SYSTEMS ENGINEERING MASTERS LEVEL APPRENTICESHIP

ASSESSMENT PLAN

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INDEX

OVERVIEW

The Systems Engineering Masters Apprenticeship Programme (SEMAP) aims to create rounded professional Systems Engineers who understand and can practise Systems Engineering. Primarily focussed on the Defence sector, successful apprentices will be able to undertake INCOSE[1] Practitioner level Systems Engineering roles across Defence projects, and also in other sectors since many of the core skills will be transferable.

Assessment Overview

The apprenticeship combines academic learning and vocational training to develop practitioner level systems engineers. The academic and vocational elements complement each other and provide a base from which each apprentice can develop, refine and apply their knowledge, skills and behaviours.

Each apprentice will undertake a tailored programme of level 7 academic tuition and vocational training in their workplace. This programme will reflect the aspirations of the apprentice and the needs of the employer, around the relative emphasis given to different systems engineering competencies and any specialist learning required, for example in particular domains.

Apprentices must complete a post graduate diploma in systems engineering (120 credits at level 7) or equivalent; accreditation of prior learning is allowable where appropriate. Note that apprentices may additionally wish to obtain an MSc, which would comprise a thesis/project being added to the diploma – but this would formally be outside the apprenticeship.

Academic tuition should provide the underpinning knowledge and skills required to complete the apprenticeship, but alone will not provide the Practitioner level standard required.

Vocational based activities will provide the mechanism for an apprentice to build on the underpinning academic knowledge and skills and develop and refine them through applying them on real work problems and projects. It is this experience and application that will develop practitioner level systems engineers. It is expected that reflective and progressive learning and understanding is captured and recorded throughout the apprenticeship in the apprentice's 'logbook' or development record. Within this record, each apprentice will collate evidence of activities undertaken, what they have leant and what skills and a reflection of the knowledge and competencies they have gained. During the final stages of the apprenticeship, typically within the last 3 to 6 months, the apprentice will prepare a portfolio of evidence, which in conjunction with the apprentice's logbook/development record, will provide the basis for the end point review, which will be used to confirm achievement of the apprenticeship Standard's aims.

The time required to complete this apprenticeship will be determined by the academic award and the time required to build up this supporting evidence.

The final assessment of the apprenticeship (the Synoptic End Point Assessment) will converge the academic learning and vocational development and will include:

- A panel review of the portfolio of evidence prepared by the apprentice, to ensure it meets the requirements of the standard in its entirety, and
- A VIVA presentation and structured Interview in which each apprentice will explore and demonstrate their knowledge, what they have done and how they have performed against the requirements of the standard.

A minimum of three assessors, including at least one individual independent of the apprentice, will form a panel that will confirm satisfactory achievement of the Standard. All assessors will be expected to meet certain minimum experience based criteria in the field of Systems Engineering. In

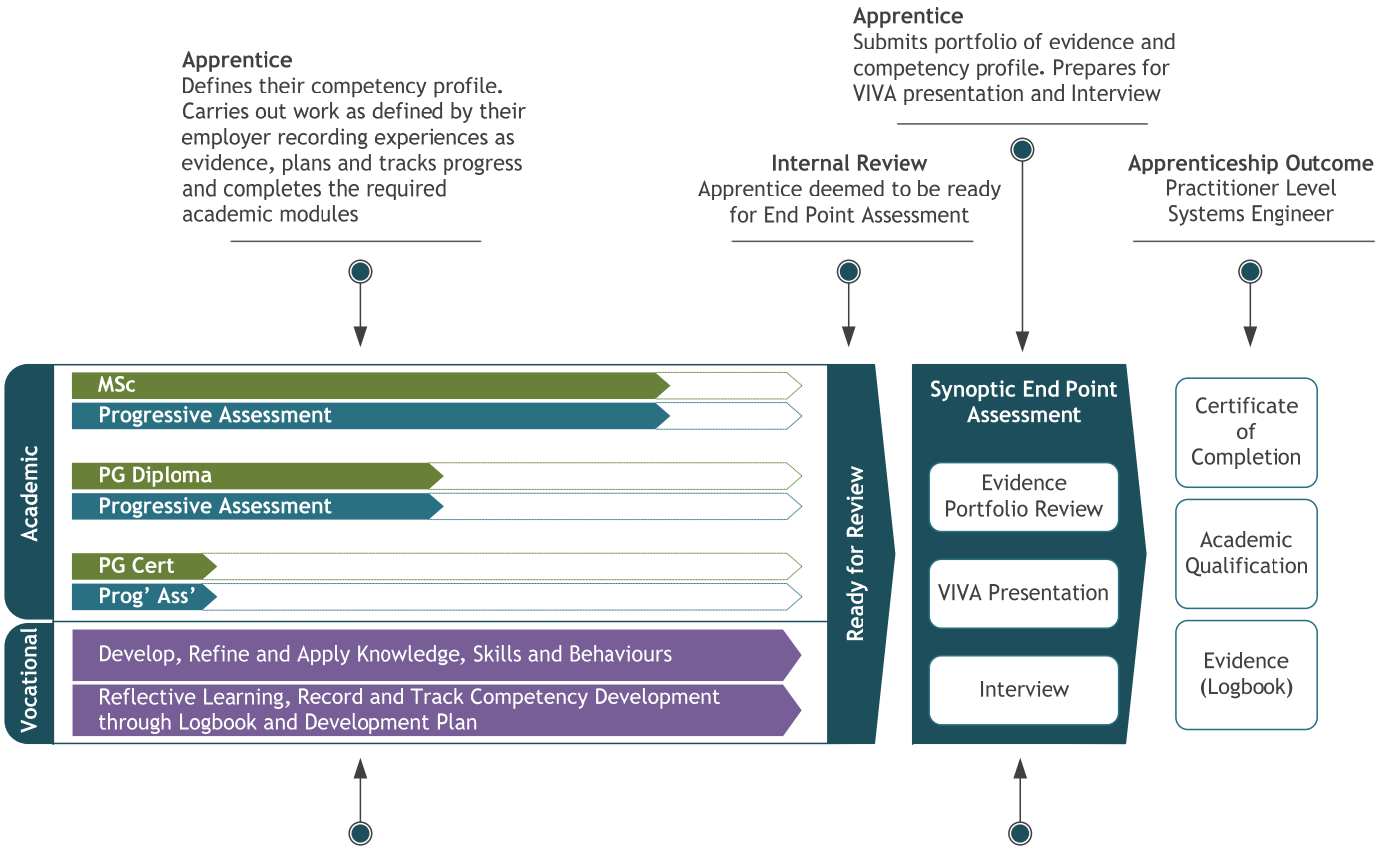
[1] International Council on Systems Engineering, the international professional body for Systems Engineering

addition these assessors will be supported with assessor training and an external assessment organisation engaged to verify correct scheme administration, for fairness and consistency.

