Fire Safety Engineering

Competencies Report

Report 5 of this Series

THE WARREN CENTRE

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FIRE SAFETY ENGINEERING PROJECT

This is the second research project of The Warren Centre at the University of Sydney relating to Fire Safety Engineering. The first project in 1989 paved the way for the creation of the Fire Code Reform Centre to co-ordinate fire research nationally in 1994 and gave major impetus to the development of the performance-based Building Code of Australia, published in 1996. This current Warren Centre Project on fire safety engineering will address many of the major challenges facing governments, regulatory authorities and practitioners in relation to fire safety engineering and community safety in buildings.

OUR PROJECT SPONSORS

The Warren Centre thanks our project sponsors who made this research and these reports possible. This report represents the technical judgment and opinions of expert authors in the field of Fire Safety Engineering and the building design industry. These views are not necessarily endorsed or adopted by the sponsors.

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The status of the engineering profession and the necessity for all members practising the profession to be licensed.

WILLIAM HENRY WARREN

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Executive Summary

THIS REPORT PROPOSES A COMPETENCY FRAMEWORK FOR FIRE SAFETY ENGINEERS.

THE COMPETENCY FRAMEWORK PROPOSED POINTS TOWARDS AN ACCREDITATION FRAMEWORK FOR PROFESSIONAL ENGINEERS. THE FRAMEWORK CONSISTS OF TWO STAGES OF COMPETENCY AND IS BASED ON THE ENGINEERS AUSTRALIA MODEL COMPETENCY FRAMEWORK AND ON THE COMPETENCIES EXPECTED FROM AN ENGINEER EXITING AN ACCREDITED ENGINEERING DEGREE PROGRAM IN ONE OF THE WASHINGTON ACCORD SIGNATORY COUNTRIES.

This competency framework recognises that a Fire Safety Engineer should have the same general competencies as any other engineer and that the discipline specific knowledge has to be outcomes-based. Furthermore, there has to be a recognition that there are at least two clear modes in which a Fire Safety Engineer will practice: as either a generalist or a specialist. The competencies required of a professional engineer to function in these two modes are different, and therefore a competency framework that enables both of the different modes of operation is necessary.

To enable both practice modes, the complete competency framework has to include some competencies commonly associated with Architecture.

The intended method of attainment of Stage 1 competencies by an individual is though the conferment of a degree by a degree granting institution which has been accredited by the national professional body for engineering as satisfying the required competencies for that first stage. This means that the degree granting institution and the national professional body

This report responds to a need to professionalise Fire Safety Engineering and to increase the consistency of competence of Fire Safety Engineers throughout Australia.

have to agree curriculum and pedagogy as well as staff and environment that can deliver a degree that provides adequate exit level competencies. This agreement is delivered through the process of academic course accreditation. Through this process, the professional bodies and the degree granting institution agree the means by which the competencies will be attained. The professional bodies and the degree granting institutions must also agree how the product (i.e. the graduate) of the academic program will be assessed.

The accreditation process grants credibility to the Fire Safety Engineering graduates because it certifies that completion of the degree represents attainment of Stage 1 of the professional engineer accreditation process. This accreditation process is at the core of "professional monopoly," which is essential for a professional framework to be functional.

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Stage 2 follows Stage 1, and the competencies defined by this framework for Stage 2 are mostly based on experience, continuous professional development and continuous and demonstrable auditing. The definition of the Stage 2 competencies is the prerogative of the national professional body.

This report responds to a need to professionalise Fire Safety Engineering and to increase the consistency of competence of Fire Safety Engineers throughout Australia. This was identified elsewhere in this Warren Centre project on Fire Safety Engineering. The realisation of this objective requires a more detailed and precise definition of what knowledge, skills and attributes deem competent a Fire Safety Engineer, and it also requires raising of the bar within the professional community to demonstrate that these knowledge requirements, skills and attributes are consistently met.

Raising the bar means not only the establishment but also the implementation of a rigorous competency and accreditation framework for professional engineers. An important and currently non-existent component of this framework are the academic courses on which their Stage 1 competencies and attributes are typically based. It is clear that implementation of this framework requires the development of the academic programs and their accreditation. While resources should be invested in developing programs that could deliver Stage 1 competencies, every program granting degrees should put all necessary efforts to raise the bar and achieve academic course accreditation.

1. Introduction

When discussing a competency framework, it is necessary to draw a clear distinction of the various compenents that may make up that framework, since inevitably there is confusion surrounding the terminology. Generally, any professional competency framework will comprise various elements of competency which include knowledge, skills and attributes. An attribute is a quality or a feature of an individual that may be regarded as characteristic of them. In contrast to a trait which is often considered to be ingrained, an attribute may be attained through external influence. Knowledge is the understanding of key principles and information about the particular field. A skill is an ability to carry out a task well, including through the application of knowledge. There are several competencies required for practice, and each of these competencies is generally a mix of knowledge, skills and attributes. Thus knowledge, a skill or an attribute may be defined as an element of competency.

The purpose of any competency framework for professional engineers should be to define the knowledge, skills and attributes, i.e. the elements of competency that as a whole are required to be able to demonstrate a level of competency that a professional practising engineer should possess.

The need for a definition of what is deemed a competent a Fire Safety Engineer was described in detail elsewhere in this Warren Centre project.[1] This current document responds to that need as well as to the role of Fire Safety Engineers described earlier in the Warren Centre "Roles Report"[2] and describes a competency framework for Fire Safety Engineers.

No matter what the details of the process, the desired result of the process of admission to professional practice as a Fire Safety Engineer in in Australia should yield an individual with a demonstrated level of competency on a par with other engineers admitted to the Engineers Australia (EA) National Engineers Register (NER) and granted the title of Chartered Professional Engineer (CPEng).

Alternatively, the comparator should be engineers who are registered to practise in a state or territory where registration is mandatory for practice. In this latter case this means an engineer possessing the competencies described in this document as demonstrated by holding NER registration or equivalent would be awarded a title such as Registered Professional Engineer Queensland (RPEQ) or equivalent.

It must be noted that the legislative landscape for Fire Safety Engineering in Australia is changing at the moment (as of February 2020). Therefore, for added clarity, the level of competency being discussed is that of Chartered or Professional Engineer. According to the Engineering Council UK, Chartered Engineers (CEng) *"develop solutions to engineering problems using new or existing technologies through innovation, creation and change and they may have technical accountability for complex systems with significant levels of risk".*

The process for admission to professional practice (which includes course accreditation) is typically managed by a national professional body, such as Engineers Australia (EA), which represents and promotes the interests of engineers in their home country. Assessment

[1] Torero J., Lange, D., Horasan, M., Osorio, A., Maluk, C., Hidalgo, J., Johnson, P., (2019) The Education Report: Current Status of Education, Training and Stated Competencies for Fire Safety Engineers; The Warren Centre for Advanced Engineering, Sydney.
[2] Fire Safety Engineering - Roles of Fire Safety Engineers Report.

of competency may be done, or guided by, a national or an international professional body which represents a body of engineers in a specific discipline.

The exact terminology for the different stages in the process of being admitted to professional practice varies by jurisdiction around the world. For clarity, throughout this report we refer to the Australian context unless otherwise stated.

In the Australian context, the accreditation framework details Stage 1 and Stage 2 competencies in a manner which is consistent with the two-stage competency framework currently employed by Engineers Australia and other professional organisations located in countries which are signatories to the Washington Accord.[3] In the previously cited Education Report, these stages were referred to as tiers of accreditation, however the terminology here is adjusted to match more closely the terminology used by Engineers Australia.

Stage 1 accreditation is the educational component. It is achieved through the completion of a program of study at a university that is recognised by a relevant professional body as providing education covering not only the systematic body of theory that underpins a profession but also in the application of that theory and other necessary graduate attributes. These elements of competency will be discussed in more detail later in this report.

The recognition of the degree program by the professional organisation is also called accreditation (not to be confused with the Stage 1 accreditation that is awarded to individuals as part of their route to professional practice). If a degree program is accredited, the institution granting the degree program is given the power to grant degrees that are recognised by the relevant professional body. An individual obtaining such a degree is therefore deemed to have met Stage 1 accreditation requirements.

Aside from an indicator that an individual has gone through all of the checks and balances in the attainment of academic achievement commensurate with tertiary education, one of the most significant benefits with this Stage 1 accreditation is that when an individual achieves this by virtue of having completed an accredited degree program, then this may be recognised internationally. By virtue of mutual recognition of accreditation of degree programs by signatories to the Washington Accord, there is increased mobility of engineers having received a Stage 1 accredited degree. It is also accepted that, in principle, Stage 1 accreditation of a degree program delivers an internationally consistent level of quality.

The Washington Accord stipulates the skills and attributes that graduates of accredited degree programs are expected to possess. These are generic, not covering any specific discipline. The graduate attribute profile of the Washington Accord has 12 elements. Demonstrating attainment of these 12 elements is supported by a Knowledge Profile and a definition of the level of problem-solving.

The specific elements of technical content required are generally established through a dialogue between the national professional body and the degree granting institution. In many cases, these are specific to a discipline or even a jurisdiction. A degree program seeking Stage 1 accreditation has to demonstrate, to the national professional body, that the degree program meets the generic requirements

[3] There are many other Accords, which are regionally dependant. The Washington Accord is the relevant Accord for this process in Australia.

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The degree granting institution has to demonstrate that graduates will be proficient in both generic and specific requirements.

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defined in the Washington Accord as well as the detailed theoretical content underpinning the specific engineering discipline.

The degree granting institution has to demonstrate that graduates will be proficient in both generic and specific requirements. This proficiency is demonstrated on a regular basis through accreditation visits where representatives of the national professional body interview staff from the degree granting institution as well as graduates and industry advisors.

An accredited degree from a degree granting institution is not the only path towards fulfilling Stage 1 accreditation requirements. A variety of routes are available for engineers, and indeed for Fire Safety Engineers, not just in Australia but globally, In the earlier Education Report, it was noted that this alternative route was the norm in Fire Safety Engineering,

which is in direct contrast to some of the other more traditional engineering disciplines. When following this alternative route, the attributes expected of an individual achieving the Stage 1 accreditation are the same. However when it is not possible to demonstrate this based on the formal university education undertaken, then a detailed individual assessment should be made of the same individuals' skills and attributes. It is important to note that the detailed assessment has to be extremely rigorous because it substitutes not only all the requirements fulfilled through the attainment of an accredited tertiary education degree but also all the requirements associated with the accreditation of such a program.

Stage 2 accreditation is achieved through a period of supervised professional practice and is based on the development of experience in application and dealing with clients, amongst others. While many of the competencies required for practice are attained in Stage 1, this Stage 2 accreditation is supposed to be representative of the engineers' ability to practise competently in the professional environment.

Both Stage 1 and Stage 2 competencies are the subject of this document.

2. Existing Engineering Competency Frameworks

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2.1 INTERNATIONAL ENGINEERING ALLIANCE

Operating on a principle of substantial equivalence, signatories to the Washington Accord recognise that the graduate attributes possessed by graduates of accredited degree programs are largely the same, irrespective of the structure and specific approach to delivering the educational foundation. Content is therefore not specified by the Washington Accord, but rather the competencies reflecting the graduate attributes are specified in this outcomes-based approach. Defined elements of competency reflecting the knowledge base address: mathematical and natural sciences; as well as general engineering sciences; and discipline-specific engineering sciences. These technical elements are combined with non-technical attributes that are expected of a degree exit-level engineer, including contextual knowledge, knowledge about project management, project finance, professional ethics, communication skills, etc.

These various elements of competency reflecting the knowledge base and skills of an engineer are combined in the Washington Accord attributes with additional attributes reflecting skill in the core process of design, including problem analysis, synthesis of solutions and evaluation of proposed solutions.

2. Existing Engineering Competency Frameworks

It is important to reiterate that the Washington Accord only addresses general engineering competency, and it assumes that individual engineering disciplines have also established the complementary knowledge requirements specifically associated to the discipline. As indicated before, these can be specific to a jurisdiction, so long as they are sanctioned by the national professional body.

The relationship between these different elements of competency is shown schematically in Figure 1. The resulting Washington Accord graduate attributes are summarised in Table 1. These graduate attributes are supported by a Knowledge Profile which is summarised in Table 2. The complete Washington Accord graduate attribute list, including Knowledge Profile and the problem-solving profiles, is included in Appendix 1. The box representing Engineering Specialism corresponds to the discipline related knowledge described in the paragraph above.

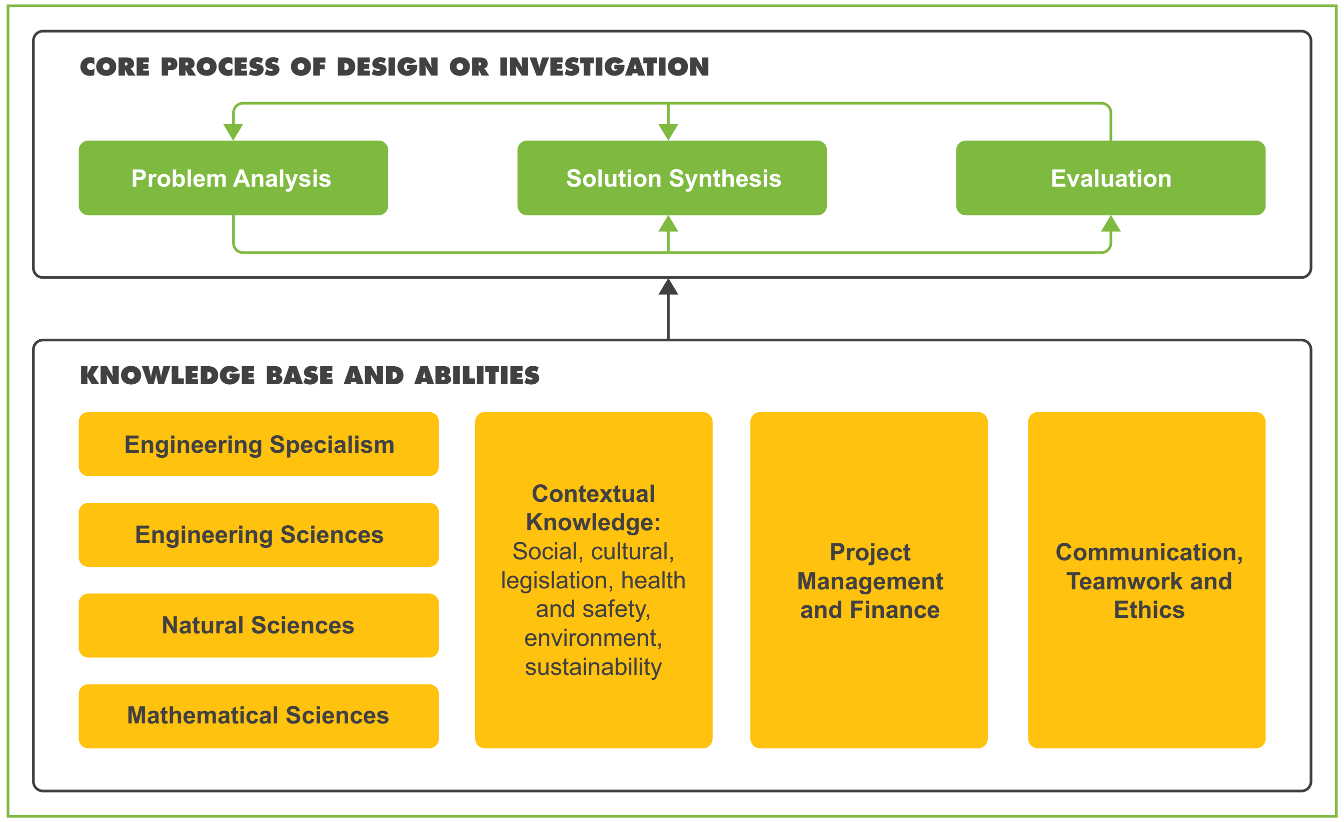

Figure 1: A conceptual model underlying the Graduate Attributes, modified from Hanrahan[4]

[4] Hanrahan, Hu; The Washington Accord: History, Development, Status and Trajectory; American Society for Engineering Education International Conference 2008.

