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Public Skills Australia

Milestone 3 – Training Needs Analysis Report

Fire and Emergency Services - Complex Infrastructure

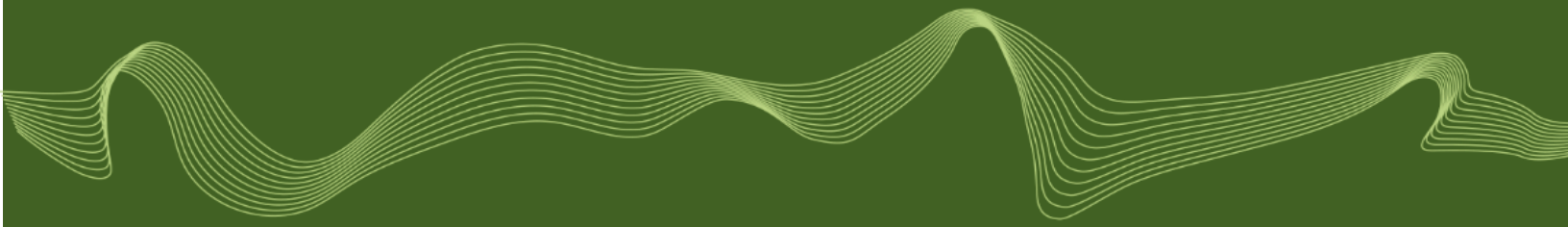
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Acknowledgement of Country

Public Skills Australia respectfully acknowledges the Traditional Custodians of country throughout Australia and their connections to land, sea and community.

We pay our respect to their Elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples today.



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Introduction

As infrastructure continues to evolve, firefighters[1] are increasingly required to respond to emergencies[2] involving complex infrastructure. Such emergencies are defined as those specifically relating to:

> Built environments where size, layout, hazards, occupancy, or systems significantly complicate response, command and control, and safety. These are typically high consequence incidents, presenting unique operational challenges to the firefighters who respond to them.

For the purposes of this report all challenges, themes and considerations apply as they relate to this definition.

Fire and Emergency Service Complex Infrastructure Project

Public Skills Australia's *2025 Public Safety Workforce Insights Report* identified a workforce challenge regarding responding to incidents involving complex infrastructure. The *Fire and Emergency Service Complex Infrastructure Project* (the project) aimed to establish a robust evidence base through a Training Needs Analysis (TNA) to ascertain how the PUA Public Safety Training Package could support training for complex infrastructure emergencies. This was achieved by identifying the knowledge and skill requirements for responding to complex infrastructure emergencies and then mapping these requirements against the current PUA Public Safety Training Package and identifying gaps in the current training products.

Phase 1

Phase 1 of the project required two key milestones:

- Milestone 2: Stakeholder Insights Report
- Milestone 3: Training Needs Analysis.

Phase 2

Dependent on the outcome of Phase 1, Phase 2 would see an update of the PUA Public Safety Training Package to address the knowledge and skill requirements identified in Phase 1.

[1] Throughout this Training Needs Analysis, the term 'firefighter' is used collectively and includes all services responding to fire incidents including volunteer firefighters.

[2] For the purposes of this report, the term 'emergency(ies)' should be read to include and reference 'incident(s)' and vice versa.

Milestone 2: Stakeholder Insights Report

Drawing on consultations with stakeholders and subject matter experts across Australia and internationally, the *Stakeholder Insights Report* (the report) identified three priority complex infrastructure types:

HIGH AND MID-RISE BUILDINGS	LARGE VOLUME SPACES	TRANSPORT TUNNELS

The three complex infrastructure types were prioritised due to the high-consequence nature of incidents and the operational complexity they present to Fire and Emergency Services. Consultations during and post workshops highlighted several challenges for responding to complex infrastructure emergencies, including:

CHALLENGE 1:

In the absence of specific complex infrastructure training products, firefighters may rely on training more suited to residential structure fires[3] when responding to incidents in complex infrastructure environments.