Successful apprentices will receive:

- An apprenticeship certificate showing achievement of the apprenticeship standard as an INCOSE Systems Engineering Practitioner, recognised by many of the largest organisations within the sector,
- an academic award – typically a Post Graduate Diploma in Systems Engineering, but potentially a Post Graduate Certificate or MSc,
- an evidence portfolio detailing the knowledge, skills and behaviours attained.

This assessment approach is illustrated in the following diagram and then described in detail in the rest of the assessment plan.



Training Provider
Maps and assesses work against the Standard, provides guidance to enable the apprentice to practice and develop their knowledge, skills and behaviours

Employer
Identifies opportunities for the apprentice to carry out work, helps develop and track progress and assesses readiness for End Point Assessment

Independent Lead Assessor
Chair of the End Point Assessment panel. Has veto power over other assessment panel members

Assessment Panel
Assesses and grades the apprentice on the basis of the evidence review, VIVA and Interview.

Independent Moderation
Assessment organisation provides quality controls and moderation of assessment. The moderator is separate to the Independent Lead Assessor

Competency Profile

At the beginning of the apprenticeship, the apprentice, in conjunction with their Employer mentor, will develop a personalised **practitioner level competency profile**, mapped against the Standard and the underpinning Systems Engineering Competency framework.

This profile will be used to define what the apprentice must achieve to complete the apprenticeship and meet the standard. Each apprentice will be able to tailor their profile to reflect their own areas of interest and the type of work their employer conducts. This tailoring process must follow certain rules to ensure all apprentices are assessed fairly and each receives rounded and comparable training.

These rules will reflect the standard, drawing principally on the INCOSE UK Systems Engineering Competencies Framework (2010), the required behavioural competencies and tailoring around particular specialist or domain competencies.

A formal learning agreement will be created between the apprentice, the employer and lead provider.

The detailed assessment criteria relating to the INCOSE UK Systems Engineering Competencies Framework can be found in Appendix A – Assessment Review Criteria.

These rules are being refined and will be added in mid-June.

Development Plan

To support the apprentice in attaining their agreed competency profile, the apprentice should use a development plan to define the learning objectives of each work assignment. Defining these objectives will help focus the apprentice on particular tasks which will result in the competencies being developed and demonstrated. The Employer mentor will guide and advise the apprentice in creating their development plans, which may take various forms.

It is anticipated that the development plans will be a live document which the apprentice will update throughout the apprenticeship. The development plan should form part of the apprentice's logbook / development record.

ACADEMIC AND VOCATIONAL LEARNING

On-Programme Training and Assessment

Apprentices must complete a post graduate diploma in systems engineering (120 credits at level 7) or equivalent; accreditation of prior learning is allowable where appropriate.

Academic learning will be at Level 7 and will comprise core and elective modules. Core modules will be specified to ensure each apprentice is afforded the same fundamental knowledge, skills and behavioural information necessary for a systems engineering practitioner. This commonality in teaching will provide a consistent level of knowledge among all apprentices. Elective modules will be offered to allow each apprentice to specialise (if they so wish) in a certain area or field.

Academic tuition alone will not provide the apprentice with the necessary practitioner skills required to complete the apprenticeship. The tuition will however provide each apprentice with a platform from which they can refine their knowledge, skills and behaviours through vocational practice.

Academic Learning

The level 7 academic tuition will be likely to be provided by Higher Educational Institutions (HEIs). Tuition will typically be in either block release format (a 5 day residential course), or distance learning format (where tuition is provided electronically, for example through webinars).

The modules provided will be validated to ensure their intended learning objectives map to those of the overall apprenticeship.

Each academic module will consist of three elements: pre-reading and preparation, delivery and finally assessment.

Apprentices completing a full MSc will be expected to complete a thesis or individual project in addition to the academic tuition. This will provide the apprentice with the opportunity to undertake an in-depth study of an area of particular interest.

Academic Assessment

Each academic module offered will be assessed in a way most appropriate to measure the learning objectives of the module. Assessments will be designed to ensure the learning objectives have been correctly understood and can be applied.

Academic modules may be assessed using a combination of assignment, group assessments, presentations and examinations, which will encourage reflection and application in context, using case study examples.

Formal assessments, such as essay assignments, practical assignments, or dissertation style research may be carried out in the apprentice's own organisation. Written and oral examinations, problem solving exercises and presentations may require the apprentice to be assessed at the academic institution's site.

Academic assessments conducted at academic institutions are regulated to ensure quality and consistency, in accordance with the UK Quality Code for Higher Education (the Quality Code).

Academic Mentoring

Academics will both provide tuition, mapped to the standard, and support and feedback to the apprentice, in the form of mentoring throughout the academic phase of the scheme. Academics through the tuition and mentoring will provide feedback and set advisory learning objectives for the apprentice, so they can further develop through vocational assignments.

For those apprentices undertaking an MSc academic award, mentoring will be an important part of the thesis section. Close supervision and mentoring will be required to ensure a successful outcome of this stage of the apprenticeship and will be likely to involve both the employer and academic provider.

On-Programme Vocational Learning

Academic tuition will be supplemented with vocational learning through structured vocational assignments. These two elements of the apprenticeship will form a cohesive mechanism to allow each apprentice to develop the knowledge, skills and behaviours required.

Vocational assignments (real projects within employers) with targeted aims (defined within the development plan of the apprentice and defined with the help of the apprentice's Employer mentor) will create an environment in which the apprentice can start to apply, refine and learn from their skills, knowledge and behaviours. Multiple vocational assignments will take place throughout the apprenticeship to allow the apprentice to acquire the broad skills and knowledge required to become a rounded systems engineering practitioner.