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TABLE 1: WASHINGTON ACCORD GRADUATE ATTRIBUTES[5]

ELEMENT	WASHINGTON ACCORD GRADUATE ATTRIBUTES
Engineering knowledge	WA1: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialisation as specified in WK1 to WK4 respectively to the solution of complex engineering problems
Problem analysis	WA2: Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences (WK1 to WK4).
Design / development of solutions	WA3: Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health, and safety, cultural, societal and environmental considerations (WK5).
Investigation	WA4: Conduct investigations of complex problems using research- based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
Modern tool usage	WA5: Create, select and apply appropriate techniques, resources and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations (WK6).
The engineer and society	WA6: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems (WK7).
Environment and sustainability	WA7: Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts (WK7).
Ethics	WA8: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice (WK7).
Individual and teamwork	WA9: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
Communication	WA10: Communicate effectively on complex engineering activities with the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
Project management and finance	WA11: Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work as a member and leader in a team, to manage projects and in multi-disciplinary environments.
Life-long learning	WA12: Recognise the need for, and have the preparation and ability to engage in, independent and life-long learning in the broadest context of technological change.

It is important to reiterate that the Washington Accord only addresses general engineering competency.

[5] WA graduate attributes

TABLE 2: WASHINGTON ACCORD KNOWLEDGE PROFILES

ELEMENT	WASHINGTON ACCORD KNOWLEDGE PROFILE
WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline.
WK2	Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge that supports engineering design in a practice area.
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline; ethics and the professional responsibility of an engineer to public safety; and the impacts of engineering activity – economic, social, cultural, environmental and sustainability.
WK8	Engagement with selected knowledge in the research literature of the discipline.

Attributes and skills attained in a Washington Accord degree reflect a specific level of problem-solving and the level of engineering activity that is taught and assessed during the educational component. An exit-level graduate of an engineering program accredited to Washington Accord standard would be expected to be able to analyse and synthesise solutions to engineering problems characterised by different elements, including:

- the depth of knowledge required;
- the range of conflicting requirements, or drivers and constraints to the problem;
- the depth of analysis required;
- the extent of applicable codes;
- the extent of stakeholder involvement; and
- the needs and interdependencies between parts or sub-problems.

For some engineering problems, a standard solution exists. Engineering problems designated as "complex" have additional challenges. For complex engineering problems, these additional elements apply to the problem-solving profile. Complex engineering problems:

- Cannot be resolved without in-depth engineering knowledge which allows a fundamentals-based, first principles analytical approach;
- Involve wide-ranging or conflicting technical, engineering and other issues;
- Have no obvious solution and require abstract thinking and originality in analysis to formulate suitable models;
- Involve infrequently encountered issues;
- Are outside of problems encompassed by standards and codes of practice for professional engineering;
- Involve diverse groups of stakeholders with widely varying needs; or
- Involve high-level problems including many component parts or sub-problems.

Finally, complex engineering problems may also have the following features:

- Involve the use of diverse resources (and for this purpose resources include people, money, equipment, materials, information and technologies);
- Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues;
- Involve creative use of engineering principles and research-based knowledge in novel ways;
- Have significant consequences in a range of contexts, characterised by difficulty of prediction and mitigation; or
- Can extend beyond previous experiences by applying principles-based approaches.

This outcomes-based approach to engineering accreditation is the basis of the Stage 1 accreditation of engineers in the signatory countries to the Washington Accord. As noted, the content of a degree accredited according to the Washington Accord is not specified in the agreement. However, there is general consensus reflected in the attributes that engineering programs that can lead to registration as a Professional Engineer or Chartered Engineer incorporate mathematical sciences, the natural sciences, the engineering sciences as well as engineering discipline-specific knowledge into a knowledge base with the other soft attributes mentioned above to address complex engineering problems.

When addressing the discipline specific knowledge, for consistency, it is also important

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This outcomes-based approach to engineering accreditation is the basis of the Stage 1 accreditation of engineers in the signatory countries to the Washington Accord.

to use an outcomes-based approach. For example, it is not the aim to create a curriculum that includes Fire Dynamics, but it is the aim to deliver the program outcome that graduate engineers possess, i.e. the capability to apply Fire Dynamics principles to make appropriate designs, fire mitigations and risk assessments.

The degree program will include appropriate assessment that enables verification of the required competency. An evaluation of the assessment methods that includes the inspection of samples of student assessment is part of all accreditation processes. Furthermore, accreditation visits include interviews with graduates that serve to establish the required competencies. In most juridictions, program that have not produced graduates can only be accredited on a temporary basis.

The majority of programs accredited to Washington Accord standard have a duration of 4 or 5 years post-secondary learning, with the majority of jurisdictions seeking a masters level education for university degree exit-level engineers. Australia is different in this respect, with the majority of accredited educational programs having a duration of 4 years and resulting only in a bachelors level education, although this still meets the requirements of the Washington Accord.

The elements of competency are consistent between the Washington, Dublin and Sydney Accords which cover the educational requirements of Chartered Professional Engineers, Incorporated Engineers and Engineering Technicians. What differentiates these distinct levels of engineering professional is the depth to which these elements are demonstrable in the exit-level engineer; and the complexity of the engineering problems solved in the degree program. Chartered Professional Engineers are expected to define and analyse broad and complex engineering problems, Incorporated Engineers are expected to be able to solve broadly-defined engineering problems, and Engineering Technicians are expected to be able to solve well-defined engineering problems.

In addition to the different Accords covering engineering education, the International Engineering Alliance (IEA) also maintains a number of agreements designed to promote mobility of professional engineers between the signatory countries. Of particular relevance to this discussion is the Asia Pacific Economic Cooperation (APEC) agreement between countries in the Asia-Pacific region[6] and the International Professional Engineers Agreement (IPEA)[7] which is an agreement between engineering organisations in the member jurisdictions of the IEA, which creates the framework for the establishment of an international standard of competence for professional engineering. The IEA professional competencies are summarised in Table 3.

[6] Asia-Pacific Economic Cooperation; Human Resources Development Working Group; The Apec Engineer Manual Version 7 June 2009
[7] IPEA Agreement; https://www.ieagreements.org/agreements/ipea/

As can be seen from Figure 1 and Tables 1 to 3, competencies are defined in very similar terms by all different Accords, Alliances or Agreements. Thus, similar Stage 1 Engineering related competencies can be deemed to be globally accepted. The competency framework of Engineers Australia (EA) is no different.

TABLE 3: IEA PROFESSIONAL COMPETENCIES

DIFFERENTIATING CHARACTERISTIC	PROFESSIONAL ENGINEER
Comprehend and apply universal knowledge: Breadth and depth of education and type of knowledge.	EC1: Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice.
Comprehend and apply local knowledge: Type of local knowledge.	EC2: Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice specific to the jurisdiction in which he/she practices.
Problem analysis: Complexity of analysis.	EC3: Define, investigate and analyse complex problems.
Design and development of solutions: Nature of the problem and uniqueness of the solution.	EC4: Design or develop solutions to complex problems.
Evaluation: Type of activity.	EC5: Evaluate the outcomes and impacts of complex activities.
Protection of society: Types of activity and responsibility to public.	EC6: Recognise the reasonably foreseeable social, cultural and environmental effects of complex activities generally, and have regard to the need for sustainability; recognise that the protection of society is the highest priority.
Legal and regulatory: No differentiation in this characteristic.	EC7: Meet all legal and regulatory requirements and protect public health and safety in the course of his or her activities.
Ethics: No differentiation in this characteristic.	EC8: Conduct his or her activities ethically.
Manage engineering activities: Types of activity.	EC9: Manage part or all of one or more complex activities.
Communication: No differentiation in this characteristic.	EC10: Communicate clearly with others in the course of his or her activities.
Lifelong learning: Preparation for and depth of continuing learning.	EC11: Undertake CPD activities sufficient to maintain and extend his or her competence.
Judgement: Level of developed knowledge, and ability and judgement in relation to the type of activity.	EC12: Recognise complexity and assess alternatives in light of competing requirements and incomplete knowledge. Exercise sound judgement in the course of his or her complex activities.
Responsibility for decisions: Type of activity for which responsibility is taken.	EC13: Be responsible for making decisions on part or all of complex activities.

The degree program will include appropriate assessment that enables verification of the required competency.

2.2 ENGINEERS AUSTRALIA

The competency framework of Engineers Australia (EA) is divided into two broad sections: Stage 1 competencies for a mature, professional engineer; and stage 2 competencies for an experienced professional engineer. The former serves to describe the expectations relevant for first stage accreditation while the latter reflects the professionalism expected from anyone completing the second stage.

The stage 1 competencies form a set of individually assessable outcomes that are the components indicative of the graduate's acquired competence to practice at the appropriate level. Different attributes are defined for the Washington, Sydney and Dublin Accords, reflecting the different level of competency to be attained by a graduate before being able to exercise engineering professional practice under one of the different related tiers of registration.

The process for Stage 1 accreditation is enabled in Washington Accord signatory countries through the completion of an accredited degree program. The specific elements of competency further define what is expected of a graduate from such an accredited program. Graduate Attributes are clear, succinct statements of the expected capability, qualified if necessary by a range of indicators appropriate to the type of program.

Engineers Australia identifies three Stage 1 competencies that are covered by 16 mandatory elements of competency. These Stage 1 competencies are the knowledge and

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> Accreditation visits to tertiary education institutions or accreditation panels for individuals are examples of competent assessment.

skill base, the engineering application ability, and the professional and personal attributes of an engineer. The underlying elements of competency are:

Knowledge and skill base, comprising:

- Comprehensive, theory-based under standing of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline;
- Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline;
- In-depth understanding of specialist bodies of knowledge within the engineering discipline;
- Discernment of knowledge development and research directions within the engineering discipline;
- Knowledge of engineering design practice and contextual factors impacting the engineering discipline; and
- Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline.

Engineering application ability, comprising:

- Application of established engineering methods to complex engineering problem solving;
- Fluent application of engineering techniques, tools and resources;
- Application of systematic engineering synthesis and design processes; and
- Application of systematic approaches to the conduct and management of engineering projects.

Professional and personal attributes, comprising:

- Ethical conduct and professional accountability;
- Effective oral and written communication in professional and lay domains;
- Creative, innovative and pro-active demeanour;
- Professional use and management of information;
- Orderly management of self, and professional conduct; and
- Effective team membership and team leadership.

As stated above, a comparison of these elements of competency with the Graduate Attributes identified in the Washington Accord and which are summarised in Table 1 shows a very close correlation. Engineers Australia also list detailed indicators of attainment for these competencies. These are listed, alongside the elements of competency in Appendix 1.

Engineers Australia also maintains a Stage 2 competency standard, which reflects the competencies that are expected of an engineer seeking to attain admission to professional practice. As with the Stage 1 competencies, there are 16 elements of competency, which are:

- Deal with ethical issues;
- Practise competently;
- Responsibility for engineering activities;
- Develop safe and sustainable solutions;
- Engage with the relevant community and stakeholders Identify, assess and manage risks;
- Meet legal and regulatory requirements;
- Communication;
- Performance;
- Taking action;
- Judgement;
- Advanced engineering knowledge;
- Local engineering knowledge;
- Problem analysis;
- Creativity and innovation; and
- Evaluation.

Again, as with the Stage 1 competencies, these Stage 2 elements of competency have indicators of attainment associated with them to assist in the evaluation of individuals seeking admission to professional practice. The indicators and the competency elements are listed in Appendix 3.

These competencies and the indicators of attainment are written in a generic way, such that they may be used to determine whether or not an individual has achieved the standard of competence for either Stage 1 or Stage 2 accreditation for any engineering discipline. However, this creates difficulties when trying to assess competency for a specific engineering discipline since these competencies will vary in appearance from one engineering discipline to another. Accreditation of an individual or of a degree program therefore requires either competency from the assessor or a detailed description of what exactly these competencies look like for a specific engineering discipline. The former approach is generally considered more effective, given the constant evolution of engineering disciplines. Accreditation visits to tertiary education institutions or accreditation panels for individuals are examples of competent assessment.

2.3 ENGINEERING COUNCIL (UK)

In the UK, the route to Stage 1 accreditation of an individual engineer is through the completion of an accredited integrated masters degree in engineering (MEng); or through the completion of a bachelors program partially accredited as meeting the educational requirement for CEng followed by further learning to masters level. Regardless of which route is taken, the final outcome in terms of competencies is the same.

Each type of accredited engineering degree provides a solid basis in engineering principles, including science and mathematics; engineering analysis; design; economic, legal, social, ethical and environmental context; engineering practice; and additional general skills. In the integrated masters level, there is an expectation that the learning outcomes are deeper and broader than those achieved at the bachelors level. There is also a greater degree of focus on individual and group design projects with industrial involvement as part of the degree program or that are practice-based.

3. Other Relevant Competency Frameworks

This creates difficulties when trying to assess competency for a specific engineering discipline since these competencies will vary in appearance from one engineering discipline to another.

Fire Safety Engineering sits at the complex interface between specialised and generalist practice. That is to say that the fire safety engineer is not only influenced by other disciplines in the design team, incorporating their drivers and constraints into specific aspects of the fire safety strategy but also has the capacity to significantly influence all other aspects of the design, imposing additional drivers and constraints on other disciplines. The former is a specialist role while the latter is a generalist practice. Few disciplines have a sufficiently broad impact in design to be able to operate in both modes (maybe Architecture is another discipline).

As explained throughout this project, the current regulatory framework implicitly places Fire Safety Engineering as a speciality within the disciplines participating in the construction process. Nevertheless, there are many characteristics of Fire Safety Engineering that require the professional Fire Safety Engineer to also operate within a generalist framework. While not explicit, this is recognised in the SFPE - Recommended Minimum Competencies for Fire Protection Engineering,[8] where the following definition is presented:

"A Fire Protection Engineer is an individual who, by formal training and professional experience, carries the necessary competency, and has the skills to provide guidance and direction to protect life, property and environment from threats posed by fire and its related mechanism."

The generalist role can be identified as "*providing guidance*" while the specialist role as "*providing direction.*"

Figure 2 shows an idealised delivery framework where the Fire Safety Engineer can operate either as a specialist or a generalist. If the Fire Safety Engineer operates as a specialist, priority is placed on the technical skills unique to Fire Safety Engineering.

An example, might be a specialist in fire performance of structures, smoke control or egress. In these examples, the Fire Safety Engineer responds to a designer and is meant to provide adequate solutions that optimise resources and deliver the requested functionality. In the definition of solutions, the Fire Safety Engineer has to show awareness of the needs of other professionals. Nevertheless, the responsibility to optimise all components of the integrated design rests with the designer who, in this case this may be the architect.

As required by the regulatory framework, the Fire Safety Engineer can play a role in an approvals process and be required to certify that the complete fire safety strategy and package of fire safety measures meet the

[8] https://www.sfpe.org/page/CompetenciesforFPE

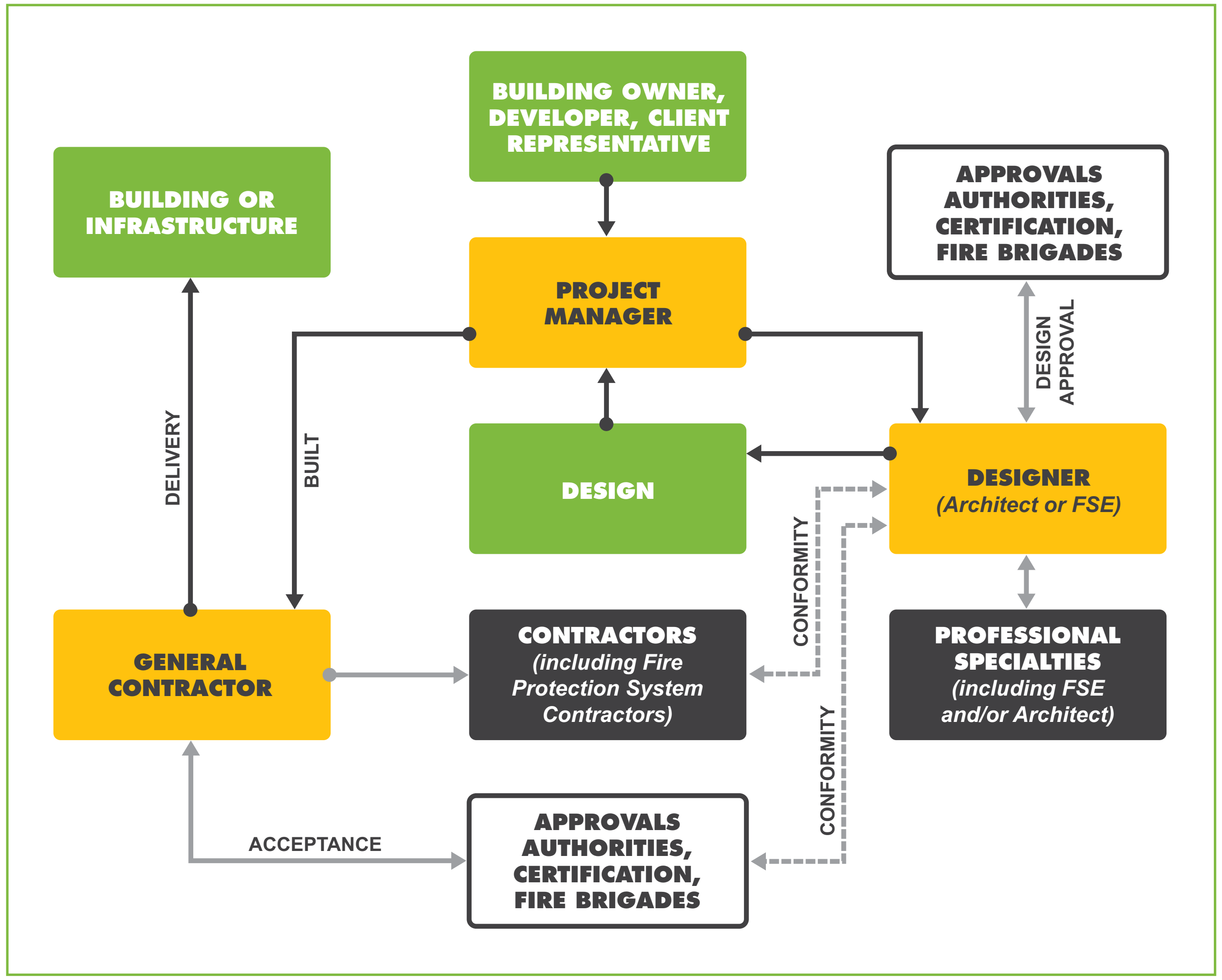

Figure 2 Idealised delivery framework

building code and regulatory requirements. The overall responsibility regarding the fitness of the design towards societal requirements rests with the designer. Thus, approvals are linked to the designer.