CHALLENGE 2:

Knowledge transfer frequently occurs through on the job mentoring in addition to structured training.

CHALLENGE 3:

Training is required that prepares firefighters to respond to different building types, systems, hazards and risks present in these environments.

These findings reinforced the need for this Training Needs Analysis (TNA) to map the additional skills and knowledge requirements against the existing PUA Public Safety Training Package, and to identify opportunities to better prepare firefighters to respond to a range of building types and safely navigate the complexities of building systems and the hazards and risks associated with these environments.

[3] Residential house fires were described by stakeholders as 'typical' one-to two-storey house fires.

HIGH AND MID-RISE BUILDINGS

High and mid-rise buildings are multi-storey structures, with high-rises typically being 25 metres and above, and mid-rises being below 25 metres in height. Specific categories of these infrastructure types where enhanced capability may be required include:

- ***High rise and multi storey buildings:*** *Buildings such as office towers, apartment buildings, and hotels present unique challenges due to vertical access, complex evacuation requirements, fire behaviour (including wind driven fires and combustible cladding) and smoke movement through shafts and stairwells.*
- ***Mixed-use or multi-occupancy complexes:*** *Buildings combining residential, commercial, and public spaces present different risk profiles in their structure and occupancy, which increases coordination complexity.*
- ***High-risk or special-use buildings:*** *Buildings such as data centres, and energy infrastructure, occupants and/or contents that increase the consequences of fire.*
- ***Massive timber or tall timber buildings:*** *Buildings made of engineered timber (e.g. cross-laminated timber) presents challenges due to its combustible structural elements and unique fire behaviour.*

LARGE VOLUME SPACES

Large volume spaces are structures with expansive open floor areas and high ceilings, characterised by limited internal walls and compartmentation. Infrastructure categories where enhanced capability may be required include:

- ***Waste facilities:*** *These facilities are complex due to high fire loads and deep-seated fires, often involving lithium-ion batteries, poor visibility and extended fire duration. This includes illegal waste storage facilities (housing unknown types and quantities of chemical waste and other dangerous waste products).*
- ***Automated vehicle parking systems (car stackers):*** *Usually located in densely populated urban areas, these spaces can restrict access for firefighters. Densely packed vehicles often cause rapid fire spread.*
- ***Automated storage and retrieval systems (ASRS):*** *With automated warehouses, the use of robotic retrieval systems can mean rapid fire spread, large fuel loads, large compartments, limited access for firefighting, limited visibility, and sprinkler systems being less effective due to the deep-seated nature of fires within densely packed items and racks.*

TRANSPORT TUNNELS

Transport tunnels are enclosed, linear transport structures, often underground, with confined geometry, limited access points and natural ventilation. Challenges for firefighters include scale, limited access, communication and ventilation.

Milestone 3: Training Needs Analysis

Milestone 3, the Training Needs Analysis (TNA), in summary:

Identifies seven knowledge and skill themes required for responding to incidents involving complex infrastructure:			
1. Fire behaviour	2. Fire dynamics	3. Smoke behaviour	4. Water properties
5. Infrastructure features	6. Building systems	7. Building codes and standards	

Recommends that training products which address the knowledge and skills required to respond to incidents within complex infrastructure environments are developed while considering:	
The depth of complex infrastructure related content	Organising fundamental knowledge and skills.

Further recommends that the following knowledge and skills requirements for complex infrastructure environments should be considered in any training product development:	
Fire behaviour and dynamics	Smoke behaviour and management
Water properties and supply	Regulatory awareness

Training Needs Analysis

A TNA is a systematic process used to address and identify performance gaps that hinder the achievement of objectives. It focuses on determining potential gaps between the current and desired knowledge and skills required to perform a role effectively.[4] For the purposes of this report:

'Knowledge requirements' refers to information, concepts and theories required to understand work.	'Skill requirements' refers to the technical/practical proficiencies gained through training/experience.