Each apprentice will gather and record evidence of each of their vocational assignments during the apprenticeship and map this to their competency profile reflecting on what they have done, what they have achieved and what competencies they have developed/demonstrated. This can be recorded and presented in any format or media and is referred to generically as a 'logbook'.

Vocational Review and Mentoring

There will be no formal on-programme assessments of the vocational aspect of this apprenticeship, until the synoptic end point assessment. However, regular reviews of the apprentice's progress should be made by the Employer mentor. These reviews will track the progress of the apprentice towards attaining the competency levels required (defined by the apprentices competency profile) and reflectively review the apprentice's development plans and feedback received.

Reviews may typically take place after each work assignment, although the timing and frequency will be down to each employer.

Academic learning and/or vocational learning will continue until the apprentice has reached the required standard of the apprenticeship. At this point the apprentice will prepare their portfolio of evidence and once ready, be put forward for the synoptic end point assessment.

END POINT ASSESSMENT

The Synoptic End Point Assessment will be a convergent assessment of the whole apprenticeship. It is designed to assess the apprentice against their competency profile and thus the standard. The apprentice will undertake the assessment as and when they are ready. This assessment will typically be held at the employer's premises.

Forms of Assessment

Portfolio of Evidence Review

Before the Synoptic End Point Assessment, each apprentice will prepare and submit a supporting 'portfolio of evidence' along with their competency profile. This portfolio will summarise and showcase evidence illustrating the application of the systems engineering knowledge, skills and behaviours detailed in the standard. Apprentices are advised to record evidence throughout the apprenticeship in a 'logbook' – see above, to inform the portfolio.

The portfolio may contain example work conducted throughout the apprenticeship, or provide evidential summaries of work which will enable the apprentice to demonstrate what they have done, what they have learnt and how they have applied this knowledge and skill to real work projects and problems.

Evidence described within the portfolio should be supported by any documents, presentations, journal entries or relevant material (where applicable), to show how an apprentice has demonstrated the knowledge, skills and behaviours required.

Employers (Employer mentors) should assist the apprentice in planning, creating and recording evidence to create their logbook and later portfolio. Employers should help apprentices develop their portfolio of evidence through structured learning objectives, recorded in the apprentice's development plan and should ensure opportunities to obtain the necessary competencies, skills and knowledge are identified. Progressive review of the logbook by mentors should ensure the evidence covers the totality of the standard.

The compiled portfolio of evidence will be reviewed internally (by the Employer mentor and the Employer Assessor) to ensure it meets the standard required. If both agree it does, it will be submitted to the Synoptic End Point Assessment panel for review. Where agreement cannot be reached, the disagreeing party will provide guidance to the apprentice and other party to resolve the issue, this will be likely to be a recommendation to provide more evidence in a particular area. The panel, which will incorporate independent review will make a judgement of the quality and totality of the evidence. The panel may also pick up on particular aspects of evidence which they may wish to discuss during the interview stage, either to confirm judgement or to probe to obtain further information upon which to base a judgement.

If the review and assessment of the portfolio of evidence, in its entirety **does not** contain sufficient evidence to meet the standard then it will be deemed to **fail**, and the VIVA presentation and interview will **not** take place. Given the VIVA and Interview are based upon this portfolio of evidence, this review point validates that the apprentice is ready for final review. The assessment organisation will provide guidance on the nature of the portfolio of evidence for the apprentice and employers to ensure consistent assessment can be conducted.

VIVA Presentation

Each apprentice will be asked to prepare a VIVA presentation. The subject of the presentation can be selected by the apprentice but the content must reflect practitioner level understanding in that area. Typically this presentation will be based upon work competed and captured in the apprentice's portfolio of evidence.

The VIVA presentation is expected to be 20 to 30 minutes long followed by up to 30 minutes of questioning from the assessment panel. Assessment will be made on quality, clarity and the demonstration of using systems engineering principles, processes and methods and a systems approach in the workplace.

The purpose of the presentation is to:

- Convince and give confidence to the panel that all necessary competencies have been obtained (by demonstrating and talking about a sample selection),
- Probe the knowledge of the apprentice in a particular area, and
- Probe the apprentice's general systems engineering understanding and application.

A structured brief will be developed by the assessment organisation (in conjunction with the employer assessors) to support the structure and content of the VIVA assessment. This will ensure a consistent approach to assessment is taken. The assessment organisation will also provide guidance for the apprentice.

Interview

The Interview is a structured discussion between the apprentice and the assessment panel. It will focus on the portfolio of evidence the apprentice has submitted and the content of the VIVA presentation. It will cover **what** the apprentice has done (and the competencies gained) and **how** they have approached what they have done.

This enables this assessment to cover a broad range of knowledge, skills and behaviours prescribed in the standard, particularly the apprentice's domain understanding and specialist skills and understanding.

The purpose of the interview is to:

- Clarify any questions the panel has around the evidence portfolio.
- Confirm and validate the judgements about the quality of the work complete.
- Confirm that the portfolio of evidence is the apprentices own work.
- Confirm the apprentice understands what has been written and can defend it verbally.
- Explore particular areas of the work, including how it was carried out and what was done in more detail.
- Provide a basis for the independent employer mentor to make a holistic decision about the grade to be awarded.

A structured brief will be developed by the assessment organisation (in conjunction with the employer assessors) to support the structure and content of this interview. This will ensure a consistent approach to assessment is taken and all areas of the standard are covered. The assessment organisation will also provide guidance for the apprentice.

Process

The Synoptic End Point Assessment will be conducted by a panel formed of the Employer assessor and mentor (optional role), an independent employer assessor, an academic (optional role) and, at times, an assessor from the assessment organisation who will be responsible for moderation of the assessment process as a whole. Employer panel members will be leading professionals in their field, with the skills and experience to represent the sector and make a valid judgement. The requirements for each of these panel members is outlined in the 'assessment roles' section below.

The assessment panel will make a holistic assessment of each apprentice's work on the basis of the evidence supplied in the supporting portfolio of evidence and through the VIVA presentation and Interview.

The chair of the synoptic end point assessment panel will be an independent employer assessor, originating from a different company to that of the apprentice. The chair will have overall veto rights on the judgement of the panel ensuring an impartial judgement from an independent source.

An assessment organisation will be responsible for co-ordination of the panels, and may attend some as part of the process to ensure consistent and fair outcomes.