Fire Safety Engineering however can have a major influence on most of the design and construction solutions implemented by other professionals, informing, for example, materials used and their configuration, the overall layout of the building, the required performance and integration of HVAC systems in the building, the building envelope design, etc. Therefore the Fire Safety Engineer can operate as a generalist that acts as a designer that coordinates other disciplines around adequate fire safety solutions and integrates specialist knowledge from other disciplines (eg. structural engineering, building services, etc.) around the design of a fire safety strategy. Furthermore, the Fire Safety Engineer could be called to take a central role in the design process. In that case, the competencies of the Fire Safety Engineer may resemble more those currently deemed essential for architects.

Thus, the Royal Institute of British Architects (RIBA) competency framework[9] is an additional source to consult for the identification of relevant competencies in

[9] RIBA, Professional Experience and Development Record (PEDR) – Criteria for Validation Part 3 - 2019 - https://www.pedr.co.uk/Guide/StudentPart3Criteria

addition to those described in previous sections. For reference, the current RIBA competencies for the areas of Professionalism; Clients, users and delivery of services; Legal framework and processes; Practice and management; and building procurement are listed in Appendix 5.

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4. Objectives of a Revised Competency Framework

"The Roles Report" describes the range of practice or roles of Fire Safety Engineers required in relation to design, analysis, verification, as well as construction/ inspection, commissioning, post-occupancy evaluation, and for peer review, certification and authority approvals. The report is framed around a vision of the development of the roles for Fire Safety Engineers into the future and based on a much more integrated and holistic approach to fire safety design and review, from planning and concept design through to construction, commissioning and handover to the building owner/manager. Having said this, it is more of a future vision. This holistic design approach that flows from concept design through to commissioning and handover is currently practised by some Fire Safety Engineers on a number of projects across Australia, but is not representative of the practice for all projects.

The Roles Report covers Fire Safety Engineers working within design teams, those undertaking independent peer reviews, and those Fire Safety Engineers working in the fire services and undertaking project reviews.

While the vision of the Roles Report aims for more widespread design practice based on this holistic approach in the future, there has been no regulatory driver making this holistic design approach mandatory. In many cases, practice has been inevitably bounded by the activities currently undertaken by other professions such as certifiers and other designers interacting with the Fire Safety Engineer within the design practice. This is a reality that is necessary to be understood to enable this report to provide an evolutionary pathway to Fire Safety Engineering. Postulating this idealised vision to be adopted by all Fire Safety Engineers and to bind future regulation and professional practice will help identify necessary actions that will enable Fire Safety Engineering to attain its ideal position and stature within an improved regulatory and professional framework.

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5. Fire Safety Engineering Competency Framework

The process for developing the proposed competencies for Fire Safety Engineering has at its foundation the proposed roles that have been detailed in the Roles Report. The structure is based on the current Engineers Australia Stage 1 and Stage 2 competency standards detailed previously, with the elements of competency modified to reflect the competencies required to fulfil these roles. There are two additional aspects reflected in the proposed competencies:

- First of all, in response to the identification of Fire Safety Engineering as both a generalist and a specialist area of practice, a number of additional competencies have been adopted from the RIBA competency framework where these are relevant and where they were not already identifiable in the Engineers Australia competency standards.
- Secondly, additional competencies have also been added which reflect many of the conclusions of the earlier reports of this Warren Centre project. In particular, the need for Fire Safety Engineers to be able to identify where the developments in other engineering disciplines could negatively impact upon the current practice of their own profession and the application of their own specialist body of knowledge.

The subsequent sections list the Stage 1 and the Stage 2 competencies as well as the indicators of attainment proposed for these.

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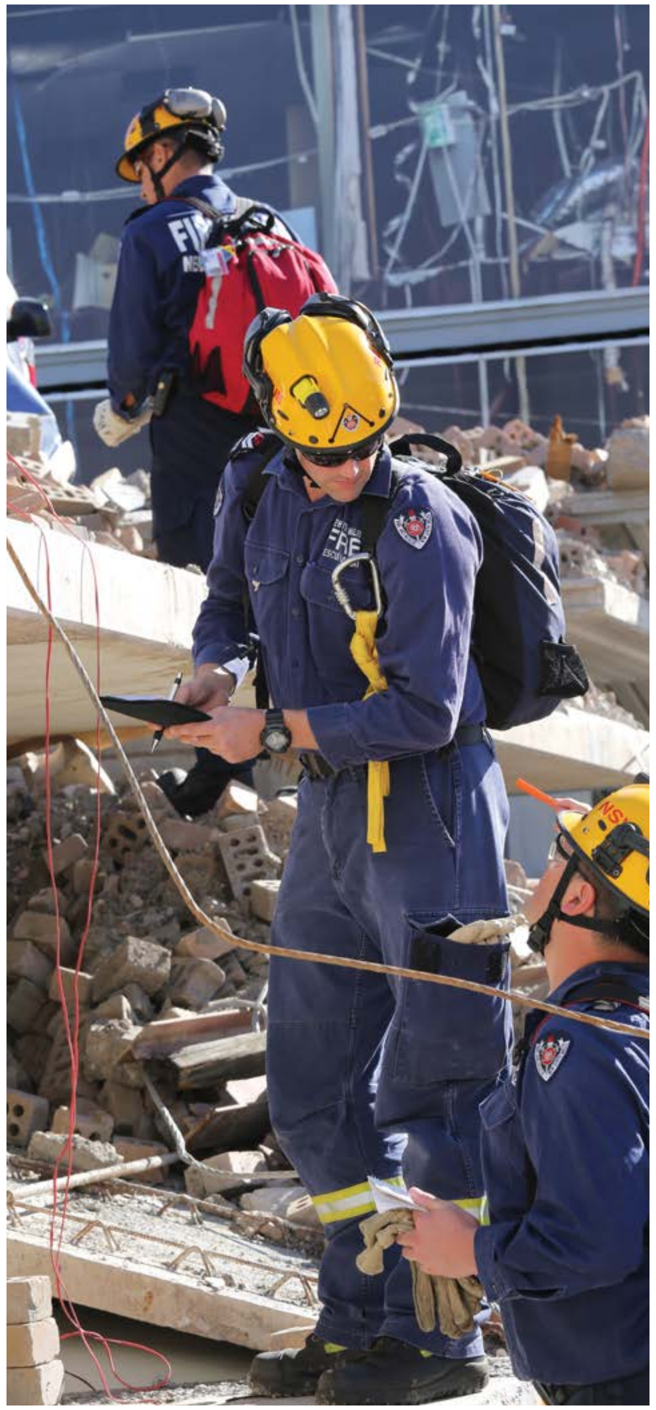


Identify necessary actions that will enable Fire Safety Engineering to attain its ideal position and stature within an improved regulatory and professional framework.

5.1 STAGE 1 COMPETENCIES

5.1.1 KNOWLEDGE AND SKILL BASE

Whether the professional operates as a generalist or a specialist, the Fire Safety Engineer is required to master a comprehensive array of specialist knowledge. Specialist knowledge is therefore an essential component of Fire Safety Engineering. This knowledge is unique to the profession and serves to define some of the elements of competency for the Fire Safety Engineer. Awareness of this specialised knowledge is required from many of the other professionals participating in the design and construction process. Nevertheless, none of these other professionals can serve as a substitute to the Fire Safety Engineer. As established by the SFPE - Recommended Minimum Competencies for Fire Protection Engineering[10] and the Model Curriculum[11] relevant specialist knowledge in Fire Safety Engineering includes at least the following technical subject matters:

1. Implementation of an effective fire safety strategy;
2. Principles of risk assessment;
3. Principles of building and infrastructure design;
4. Principles of people movement, human behaviour and crowd management and the application of analytical and computational tools;
5. Principles of fire dynamics, chemistry, fluid mechanics, heat transfer, combustion and the associated mathematical, analytical and computational skills;
6. Principles of fire protection: design, implementation, commissioning and maintenance;
7. Principles of solid mechanics, structural behaviour and the application of relevant analytical and computational tools;
8. Principles of firefighting;
9. Applicable regulatory framework; and
10. Awareness of the needs and principles of other professions operating within design and construction.

While these lists provide a set of essential technical components and can serve as guidance when defining curriculum, it is essential for national professional organisations to engage in a dialogue with degree granting institutions to establish how this knowledge will be introduced into a Stage 1 educational process. Given that engineering education accreditation is framed within an outcomes-based approach, discipline-based knowledge also has to be placed within the same structure. The degree granting institutions need to put forwards a pedagogical model that achieves the learning outcomes and covers the required knowledge and the national professional organisations have to accept that this model is appropriate. This will deliver the confidence that the graduates of this Stage 1 process have the required attributes. By itself, and without the general attributes and program accreditation process described above, the list of knowledge areas is insufficient.

This specialist knowledge however, as is clear from the Engineers Australia competency standard and the IEA's Graduate Attributes for a Washington Accord level degree, is only a part of the required knowledge and skill base for the practice of Fire Safety Engineering.

[10] SFPE - Recommended Minimum Competencies for Fire Protection Engineering 2018
[11] Magnusson, S.E.; Drysdale, D.D.; Fitzgerald, R.W.; Mowrer, F.; Quintiere, J.; Williamson, R.B.; Zalosh, R.G.; A proposal for a model curriculum in Fire Safety Engineering; Fire Safety Journal, Volume 25, Issue 1, July 1995, Pages 1-88.

The complete set of competencies required for practice in Fire Safety Engineering related to the knowledge and skill base are as follows:

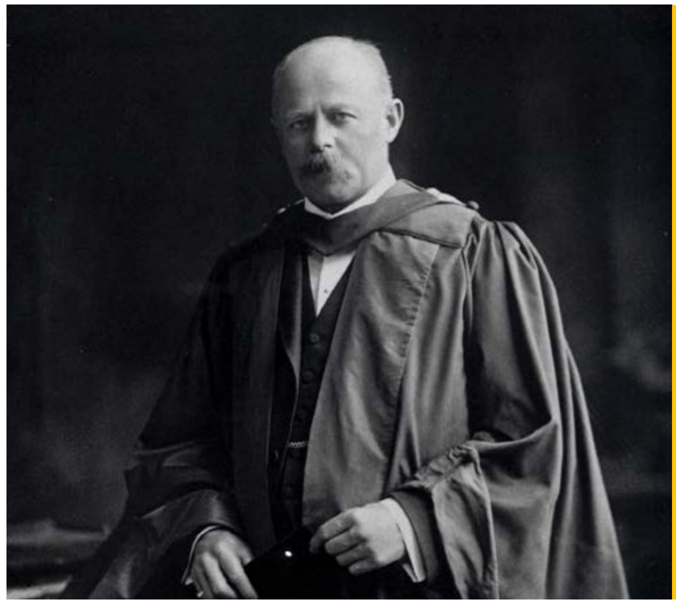
1. Comprehensive, theory-based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to Fire Safety Engineering.
2. In depth understanding of the body of knowledge pertaining to one of the specialist bodies of knowledge in Fire Safety Engineering.

This is what is reflected in the majority of curricula that are proposed for Fire Safety Engineering. In addition to these above, most general engineering curricula will provide a solid foundation in mathematics, numerical analysis, statistics and computer and information sciences. However, these must be applied to the field of Fire Safety Engineering. This is reflected in the required competency:

3. Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the tools used in Fire Safety Engineering.

In addition to these above, and often neglected from curricula whilst incorporated in many degree programs around the world are the following elements of competency:

4. Discernment of knowledge development and research directions within the Fire Safety Engineering discipline.
5. Knowledge of developments and research directions in related areas of practice which may impact upon the Fire Safety Engineering discipline.
6. Awareness of the needs and requirements of professional disciplines and other stakeholders within the design and construction process and an understanding of how the Fire Safety Engineering process influences and interacts with these professional disciplines or stakeholders.
7. Awareness of the role and activities of other disciplines and stakeholders within the design and construction process and an understanding of how the Fire Safety Engineering process is influenced by these professional disciplines and stakeholders.
8. Understanding of the scope, principles, norms, accountabilities and bounds of sustainable Fire Safety Engineering practice.



The status of the engineering profession and the necessity for all members practising the profession to be licensed.

WILLIAM HENRY WARREN

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These elements of competency are in many cases a mapping of the Engineers Australia Stage 1 elements, except for example items 5 and 7, which reflect the additional elements required to fulfil the revised role of Fire Safety Engineers.

For each of these elements of competency, specific indicators of attainment are proposed. These are listed in Table 4. Here it must be noted that the examples given in the indicators proposed are not intended to be an exhaustive list. Fire Safety Engineering is multidisciplinary and not every engineer will attain fluency in development and application of all of the examples.

One other thing to note is that the wording of these indicators is consistent with the wording of the generic indicators used by Engineers Australia. For example, the indicators proposed for the element of competency, "Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the tools used in Fire Safety Engineering", require a *fluency in development and application* of fire engineering tools. The fluent development and application of engineering models or techniques is something that is currently taught and assessed in a degree accredited against the Washington Accord Graduate Attributes. The equivalent generic indicator is worded similarly: "Develops and fluently applies relevant investigation analysis, interpretation, assessment, characterisation, prediction, evaluation, modelling, decision making, measurement, evaluation, knowledge management and communication tools and techniques pertinent to the engineering discipline." While this may sound like a high degree of competency, it should be noted that the degree of fluency is something that will be assessed when the degree programs are accredited by the professional organisations and that for Fire Safety Engineering to be put on an equal footing as other professional engineering disciplines that these competencies must reflect a rigour that is at least as comprehensive as is required for other disciplines.

TABLE 4: ELEMENTS OF COMPETENCY "KNOWLEDGE AND SKILL BASE" AND PROPOSED INDICATORS OF ATTAINMENT

ELEMENT OF COMPETENCE	INDICATOR OF ATTAINMENT
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Comprehensive, theory-based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to Fire Safety Engineering.	a) Demonstrates an ability to apply a combination of knowledge relevent to Fire Safety Engineering (including chemistry and combustion, fire dynamics, fluid mechanics, heat and mass transfer, suppression and detection, human behaviour and fire, solid mechanics, structural fire engineering, thermodynamics, and solid mechanics – reflecting the core modules as defined by Magnussen et al in their model curriculum in fire safety engineering[12]) as well as engineering fundamentals to systematic investigation, interpretation, analysis and innovative solution of complex problems and broader aspects of Fire Safety Engineering practice.
Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the tools used in Fire Safety Engineering.	a) Develops and fluently applies relevant investigation analysis, interpretation, assessment, characterisation, prediction, evaluation, modelling, decision making, measurement, evaluation, knowledge management and communication tools and techniques pertinent to the engineering discipline. This may include, depending on the specialist area of competence in Fire Safety Engineering, e.g. (but not limited to): • ability to develop and fluently apply compartment fire models, including CFD and zone models as well as simpler representations of fire development inside of compartments, as appropriate to a variety of Fire Safety Engineering problems; • ability to develop and fluently apply finite element analysis software to a variety of problems in Structural Fire Engineering, including heat transfer problems and mechanical problems; • ability to develop and fluently apply egress models (software tools and other methods) to the study of the evacuation of occupants from buildings; • ability to develop and fluently apply heat transfer models to Fire Safety Engineering problems; • ability to justify the use and application of methods of analysis by reference to current literature and state of the art; and • ability to develop and apply basic fire engineering skills to simple problems in fire science and which may be solved using the above.
In-depth understanding of the body of knowledge pertaining to at least one of the specialist areas in Fire Safety Engineering.	a) Proficiently applies advanced technical knowledge and skills in at least one specialist practice domain of the engineering discipline, for example: • fire safety management; • human behaviour in fire; • structural fire engineering; • smoke control; • ignition and flame spread; • fire protection systems (both active and passive)active and passive; • detection; • fire dynamics; • fire prevention; • fire safety management; and • fire brigade intervention. b) Has detailed knowledge of the interfaces and interactions between the various aspects of Fire Safety Engineering.

