Next Generation Higher National Unit Specification

Engineering Systems: Validation and Verification (SCQF level 7)

Unit code: J89H 47

SCQF level: 7 (24 SCQF credit points)

Valid from: session 2024–2025

Prototype unit specification for use in pilot delivery only (version 5.0) October 2024

This unit specification provides detailed information about the unit to ensure consistent and transparent assessment year on year.

This unit specification is for teachers and lecturers and contains all the mandatory information required to deliver and assess the unit.

This edition: October2024 (version 5.0)

Unit purpose

This unit provides learners with knowledge and skills specific to systems engineering.

They learn about a variety of topics, including:

- key components in systems and how they interconnect, including the block diagram approach
- quality assurance, including verification and validation, and methods of doing these in an engineering environment
- reliability and its purpose in the context of engineering systems

The target group for this unit is learners who want to develop their core engineering design and analysis skills to support a career in systems engineering.

Entry is at your centre's discretion. However, we recommend that learners have one or more of the following:

- broad knowledge and understanding of electrical, electronic, and mechanical concepts and theorems at SCQF level 6, for example in subjects related to electrical engineering, electronics or mechanical principles
- knowledge and understanding of manufacturing principles, and project and risk management at SCQF level 6, for example in subjects related to manufacturing principles, or project and risk management
- relevant, equivalent workplace experience or SCQF level 6 qualifications, for example Higher Physics or a National Certificate (NC) in Engineering Systems

This unit provides learners with suitable knowledge and skills to progress to further study, or employment in a wide range of engineering industries.

Unit outcomes

Learners who complete this unit can:

1 apply key concepts of system integration
2 use verification and validation techniques in system modelling
3 identify methods of assuring quality in engineering systems
4 explain the importance of reliability to engineering design

Evidence requirements

All outcomes can be assessed holistically using product, written and/or oral recorded evidence. Learners generate evidence under controlled or supervised, open-book conditions, and it must be authenticated as being all their own work. The evidence must contain a mix of knowledge and skills items that matches the evidence requirements of the unit, and include various forms of evidence, such as:

- assignments
- case studies
- reports
- essays
- simulations
- structured controlled tests
- practical evidence
- other relevant sources of evidence

Where sampling is indicated, you must teach all content in the 'Knowledge and skills' section and it must be available for assessment. Learners should not know which items they will be assessed on in advance. You must use a different sample for each assessment occasion.

Outcome 1

The following items are all required for every assessment:

- Describe how block diagram components operate.
- Explain how block diagram components can be constructed to communicate the functions of a complex system.
- Draw a complete block diagram that illustrates the functionality of a system.

One of the following four items is required for each assessment:

- Explain how data is transferred through a complex system through point-to-point or point-to-multipoint communication channels.
- List and describe the characteristic differences between analogue and digital data communication.

- Describe how the communication medium relates to the data structure, for example the use of voltage signals to communicate across electrical wires or the use of electromagnetic signals to communicate across optical fibre.
- Describe the role of machines as a converter of electrical and mechanical data structures.

Outcome 2

- Define the purpose of validation and verification in the design of quality-managed engineering systems.
- Describe two verification and validation activities, and explain what each activity seeks to demonstrate.
- Apply a validation and verification technique to a system under study. For this, you could supply learners with a case study or problem-based-learning (PBL) scenario.

Outcome 3

- Define the purpose of quality assurance as a means of protecting an engineering system from mistakes, errors and defects.
- Evaluate two methods and practices that are commonly employed to assure quality.
- Identify the relevant national, international and industrial standards applicable to quality assurance and describe key concepts.

Outcome 4

- Describe the purpose of reliability engineering as a means of managing a system function in an operating environment that has an inherent risk of failure.
- Describe key concepts of reliability engineering that are commonly employed to manage risk of failure. Concepts include design resilience (for example redundancy, diversity and segregation), maintenance strategies, mean time to failure (MTTF) analysis and fault tree analysis.