[4] An analysis of this kind is typically undertaken when an organisational or operational issue is identified and where training or education is likely to improve performance and operational outcomes.

Methodology

Public Skills Australia undertook the TNA using a combination of consultations and targeted desktop research to identify knowledge and skill requirements for firefighters responding to complex infrastructure emergencies. The consultations were designed to gather perspectives from practitioners and subject matter experts on training gaps and capability requirements and aimed to:

- Identify gaps in the skills and knowledge outlined in the PUA Public Safety Training Package.
- Recognise emerging capability requirements associated with complex infrastructure.
- Establish whether new PUA Public Safety Training Package training products should be developed.

Perspectives from practitioners and subject matter experts on the knowledge and skill were analysed to identify common themes, areas of agreement and current gaps in the PUA Public Safety Training Package. Public Skills Australia mapped the identified themes against ten selected units of competency:

PUAFIR203	Respond to urban fire	PUASAR025	Undertake confined space rescue
PUASAR023	Participate in a first response urban search and rescue Category 1	PUASAR031	Undertake an urban search and rescue Category 2 rescue technician
PUAFIR302	Suppress urban fire	PUAFIR403	Assess building plans
PUAFIR507	Inspect building fire safety systems	PUAFIR220	Respond to isolated structure fire
PUAOPE022	Manage logistics for a complex incident	PUAFIR411	Provide safety advice at an urban incident

Consultations

Public Skills Australia undertook consultations with the following stakeholders:[5]

- Department of Fire and Emergency Services
- Fire and Rescue New South Wales
- Fire Rescue Victoria
- Northern Territory Fire and Rescue Service
- Queensland Fire and Rescue
- South Australian Metropolitan Fire Service
- Tasmania Fire

[5] Stakeholders included representatives working within the enterprise RTO components of Fire and Emergency Services organisations, representatives of employee bodies and international subject-matter experts.

Thematic Analysis

Complex infrastructure incidents present a range of distinct challenges for Fire and Emergency Services.[6] Throughout consultations, stakeholders consistently emphasised that effective response requires a combination of technical understanding (knowledge requirements) and practical tasks (skill requirements).

Stakeholders pointed out a range of knowledge and skills required by firefighters when responding to complex infrastructure incidents. Public Skills Australia reviewed and synthesised this input, grouping the identified knowledge and skill requirements into common themes to support analysis.

Table 1 provides a breakdown of the seven themes, detailing the specific technical concepts and key words raised during consultations and the definitions used in the thematic analysis. These themes should be revalidated through the development of units of competency for complex infrastructure.

Table 1 Seven themes and associated knowledge and skill requirements

FIRE BEHAVIOUR	
Stack effect Piston effect Travelling fires Wind driven fires Compartmentation	The study of how flames ignite, spread and interact with their environment.
FIRE DYNAMICS	
Physics of fire Chemistry of fire Heat release rate	The study of how chemistry, fire science, material science, fluid mechanics and heat transfer interact to influence fire behaviour.
SMOKE BEHAVIOUR	
Coandă effect Smoke travel Smoke effect on humans	Study of the characteristics of smoke produced during a fire, to determine the fire's behaviour, size, location and potential threats.
WATER PROPERTIES	
Water systems Pressure/ flow rate Hose/nozzle/branch Pump/hydrant/booster systems	The physical and thermal characteristics of water that determine its effectiveness as an extinguishing media.

[6] During the TNA consultation, stakeholders in several jurisdictions raised maritime incidents as an emerging operational challenge, including fires on boats, ships or yachts both at sea and within marinas. Maritime incidents were not raised during consultations for the *Stakeholder Insights Report* so were therefore not included.

INFRASTRUCTURE FEATURES	
Internal layouts Stairwells/lifts Occupancy type Cladding Modern fuels	The built, installed or fixed elements of infrastructure that may influence fire behaviour, firefighting safety and access and egress.
BUILDING SYSTEMS	
Hydrant/booster systems Sprinkler/deluge systems Ventilation systems Control panels/lift keys	One or any combination of the methods used in a building to facilitate fire safety.
BUILDING CODES AND STANDARDS	
National Construction Code Building standards Historic codes and standards	Sets out, with reference to the National Construction Code, the minimum technical requirements for new buildings, including equipment, services, systems and features relevant to fire safety.