[12] Magnussen et al

ELEMENT OF COMPETENCE	INDICATOR OF ATTAINMENT
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Discernment of knowledge development and research directions within the Fire Safety Engineering discipline.	a) Knowledge of current and recent literature as pertaining to the fundamentals of the body of knowledge underpinning the profession. b) Ability to critically evaluate and summarise the state of the art in at least one specialist practice domain within the discipline. c) Ability to critically evaluate Fire Safety Engineering designs and solutions based on an understanding of the current state of the art as well as the body of knowledge underpinning the profession. d) Ability to identify research needs for the progression of fire engineering practice.
Knowledge of developments and research directions in related areas of practice which may impact upon the Fire Safety Engineering Discipline.	a) Ability to identify where developments in the built environment create additional fire safety hazards. b) Ability to critically evaluate the fire safety strategy of a building accounting for the impact of additional hazards identified as a result of changes in the built environment.
Awareness of the needs and requirements of professional disciplines and other stakeholders within the design and construction process and an understanding of how the Fire Safety Engineering process influences and interacts with these professional disciplines or stakeholders.	a) Identifies and applies systematic principles of architectural and engineering design relevant to Fire Safety Engineering and understands where Fire Safety Engineering design fits into that process. b) Identifies and understands the interactions between engineering systems and people in the social, cultural, environmental, commercial, legal and political contexts in which they operate, including both the positive role of engineering in sustainable development and the potentially adverse impacts of engineering activity in the engineering discipline. c) Appreciates the issues associated with international engineering practice and global operating contexts. d) Is aware of the founding principles of human factors relevant to the engineering discipline. e) Is aware of the fundamentals of business and enterprise management. f) Identifies the structure, roles and capabilities of engineering and other disciplines and stakeholders with whom they work, including clients, emergency services personnel, peer reviewers, and approval officials.
Awareness of the role and activities of other disciplines and stakeholders within the design and construction process and an understanding of how the Fire Safety Engineering process is influenced by these professional disciplines and stakeholders.	a) Demonstrates an understanding of the overall design principles and process in the built environment. b) Demonstrates an understanding of architectural and engineering practice. c) Demonstrates an understanding of integrated design and professional interactions in the built environment. d) Is aware of the importance of competency limits of practitioners. e) Demonstrates an understanding of cross-disciplinary interaction in engineering practice.

The generalist Fire Safety Engineer should demonstrate awareness of the needs and requirements of professional disciplines within the design and construction process.

ELEMENT OF COMPETENCE	INDICATOR OF ATTAINMENT
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Understanding of the scope, principles, norms, accountabilities and bounds of sustainable Fire Safety Engineering practice.	a) Appreciates the basis and relevance of standards and codes of practice, including the fire safety objectives, the Performance Requirements, the opportunities for Performance Solutions as well as the Deemed to Satisfy / prescriptive solutions in the building regulations, their origin and application, as well as legislative and statutory requirements applicable to the Fire Safety Engineering discipline. b) Demonstrated knowledge of historical literature within the field and how this influences practice today. c) Appreciates the principles of safety engineering, risk management and the health and safety responsibilities of the professional engineer, including legislative requirements applicable to the Fire Safety Engineering discipline. d) Appreciates the social, environmental and economic principles of sustainable Fire Safety Engineering practice. e) Understands the fundamental principles of engineering project management as a basis for planning, organising and managing resources. f) Appreciates the formal structures and methodologies of systems engineering as a holistic basis for managing complexity and sustainability in engineering practice. g) Knowledge of the relevant legal systems, civil liabilities and the laws of contract and tort (delict). h) Knowledge of professional ethics as may be applied in the practice of Fire Safety Engineering.

As with the specialist knowledge, all other generic indicators, whether they are used by Engineers Australia or not, are just a guideline that sets the principles by which a Stage 1 engineering program is defined. Once again, the implementation of these guidelines requires a well-structured pedagogy that is capable of delivering the necessary attributes through an outcome-based approach. These guidelines therefore only provide, in very general terms, the competencies expected of an engineer and without a process of accreditation remain insufficient. In the case of the general aspects of engineering, the process of accreditation is more stringent, in that the pedagogy implemented by the degree granting institution cannot omit any of them unless explicitly agreed that the competency can be attained through a combination of others. The principle is that competencies associated to specialist knowledge might have specificities not applicable to everyone within Engineers Australia or the Washington Accord, but general competencies are the common basis of engineering thus need to be respected by all.

A final but very important aspect is that the accreditation process also involves the agreement that those imparting the degree program have the correct competencies to do so. Traditionally this has been done by establishing that a certain fraction of those involved in the program must have the necessary qualifications to practise the profession (eg, CPEng, NER) but also can include requirements of experience or, more commonly, higher educational credentials (eg. PhD).

5.1.2 ENGINEERING APPLICATION ABILITY

When understanding the introduction of discipline based knowledge, it is essential to understand the role the engineer needs to play and the manner in which the knowledge will be applied. For example, while principles of building and infrastructure design should always be part of the technical knowledge of a Fire Safety Engineer, for a specialist, this falls within the context of general awareness. If the Fire Safety Engineer is expected to act as a generalist, then design principles become a core skill of the Fire Safety Engineer.

The generalist Fire Safety Engineer should demonstrate awareness of the needs and requirements of professional disciplines within the design and construction process but also understand how Fire Safety Engineering influences and interacts with these professional disciplines. Integrated and iterative design, which are at the core of architectural education, therefore become the primary driver of Fire Safety Engineering. To introduce these skills and attributes within the education of the Fire Safety Engineer, some elements of technical knowledge, which have been at the core of curricula in Fire Safety Engineering to date, need to be deemphasised in a very careful manner. The generalist will therefore be required to be supported by the specialist.

In contrast, a Fire Safety Engineer specialised in structural fire analysis will require detailed technical knowledge that creates a common base with structural engineers. The needs and requirements of professional disciplines within the design and construction can be refocused towards the needs of structural engineers, and the time released in the curriculum dedicated to develop the required discipline-based knowledge.

Through the process of accreditation of a program, a dialogue between the professional bodies and the degree granting institution will define the ultimate structure of the program. It is not unusual for most engineering disciplines to undergo these distinctions which can be found in any university engineering department.

The following elements of competency are therefore proposed under the overall competence of engineering application ability:

- Application of established Fire Safety Engineering methods to complex fire engineering problem solving;
- Fluent application of Fire Safety Engineering techniques, tools and resources;
- Application of systematic Fire Safety Engineering synthesis and design processes; and
- Application of the range of services offered by Fire Safety Engineering to the conduct and management of engineering projects, including to all those disciplines being influenced by Fire Safety Engineering and as a result be able to deliver the necessary services in a manner that prioritises the interests of society while respecting and having regard to the client and other stakeholders.

The wording of these competencies needs to reflect the focus of the Fire Safety Engineering curriculum proposed by Woodrow et al., which is not on the solution to the problem but rather its definition.[13] This helps to deemphasise the technical knowledge whilst allowing the exit-level graduate to demonstrate ability in its application. These elements of competency closely reflect the elements in the Engineers Australia Stage 1 competency standard for engineering application ability.

[13] M. Woodrow, L. Bisby, J.L. Torero; A nascent educational framework for fire safety engineering; https://doi.org/10.1016/j.firesaf.2013.02.004

Proposed indicators of attainment are listed in Table 5.

TABLE 5: ELEMENTS OF COMPETENCY "ENGINEERING APPLICATION ABILITY", AND PROPOSED INDICATORS OF ATTAINMENT

ELEMENT OF COMPETENCE	INDICATOR OF ATTAINMENT
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Application of established Fire Safety Engineering methods to complex fire engineering problem solving.	a) Identifies, discerns and characterises salient issues, determines and analyses causes and effects, justifies and applies appropriate simplifying assumptions, predicts performance and behaviour, synthesises solution strategies and develops substantiated conclusions. b) Ensures that all aspects of engineering activity are soundly based on fundamental principles by diagnosing and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic. c) Competently addresses complex fire engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging and sometimes conflicting technical and non-technical factors. d) Investigates complex problems using research-based knowledge and research methods. e) Partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then re-combines to form a whole, with the integrity and performance of the overall system as the paramount consideration. f) Conceptualises alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice. g) Critically reviews and applies relevant standards and codes of practice underpinning the engineering discipline and nominated specialisations. h) Identifies, quantifies, mitigates and manages technical, health, environmental, safety and other contextual risks associated with engineering application in the designated engineering discipline. i) Interprets and ensures compliance with relevant legislative and statutory requirements applicable to the engineering discipline.

> For Fire Safety Engineering to be put on an equal footing as other professional engineering disciplines that these competencies must reflect a rigour that is at least as comprehensive as is required for other disciplines.

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ELEMENT OF COMPETENCE	INDICATOR OF ATTAINMENT
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Fluent application of Fire Safety Engineering techniques, tools and resources.	a) Has an ability to proficiently identify, select and apply the various components of a fire safety strategy as required by the problem at hand. b) Constructs or selects and applies from a qualitative description of a phenomenon, process, system, component or device an appropriate model based on fundamental scientific principles and justifiable simplifying assumptions. c) Determines properties, performance, failure modes, limitations, and other inherent parameters of a fire safety strategy relevant to Fire Safety Engineering. d) Applies a wide range of Fire Safety Engineering tools for analysis, simulation, visualisation, synthesis and design, including assessing the accuracy and limitations of such tools, and validation of their results. e) Applies formal systems engineering methods to address the planning and execution of complex problems in Fire Safety Engineering. f) Designs and conducts experiments, analyses and interprets result data and formulates reliable conclusions. g) Analyses sources of error in applied models and experiments; eliminates, minimises or compensates for such errors; quantifies significance of errors to any conclusions drawn. h) Safely applies laboratory, test and experimental procedures appropriate to Fire Safety Engineering. i) Understands the need for systematic management of the fire safety strategy. j) Understands the role of quality management systems, tools and processes within a culture of continuous learning and improvement.

There are certain other professional and personal attributes expected of a degree exit-level engineer.

ELEMENT OF COMPETENCE	INDICATOR OF ATTAINMENT
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Application of systematic Fire Safety Engineering synthesis and design processes.	a) Proficiently applies technical knowledge and open-ended problem-solving skills as well as appropriate tools and resources to design the fire safety strategy to satisfy stakeholder requirements. b) Addresses broad contextual constraints such as social, cultural, environmental, commercial, legal, political and human factors, as well as health, safety and sustainability imperatives as an integral part of the fire engineering design process. c) Executes and leads a whole systems design cycle approach including tasks such as: • determining client and other stakeholder requirements and identifying the impact of relevant contextual factors; • ensuring that the project scope requirements and contractual obligations are met; • systematically addressing sustainability criteria; • working within projected development, production and implementation constraints; • eliciting, scoping and documenting the required outcomes of the design process and defining acceptance criteria; • identifying, assessing and managing technical, health and safety risks integral to the design process; • writing engineering reports and / or specifications, that fully satisfy the formal requirements; • ensuring compliance with essential engineering standards and codes of practice; • partitioning the design task into appropriate components of the fire safety strategy; that can be separately addressed and subsequently integrated such that it may be demonstrated that overall performance objectives are achieved; • identifying and analysing possible design approaches and justifying an optimal approach; • developing and completing the design using appropriate engineering principles, tools, and processes; • integrating functional elements to form a coherent design solution; • quantifying the materials, components, systems, equipment, facilities, engineering resources and operating arrangements needed for implementation of the solution; • checking the design solution for each element and the integrated system against the engineering specifications; • devising and documenting tests that will verify the performance of the elements and the integrated realisation; • prototyping/implementing the design solution and verifying performance against specification; and • documenting, commissioning and reporting the design outcome. d) Is aware of the accountabilities of the professional engineer in relation to the 'design authority' role.

ELEMENT OF COMPETENCE	INDICATOR OF ATTAINMENT
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Application of the range of services offered by Fire Safety Engineering to the conduct and management of engineering projects; including to all those disciplines being influenced by Fire Safety Engineering and as a result be able to deliver the necessary services in a manner that prioritises the interests of society while respecting and having regard to the client and other stakeholders.	a) Demonstrates awareness of fire safety as a social obligation, including the understanding of all different population sectors (Understanding of population sectors implies knowledge of the role society attributes to the different groups in regards to the delivery of their own safety). b) Demonstrates an understanding of types of clients, their priorities and the management of the relationship. c) Contributes to and/or manages complex engineering project activity, as a member and/or as the leader of an engineering team. d) Seeks out the requirements and associated resources and realistically assesses the scope, dimensions, scale of effort and indicative costs of a complex engineering project. e) Accommodates relevant contextual issues into all phases of engineering project work, including the fundamentals of business planning and financial management. f) Proficiently applies basic systems engineering and/or project management tools and processes to the planning and execution of project work, targeting the delivery of outcomes to a professional market and to a professional standard. g) Is aware of the need to plan and quantify performance over the full life-cycle of a project, managing engineering performance within the overall implementation context. h) Demonstrates commitment to sustainable engineering practices and the achievement of sustainable outcomes in all facets of engineering project work.

5.1.3 PROFESSIONAL AND PERSONAL ATTRIBUTES

In addition to the knowledge and skill base and the engineering application ability that deems competent a Fire Safety Engineer, there are certain other professional and personal attributes expected of a degree exit-level engineer. The professional and personal attributes should be obtained by going through the process of undertaking a substantial tertiary education. They are the result of working and being assessed in such an environment and include:

- Demonstrate overall competence and the ability to behave with integrity, in the ethical and professional manner appropriate to their role;
- Effective oral and written communication in professional and lay domains;
- Creative, innovative and proactive demeanour;
- Professional use and management of information;
- Orderly management of self and professional conduct;
- Effective team membership and team leadership; and
- Legal framework and processes.

TABLE 6: ELEMENTS OF COMPETENCY "PROFESSIONAL AND PERSONAL ATTRIBUTES" AND PROPOSED INDICATORS OF ATTAINMENT

ELEMENT OF COMPETENCE	INDICATOR OF ATTAINMENT
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Demonstrate overall competence and the ability to behave with integrity, in the ethical and professional manner appropriate to their role.	a) Demonstrates commitment to uphold relevant Code of Ethics of the accrediting body in Fire Safety Engineering, and established norms of professional regulation, conduct and discipline pertinent to the fire safety engineering discipline. b) Demonstrates an understanding of the Fire Safety Engineer's obligation to society and the protection of the environment. c) Understands the need for 'due-diligence' in certification, compliance and risk management processes. d) Understands the accountabilities of the professional engineer and the broader engineering team for the safety of others and for protection of the environment. e) Is aware of the fundamental principles of intellectual property rights and protection. f) Demonstrates capacity for autonomous working and taking responsibility within a practice context. g) Demonstrates attributes of integrity, impartiality, reliability, accountability and courtesy.
Effective oral and written communication in professional and lay domains.	a) Is proficient in listening, speaking, reading and writing English, including: • comprehending critically and fairly the viewpoints of others; • expressing information effectively and succinctly, issuing instruction, engaging in discussion, presenting arguments and justification, debating and negotiating to technical and non-technical audiences and using textual, diagrammatic, pictorial and graphical media best suited to the context; • representing an engineering position, or the engineering profession at large to the broader community; and • appreciating the impact of body language, personal behaviour and other non-verbal communication processes, as well as the fundamentals of human social behaviour and their cross-cultural differences. b) Prepares high-quality engineering documents such as progress and project reports, reports of investigations and feasibility studies, proposals, specifications, design records, drawings, technical descriptions and presentations pertinent to the discipline of Fire Safety Engineering, including written fire safety strategy documents, fire safety design briefs, Fire Safety Engineering reports, and fire safety manuals. c) Demonstrates an ability for effective communication, presentation, confirmation and recording. d) Demonstrates competency and flexibility in dealing with new and challenging interpersonal situations.
Creative, innovative and pro-active demeanour.	a) Applies creative approaches to identify and develop alternative concepts, solutions and procedures, appropriately challenges engineering practices from technical and non-technical viewpoints; identifies new technological opportunities. b) Seeks out new developments in the engineering discipline and specialisations and applies fundamental knowledge and systematic processes to evaluate and report potential. c) Is aware of broader fields of science, engineering, technology and commerce from which new ideas and interfaces may be drawn and readily engages with professionals from these fields to exchange ideas.