Knowledge and skills

The following table shows the knowledge and skills covered by the unit outcomes:

Knowledge	Skills
Learners should understand how to: ♦ explain data transmission through complex systems ♦ describe the role of machines in multi-complex systems ♦ describe the purpose of both validation and verification activities ♦ describe methods of validating and verifying a system ♦ explain the importance of quality assurance in engineering systems ♦ describe methods for quality assurance ♦ identify the relevant British, EU and industrial standards applicable to quality assurance and describe key concepts ♦ describe the purpose of reliability as applied to engineering systems ♦ describe key concepts of reliability engineering	Learners can: ♦ describe how block diagram components operate ♦ explain how block diagram components can be constructed to communicate the functions of a complex system ♦ draw a complete block diagram that illustrates the functionality of a system ♦ explain how data is transferred through a complex system through point-to-point or point-to-multipoint communication channels ♦ list and describe the characteristic differences between analogue and digital data communication ♦ describe how the communication medium relates to the data structure, for example the use of voltage signals to communicate across electrical wires or the use of electromagnetic signals to communicate across optical fibre ♦ describe the role of machines as a converter of electrical and mechanical data structures ♦ define the purpose of validation and verification in the design of quality-managed engineering systems ♦ describe two verification and validation activities, and explain what each activity seeks to demonstrate ♦ apply a validation and verification technique to a system under study; for this, you could supply learners with a case study or problem-based-learning (PBL) scenario ♦ define the purpose of quality assurance as a means of protecting an engineering system from mistakes, errors and defects

Knowledge	Skills
	Learners can: ♦ evaluate two methods and practices that are commonly employed to assure quality ♦ identify the relevant national, international and industrial standards applicable to quality assurance and describe key concepts ♦ describe the purpose of reliability engineering as a means of managing a system function in an operating environment that has an inherent risk of failure ♦ describe key concepts of reliability engineering that are commonly employed to manage risk of failure; concepts include design resilience (for example, redundancy, diversity and segregation), maintenance strategies, MTTF analysis and fault tree analysis

Meta-skills

Throughout the unit, learners develop meta-skills to enhance their employability in the engineering sector.

Self-management

Learners develop their focusing, adapting and initiative skills as they study the course material. They can provide evidence of these in their reflective reports.

Social intelligence

Learners develop their communication skills. Examples of this would be drawing the block diagram for outcome 1, and applying validation and verification techniques.

Innovation

Learners develop their curiosity, sense-making and critical thinking skills. Considering alternative engineering activities, and evaluating quality assurance methods and practices could count as evidence of this.

Literacies

Learners develop core skills in the following literacies:

Numeracy

Learners develop their numeracy through quantifying the quality of the engineering system, and considering validation and verification techniques.

Communication

Learners develop their communication skills by studying the course material and engaging with fellow learners, and their teacher or lecturer.

Digital

Learners develop their digital literacy by accessing the course material through a virtual learning environment, if applicable.

Delivery of unit

This unit is part of the Higher National Certificate (HNC) in Engineering. The framework includes mandatory and optional units, and you can tailor the selected combination of units to specific qualifications.

The notional design length is 120 hours, however, the amount of time you allocate to each outcome is at your centre's discretion. We suggest the following distribution of time, including assessment:

Outcome 1 — Apply key concepts of system integration
(30 hours)

Outcome 2 — Use verification and validation techniques in system modelling
(30 hours)

Outcome 3 — Identify methods of assuring quality in engineering systems
(30 hours)

Outcome 4 — Explain the importance of reliability to engineering design
(30 hours)

Additional guidance

The guidance in this section is not mandatory.

Content and context for this unit

This unit gives learners some of the knowledge and skills they need to support a career in systems engineering.

Apply key concepts of system integration (outcome 1)

This introduces learners to key concepts in systems integration. This knowledge provides a foundation that supports later study of systems engineering concepts. The study of data transfer should include analogue and digital communication methods, such as single-ended, differential, current, voltage and radio frequency.

Use verification and validation techniques in system modelling (outcome 2)

This introduces learners to system verification and validation. This gives them a firm understanding of the importance of robust engineering design. In addition, teach them how to apply these techniques, which benefits them in their future career in systems engineering.

Identify methods of assuring quality in engineering systems (outcome 3)

This introduces learners to quality assurance. This reinforces their understanding of the importance of robust engineering design. Learners also gain knowledge of the key quality assurance methods and standards of practice.

Explain the importance of reliability to engineering design (outcome 4)

This introduces learners to reliability in systems engineering. This provides them with an understanding of how engineering projects are implemented in the real world, where the risk of failure is a threat that needs to be understood and managed.

There are no specific resources required for this unit other than information and communications technology (ICT).

Approaches to delivery

We advise that learners complete outcome 1 first. They can then complete outcomes 2, 3 and 4 in any order.

Outcome 1 introduces learners to key concepts in systems engineering, so they would benefit from this foundational knowledge before they move on to the subsequent topics. Outcomes 2, 3 and 4 contain discrete subject matter, and are not interdependent.

