatly appreciated. Without their support and ability to manage themselves, I would not have been able to complete an international study tour of this magnitude. Their support is ongoing, and that allows me to continue my passion and motivation towards enhancing emergency responder and public safety in complex environments.

Statement by Candidate:



(signature)

I declare that the information given in this application is to the best of my knowledge, complete and accurate. I agree to observe the conditions of the Award known as the Combined Emergency Services Foundation Scholarship Scheme and to advise the Directors of the details it requires in the administration of the Award.

13 June 2019

(date)

Recommendation by Head of Associated organisation: (Yes) / No

Remarks:

Refer to following page for letter of endorsement and support provided Gavin Freeman AFSM, Country Fire Authority Acting Chief Executive Officer / Chief Officer

Priority Order N#:

Refer to letter on following page

(signature)

28 May 2019

(date)

Patron: Her Excellency the Honourable Linda Dessau AC, Governor of Victoria

Office of the CEO
Headquarters
8 Lakeside Drive, Burwood East Vic 3151
Phone: 9262 8605

28 May 2019

Mr James Wong
Senior Station Officer
Country Fire Authority
8 Lakeside Drive
BURWOOD EAST 3151

By email: j.wong@cfa.vic.gov.au

Dear James

I write in regard to your Emergency Services Foundation Scholarship report titled *'Air Systems for Emergency Responders'*.

Upon reading your report, it is evident that you have gained a strong understanding of the air systems for emergency responders, including FARS, which has the potential to improve our Emergency Management Sector in a number of valuable ways, as it has already done so internationally.

Within your report, I have found the concept of Installed Firefighter Air Systems fascinating and I can see how introducing this concept has the possibility to strengthen our approach to firefighter safety. The further development of the concept in Australia will depend on the engagement with industry and the acceptance of the approach by our responders.

I know you have continued to pursue these options through engagement with the National Urban operations and the National Built Environment groups of AFAC.

Congratulations on your research project and well done on the thorough, passionate and professional approach you have bought to this task.

Yours sincerely,

Gavin Freeman AFSM
Acting Chief Executive Officer / Chief Officer

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