ELEMENT OF COMPETENCE	INDICATOR OF ATTAINMENT
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Professional use and management of information.	a) Is proficient in locating and utilising information including accessing, systematically searching, analysing, evaluating and referencing relevant published works and data; is proficient in the use of indexes, bibliographic databases and other search facilities. b) Critically assesses the accuracy, reliability and authenticity of information. c) Is aware of common document identification, tracking and control procedures. d) Respects intellectual properties, copyrights and commercial-in-confidence information.
Orderly management of self and professional conduct.	a) Demonstrates commitment to critical self-review and performance evaluation against appropriate criteria as a primary means of tracking personal development needs and achievements. b) Understands the importance of being a member of a professional and intellectual community, learning from its knowledge and standards, and contributing to their maintenance and advancement. c) Demonstrates commitment to life-long learning and continuing professional development. d) Manages time and processes effectively, prioritises competing demands to achieve personal, career and organisational goals and objectives. e) Thinks critically and applies an appropriate balance of logic and intellectual criteria to analysis, judgement and decision making. f) Presents a professional image in all circumstances, including relations with clients, stakeholders, as well as with professional and technical colleagues across wide-ranging disciplines.
Effective team membership and team leadership.	a) Understands the fundamentals of team dynamics and leadership. b) Functions as an effective member or leader of diverse engineering teams, including those with multi-level, multi-disciplinary and multi-cultural dimensions. c) Earns the trust and confidence of colleagues through competent and timely completion of tasks. d) Recognises the value of alternative and diverse viewpoints, scholarly advice and the importance of professional networking. e) Confidently pursues and discerns expert assistance and professional advice. f) Takes initiative and fulfils the leadership role whilst respecting the agreed roles of others. g) Displays a capacity for team member development, motivation, supervision and planning.

Through the process of accreditation of a program, a dialogue between the professional bodies and the degree granting institution will define the ultimate structure of the program.

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ELEMENT OF COMPETENCE	INDICATOR OF ATTAINMENT
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Legal framework and processes.	a) Demonstration of an understanding of the following: • society's expectations of safety and wellbeing; and • the relevant legal systems, civil liabilities and the laws of contract and tort (delict); b) Demonstration of awareness of the following: • building codes, regulations and standards related to Fire Safety Engineering; • planning and conservation regulatory frameworks, guidance and processes; • building regulations and standards, guidance and processes; • terms within construction contracts implied by statute; • health and safety legislation and regulations; • statutory undertakers and authorities, their requirements and processes; • environmental and sustainability legislation; • historic buildings legislation; and • accessibility and inclusion legislation. c) Demonstrates an understanding of duty of care, professional liability, negligence and professional indemnity including insurance.

Engage constructively with clients, fire brigades and emergency services personnel, and with inspectors, certifiers and other stakeholders in regard to design, construction and certification of projects.

5.2 STAGE 2 COMPETENCIES

As noted previously in this document, the Stage 2 competencies are those elements of competency that are attained during a period of professional practice supervised by individuals themselves fully accredited in fire safety engineering by an appropriate professional body. These competencies and their elements are mostly based on experience, continuous professional development, and continuous and demonstrable auditing. The definition of Stage 2 is therefore the prerogative of the national professional body, the body with a community mandate for coordinating the registration of the profession, and should be published in a transparent and clear manner.

As with the Stage 1 competencies, Engineers Australia publish generic Stage 2 competencies. Table 7 presents a minor modification proposed to these to represent a discipline specific Stage 2 competencies for Fire Safety Engineering.

TABLE 7: ELEMENTS OF COMPETENCY FOR STAGE 2 ACCREDITATION AND PROPOSED INDICATORS OF ATTAINMENT

ELEMENT OF COMPETENCE (SPECIALIST)	INDICATOR OF ATTAINMENT (FIRE)
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Deal with ethical issues[14]	a) Appraise and respond appropriately to ethical dilemmas in the practice area. b) Recognise an unethical situation or illegal situation; take appropriate action. c) Engage in ethical reflective practice. d) Exercise responsibilities in an ethical manner.
Practise competently	a) Regularly assess their own own competence (in the absence of assessment by a more experienced leader or manager) and continually acquire new knowledge and skills: • as needed in order to respond to changes in the built environment that challenge the body of knowledge of Fire Safety Engineering; and • as needed in order to respond to limitations in one's own competence. b) Maintain a concise description of their areas of competence and operate within their boundaries. c) Maintain records of Continuing Professional Development activities.

[14] Engineers Australia Code of Ethics

ELEMENT OF COMPETENCE (SPECIALIST)	INDICATOR OF ATTAINMENT (FIRE)
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Responsibility for engineering activities	a) Consistently document work in a way that would enable another person of comparable ability to continue and complete work should they be unable to do so due to circumstances beyond their control. b) Seek peer reviews and comments of their own contributions and make improvements to work based on their suggestions. c) Provide reviews and constructive comments to help others improve their own work. d) Authorise managerial decisions only on the basis of an informed understanding of the costs, risks, consequences and limitations. e) Demonstrate responsibility for coordination and integration of design team input. f) Provide design, construction, commissioning or other certification or compliance assessments where required by project or regulatory processes. g) Plans and implements best-practice methods of quality management and continuous improvement.
Develop safe and sustainable solutions	a) Provide for the safety of workers and others in design, manufacture, construction, commissioning, use, decommissioning, demolition, removal and disposal of plant, products, substances or structures related to Fire Safety Engineering. b) Take into account well-accepted standards of practice for design safety, while making the most economic use of financial, human effort, energy and material resources. c) Develop sustainable business solutions that balance the impact of present business activities with the economic, social and environmental prospects of future generation. d) Manage engineering or non-engineering activities to enhance the economic, social and environmental prospects of future generations.
Engage with the relevant community and stakeholders	a) Consider safety, environmental, public health, community expectation, and other public interest issues relevant to the industry, business or government activity. b) Engage responsibly with appropriate communities to convey information on the consequences of industry, business or government decisions and potential solutions to management challenges. c) Take into account the reliance of others on engineering expertise when engaging with the community. d) Engage constructively with clients, fire brigades and emergency services personnel, and with inspectors, certifiers and other stakeholders in regard to design, construction and certification of projects.

The Stage 2 competencies are those elements of competency that are attained during a period of professional practice supervised by individuals themselves fully accreditated in fire safety engineering by an appropriate professional body.

Cultivate an attitude of innovation and creativity to add value for clients or sponsors of the service, process or system.

ELEMENT OF COMPETENCE (SPECIALIST)	**INDICATOR OF ATTAINMENT (FIRE)**
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Identify, assess and manage risks.	a) Identify, assess and manage project, process, environmental, system or safety risks that could be caused by material, economic, social or environmental factors, particularly as a result of fire and related hazards. b) Establish and maintain a documented audit trail of technical and operational changes during system or service development, change management or service delivery. c) Follow a systematic documented method and work in consultation with stakeholders and other informed people to identify unpredictable events (threats, opportunities, and other sources of uncertainty or missing information) that could influence outcomes. d) Assess the likelihood of each event, and the consequences, including commercial, reputation, safety, health, environment, regulatory, legal, governance, and social consequences. e) Devise ways to influence the likelihood and consequences to minimise undesirable consequences, and maximise benefits. f) Help in negotiating equitable ways to share any costs and benefits between stakeholders and the community.
Meet legal and regulatory requirements and contractual obligations.	a) Identify and comply with business codes, standards of compliance or legal instruments relevant to Fire Safety Engineering. b) Develop commercial contracts that cover, for example: procurement of services, professional expertise, feasibility studies, access to information or employment. c) Seek advice, rulings or opinions from time to time to ensure that their understanding of legal and regulatory requirements is up-to-date. d) Practise within legal and regulatory requirements. e) Negotiate appropriate approvals from regulatory authorities as part of the process of Fire Safety Engineering. f) Demonstrate competency in the following: • allocation and management of resources; • briefing, organising and the programming of services appropriate to appointment; • obligations to stakeholders, warranties and third-party rights; • communication, progress reporting and the provision of appropriate and timely advice; • budget and financial awareness and cost monitoring or control; • invoicing, payment of fees and financial management; • intellectual property rights and copyright law; and • negotiate the necessary contractual arrangements with other stakeholders.

ELEMENT OF COMPETENCE (SPECIALIST)	**INDICATOR OF ATTAINMENT (FIRE)**
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Communication	a) Respect confidentiality obligations. b) Build and maintain collaborative relationships with other people, gaining their respect, trust, confidence and willing, conscientious collaboration. c) Exercise informal leadership in order to coordinate the activities of diverse people who contribute to leadership and management activities. d) Collaborate effectively within multi-disciplinary teams including other professions in the workplace. e) Lead and sustain discussion with others and, where appropriate, integrate their views to improve deliverables. f) Convey new concepts and ideas to technical and non-technical stakeholders. g) Deliver clear written and oral presentations on matters related to Fire Safety Engineering in English or in a language appropriate to the work situation. h) Ability to communicate at all levels.
Performance	a) Build, develop and maintain relationships with service, process or system owners, sponsors, partners, providers and contractors. b) Dialogue with a client, sponsor, organisation, government or other social actors to jointly develop an accurate understanding of customer needs, opportunities and priorities, and work with them to develop solutions in terms of commercial and legal possibilities. c) Cultivate an attitude of innovation and creativity to add value for clients or sponsors of the service, process or system. d) Apply leadership and management performance requirements that create the greatest benefits or value for stakeholders, keeping in mind the tolerance for uncertainty of different stakeholders that are providing financial or other resources in the anticipation of future benefits. [Performance requirements could include the need to keep to a desired schedule, long-term cost effectiveness, minimising upfront capital expense, accelerated financial returns or social or environmental benefits, service delivery and operational reliability, among others.] e) Question the contract or agreement that governs the scope of work, and ensure that it allows for the possibility for suspension of work due to circumstances beyond their control.

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ELEMENT OF COMPETENCE (SPECIALIST)	INDICATOR OF ATTAINMENT (FIRE)
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Taking action	a) Contribute to and prepare successful proposals, bids, technical qualification and tender documents for industry, business or government activity. b) Demonstrate initiative and leadership in coordinating technical, commercial, social and environmental aspects of industry, business or government activity. c) Gain sufficient confidence from stakeholders for them to provide financial and other resources to conduct their work independently on the understanding that the FSE will deliver agreed results on time within a given cost target. d) Apply and use appropriate formal coordination and management systems and organisational processes in the practice of Fire Safety Engineering. e) Report progress relative to the agreed schedule, expenditure relative to the budget, provide agreed deliverables, and report on any outstanding issues. f) Manage projects through cost, quality, safety, environmental and risk control, scoping and integration of physical resources and people, procurement, monitoring progress and finalisation. g) Keep financial and other records to substantiate the effective application of finance and other resources provided in support of their work, in a form that is appropriate to meet the needs of agencies that will audit the conduct of the work.
Judgement	a) Deal decisively with management activities which have significant consequences and diverse or conflicting stakeholder interests. b) Supervise, monitor and evaluate the progress of managerial work performed by other people, diagnosing performance deficiencies and negotiating appropriate remedial measures, such as providing training and assistance, and keep within allocated budgets for labour and other expenses. c) Seek appropriate advice and decide whether to proceed or suspend work when faced with unexpected opportunities, obstacles, performance deficiencies, impending or actual failures, perceived or actual conflict of interest. d) Undertand the role of "engineering judgement" or "professional judgement" and the liability implications in Fire Safety Engineering.
Business development	a) Develop and apply current research papers to inform and shape perceptions of legal and commercial possibilities to meet [client] needs, including the contribution of creative fire safety design concepts and innovative solutions where appropriate. b) Apply advanced theory-based knowledge of commercial, policy and governance fundamentals at the forefront of a management practice to the delivery of services, systems and programs. c) Use mathematical, numerical and computational tools pertinent to a scientific approach to management practice to predict service delivery, commercial, environmental and social performance. d) Apply the principles and theories of management practice and mathematics to help make accurate performance predictions, including predicting failure. e) Apply commercial fundamentals and logic to the development and operation of complex financial, commercial service delivery or managerial systems.

5. Fire Safety Engineering Competency Framework

ELEMENT OF COMPETENCE (SPECIALIST)	INDICATOR OF ATTAINMENT (FIRE)
Element of competence as worded for Fire Safety Engineering	*Proposed indicators of attainment for Fire Safety Engineering*
Local engineering knowledge	a) Apply accepted local regulations and management practices and locally applied international protocols. b) Take into account local environmental plans, conditions, constraints and opportunities. c) Keep themself informed about new and emerging technologies, techniques, services, businesses, regulations, management theories and science relevant to their leadership and management. d) Demonstrate the application of local knowledge and practices, including unwritten business knowledge contributed by informed peers and experts knowledgeable in the area of management.
Problem analysis	a) Accurately determine the main issues that require addressing in analysing the problem and reliably identify opportunities to improve outcomes. b) Work with clients to reach an agreed understanding of the expected capability or functionality of the required service, process, system or program. c) When the FSE identifies or is presented with management problems, they adopt appropriate research methods to locate previously known solutions to similar problems, including seeking advice or help from informed people. d) Conduct research, investigation and analysis in relation to service, program, process or system. e) Engage in dialogue with appropriate people to reach an agreed understanding of commercial issues for which there are no wellunderstood and reliable solutions.
Creativity and innovation	a) Apply their knowledge of Fire Safety Engineering to ensure that the fire safety strategy performs as agreed with the client and other stakeholders, and that the desin respects other constraints imposed on it by all stakeholders. b) Develop fire safety concepts to meet requirements and specify, document, verify, validate, measure and monitor these concepts as part of the fire safety engineering process. c) Review opportunities in work portfolio for enhancing the delivery of Fire Safety Engineering. d) Apply the benefits of continuous technical change and innovation to enhance the fire safety outcomes delivered.
Evaluation	a) Evaluate ongoing programs, services and processes to identify and diagnose performance deficiencies or opportunities, impending or actual failures, and propose remedies and solutions. b) Monitor and evaluate programs, services, processes or systems against whole of life criteria (cost, quality, safety, reliability, maintenance, aesthetics, fitness for purpose and social and environmental impact and decommissioning). c) Evaluate programs, services, processes or systems outcomes against the original specification or design brief. d) Diagnose performance deficiencies, conceive and design remedial measures and predict performance of modified systems, processes, programs or services. e) Evaluate service, program, process or systems outcomes for practicality and maintainability as input to future design improvement. f) Assess and use technical information and statistics correctly to ensure that opportunities are based on sound evidence.

6. Summary

The accreditation process should include the assessment of past graduates of the program.

One of the general conclusions of the earlier reports in this Warren Centre project has been that there is a need to "raise the bar" of Fire Safety Engineers, and the first stage to do this is to consider the competencies required for accreditation of individuals. The review group for this report are collectively of the opinion that the appropriate level is that reflected by the competency framework of the IEA and therefore Engineers Australia.

This report details the background and development of a series of competencies for Fire Safety Engineering that are aligned with the Washington Accord competencies and which could be used for first stage accreditation. This first stage accreditation could be done via completion of a degee accredited according to the Washington Accord or through a Stage 1 assessment. The former implies a dialogue between the national professional organisations and a degree granting institution that results in an accredited degree program. The latter is the responsibility of the national professional institutions that set requirements that are consistent with what is expected with the Graduate Attributes obtained by someone completing an accredited degree program.

If this first stage is achieved through the completion of a Washington Accord accredited degree program, then the degree program will have been assessed to ensure that the graduates of this program possess the knowledge, skills and professional and personal attributes listed. The process of accreditation represents a dialogue between the national professional organisations and the degree granting institution where discipline-based knowledge and general knowledge are structured around a pedagogy and delivered by staff that the profession has deemed acceptable. Furthermore, the accreditation process should include the assessment of past graduates of the program.