Quality Assurance

The assessment methods described are designed to produce outcomes that are consistent and reliable, allowing a fair and proper comparison between apprentices employed in different types and sizes of organisations. The processes described in this section are designed to ensure the consistent application of the assessment process and standard.

The apprenticeship standard defines what is required in terms of the knowledge, skills and behaviours of a practitioner level systems engineer. Our assessment approach encapsulates and resonates the standard through each assessment, ensuring that judgements on occupational competence are consistent and that there is standardisation and comparability between employers.

Some of the materials and reference documentation required for assessment already exist and have been provided by INCOSE for use on this apprenticeship. These materials include two documents, a competency framework for systems engineers, which will be used by each apprentice to define their competency profile and development plans, and a guide to competency evaluation, which will be used as the basis from which assessment will be made at the Synoptic End Point Assessment.

Guidance material for selection of industry assessors and detail interpretation guidance of the INCOSE competency framework criteria, are seen as a necessary precursor for the Synoptic End Point Assessments.

Assessment organisations must have:

- The ability to produce guidance on assessments, including the tools and materials required to deliver assessment,
- Experience in delivering assessments,
- Basic sector knowledge and understanding,
- Standing within the sector,
- Capable staff with sector experience,
- An internal quality assurance process,
- A customer service process,
- Training and governance plans for long term sustainability,
- Management and coordination arrangements for delivering assessment, and
- Geographical coverage.

Employers can use any assessment organisation on the Skills Funding Agency (SFA) register of apprenticeship assessment organisations approved to offer services against this plan.

Assessment organisations are expected to work collaboratively with Employers and the professional body INCOSE to develop the assessment and supporting tools and techniques. Tools and techniques developed should be designed to safeguard consistent and comparable results.

Where required, Synoptic End Point Assessment panel members will be trained and approved to use the assessment tools by the assessment organisation. They will be provided with guidance and supporting information to help ensure that all assessments are conducted and completed consistently against the required specification. They will ensure that individuals carrying out the assessment will be capable, hold the level of sector experience required and are trained as required.

The assessment organisation will also provide guidance for apprentices on the end-point assessment tools and process, ensuring comparability of evidence and opportunity to demonstrate competence.

The selected assessment organisation will be required to have robust internal quality assurance processes to ensure consistent and valid assessments are maintained.

The assessment organisation will carry out moderation of the assessments and will monitor the quality and consistency of judgements of the panel. They will operate a complaints and appeals process in relation to the End Point Assessment.

GRADING

Both academic and vocational aspects of the apprenticeship will be independently assessed.

The Synoptic End Point Assessment acts as the convergent point between academic and vocational elements of the apprenticeship. It is at this point that both academic learning and work experience will be synoptically assessed and a grade awarded to the apprentice for the apprenticeship.

Where an academic award is achieved, it will be assessed and awarded independently (by the academic provider).

Academic Grading

The academic grading will be made in line with the individual's academic institutions regulations. As a guide the following grading criteria will be applied:

- **Pass** – The apprentice has successfully obtained 120 credits of Level 7 Systems Engineering learning with a minimum average mark greater than 50%, or
- **Fail** – The apprentice has failed to successfully obtain 120 credits of Level 7 Systems Engineering learning with a minimum average mark greater than 50% in the academic assessment.

Academic modules use a credit weighting system. The average mark is obtained by calculating the weighted score obtained for each module relative to its overall credit rating and summing together these figures. This summed value is the overall average mark.

Synoptic End Point Assessment Grading

The Synoptic End Point Assessment will be a competency based assessment. The End Point Assessment panel will review the evidence provided and question the apprentice against the standard (knowledge, skills and behaviours) to determine an overall grade. This grade will be defined as either:

- **Pass** – The apprentice has successfully passed the Synoptic End Point Assessment by demonstrating their competence against their agreed competency profile and the required practitioner level standard, or
- **Fail** – The apprentice has failed to demonstrate their competence against their agreed competency profile and does not meet the required practitioner level standard.

PROFESSIONAL REGISTRATION

This apprenticeship has not been designed specifically to integrate into a professional registration process. As such professional registration is **not** an outcome of this apprenticeship.

However, given this apprenticeship provides training and tuition at level 7, it is likely that an apprentice would be ready to apply for professional registration at the end of this apprenticeship.

Given the mix of academic learning and structured vocational learning and experience, it is likely that an apprentice will gain the portfolio of evidence required for professional registration. If an apprentice would like to use the portfolio of evidence captured and recorded in this apprenticeship as evidence for professional registration, they are free to structure it accordingly, and reference it against UKSPEC alongside referencing progression against the apprenticeship standard. In this instance, the apprentice could use the same evidence portfolio for both the apprenticeship and professional registration process (removing the need to duplicate the information).

It is at the apprentice's discretion as to the method to capture evidence for this apprenticeship and that required for professional registration.

For those apprentices with an objective of achieving professional status the academic modules delivered as part of this apprenticeship will likely be accredited by a number of professional institutions and will therefore contribute towards the requirements for professional registration. For more information, please contact the relevant higher educational institution.

ASSESSMENT ROLES

Assessment of the Apprenticeship

The Systems Engineering apprenticeship has two main types of assessment, academic and vocational. Each will be assessed by different individuals, from both within an apprentice's organisation and externally. This approach is designed to provide integrity to the scheme, ensuring impartiality and a consistent assessment to all apprentices across the breadth of the apprenticeship.

Table 1 provides a summary of the main forms of assessment within this apprenticeship, along with the result of successfully completing that assessment.

Table 1 – Assessment Roles

Form of Assessment	Assessor	Result of Assessment
Academic Assessment	Academia	Credit towards Academic Award
Vocational Review (Informal assessment)	Employer Mentor	Approved evidence portfolio
Synoptic End Point Assessment	Independent Employer Assessor Employer Assessor Employer Mentor (optional) Academia (optional) Assessment Organisation – Assessor (optional)	Completion of the apprenticeship

Assessment Roles and Role Requirements

This section describes the required roles and responsibilities of those involved in assessment. The roles include:

- Academia,
- The Employer Mentor,
- The Assessment Organisation – Assessor,
- The Employer Assessor, and
- The Independent Employer Assessor.

Academia

Academic tuition will be delivered by higher educational systems engineering institutions in the UK, tailored to the objectives of this apprenticeship. Academia will be responsible for providing the academic tuition, support and assessment throughout the apprenticeship.