Deliver these outcomes in a learning space or virtual learning environment. You should teach primarily using problem-based-learning (PBL) techniques, such as case studies and mini projects, supported by other methods. The holistic teaching format of PBL encourages learners to consider the deeper context of the theory.

Approaches to assessment

In line with the approach to delivery, you should take a holistic approach to assessment. This consists of a review of case study reports and mini projects.

For case studies and mini projects, you can assess knowledge and skills through coursework exercises. Learners must generate product evidence (for example, in the form of a coursework report), which they should produce under controlled or supervised, open-book conditions.

Learners could demonstrate evidence of all knowledge and skills in the context of one or more overarching complex systems engineering scenarios. They should collate all evidence in their individual portfolio.

Learners could keep a linear reflective account to measure their meta-skills, digital literacies, professional skills and wider employer-desired skills. They should record this in their portfolio.

You should provide learners with support, guidance and feedback on areas of development, and signpost developmental opportunities.

Because of the open-book nature of the assessment, you must take care to ensure authenticity. You could do this by using variable values in the coursework, making use of oral questioning and using originality-checking software, as appropriate.

Opportunities for e-assessment

Assessment that is supported by information and communication technology (ICT), such as e-testing or the use of e-portfolios or social software, may be appropriate for some assessments in this unit.

If you want to use e-assessment, you must ensure that you apply the national standard to all evidence and that conditions of assessment (as specified in the evidence requirements) are met, regardless of the mode of gathering evidence.

Equality and inclusion

This unit is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

You should take into account the needs of individual learners when planning learning experiences, selecting assessment methods or considering alternative evidence.

Guidance on assessment arrangements for disabled learners and/or those with additional support needs is available on the assessment arrangements web page: www.sqa.org.uk/assessmentarrangements.

Information for learners

Engineering Systems: Validation and Verification (SCQF level 7)

This information explains:

- what the unit is about
- what you should know or be able to do before you start
- what you need to do during the unit
- opportunities for further learning and employment

Unit information

This unit provides you with knowledge and skills specific to systems engineering. It forms part of the Higher National Certificate (HNC) in Engineering, which is aimed at learners who wish to become engineering technicians.

In this unit, you learn about topics such as block diagrams, system integration, data transmission, and verification and validation.

Unit outcomes

On completion of this unit, you can:

1 apply key concepts of system integration
2 use verification and validation techniques in system modelling
3 identify methods of assuring quality in engineering systems
4 explain the importance of reliability to engineering design

Outcome 1 — introduces you to key concepts in systems integration. This knowledge provides a foundation that supports later study of systems engineering concepts.

Outcome 2 — introduces you to system verification and validation. This gives you a firm understanding of the importance of robust engineering design. In addition, you learn how to apply these techniques, that benefits you in your future career in systems engineering.

Outcome 3 — introduces you to quality assurance. This reinforces your understanding of the importance of robust engineering design.

Outcome 4 — introduces you to reliability in systems engineering. This provides you with an understanding of how engineering projects are implemented in the real world, where the risk of failure is a threat that needs to be understood and managed.

There is a holistic approach to assessment, where you demonstrate evidence of all knowledge and skills in the context of one or more overarching complex systems engineering scenarios.

You are assessed by a variety of ways, including review of case study reports and mini projects. You should collate all evidence in your individual portfolio.

Meta-skills

Throughout the unit, you can develop meta-skills to enhance your employability in the engineering sector.

Meta-skills include self-management, social intelligence and innovation.

Self-management

You develop the skills of focusing, adapting and initiative as you study the course material.

Social intelligence

You develop your communication skills as you receive information from your teacher or lecturer.

Innovation

You develop the skills of curiosity, sense-making and critical thinking. An example of this is considering alternative engineering activities.

Administrative information

Published: October 2024 (version 5.0)

Superclass: VE

History of changes

Version	Description of change	Date
2.0	♦ Additional wording in 'Evidence requirements' to clarify sampling for assessment of outcome 1. ♦ Minor punctuation edits for clarity and readability in 'Additional guidance' section. ♦ Changed 'section' to 'information' in 'Information for learners' section for consistency across units.	August 2023
3.0	New unit title and code following change request from pilot centre.	July 2024
4.0	Additional wording to clarify conditions of assessment.	August 2024
5.0	Approaches to assessment updated	October 2024

Note: please check SQA's website to ensure you are using the most up-to-date version of this document.