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The conclusion is that an accredited degree program can be trusted by the profession to deliver graduates with the appropriate Stage 1 competencies.

A point that emerges from the competencies and that needs to be emphasised is that discipline based knowledge alone is not enough. The Stage 1 accreditation expects many other skills and attributes in an engineer.

This is what is expected of other engineering disciplines, and the proposed competencies raise the bar of Fire Safety Engineers to a level consistent with other engineering disciplines. In many ways, therefore, the proposed indicators of attainment reflect a degree exit-level fire safety engineer.

By virtue of the basis for the proposed competencies, these proposed competencies also reflect a WA accredited degree in Fire Safety Engineering. As is the case with other Washington Accord level degrees, such degrees would operate on the principle of substantial equivalence, enabling mobility of engineers between countries who are signatories to the Accord.

What these competencies do not do is to act as a substitute for the accreditation process of tertiary education institutions. Without the accreditation process the discipline-based knowledge and general competencies are too generic and are devoid of a pedagogy. There is no guarantee that the degree granting institution provides an adequate environment and that those delivering the pedagogy are capable of doing so.

Most fundamentally, in the absence of an accredited program, there is no agreement between the profession and the degree granting institution that the product of the degree program possesses the Graduate competencies that the profession deems necessary to enter the Stage 2 process. Without this agreement, accredited professionals are not empowered to demand monopoly over their profession. If they were to attempt to do so, others could easily challenge their competency.

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One of the benefits of the proposed approach is, therefore, that it could be used as a guide for assessors when evaluating applicants for an alternative or "equivalent" pathway. That is to say, if these are the elements of competency expected from an exit-level graduate of an accredited degree in Fire Safety Engineering then this is the benchmark for Stage 1 accreditation. Adoption of these competencies would then lead to consistency in that evaluation process, whilst enabling people from other non-WA accredited degrees to see a very transparent path to having their qualifications recognised here in Australia. This will innevitably raise the bar to the level that collectively industry in Australia requires and will enable Fire Safety Engineers to fulfil the revised roles proposed in this Warren Centre project. This is in addition to the other benefits for the Higher Education sector in terms of clarity of what is expected by industry of an exit-level engineer when seeking accreditation for a degree program.

In addition to these Stage 1 competencies, this report also details proposed Stage 2 competencies. These are also aligned with the International Engineering Alliance, who coordinates the Washington Accord, but these competencies are only achievable after a period of supervised practice.

Stage 2 competencies are only relevant once Stage 1 competencies have been adequately structured. Furthermore, they are only the responsibility of a national professional body, and thus their definition needs to be commissioned and agreed by the profession. The recommendations in this report represent a first proposal based on competencies regularly defined for other engineering disciplines.

These proposed competencies are intended to deliver a flow of adequately qualified professionals. However, these cannot exist in isolation, and every licensing framework for professional engineers has two other components, which must be born in mind when finalising recommendations from this Warren Centre project and implementing them:

- Ongoing and meaningful continual professional development obligations; and
- Real and thorough ongoing auditing of competency and currency, including effective enforcement when those standards are not met.

Finally, raising of the bar does not only apply to the individuals seeking accreditation. It also applies to the higher education institutions who produce graduates in Fire Safety Engineering. If a higher education institution is not able to attain accreditation for their degree against the agreed graduate profile, then the responsibility is on them to adjust the program, change the staff or modify the courses that they deliver.

Having established the need to raise the bar, then it follows that the profession should not let the competencies of the exit-level graduate of the available degree programs determine the level of competency that the profession accepts. This would be the same as watering down the requirements compared with other engineering disciplines, which was cautioned against in this report. Higher Education institutions will therefore need support to develop the degree programs that are able to produce the exit-level engineer described in this report.

7. Glossary of Terms

TERM	**DEFINITIONS AND NOTES OF EXPLANATION** Where definitions are included in the NCC Volume One Building Code of Australia, they are in **bold**. Other definitions or notes of explanation have been developed in this Warren Centre Project as a means to use consistent language throughout the Project reports.
Accreditation	Refers to professional accreditation from organisations like EA NER and IFE, which look at educational achievements and supervised experience plus CPD *(Peter Johnson)* This also applies to accredited education courses for fire safety engineering, which there is one at UQ *(Peter Johnson)* A scheme that captures appropriately qualified practitioners, sets minimum standards of professional practice and requires appropriate levels (if any) of insurance for consumers. (See *the Warren Centre's forthcoming Report on the State of Fire Safety Engineering Regulation, Control and Regulation in Australia, the "Task 1.1 Report".*) Products (Certificate of Accreditation) - A certificate issued by a State or Territory accreditation authority stating that the properties and performance of a building material or method of construction or design fulfil specific requirements of the BCA *(NCC, vol 1, amdt 1)*
Accreditation (degree program)	The formal recognition of a degree program offered by a degree-granting institution; by a body representing a profession; that an exit- level graduate from the degree program satisfies the requirements for stage 1 accreditation (as an individual).
Accreditation (individual)	The formal recognition that a person has the required competency for practice, recognised in comparison to either the stage 1 or the stage 2 levels of competency.
APEC	The Asia Pacific Economic Cooperation agreement
Assessment Method	**Means a method that can be used for determining that a Performance Solution or Deemed-to-Satisfy Solution complies with the Performance Requirements**. *(NCC, vol 1, amdt 1)* The means by which a building proponent proves that a solution achieves the Performance Requirements. These include: • Evidence to support that the use of a material or product, form of construction or design meets a Performance Requirement or a Deemed-to- Satisfy Provision as described in A2.2; • Verification Methods; • Expert Judgement; and • Comparison with the Deemed-to-Satisfy Provisions. *(NCC, vol 1, amdt 1)*
Attribute	An attribute is a quality or a feature of an individual that may be regarded as characteristic of them.
CEng	Chartered Engineer
Certification	In NSW, such "licensed" engineers are called C10 certifiers in FSE with the emphasis on certification rather than design *(Peter Johnson)*
Competence	Competence is the ability to perform in a role with a high degree of efficacy in regards to the expectations that are placed on that role.
CPEng	Chartered Professional Engineer
Deemed-to-Satisfy Provisions	Make up the bulk of the NCC. **Means provisions deemed to satisfy the *Performance Requirements***. *(NCC, vol 1, amdt 1)*
Dublin Accord	The Dublin Accord is an agreement between national professional bodies in different jurisdictions. It describes the attributes required for first stage accreditation as an Engineering Technician or Engineering according to the process described by the IEA. The Dublin accord covers international recognition of engineering technician qualifications.

TERM	DEFINITIONS AND NOTES OF EXPLANATION
EA	Engineers Australia
EC	Element of competency
ECUK	The Engineering Council of the UK
Equivalent	**Equivalent to the level of health, safety and amenity provided by the *Deemed- to-Satisfy Provisions*.** *(NCC, vol 1, amdt 1)*
Fire Brigade	**Means a statutory authority established under an Act of Parliament having as one of its functions the protection of life and property from fire and other emergencies.** *(NCC, vol 1, amdt 1)* It may be a professional brigade with full-time firefighters or a volunteer brigade. Many companies employ their own private fire services. The standard of these private fire services varies greatly. They are excluded from the definition of a fire brigade. *(NCC, Guide, amdt 1)*
Fire Safety Engineer	An appropriately qualified and experienced practitioner who, through sound and robust engineer practice, provides services that achieve reductions of risk for life for people in buildings, reduction in property and environmental damage from building fires and the implementation of cost-effective fire safety codes and regulations.
HVAC	Heating Ventilation and Air Conditioning
IEA	The International Engineering Alliance
IEng	Incorporated Engineer
IPEA	The International Professional Engineers Agreement
Knowledge	An understanding of facts or information specific to the field gained through education or experience.
Licensing	A government legislative scheme that captures appropriately qualified practitioners, to the exclusion of any other persons or practitioners and sets minimum standards of professional practice and requires appropriate levels (if any) of insurance for consumers. Persons not licensed are prohibited from practice (i.e. plumbing, electrical or driving licensing schemes).
MEng	Integrated master of engineering
NER	The National Engineers Register
Performance Requirement	**Means a requirement which states the level of performance which a Performance Solution or a Deemed-To-Satisfy Solution must meet.** *(NCC, vol 1, amdt 1)* Performance requirements outline the levels of accomplishment different buildings must attain. There are three options to comply with the Performance Requirements: Deemed-to-Satisfy Solutions, Performance Solutions or a combination of both. *(NCC, vol 1, amdt 1)*
Performance Solution (Alternative Solution)	**Means a method of complying with the Performance Requirements other than by a Deemed-To-Satisfy Solution.** *(NCC, vol 1, amdt 1)* A Performance Solution is unique for each individual situation. These solutions are often flexible in achieving the outcomes and encouraging innovative design and technology use. It is a route which is not included in a DTS Solution. It complies with the NCC when the Assessment Method demonstrates compliance with the Performance Requirements. If it is demonstrated to be at least equivalent to a DTS Provision, the Performance Solution is deemed to have achieved compliance with the relevant Performance Requirement. *(NCC, vol 1, amdt 1)*
RIBA	The Royal Institute of British Architects
RPEQ	Registered Professional Engineer Queensland
SFPE	The Society of Fire Protection Engineers

7. Glossary of Terms

TERM	DEFINITIONS AND NOTES OF EXPLANATION
Skill	A skill is an ability to carry out a task well.
Sydney Accord	The Sydney Accord is an agreement between national professional bodies in different jurisdictions. It describes the exit level attributes required for first stage accreditation to IEng or Engineering Technologist status according to the process described by the IEA. The Sydney Accord covers degrees of three years duration post-secondary school.
Washington Accord	The Washington Accord is an agreement between national professional bodies in different jurisdictions. It describes the exit level attributes required for first stage accreditation to CEng or CPEng status according to the process described by the IEA. Accredited degree programs usually last for between 4 and 5 years depending on the territory and result in a BEng or an MEng degree or a degree of substantial equivalence.
WA	Washington Accord Graduate Attribute
WK	Washington Accord Knowledge Profile

8.
Appendix 1
IEA Generic Framework

GRADUATE ATTRIBUTES

THE WASHINGTON ACCORD GRADUATE ATTRIBUTE PROFILE HAS 12 ELEMENTS, SUPPORTED BY A KNOWLEDGE PROFILE, WK1-WK8, AND A DEFINITION OF THE LEVEL OF PROBLEM SOLVING.

No.	ELEMENT	WASHINGTON ACCORD GRADUATE ATTRIBUTES
1	Engineering knowledge	WA1: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialisation as specified in WK1 to WK4 respectively to the solution of complex engineering problems.
2	Problem analysis	WA2: Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences (WK1 to WK4).
3	Design / development of solutions	WA3: Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health, and safety, cultural, societal and environmental considerations (WK5).
4	Investigation	WA4: Conduct investigations of complex problems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
5	Modern tool usage	WA5: Create, select and apply appropriate techniques, resources and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations (WK6).
6	The engineer and society	WA6: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems (WK7).
7	Environment and sustainability	WA7: Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts (WK7).
8	Ethics	WA8: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice (WK7).
9	Individual and teamwork	WA9: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
10	Communication	WA10: Communicate effectively on complex engineering activities with the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
11	Project management and finance	WA11: Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work as a member and leader in a team, to manage projects and in multi-disciplinary environments.
12	Life-long learning	WA12: Recognise the need for, and have the preparation and ability to engage in, independent and life-long learning in the broadest context of technological change.

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KNOWLEDGE PROFILE

THE WASHINGTON ACCORD KNOWLEDGE PROFILE HAS EIGHT ELEMENTS.

ELEMENT	WASHINGTON ACCORD KNOWLEDGE PROFILE
WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline.
WK2	Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge that supports engineering design in a practice area.
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; and the impacts of engineering activity – economic, social, cultural, environmental and sustainability.
WK8	Engagement with selected knowledge in the research literature of the discipline.

PROBLEM ATTRIBUTES

COMPLEX ENGINEERING PROBLEMS HAVE A RANGE OF ATTRIBUTES. AT LEAST SOME OF THE FOLLOWING MAY BE ENCOUNTERED WITHIN A PROFESSIONAL ENGINEERING EDUCATION PROGRAM.

ELEMENT	PROBLEM SOLVING PROFILES
Depth of knowledge required	WP1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamentals-based, first principles analytical approach.
Range of conflicting requirements	WP2: Involve wide-ranging or conflicting technical, engineering and other issues.
Depth of analysis required	WP3: Have no obvious solution and require abstract thinking and originality in analysis to formulate suitable models.
Familiarity of issues	WP4: Involve infrequently encountered issues.
Extent of applicable codes	WP5: Outside problems encompassed by standards and codes of practice for professional engineering.
Extent of stakeholder involvement and needs	WP6: Involve diverse groups of stakeholders with widely varying needs.
Interdependence	WP 7: High level problems including many component parts or sub-problems.

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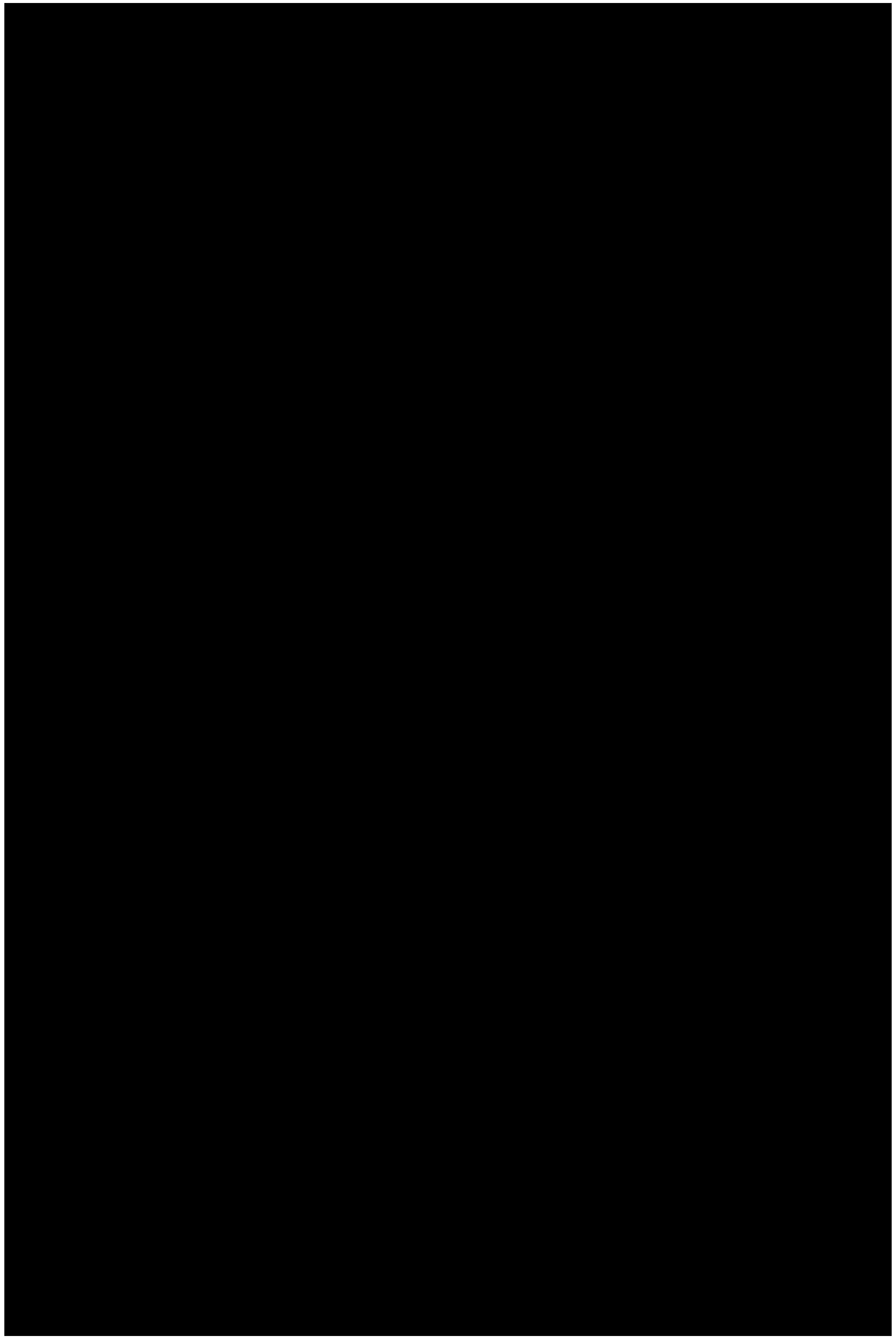
ENGINEERING ACTIVITIES

THE ATTRIBUTES OF COMPLEX ENGINEERING ACTIVITIES, SOME OF WHICH MIGHT REASONABLY BE ENCOUNTERED BY A PROFESSIONAL ENGINEERING UNDERGRADUATE (EG. DURING CAPSTONE DESIGN OR A PERIOD OF INDUSTRY EXPERIENCE).