Academia will be expected to:

- Provide the apprentice with the specific learning objectives of each module studied so they can better define the objectives of vocational assignments,
- Provide the specific academic tuition mapped to the INCOSE Competency Framework and UK-SPEC, meeting the requirements of Employers,
- Set and assess academic assignments and facilitate moderation and cross assessment,
- Provide support and feedback to apprentices throughout the scheme (academic mentoring),

- When required, liaise with the Employer mentors to obtain feedback on delivered content and guidance given to apprentices, and
- Sit on the Synoptic End Point Assessment panel, review evidence and provide an assessment (Optional Role).

The Employer Mentor

The Employer mentor will assist in planning, monitoring and reviewing the apprentice's vocational work. The following recommendations provide guidance on the criteria for selecting an Employer mentor, to ensure they are suitably qualified, versed and experienced in Systems Engineering:

- The appointment of Employee Mentors shall be in agreement with the nominated Employer Lead Assessor,
- Employer mentors should be professionally registered as CEng,
- Employer mentors should ideally be individual members of INCOSE UK,
- Where an Employer mentor is not an expert Systems Engineer, or has gaps in some areas, they may be supervised by a senior colleague with that knowledge – most likely to be the Systems Engineering lead for the organisation, or an Engineering Fellow in Systems Engineering.

The role of the Employer mentor will be to:

- Help the apprentice define their competency practitioner level profile,
- Help the apprentice create a Development Plan,
- Help the apprentice obtain the necessary vocational assignments to allow the apprentice to develop, refine and apply their knowledge, skills and behaviours,
- Assist the apprentice in planning their learning objectives for each work assignment,
- Review the apprentice's supporting evidence portfolio, ensure it is accurate, provide feedback/guidance and sign it off,
- Help the apprentice map their competency development against their profile,
- Provide mentoring throughout the apprenticeship (behavioural, technical and development),
- Review and approve the apprentice's portfolio of evidence prior to submission to the Synoptic End Point Assessment, and
- Sit on the Synoptic End Point Assessment panel, review evidence and provide an assessment (Optional Role).

Assessment Organisation - Assessor

The assessment organisation will be responsible for the delivery of the Synoptic End Point Assessment. The assessor will provide moderation of the End Point Assessment panel. They will typically be expected to periodically attend End Point Assessments in each Employer to provide this moderation. In addition moderation outside of the End Point Assessment may take place, to ensure assessors are able to provide assessment to the quality and standard required.

An assessor from the assessment organisation will be expected to:

- Coordinate and organise the Synoptic End Point Assessment,
- Assist the lead assessors to create assessment guidance (VIVA presentation and Interview assessment guidance),
- Ensure assessors follow the guidance of the Assessment (to ensure fair and consistent assessment),
- Record the outcome of the assessment panel, and
- Authorise the issuing of the apprenticeship Completion Certificate.

(Note that this person need not be technically expert or indeed qualified in systems engineering – their role is to ensure that the assessment process is followed and the outcome is fair and consistent. As such this individual does not need any qualifications in systems engineering or any related field).

The Employer Assessor

The Employer Assessor will typically be amongst the most senior systems engineers in the employer's organisation. They are expected to hold a level of understanding above that which is being assessed. As such they will likely be an 'expert' level systems engineer.

The Employer Assessor will make a judgement as to whether the apprentice is ready to be put forward for the End Point Assessment, by reviewing their evidence portfolio.

Once ready the Employer Assessor will also sit on the Synoptic End Point Assessment Panel.

The role of the Employer Assessor is similar to that of the Employer mentor, but the Employer Assessor will also be expected to:

- Create assessment guidance, with the support of the assessment organisation(s) (VIVA presentation and Interview assessment guidance),
- Review and agree the apprentice's supporting evidence portfolio and provide feedback/guidance,
- Review the apprentice's Competency Profile and their evidence showing development against it,
- Question the apprentice to ensure they are ready for the Synoptic End Point Assessment, and
- Sit on other employers' Synoptic End Point Assessment panels (as an Independent Employer Assessor).

Independent Employer Assessor

The Independent Employer Assessor will provide review, feedback and assessment during the Synoptic End Point Assessment to ensure that the apprentice has achieved the required vocational standard. They will reside within an organisation outside that of the apprentice. This independence will ensure consistent and fair judgements are made.

The role and responsibility of the Independent Employer Assessor remains the same as that for the Employer Assessor, with the addition of the following responsibilities:

- Act as chair of the Synoptic End Point Assessment Panel,
- Make final judgement when all panel members are not in agreement (Independent Assessor has Veto power), and
- Notify the assessment organisation assessor of the outcome of the assessment (when the assessment organisation is not present at the End Point Assessment).

IMPLEMENTATION

Assessment Delivery Cost

The overall cost of the apprenticeship will be determined by a number of factors, including the duration and level of academic qualification undertaken, the amount of vocational training and assignments needed and the ability of the apprentice to demonstrate their skills against the required standard.

Academic Costs

While these variables will vary from one apprentice to another depending on their circumstances, the academic costs associated with the obtaining an academic award are typically:

- Post Graduate Certificate (60 credits) and Certificate of Completion - £7,000,
- Post Graduate Diploma (120 credits) and Certificate of Completion - £14,000, and
- MSc (200 credits) and Certificate of Completion - £16,250.

These are typical costs prior to applying for any subsidies (e.g. from government funding). Costs incorporate the academic delivery, mentoring and assessment. An additional cost will be incurred for reassessments. Elective modules delivered by other academic institutions may also slightly alter these costs.

On-Programme Costs

The costs associated with mentoring and evidence review for the Employer mentor and planning, conducting vocational assignments and reviewing these assignments by the apprentice, will be covered in full, by Employers. There are no anticipated on-programme costs associated with this apprenticeship. Direct grants employers should seek guidance on whether any funding can be claimed for the above activities.

Where an Employer is unable to provide individuals to perform the Employer mentor role, and a mentor has to be sourced from another organisation, this may incur an additional cost to the Employer.

Apprenticeship Administration Costs

Employers are likely to incur fees from training organisations for any programme administration, the exact fee will be determined by the contractual arrangement between organisations.