Fire Behaviour

Knowledge of fire behaviour was identified as an area requiring consideration and enhanced understanding when responding to complex infrastructure emergencies. The TNA consultations reaffirmed that fire behaviour is influenced by structure type, driven by factors such as scale, compartmentation and ventilation systems. These are linked to the skills required in equipment selection, suppression tactics, smoke management and evacuation. **Stakeholders indicated that current training could be better supported by specific consideration of how fire evolves and behaves in complex infrastructure environments.**

While fire behaviour is referenced in existing training, including the PUA Public Safety Training Package, stakeholders identified the need for training products focusing on selection of appropriate tactics based on fire conditions when responding to complex infrastructure incidents.

STAKEHOLDER INSIGHT
Training products should include fire behaviour knowledge to enhance technical, tactical, strategic and operational skills in responding specifically to fires in complex infrastructure environments.

Fire Dynamics

Gaps in firefighters' knowledge of fire dynamics was identified as a critical factor impacting effective responses in complex infrastructure emergencies. Stakeholders emphasised that a strong understanding of fire dynamics is essential for interpreting and predicting fire behaviour. **Stakeholders identified that training products are required that reflect the latest research on fire dynamics in complex and high-rise structures.**

STAKEHOLDER INSIGHT

Acknowledging that complex infrastructure environments rapidly change, training products should consider how contemporary research on fire dynamics is essential for accurately predicting fire development in complex infrastructure environments.

Smoke Behaviour

Smoke behaviour emerged as a distinct challenge, particularly in enclosed infrastructure such as rail and road tunnels. Stakeholders noted that smoke accumulation in these environments can occur rapidly, endangering firefighters and others, making an understanding of the impacts of smoke on human health, smoke movement and ventilation critical to managing complex infrastructure emergencies. **TNA consultations recognised smoke behaviour and ventilation management in complex infrastructure as a significant challenge.** One stakeholder observed that "*we don't actively train on managing ventilation and smoke in tunnels … deluge and ventilation systems are key in these types of fires*." Knowledge of smoke behaviour is also important in high-rises, with smoke movement impacting areas of the building seemingly unaffected by fire.

STAKEHOLDER INSIGHT

Training products should be developed to provide a deeper, theoretical understanding of smoke behaviour and ventilation management in complex infrastructure.

Water Properties

Stakeholders identified that further knowledge and skills related to water properties, including water behaviour and water systems, could be developed to better support responses to incidents involving complex infrastructure environments. It was raised that training tends to focus on water selection, rather

than understanding the physical properties of water. **It was also raised that training products should consider that water supply in complex infrastructures can be unpredictable due to system design limitations and ageing infrastructure.**

Stakeholders further indicated the opportunity to enhance skills related to water and hose management. In high-rise settings, hose line selection and hose management skills are critical. Stakeholders cited unfamiliarity with water systems and limitations in practical skills in relation to hydrant plug-in and hose deployment in high-rise stairwells as challenges. Additionally, sourcing and managing water supply at complex infrastructure emergencies was identified as a key knowledge and skills consideration that could further support effective response to incidents in complex infrastructure environments.

STAKEHOLDER INSIGHT

Training products should allow for enhanced skills and knowledge related to managing unpredictable water systems and complex hose deployments within complex infrastructure environments.

Infrastructure Features

Infrastructure features were also identified as having an influence on fire and smoke behaviour and are therefore a critical knowledge component. 'Infrastructure features' includes both the physical attributes of the infrastructure and aspects relating to occupancy. **TNA consultations emphasised that the scale, location and internal configuration of structures pose significant challenges to fire suppression and the safe evacuation of occupants**. Multiple stakeholders raised the importance of understanding floor plans, layouts and structure use, specifically stairwells to support access, evacuation and fire suppression in high-rise buildings and large volume spaces.