ELEMENT	ENGINEERING ACTIVITIES
Range of resources	EA1: Involve the use of diverse resources (and for this purpose resources include people, money, equipment, materials, information and technologies).
Level of interactions	EA2: Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues.
Innovation	EA3: Involve creative use of engineering principles and research-based knowledge in novel ways.
Consequences to society and the environment	EA4: Have significant consequences in a range of contexts, characterised by difficulty of prediction and mitigation.
Familiarity	EA5: Can extend beyond previous experiences by applying principles-based approaches.



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9. Appendix 2

Engineers Australia Stage 1 Elements of Competency Generic Framework

COMPETENCY	No.	ELEMENT OF COMPETENCE (GENERAL) *General element of competence as worded by EA*	INDICATOR OF ATTAINMENT (GENERAL) *Indicator of attainment for non-specific engineering discipline as worded by EA*
Knowledge and skill base	1	Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.	a) Engages with the engineering discipline at a phenomenological level, applying sciences and engineering fundamentals to systematic investigation, interpretation, analysis and innovative solution of complex problems and broader aspects of engineering practice.
	2	Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.	a) Develops and fluently applies relevant investigation analysis, interpretation, assessment, characterisation, prediction, evaluation, modelling, decision making, measurement, evaluation, knowledge management and communication tools and techniques pertinent to the engineering discipline.
	3	In-depth understanding of specialist bodies of knowledge within the engineering discipline.	a) Proficiently applies advanced technical knowledge and skills in at least one specialist practice domain of the engineering discipline.
	4	Discernment of knowledge development and research directions within the engineering discipline.	a) Identifies and critically appraises current developments, advanced technologies, emerging issues and interdisciplinary linkages in at least one specialist practice domain of the engineering discipline. b) Interprets and applies selected research literature to inform engineering application in at least one specialist domain of the engineering discipline.
	5	Knowledge of engineering design practice and contextual factors impacting the engineering discipline.	a) Identifies and applies systematic principles of engineering design relevant to the engineering discipline. b) Identifies and understands the interactions between engineering systems and people in the social, cultural, environmental, commercial, legal and political contexts in which they operate, including both the positive role of engineering in sustainable development and the potentially adverse impacts of engineering activity in the engineering discipline. c) Appreciates the issues associated with international engineering practice and global operating contexts. d) Is aware of the founding principles of human factors relevant to the engineering discipline. e) Is aware of the fundamentals of business and enterprise management. f) Identifies the structure, roles and capabilities of the engineering workforce.

COMPETENCY	No.	ELEMENT OF COMPETENCE (GENERAL) *General element of competence as worded by EA*	INDICATOR OF ATTAINMENT (GENERAL) *Indicator of attainment for non-specific engineering discipline as worded by EA*
Knowledge and skill base	6	Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline.	a) Appreciates the basis and relevance of standards and codes of practice, as well as legislative and statutory requirements applicable to the engineering discipline. b) Appreciates the principles of safety engineering, risk management and the health and safety responsibilities of the professional engineer, including legislative requirements applicable to the engineering discipline. c) Appreciates the social, environmental and economic principles of sustainable engineering practice. d) Understands the fundamental principles of engineering project management as a basis for planning, organising and managing resources. e) Appreciates the formal structures and methodologies of systems engineering as a holistic basis for managing complexity and sustainability in engineering practice.
Engineering application ability	1	Application of established engineering methods to complex engineering problem solving.	a) Identifies, discerns and characterises salient issues, determines and analyses causes and effects, justifies and applies appropriate simplifying assumptions, predicts performance and behaviour, synthesises solution strategies and develops substantiated conclusions. b) Ensures that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic. c) Competently addresses complex engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging and sometimes conflicting technical and non-technical factors. d) Investigates complex problems using research-based knowledge and research methods. e) Partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then re-combines to form a whole, with the integrity and performance of the overall system as the paramount consideration. f) Conceptualises alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice. g) Critically reviews and applies relevant standards and codes of practice underpinning the engineering discipline and nominated specialisations. h) Identifies, quantifies, mitigates and manages technical, health, environmental, safety and other contextual risks associated with engineering application in the designated engineering discipline. i) Interprets and ensures compliance with relevant legislative and statutory requirements applicable to the engineering discipline.

9. Appendix 2: EA Stage 1

Discipline-based knowledge and general knowledge are structured around a pedagogy and delivered by staff that the profession has deemed acceptable.

COMPETENCY	No.	ELEMENT OF COMPETENCE (GENERAL) *General element of competence as worded by EA*	INDICATOR OF ATTAINMENT (GENERAL) *Indicator of attainment for non-specific engineering discipline as worded by EA*
Engineering application ability	2	Fluent application of engineering techniques, tools and resources.	a) Proficiently identifies, selects and applies the materials, components, devices, systems, processes, resources, plant and equipment relevant to the engineering discipline. b) Constructs or selects and applies from a qualitative description of a phenomenon, process, system, component or device a mathematical, physical or computational model based on fundamental scientific principles and justifiable simplifying assumptions. c) Determines properties, performance, safe working limits, failure modes, and other inherent parameters of materials, components and systems relevant to the engineering discipline. d) Applies a wide range of engineering tools for analysis, simulation, visualisation, synthesis and design, including assessing the accuracy and limitations of such tools, and validation of their results. e) Applies formal systems engineering methods to address the planning and execution of complex, problem solving and engineering projects. f) Designs and conducts experiments, analyses and interprets result data and formulates reliable conclusions. g) Analyses sources of error in applied models and experiments; eliminates, minimises or compensates for such errors; quantifies significance of errors to any conclusions drawn. h) Safely applies laboratory, test and experimental procedures appropriate to the engineering discipline. i) Understands the need for systematic management of the acquisition, commissioning, operation, upgrade, monitoring and maintenance of engineering plant, facilities, equipment and systems. j) Understands the role of quality management systems, tools and processes within a culture of continuous improvement.

COMPETENCY	No.	ELEMENT OF COMPETENCE (GENERAL) *General element of competence as worded by EA*	INDICATOR OF ATTAINMENT (GENERAL) *Indicator of attainment for non-specific engineering discipline as worded by EA*
Engineering application ability	3	Application of systematic engineering synthesis and design processes.	a) Proficiently applies technical knowledge and open ended problem solving skills as well as appropriate tools and resources to design components, elements, systems, plant, facilities and/or processes to satisfy user requirements. b) Addresses broad contextual constraints such as social, cultural, environmental, commercial, legal, political and human factors, as well as health, safety and sustainability imperatives as an integral part of the design process. c) Executes and leads a whole systems design cycle approach including tasks such as: • determining client requirements and identifying the impact of relevant contextual factors, including business planning and costing targets; • systematically addressing sustainability criteria; • working within projected development, production and implementation constraints; • eliciting, scoping and documenting the required outcomes of the design task and defining acceptance criteria; • identifying assessing and managing technical, health and safety risks integral to the design process; • writing engineering specifications, that fully satisfy the formal requirements; • ensuring compliance with essential engineering standards and codes of practice; • partitioning the design task into appropriate modular, functional elements; that can be separately addressed and subsequently integrated through defined interfaces; • identifying and analysing possible design approaches and justifying an optimal approach; • developing and completing the design using appropriate engineering principles, tools, and processes; • integrating functional elements to form a coherent design solution; • quantifying the materials, components, systems, equipment, facilities, engineering resources and operating arrangements needed for implementation of the solution; • checking the design solution for each element and the integrated system against the engineering specifications; • devising and documenting tests that will verify performance of the elements and the integrated realisation; • prototyping/implementing the design solution and verifying performance against specification; and • documenting, commissioning and reporting the design outcome. d) Is aware of the accountabilities of the professional engineer in relation to the 'design authority' role.

COMPETENCY	No.	ELEMENT OF COMPETENCE (GENERAL) *General element of competence as worded by EA*	INDICATOR OF ATTAINMENT (GENERAL) *Indicator of attainment for non-specific engineering discipline as worded by EA*
Engineering application ability	4	Application of systematic approaches to the conduct and management of engineering projects.	a) Contributes to and/or manages complex engineering project activity, as a member and/or as the leader of an engineering team. b) Seeks out the requirements and associated resources and realistically assesses the scope, dimensions, scale of effort and indicative costs of a complex engineering project. c) Accommodates relevant contextual issues into all phases of engineering project work, including the fundamentals of business planning and financial management. d) Proficiently applies basic systems engineering and/or project management tools and processes to the planning and execution of project work, targeting the delivery of a significant outcome to a professional standard. e) Is aware of the need to plan and quantify performance over the full life-cycle of a project, managing engineering performance within the overall implementation context. f) Demonstrates commitment to sustainable engineering practices and the achievement of sustainable outcomes in all facets of engineering project work.

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COMPETENCY	No.	ELEMENT OF COMPETENCE (GENERAL) *General element of competence as worded by EA*	INDICATOR OF ATTAINMENT (GENERAL) *Indicator of attainment for non-specific engineering discipline as worded by EA*
Professional and personal attributes	1	Ethical conduct and professional accountability.	a) Demonstrates commitment to uphold the Engineers Australia - Code of Ethics, and established norms of professional conduct pertinent to the engineering discipline. b) Understands the need for 'due-diligence' in certification, compliance and risk management processes. c) Understands the accountabilities of the professional engineer and the broader engineering team for the safety of other people and for protection of the environment. d) Is aware of the fundamental principles of intellectual property rights and protection.
	2	Effective oral and written communication in professional and lay domains.	a) Is proficient in listening, speaking, reading and writing English, including: • comprehending critically and fairly the viewpoints of others; • expressing information effectively and succinctly, issuing instruction, engaging in discussion, presenting arguments and justification, debating and negotiating - to technical and non-technical audiences and using textual, diagrammatic, pictorial and graphical media best suited to the context; • representing an engineering position, or the engineering profession at large to the broader community; and • appreciating the impact of body language, personal behaviour and other non-verbal communication processes, as well as the fundamentals of human social behaviour and their cross-cultural differences. b) Prepares high quality engineering documents such as progress and project reports, reports of investigations and feasibility studies, proposals, specifications, design records, drawings, technical descriptions and presentations pertinent to the engineering discipline.
	3	Creative, innovative and pro-active demeanour.	a) Applies creative approaches to identify and develop alternative concepts, solutions and procedures, appropriately challenges engineering practices from technical and non-technical viewpoints; identifies new technological opportunities. b) Seeks out new developments in the engineering discipline and specialisations and applies fundamental knowledge and systematic processes to evaluate and report potential. c) Is aware of broader fields of science, engineering, technology and commerce from which new ideas and interfaces may be drawn and readily engages with professionals from these fields to exchange ideas.

COMPETENCY	No.	ELEMENT OF COMPETENCE (GENERAL) *General element of competence as worded by EA*	INDICATOR OF ATTAINMENT (GENERAL) *Indicator of attainment for non-specific engineering discipline as worded by EA*
Professional and personal attributes	4	Professional use and management of information.	a) Is proficient in locating and utilising information - including accessing, systematically searching, analysing, evaluating and referencing relevant published works and data; is proficient in the use of indexes, bibliographic databases and other search facilities. b) Critically assesses the accuracy, reliability and authenticity of information. c) Is aware of common document identification, tracking and control procedures.
	5	Orderly management of self, and professional conduct.	a) Demonstrates commitment to critical self-review and performance evaluation against appropriate criteria as a primary means of tracking personal development needs and achievements. b) Understands the importance of being a member of a professional and intellectual community, learning from its knowledge and standards, and contributing to their maintenance and advancement. c) Demonstrates commitment to life-long learning and professional development. d) Manages time and processes effectively, prioritises competing demands to achieve personal, career and organisational goals and objectives. e) Thinks critically and applies an appropriate balance of logic and intellectual criteria to analysis, judgement and decision making. f) Presents a professional image in all circumstances, including relations with clients, stakeholders, as well as with professional and technical colleagues across wide ranging disciplines.
	6	Effective team membership and team leadership.	a) Understands the fundamentals of team dynamics and leadership. b) Functions as an effective member or leader of diverse engineering teams, including those with multi-level, multi-disciplinary and multi-cultural dimensions. c) Earns the trust and confidence of colleagues through competent and timely completion of tasks. d) Recognises the value of alternative and diverse viewpoints, scholarly advice and the importance of professional networking. e) Confidently pursues and discerns expert assistance and professional advice. f) Takes initiative and fulfils the leadership role whilst respecting the agreed roles of others.

10. Appendix 3

Engineers Australia Stage 2 Elements of Competency and Indicators of Attainment Generic Framework

Functions as an effective member or leader of diverse engineering teams, including those with multi-level, multi-disciplinary and multi-cultural dimensions.

ELEMENT OF COMPETENCE (GENERAL)	INDICATOR OF ATTAINMENT (GENERAL)
General element of competence as worded by EA	*Indicator of attainment for non-specific engineering discipline as worded by EA*
Deal with ethical issues	• appraise and respond appropriately to ethical dilemmas in your practice area; • recognise an unethical situation; take appropriate action; and • engage in ethical reflective practice.
Practise competently	• regularly assess your own competence (in the absence of assessment by more experienced leader or manager) and continually acquire new knowledge and skills; • maintain a concise description of your areas of competence and operate within their boundaries; and • maintain records of Continuing Professional Development activities.
Responsibility for engineering activities	• consistently document work in a way that would enable another person of comparable ability to continue and complete your work should you be unable to do so due to circumstances beyond your control; • seek peer reviews and comments of your own contributions, and make improvements to work based on their suggestions; • provide reviews and constructive comments to help others improve their own work; and • authorise managerial decisions only on the basis of an informed understanding of the costs, risks, consequences and limitations.
Develop safe and sustainable solutions	• provide for the safety of workers and others in design, manufacture, construction, commissioning, use, decommissioning, demolition, removal and disposal of plant, products, substances or structures; • take into account well-accepted standards of practice for design safety, while making the most economic use of financial, human effort, energy and material resources; • develop sustainable business solutions that balance the impact of present business activities with the economic, social and environmental prospects of future generation; and • manage engineering or non-engineering activities to enhance the economic, social and environmental prospects of future generations.
Engage with the relevant community and stakeholders	• consider safety, environmental, public health and other public interest issues relevant to the industry, business or government activity; • engage responsibly with appropriate communities to convey information on the consequences of industry, business or government decisions and potential solutions to management challenges; and • take into account the reliance of others on engineering expertise when engaging with the community.

ELEMENT OF COMPETENCE (GENERAL)	INDICATOR OF ATTAINMENT (GENERAL)
General element of competence as worded by EA	*Indicator of attainment for non-specific engineering discipline as worded by EA*
Identify, assess and manage risks	• identify, assess and manage project, process, environmental or system risks that could be caused by material, economic, social or environmental factors; • establish and maintain a documented audit trail of technical and operational changes during system or service development, change management or service delivery; • follow a systematic documented method and work in consultation with stakeholders and other informed people to identify unpredictable events (threats, opportunities, and other sources of uncertainty or missing information) that could influence outcomes; • assess the likelihood of each event, and the consequences, including commercial, reputation, safety, health, environment, regulatory, legal, governance, and social consequences; • devise ways to influence the likelihood and consequences to minimise costs and undesirable consequences, and maximise benefits; and • help in negotiating equitable ways to share any costs and benefits between stakeholders and the community.
Meet legal and regulatory requirements	• Identify and comply with business codes, standards of compliance or legal instruments relevant to a particular business, project, process or system; • develop commercial contracts that cover procurement of services, professional expertise, feasibility studies, access to information or employment; • seek advice, rulings or opinions from time to time to ensure that your understanding of legal and regulatory requirements is up-to-date; • practise within legal and regulatory requirements; • negotiate appropriate approvals from regulatory authorities for development activities; and • protect intellectual property.
Communication	• respect confidentiality obligations; • build and maintain collaborative relationships with other people, gaining their respect, trust, confidence and willing, conscientious collaboration; • exercise informal leadership in order to coordinate the activities of diverse people who contribute to leadership and management activities; • collaborate effectively within multi-disciplinary teams including other professions in the workplace; • lead and sustain discussion with others and, where appropriate, integrate their views to improve deliverables; • convey new concepts and ideas to technical and non-technical stakeholders; and • deliver clear written and oral presentations on commercial, policy, governance or technical matters in English or in a language appropriate to the work situation.