End Point Assessment Costs

The End Point Assessment will combine review from the Employer assessor and mentor (optional role), an independent lead assessor, an academic (optional role) and an assessor from the assessment organisation (periodic attendance at the End Point Review), to perform moderation of the assessment panel as a whole. Employers are expected to provide their personnel for this assessment, at no additional cost.

There will be an additional cost for the assessment organisation to perform this role. The exact cost will be determined by the contractual arrangement between the two organisations and is expected to be in the region of £XXX per apprentice?

Proportion of the cost in terms of assessment

Given the nature of the effort required for level 7 learning, from both the apprentice and the support roles, for example the Employer mentor performing mentoring, it is expected that the on-programme employer costs, alongside the academic costs will form the greatest proportion of the costs of this apprenticeship.

In terms of overall assessment, the academic assessment will weight heaviest in terms of cost. This cost is incorporated into the academic delivery and assessment, so cannot be directly compared to any other cost.

The End Point Assessment costs, relative to the on-programme costs (both employer costs and academic costs) will be minimal. It is expected that the end point assessment will consist of a day's

review of the supporting evidence by the assessment panel followed by a further half day for the VIVA presentation and Interview. The cost of this review relative to the on-programme costs is minimal.

End Point Assessment – Delivery

Academic institutions delivering the necessary qualifications are already in existence across the country. Four leading academic institutions are involved at the outset who already have the capacity to flex to increased demand. Should the demand be such, further academic organisations could be incorporated into this apprenticeship to deliver further capacity. Given the higher educational institutions are providing delivery, demand would need to surge greatly before scalability became an issue.

Assessment organisations will be required to support the end-point assessment process, which has been designed to be enable flexible delivery across the country.

Supporting Information

The following professional bodies have endorsed this apprenticeship.

- Sector Skills Council for Science, Engineering and Manufacturing Technologies (SEMTA)
- Royal Academy of Engineering
- The Institution of Engineering and Technology (IET), and

The International Council on Systems Engineering (INCOSE).

APPENDIX A – ASSESSMENT REVIEW CRITERIA

KNOWLEDGE & SKILL	DETAILED DESCRIPTION	OBJECTIVE EVIDENCE[2]
Systems Thinking	Methods and techniques to identify problems and needs, capture and manage requirements, design solutions aided by architectures, support the build process and validate solutions. An understanding of the different types of real world complex systems, including what a system is, its context within its environment and its boundaries and interfaces. An appreciation that systems may have emergent behaviours that cannot be predicted from the behaviour of individual subsystems.	Systems Concepts • Able to identify and manage complexity with appropriate techniques in order to reduce risk • Able to predict resultant system behaviour • Able to define system boundaries and external interfaces • Able to assess the interaction between humans and systems, systems and systems • Able to guide supervised practitioner Super System Capability Issues • Able to identify the super System Capability Issues which will affect the design of a system and translates these into system requirements • Able to assess extent to which the proposed system solution meets the super system capability, and provide advice on trade-offs • Able to guide supervised practitioner Enterprise and Technology Environment • Identifies the enterprise and technology issues which will affect the design of a system and translates these into system requirements • Able to produce and implement a technology plan that includes technology innovation, risk, maturity, readiness levels and insertion points • Able to contribute to delivery of enterprise improvements to enable better system development • Able to guide supervised practitioner
Holistic	Applying appropriate lifecycles	Determine and Manage Stakeholder Requirements

[2] Objective evidence for Systems Thinking, Holistic Lifecycle View and Systems Engineering Management taken from the INCOSE Guide to Competency Evaluation and used with permission.

KNOWLEDGE & SKILL	DETAILED DESCRIPTION	OBJECTIVE EVIDENCE[2]
Lifecycle View	and approaches to developing systems, including their interrelated dependencies and benefits. The skills, tasks and engineering products associated with each lifecycle phase, from identifying the problems and stakeholder needs, the system requirements through to the operation and ultimately disposal of the system.	• Has successfully elicited and validated stakeholder requirements • Has written good quality, consistent requirements • Able to derive requirements from analysis of the super system design • Able to establish acceptance criteria for requirements for the system of interest • Able to resolve and negotiate requirement conflicts in order to establish a complete and consistent requirement set for the system of interest • Identifies areas of uncertainty and risk when determining requirements • Able to challenge appropriateness of requirements in a rational way • Able to define and document an approach for requirements elicitation and management • Can assess the impact of changes to requirements on the solution and programme • Able to guide supervised practitioner System Design - Architectural Design • Able to generate alternative architectural designs that are traceable to the requirements • Able to assess a range of architectural designs and justify the selection of the optimum solution • Able to define a process and appropriate tools and techniques for architectural design • Able to choose appropriate analysis and selection techniques • Able to partition between discipline technologies and derive discipline specific requirements • Able to guide supervised practitioner System Design - Concept Generation • Understands the strengths and weaknesses of relevant technologies in the context of the requirement • Able to create and be open to a range of alternative and innovative interdisciplinary concepts • Able to down select to a number of possible alternative options and demonstrate that credible, feasible options exist

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		• Able to guide supervised practitioner System Design - Design for … • Able to identify and balance these design attributes throughout the design process • Able to work with appropriate specialists to ensure that the design effectively addresses these attributes at the correct time • Able to guide supervised practitioner System Design - Functional Analysis • Able to define the strategy and approach to be adopted for the Functional Analysis of the system • Has performed Functional Analysis. • Able to define a process and select appropriate tools and techniques for Functional Analysis • Able to guide supervised practitioner System Design - Interface Management • Able to define a process and appropriate techniques to be adopted for the interface management of system elements • Able to identify, define and control system element interfaces • Able to describe the sources of complexity for the interface management of the system, e.g. multinational programmes, multiple suppliers, different domains, novel technology, etc. • Able to liaise and arbitrate where there are conflicts in the definition of interfaces • Able to identify consequences of changes to interfaces on the system elements, system and/or system of systems e.g. a change to a mechanical interface may impact thermal performance • Able to guide supervised practitioner System Design - Maintaining Design Integrity • Able to identify parameters to track critical aspects of the design