Several stakeholders also noted that there is limited training on responding to different infrastructure features within complex infrastructure (such as lithium-ion batteries). Notably, firefighters were reported to be uncertain at times about how to appropriately manage such features, especially in large volume spaces such as warehouses and self-storage sites.

STAKEHOLDER INSIGHT

Training products should address how different infrastructure features influence how fire and smoke behave, necessitating different tactical approaches.

Building Systems

Across the TNA consultations, stakeholders consistently identified building systems as a key knowledge requirement for effective response to a complex infrastructure emergency. Building systems are one or any combination of the methods used in a building to facilitate firefighting operations. Within this context the systems most frequently cited include:

Hydrant systems	Sprinkler systems	Deluge systems
Booster systems	Ventilation systems	Control panels/lift keys.

Stakeholders emphasised that training products should promote a more detailed understanding of building systems. As one stakeholder noted "*getting the building systems to work in a safe manner is important"*, while another stressed the importance of "*understanding if these systems are working well while there is a fire*."

Stakeholders reported some gaps in operational understanding of specific systems in complex infrastructure environments, such as hydrant and booster systems, sprinklers and ventilation systems. These gaps are compounded by the challenges of inadequately maintained systems, and the unpredictability of water systems in high-rise buildings due to design limitations, underscoring that firefighters are often unaware of these systems' constraints and performance.

STAKEHOLDER INSIGHT

Training products should connect theoretical awareness of building systems and related operational skills with practical aspects of responding to complex infrastructure emergencies.

Building Codes and Standards

Stakeholders drew attention to challenges arising from changes to the National Construction Code (NCC) and building standards, noting that fire safety systems and features can vary widely depending on when a building was constructed. It was expressed that although the NCC has changed over time, the fire safety systems installed within the buildings reflect the standards at the time of construction, resulting in variation across buildings and structures in Australia.

Furthermore, it was emphasised that firefighters cannot assume fire safety systems will be the same across all types of structures. For example, one stakeholder noted that "*older buildings under 25 metres*

don't have sprinklers and protected evacuation pathways, but the new ones do", pointing out that some buildings are also being fitted with new technologies such as electric vehicle battery chargers. This variability across building codes over time complicates operations since firefighters must identify the presence or absence of different systems in a timely manner. **Stakeholders identified that issues such as knowledge of these systems and their variability across structures is important when responding to complex infrastructure emergencies.**

STAKEHOLDER INSIGHT

Training products should include awareness of NCC, building codes and building systems, as well as the changes to these over time.

Knowledge and Skill Trends

While all identified knowledge and skill requirement themes were raised by stakeholders in consultations, they were not raised in every jurisdiction. The chart below illustrates that although stakeholders emphasised different operational pressures, there is strong and recurring alignment about the knowledge and skills required for responding to complex infrastructure emergencies.

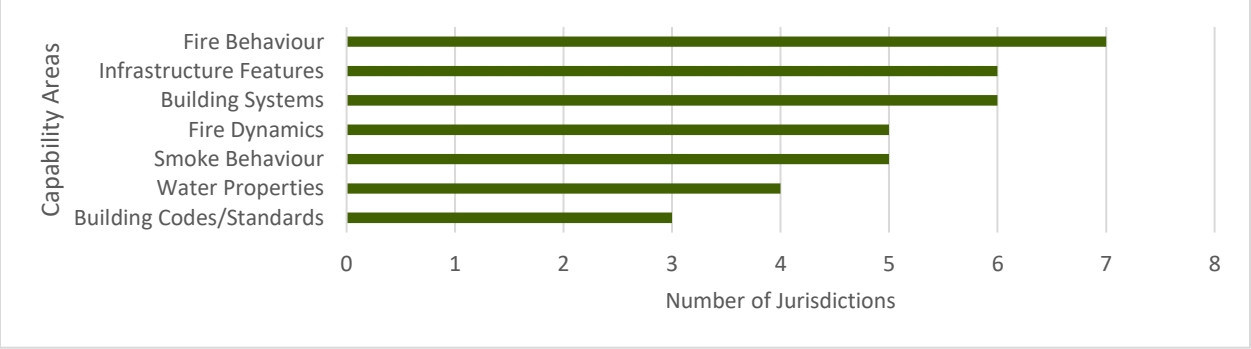


Figure 1 Knowledge and skills most frequently identified by stakeholders.