Appraise and respond appropriately to ethical dilemmas in your practice area.

ELEMENT OF COMPETENCE (GENERAL)	INDICATOR OF ATTAINMENT (GENERAL)
General element of competence as worded by EA	*Indicator of attainment for non-specific engineering discipline as worded by EA*
Performance	• build, develop and maintain relationships with service, process or system owners, sponsors, partners, providers and contractors; • dialogue with a client, sponsor, organisation, government or other social actors to jointly develop an accurate understanding of customer needs, opportunities and priorities, and work with them to develop solutions in terms of commercial and legal possibilities; • cultivate an attitude of innovation and creativity to add value for clients or sponsors of the service, process or system; • apply leadership and management performance requirements that create the greatest benefits or value for stakeholders, keeping in mind the tolerance for uncertainty of different stakeholders that are providing financial or other material resources in the anticipation of future benefits. [Performance requirements could include the need to keep to a desired schedule, long-term cost effectiveness, minimising upfront capital expense, accelerated financial returns or social or environmental benefits, service delivery and operational reliability, among others]; and • question the contract or agreement that governs your work, and ensure that it allows for the possibility that you may not be able to complete the work due to circumstances beyond your control.
Taking action	• contribute to successful proposals, bids, technical qualification and tender documents for industry, business or government activity; • demonstrate initiative and leadership in coordinating technical, commercial, social and environmental aspects of industry, business or government activity; • gain sufficient confidence from stakeholders for them to provide you with financial and other resources to conduct your work independently on the understanding that you will deliver agreed results on time within a given cost target; • apply and use appropriate formal coordination and management systems and organisational processes such as project management, quality management, production management, logistics, enterprise resource and planning systems, maintenance management, configuration management, information management; • report progress relative to the agreed schedule, expenditure relative to the budget, provide agreed deliverables, and report on any outstanding issues; • manage projects through cost, quality, safety, environmental and risk control, scoping and integration of physical resources and people, procurement, monitoring progress and finalisation; and • keep financial and other records to substantiate the effective application of finance and other resources provided in support of your work, in a form that is appropriate to meet the needs of agencies that will audit the conduct of the work.
Judgement	• deal decisively with management activities which have significant consequences and diverse or conflicting stakeholder interests; • supervise, monitor and evaluate the progress of managerial work performed by other people, diagnosing performance deficiencies and negotiating appropriate remedial measures, such as providing training and assistance, and keep within allocated budgets for labour and other expenses; and • seek appropriate advice and decide whether to proceed or suspend work when faced with unexpected opportunities, obstacles, performance deficiencies, impending or actual failures.

ELEMENT OF COMPETENCE (GENERAL)	INDICATOR OF ATTAINMENT (GENERAL)
General element of competence as worded by EA	*Indicator of attainment for non-specific engineering discipline as worded by EA*
Advanced engineering knowledge	• develop and apply current research papers to inform and shape perceptions of legal and commercial possibilities to meet [client] needs; • apply advanced theory-based knowledge of commercial, policy and governance fundamentals at the forefront of a management practice to the delivery of services, systems and programs; • use mathematical, numerical and computational tools pertinent to a scientific approach to management practice to predict service delivery, commercial, environmental and social performance; • apply the principles and theories of management practice and mathematics to help make accurate performance predictions, including predicting failure; and • apply commercial fundamentals and logic to the development and operation of complex financial, commercial service delivery or managerial systems.
Local engineering knowledge	• apply accepted local regulations and management practices and locally applied international protocols; • take into account local environmental plans, conditions, constraints and opportunities; • keep yourself informed about new and emerging technologies, techniques, services, businesses, regulations, management theories and science relevant to your leadership and management; and • demonstrate the application of local knowledge and practices, including unwritten business knowledge contributed by informed peers and experts knowledgeable in the area of management.
Problem analysis	• accurately determine the main issues that require addressing in analysing the problem and reliably identify opportunities to improve outcomes; • work with customer or employer to reach an agreed understanding of the expected capability or functionality of the required service, process, system or program; • when you identify or are presented with management problems, adopt appropriate research methods to locate previously known solutions to similar problems, including seeking advice or help from informed people; • conduct research, investigation and analysis in relation to service, program, process or system; and • engage in dialogue with appropriate people to reach an agreed understanding of commercial issues for which there are no wellunderstood and reliable solutions.
Creativity and innovation	• apply your knowledge of materials and physical and abstract objects to work out how to rearrange them so they perform the required function with the agreed aesthetics, level of performance or properties, taking into account the most effective ways to create value for the sponsors, clients, end users and investors in services, programs, processes or systems; • develop concepts to meet requirements and specify, document, build, test, verify, validate, measure and monitor business systems, processes or services; • review opportunities in work portfolio for enhancing programs, processes, systems and services, assesses viability and initiate actions; and • apply the benefits of continuous technical change and innovation to enhance the outcomes delivered.

ELEMENT OF COMPETENCE (GENERAL)	INDICATOR OF ATTAINMENT (GENERAL)
General element of competence as worded by EA	*Indicator of attainment for non-specific engineering discipline as worded by EA*
Evaluation	• evaluate ongoing programs, services and processes to identify and diagnose performance deficiencies or opportunities, impending or actual failures, and propose remedies and solutions; • monitor and evaluate programs, services, processes or systems against whole of life criteria (cost, quality, safety, reliability, maintenance, aesthetics, fitness for purpose and social and environmental impact and decommissioning); • evaluate programs, services, processes or systems outcomes against the original specification or design brief; • diagnose performance deficiencies, conceive and design remedial measures and predict performance of modified systems, processes, programs or services; • evaluate service, program, process or systems outcomes for practicality and maintainability as input to future design improvement; and • assess and use technical information and statistics correctly to ensure that opportunities are based on sound evidence.

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11. Appendix 4

Engineering Council UK Stage 1 Competencies Generic Framework

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SCIENCE AND MATHEMATICS

Science and mathematics Engineering is underpinned by science and mathematics, and other associated disciplines, as defined by the relevant professional engineering institution(s). Graduates will need the following knowledge, understanding and abilities:

- A comprehensive knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, and an understanding and know-how of the scientific principles of related disciplines, to enable appreciation of the scientific and engineering context, and to support their understanding of relevant historical, current and future developments and technologies;
- Knowledge and understanding of mathematical and statistical methods necessary to underpin their education in their engineering discipline and to enable them to apply a range of mathematical and statistical methods, tools and notations proficiently and critically in the analysis and solution of engineering problems;
- Ability to apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline and the ability to evaluate them critically and to apply them effectively;
- Awareness of developing technologies related to own specialisation;
- A comprehensive knowledge and understanding of mathematical and computational models relevant to the engineering discipline, and an appreciation of their limitations; and
- Understanding of concepts from a range of areas, including some outside engineering, and the ability to evaluate them critically and to apply them effectively in engineering projects.

ENGINEERING ANALYSIS

Engineering analysis involves the application of engineering concepts and tools to the solution of engineering problems. Graduates will need:

- Understanding of engineering principles and the ability to apply them to undertake critical analysis of key engineering processes;
- Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques;
- Ability to apply quantitative and computational methods, using alternative approaches and understanding their limitations, in order to solve engineering problems and to implement appropriate action;
- Understanding of, and the ability to apply, an integrated or systems approach to solving complex engineering problems;
- Ability to use fundamental knowledge to investigate new and emerging technologies; and
- Ability to extract and evaluate pertinent data and to apply engineering analysis techniques in the solution of unfamiliar problems.

DESIGN

Design at this level is the creation and development of an economically viable product, process or system to meet a defined need. It involves significant technical and intellectual challenges and can be used to integrate all engineering understanding, knowledge and skills to the solution of real and complex problems. Graduates will therefore need the knowledge, understanding and skills to:

- Understand and evaluate business, customer and user needs, including considerations such as the wider engineering context, public perception and aesthetics;
- Investigate and define the problem, identifying any constraints including environmental and sustainability limitations; ethical, health, safety, security and risk issues; intellectual property; codes of practice and standards;
- Work with information that may be incomplete or uncertain, quantify the effect of this on the design and, where appropriate, use theory or experimental research to mitigate deficiencies;
- Apply advanced problem-solving skills, technical knowledge and understanding to establish rigorous and creative solutions that are fit for purpose for all aspects of the problem including production, operation, maintenance and disposal;
- Plan and manage the design process, including cost drivers, and evaluate outcomes;
- Communicate their work to technical and non-technical audiences;
- Demonstrate wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations; and
- Demonstrate the ability to generate an innovative design for products, systems, components or processes to fulfil new needs.

ECONOMIC, LEGAL, SOCIAL, ETHICAL AND ENVIRONMENTAL CONTEXT

Engineering activity can have impacts on the environment, on commerce, on society and on individuals. Graduates therefore need the skills to manage their activities and to be aware of the various legal and ethical constraints under which they are expected to operate, including:

- Understanding of the need for a high level of professional and ethical conduct in engineering, a knowledge of professional codes of conduct and how ethical dilemmas can arise;
- Knowledge and understanding of the commercial, economic and social context of engineering processes;
- Knowledge and understanding of management techniques, including project and change management, that may be used to achieve engineering objectives, their limitations and how they may be applied appropriately;
- Understanding of the requirement for engineering activities to promote sustainable development and ability to apply quantitative techniques where appropriate;
- Awareness of relevant legal requirements governing engineering activities, including personnel, health & safety, contracts, intellectual property rights, product safety and liability issues, and an awareness that these may differ internationally;
- Knowledge and understanding of risk issues, including health & safety, environmental and commercial risk, risk assessment and risk management techniques and an ability to evaluate commercial risk; and
- Understanding of the key drivers for business success, including innovation, calculated commercial risks and customer satisfaction.

ENGINEERING PRACTICE

This is the practical application of engineering skills, combining theory and experience, and use of other relevant knowledge and skills. This can include:

- Understanding of contexts in which engineering knowledge can be applied (eg operations and management, application and development of technology, etc);
- Knowledge of characteristics of particular equipment, processes, or products, with extensive knowledge and understanding of a wide range of engineering materials and components;
- Ability to apply relevant practical and laboratory skills;
- Understanding of the use of technical literature and other information sources;
- Knowledge of relevant legal and contractual issues;
- Understanding of appropriate codes of practice and industry standards;
- Awareness of quality issues and their application to continuous improvement;
- Ability to work with technical uncertainty;
- A thorough understanding of current practice and its limitations, and some appreciation of likely new developments;
- Ability to apply engineering techniques taking account of a range of commercial and industrial constraints; and
- Understanding of different roles within an engineering team and the ability to exercise initiative and personal responsibility, which may be as a team member or leader.

ADDITIONAL GENERAL SKILLS

Graduates must have developed transferable skills, additional to those set out in the other learning outcomes, that will be of value in a wide range of situations, including the ability to:

- Apply their skills in problem solving, communication, working with others, information retrieval and the effective use of general IT facilities;
- Plan self-learning and improve performance, as the foundation for lifelong learning/CPD;
- Monitor and adjust a personal program of work on an on-going basis; and
- Exercise initiative and personal responsibility, which may be as a team member or leader.

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12. Appendix 5

RIBA Competency Framework

> The candidate will have a clear understanding of the architect's obligation to society and the profession.

THE RIBA COMPETENCY FRAMEWORK IS SPLIT INTO 5 COMPETENCIES, DESCRIBED BELOW ALONG WITH THE RIBA INDICATORS OF ATTAINMENT.

PC1: PROFESSIONALISM

A successful candidate will demonstrate overall competence and the ability to behave with integrity, in the ethical and professional manner appropriate to the role of architect. The candidate will have the skills necessary to undertake effective communication and presentation, organisation, self-management and autonomous working. The candidate will have a clear understanding of the architect's obligation to society and the profession, and a sufficient awareness of the limits of their competence and professional experience to ensure they are unlikely to bring the profession into disrepute.

Demonstration of an understanding of the following will contribute to this criterion being met:

- professional ethics;
- the architect's obligation to society and the protection of the environment;
- professional regulation, conduct and discipline;
- institutional membership, benefits, obligations and codes of conduct;
- attributes of integrity, impartiality, reliability and courtesy;
- time management, recording, planning and review;
- effective communication, presentation, confirmation and recording;
- flexibility, adaptability and the principles of negotiation;
- autonomous working and taking responsibility within a practice context; and
- continuing professional development.

The candidate will have the skills necessary to positively interact with statutory and private bodies or individuals, and competently deliver projects within diverse legislative frameworks.

PC2: CLIENTS, USERS, AND DELIVERY OF SERVICES

A successful candidate will be able to demonstrate understanding of the range of services offered by architects and delivering those services in a manner prioritising the interests of the client and other stakeholders. The candidate will have the skills necessary to provide a competent service, both singly and as part of a team, including understanding of client needs, appropriate communication, programming, coordination and competent delivery. This will be supported by knowledge of the briefing process, forms and terms of appointment, the means of professional remuneration, relevant legislation, and the execution of appropriate programmed and coordinated project tasks.

Demonstration of an understanding of the following will contribute to this criterion being met:

- types of clients, their priorities and the management of the relationship;
- briefing, organising and the programming of services appropriate to appointment;
- architects' contracts, terms of engagement, scope of services and relevant legislation;
- obligations to stakeholders, warranties and third party rights;
- communication, progress reporting and the provision of appropriate and timely advice;
- budget and financial awareness and cost monitoring or control;
- responsibility for coordination and integration of design team input;
- invoicing, payment of fees and financial management;
- intellectual property rights and copyright law; and
- duty of care, professional liability, negligence and professional indemnity including insurance.

PC3: LEGAL FRAMEWORK AND PROCESSES

A successful candidate will be able to demonstrate understanding of the legal context within which an architect must operate, and the processes undertaken to ensure compliance with legal requirements or standards. The candidate will have the skills necessary to positively interact with statutory and private bodies or individuals, and competently deliver projects within diverse legislative frameworks. This will be supported by knowledge of the relevant law, legislation, guidance and controls relevant to architectural design and construction.

Demonstration of an understanding of the following will contribute to this criterion being met:

- the relevant UK legal systems, civil liabilities and the laws of contract and tort (delict)*;
- planning and Conservation Acts, guidance and processes;
- building regulations, approved documents and standards, guidance and processes;
- land law, property law and rights of other proprietors;
- terms within construction contracts implied by statute;
- health and safety legislation and regulations;
- statutory undertakers and authorities, their requirements and processes;
- environmental and sustainability legislation;
- historic buildings legislation; and
- accessibility and inclusion legislation.

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PC4: PRACTICE AND MANAGEMENT

A successful candidate will be able to demonstrate understanding of the business priorities, required management processes and risks of running an architectural practice, and the relationship between the practice of architecture and the UK construction industry. The candidate will have the skills necessary to engage in business administration and ability to resource, plan, implement and record project tasks to achieve stated goals, either individually or within a team. This will be supported by knowledge of the nature of legal business entities, office systems, administration procedures and the relevant legislation.

Demonstration of an understanding of the following will contribute to this criterion being met:

- the roles of architectural practice in the construction industry;
- external factors affecting construction and practice at national and international levels;
- practice structures, legal status and business styles;
- personnel management and employment-related legislation;
- practice finance, business planning, funding and taxation;
- marketing, fee calculation, bidding and negotiation;
- resource management and job costing;
- administration, quality management, QA systems, recording and review;
- staff development, motivation, supervision and planning; and
- team working and leadership.

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PC5: BUILDING PROCUREMENT

A successful candidate will be able to demonstrate understanding of UK construction and contract law, construction procurement processes and the roles of built environment professionals. The candidate will have the skills necessary to plan project-related tasks, coordinate and engage in design team interaction, execute effective contract communication and resolve construction-related challenges and disputes. This will be supported by an understanding of contractual relationships, the obligations upon an architect acting as contract administrator, job-related administrative systems and the management of projects in the context of the candidate's professional experience.

Demonstration of an understanding of the following will contribute to this criterion being met:

- procurement methods, including for public and larger projects and relevant legislation;
- the effect of different procurement processes on program, cost, risk and quality;
- collaboration in construction and provisions for team working;
- tendering methods, codes, procedures and project planning;
- forms of contract and sub-contract, design responsibility and third party rights;
- application and use of contract documentation;
- roles of design/construction team members and their interaction;
- duties and powers of a lead consultant and contract administrator;
- site processes, quality monitoring, progress recording, payment and completion; and
- claims, litigation and alternative dispute resolution methods.

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