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		• Relates the current design to the original intent throughout the supply chain • Takes remedial actions in the presence of inconsistencies • Able to establish a system which allows the tracking of specific aspects of the design • Able to manage and trade technical margins both horizontally and vertically through the hierarchy • Able to guide supervised practitioner System Design - Modelling and Simulation • Able to define an appropriate representation of a system or system element • Has used appropriate representations of a system or system element in order to derive knowledge about the real system • Able to implement the strategy and approach to be adopted for the modelling and simulation of a system or system element • Able to guide supervised practitioner System Design - Select Preferred Solution • Able to define selection criteria, weightings of the criteria and assess potential solutions against selection criteria • Able to choose the appropriate tools and techniques for selecting the preferred solution, e.g. trade analysis, make/buy analysis • Able to perform trade analysis and justify the result chosen in terms that can be quantified and qualified • Able to negotiate trades • Able to guide supervised practitioner System Design - System Robustness • Able to define the strategy and approach to be adopted for ensuring system robustness • Able to select the appropriate techniques for ensuring system robustness • Understands the operational environment and underlying domain specific issues related to robustness

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		• Able to perform robustness trade-offs • Able to use scenarios to determine robustness • Able to specify procurement of system elements in terms of reliability, availability, maintainability and safety • Able to guide supervised practitioner System Design - Systems Integration and Verification • Able to trace verification requirements back to system requirements and vice versa • Able to write an Integration and Verification plan for a complex system, including identification of method and timing for each activity • Can demonstrate effective management of systems integration and verification activities • Able to write detailed integration and verification procedures • Able to diagnose complex faults, document, communicate and follow up corrective actions • Able to plan and prepare evidence for customer acceptance and certification • Able to identify the integration and verification environment • Able to guide supervised practitioner System Design – Validation • Able to focus on customer needs and able to communicate in the terminology of the customer/user • Able to trace validation requirements back to user needs and vice versa • Able to write validation plans for a complex system, including identification of method and timing for each activity • Able to write detailed validation procedures • Has demonstrated effective management of system validation activities • Able to assess validation results • Able to plan and prepare evidence for customer acceptance • Able to guide supervised practitioner System Design - Transition to Operation

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		• Able to communicate in the terminology of the user • Understands the system's contribution to the super system • Able to plan and oversee a transition to operation activity • Able to guide supervised practitioner
Systems Engineering Management	The ability to manage complex interdependencies between different functions of large enterprises, often involving concurrent lifecycle activities and parallel development at multiple levels of abstraction and incorporating diverse specialist disciplines. Awareness of Project & Programme Management, business, financial and commercial context and competencies.	Concurrent Engineering • Able to identify which system elements can be developed concurrently • Able to manage the interactions within a systems engineering lifecycle • Has co-ordinated concurrent activities and dealt with emerging issues • Able to contribute to the Systems Engineering Management Plan • Able to advise on concurrency issues and risks • Able to guide supervised practitioner Enterprise Integration • Able to manage the relationship between the systems engineering function and other elements of the enterprise • Able to identify systems engineering products required by other functions and vice versa • Able to use systems engineering techniques to contribute to the definition of the enterprise • Able to identify the constraints placed on the systems engineering process by the enterprise • Able to guide supervised practitioner Integration of Specialisms • Able to manage the integration of specialisms within a project/programme • Able to conduct trade-offs involving conflicting demands from the specialisms • Understands how the specialisms affect the cost of ownership • Able to identify the constraints placed on the system development by the needs of the specialisms • Able to guide supervised practitioner

KNOWLEDGE & SKILL	DETAILED DESCRIPTION	OBJECTIVE EVIDENCE[2]
		Lifecycle Process Definition • Able to identify the project/programme, enterprise and technology needs that affect the definition of the lifecycle • Able to influence the lifecycle of related super system elements • Able to identify dependencies and align the lifecycles of different system elements • Able to guide supervised practitioner Planning, Monitoring and Controlling • Able to plan systems engineering activities as part of an overall project/programme plan • Able to identify, assess, analyse and control systems engineering risks • Able to anticipate, identify, assess, analyse and control systems engineering changes • Able to influence project/programme management in order to secure the systems engineering needs of the project/programme • Able to control systems engineering activities by applying necessary corrective actions • Able to tailor systems engineering processes to meet the needs of a specific project/programme • Able to guide supervised practitioner
Domain	Understand the Defence sector, its structure, funding and functions. Understanding of how the military operates. How Systems Engineering is used and an awareness of key transversal skills, for example safety, reliability and human factors.	Understand how the Defence Sector Works, specifically Defence Policy • National Defence Policy • International Defence Regulations • National Security and Defence Alliances • Strategic Goals Defence Acquisition • Awareness of TLCM, • Acquisition, procurement and the business culture; • Recognise the place of Acquisition within Defence;

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		• Explain the four key processes of Acquisition and the role of the military within them; • Demonstrate the skills and techniques used within Acquisition and examine the role of the military; • Explain the culture of the business space and the significance of collaborative working; How Systems Engineering is used in Defence • Understand the role of Systems Engineering in the Defence Sector • Understand the benefits of using a systems approach on defence projects of all size • Understand how Systems Engineering interfaces with other disciplines in the defence industry (for example with safety) The Ministry of Defence, Government and Industry • DE&S Project Teams: • Procure, assess and bring into service new equipment • In-Service Support to operational military equipment • Life extension • Disposal and decommissioning • Wider MOD/Other Government Departments (OGD): • Research and technical support for DE&S • Capability planning and development • Defence Strategy and Policy • Military Operators • Front Line Commands • Operators and maintainers • Test and Evaluation units • Industry's involvement in • Research of concepts • Design and development • Production and manufacture

KNOWLEDGE & SKILL	DETAILED DESCRIPTION	OBJECTIVE EVIDENCE[2]
		• Test and acceptance • Maintenance and overhaul • Decommissioning • International • Concept design and research • British Embassy Technical Policy • EU/Other Nations collaborative projects
Specialisms	Knowledge of particular specialist subjects and domains to meet Employers' needs, for example in relation to emerging technologies, niche skills gaps (for example in relation to Defence Growth Partnership Projects) or in relation to business, financial or commercial skills.	Specialist areas might include, but are not limited to • Aeronautical Engineering • Chemical Engineering • Civil Engineering • Electrical Engineering • Environmental Engineering • Financial and Commercial • Human Factors Engineering • Maintainability Engineering • Manufacturing Engineering • Mechanical Engineering • Reliability Engineering • Safety Engineering • Sales and Marketing • Software Engineering