Fire behaviour was most consistently raised across jurisdictions, followed by infrastructure features, building systems, fire dynamics and smoke behaviour, reinforcing the focus on foundational theoretical knowledge that underpins operational decision-making.

STAKEHOLDER INSIGHT

To respond to complex infrastructure emergencies, firefighters need to use tactics and approaches suitable for the type of infrastructure involved and the associated hazards and risks.

Stakeholders acknowledged that while foundational knowledge and skill requirements are broadly relevant to both residential and complex infrastructure settings, their application differs substantially. This is due to the increased scale, building materials, structural and system complexity and the operational uncertainty inherent in complex infrastructure emergencies. These factors increase demands on firefighters, particularly related to tactical considerations, situational awareness and the ability to adapt to rapidly changing conditions.

Knowledge and Skill Mapping

The knowledge and skills mapping conducted by Public Skills Australia demonstrates that the seven themes identified through the TNA align to varying degrees with existing knowledge and skill requirements across the ten selected units of competency. The mapping confirms that the urban fire units are entry level training for firefighters and training products are required to address identified gaps within specialist level firefighting. Further analysis identified that the following three units of competency contained multiple elements and performance criteria referencing the knowledge and skill requirements:

- PUAFIR203 Respond to urban fire
- PUAFIR302 Suppress urban fire
- PUAFIR411 Provide safety advice at an urban incident

However, mapping confirms that these overlaps are often indirect, broad or implied within wider performance criteria, rather than related to complex infrastructure-specific requirements. This further reinforces that training products are required and address specific gaps to respond to complex infrastructure at a specialist level.

Recommendations

This report recommends that training products in the form of one or more units of competency are developed to address the knowledge and skills requirements to respond to incidents within complex infrastructure. The training product development should consider the following recommendations:

1. **Increase the depth of content:** Develop elements and performance criteria to provide the depth necessary for real-world technical and tactical adaptation.
2. **Organise fundamental knowledge and skills:** Focus on critical thinking and adaptive decision-making in complex infrastructure environments.
3. **Capture relevant knowledge and skills:** Bridge identified gaps and ensure they accurately reflect the current and evolving demands of responding to complex infrastructure incidents.

This report further recommends that the knowledge and skills pertaining to the following themes be addressed in the development of new unit/s of competency.

Fire and smoke behaviour and fire dynamics: Integrate comprehensive contemporary fire and smoke behaviour and fire dynamics within training products with a scaffolded approach to support firefighters' understanding of technical and tactical considerations.

Ventilation and smoke: Embed ventilation management by developing deeper requirements for understanding smoke behaviour and ventilation management within complex infrastructure environments.

Water properties and supply: Provide firefighters with a fundamental understanding of water properties, equipment selection and deployment for complex infrastructure emergencies.

Infrastructure-informed tactics: Focus on infrastructure-informed tactics supporting firefighters to understand how specific infrastructure features impact fire and smoke behaviour.

Regulatory awareness: Integrate an understanding of the NCC, its changes over time, and how these relate to infrastructure features.

These new unit/s of competency should be added to the elective bank of relevant qualifications.

Conclusion

As the built environment continues to evolve, complex infrastructure presents challenges for firefighters which require a corresponding uplift in capabilities. The TNA identifies a need for deeper technical knowledge and practical skill application across seven themes. Addressing gaps through training product development will support a timely response to the current challenge.