BEHAVIOURS	OBJECTIVE EVIDENCE
Please note the specific objective evidence requirements of behaviours will be refined by Employers throughout the development of the Apprenticeship	

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Carry out Continuing Professional Development	Undertake planning and review of own development needs and carry out CPD. Regularly reflect on own competence and behavioural development. Assist others with their own CPD.	• SE Practitioner Competency Profile completed on commencement of SEMAP and then regularly reviewed through the programme. • Review, and reflect on, SEMAP study materials related to professional SE learning and development (SE L&D). • Successful completion of associated SE L&D academic assignments. • Evidence of: o thoughtful reflection on CPD and its impact on career direction. o prudent behaviour, objectivity and maintenance of professional and technical integrity. o endeavours made to increase the visibility, competence and prestige of the SE profession. • Coach and mentor team members and less experienced systems engineers to help develop the breadth and depth of their competencies.
Professional Participation	Comply with the codes of conduct of own professional institution. Actively engage in forums advancing Systems Engineering as a profession.	• Review SEMAP study materials related to sustainability, the environment and society. Demonstrate understanding of these in the context of systems intended for the defence of a nation. Successful completion of associated academic assignments. • Evidence in logbook of endeavours to support the educational institutions and relevant professional/technical societies of their engineering disciplines. • Evidence in logbook of thoughtful reflection on professional participation and its impact on career direction.
Effective Communication and Systems Engineering Thought-Leadership	Effective written and oral communication, influencing, negotiation, facilitation and conflict resolution in Systems Engineering contexts across multiple domains.	• Presentation of information is well organised, accurate, clear, and detailed enough to meet the intended need. The logbook must provide prima facie evidence of this, • Evidence of adapting written and oral communication styles to meet the needs of different situations and audiences, • Proven ability to positively influence others in the achievement of individual and collective SE objectives. This is likely to include evidence of facilitation and conflict resolution and the ability to attain the intellectual ‘high ground’ during negotiations.

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Integrative Systems Engineering Leadership Behaviours	Critically observe leadership behaviours of self/others and reflect on their effectiveness, noting the importance of influence as well as authority. Demonstrate the ability to adapt own behaviours to needs of different systems engineering situations and people.	• Review and reflect on SEMAP study materials related to the behaviours of highly effective SE leaders. Successful completion of associated academic assignments. • Evidence of: o a keen focus on, and understanding of, the human dynamics that contribute to successful SE activities. o endeavours to build team cohesion. o endeavours to create vision and direction for projects and the broader business. o delegation of responsibilities when appropriate.
Change	Embrace, instigate and implement change in systems engineering contexts. Demonstrate a willingness to embrace and manage systems engineering risks, issues, opportunities, assumptions and dependencies.	• Focused on developing a system that meets the end-item product objectives. • Remains focused on the integration of all parts of the system into the whole • Can proactively develop alternative solutions, work-arounds and back-up plans for the system being changed. • Can devise strategies and solutions for dealing with the unexpected. • Assesses system/sub-system risks on an ongoing basis.
Adaptation	Demonstrate an awareness of changing situations including personal, organisational and political views. Testing, analysing, reflecting, rethinking and adapting your approach accordingly.	• Demonstrates understanding of the implications of change and ensures they are addressed throughout the entire system. • Recognises that requirements will change • Can make decisions with incomplete or imperfect data. • Understands that change is inevitable and takes appropriate actions quickly. • Can call upon other technical experts to explore different approaches to support the change. • Remains calm under pressure. • Looks at things pragmatically and understands what's going on. Doesn't over-react.

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Problem Finding	Clarify stakeholder's needs, check and evaluate existing solutions, systems and processes. Investigate, identify and clarify influencing factors and be able to effectively communicate identified issues to various interested parties.	• Integrates and provides a connection between the various engineering segments of the project. Is able to identify connections from separate elements of the project that others would not notice and brings these connections to the team's attention as a means to assist in solving underlying issues. • Can examine the implications of how technical decisions being made affect the bigger system and its architecture, reflecting significance of changing requirements. • Able to identify system interfaces. • Ability to consider the impact that changes to one sub-system are having--or might have on other sub-systems. • Can identify and corrects sub-system 'disconnects' or 'inconsistencies' that are having a negative impact on system performance or the desired outcome.
Creative Problem Solving	Approach problems from different perspectives, applying different techniques to generate ideas and solutions with others, critique ideas of your own and others, facilitate others in the development of their own ideas, decide and gain agreement on a course of action, plan and conduct this action and analyse and review the action and outcome.	• Defines problem space not solution • Systematic analysis of problem space • Searches for root cause • Develops alternative solutions • Enjoys problem solving • Determines optimum solution

BEHAVIOURS		OBJECTIVE EVIDENCE
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Visualising	Look at problems from different perspectives, able to create then move from abstract ideas and concepts to real world systems and processes, ability to communicate visually concepts and ideas and be able to assess the feasibility of practical design solutions.	• Ideas expressed from different viewpoints, focus, context, perspectives • Conveys meaning and expression while avoiding clutter from unwanted information • Levels of abstraction are not levels of elaboration • Clear and concise communication and meaning • Pattern recognition and assessment • Can use Uses visuals, such as Venn diagrams, models, pictures, charts, metaphors, archetypes, and other relevant representations, to communicate complex problems or to display the interconnections of sub-elements.

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Improving	Strive to make designs, solutions and processes better by experimenting, designing, sketching, guessing, conjecturing, thought-experimenting and prototyping by obtaining user feedback, focusing and down-selecting improvement ideas and working with design teams to improve design functionality.	Improve Processes • Increase performance levels and output • Introduce new ways of working and the phasing out of old ways • Facilitate the changes to existing ways of working Improve Organisations • Describe new skill requirements for employees • Push for cultural changes or levels of responsibility/accountability • Facilitate an employee moving from one role to another • Perform training needs analysis to optimise a role Improve Tools & Technology • Introduce and support new computer systems • Recommend or make changes to existing technology systems • Define new requirements for systems (including machinery or heavy plant equipment) • Increase the sourcing or selling of equipment/products/services through tools or technology Information • Create, deliver or present new reports • Make changes to existing reports or reporting systems • Define the requirements for new data to feed into reports • Define information patterns and templates (reports, architectural elements or information characteristics