PERSONAL COMPETENCIES AND THE REQUIREMENTS OF IEC 61508

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IEC 61508 Part 1 [Ref.2] states normative requirements for the competence of staff performing safety-related functions. Annex B of Part 1 is informative and provides guidance on what should be considered when assessing a person as competent to perform a particular safety-related role.

The requirements and information provided in IEC 61508 lacks detail on how the requirements should be achieved in practice. As a consequence a study was undertaken under the joint supervision of the HSE, IEE and BCS to address this need. The results of the study have been published by the IEE titled "Safety, Competency and Commitment" [Ref. 7].

This paper lists the requirements of IEC 61508 and describes the competency model, which was developed to meet the requirements of the standard. The opportunity is also taken to present the history on how the competency model was derived and to outline new developments.

IEC 61508 – REQUIREMENTS FOR PERSONNEL COMPETENCE

Section 6.2.1 h) of Part 1 of IEC 61508 states the requirements for competence of personnel engaged on safety-related activities:

The procedures for ensuring that applicable parties involved in any of the overall, E/E/PES or software safety lifecycle activities are competent to carry out the activities for which they are accountable; in particular, the following should be specified

- *the training of staff in diagnosing and repairing faults and in system testing;*
- *the training of operations staff;*
- *the retraining of staff at periodic intervals.*

Note 1 - Annex B provides guidelines on the competence requirements of those involved in any overall, E/E/PES or software safety lifecycle activity.

Annex B on competence of persons states:

B.1 Objective

This annex outlines considerations for ensuring that persons who have responsibilities for any overall, E/E/PES of software safety lifecycle activity are competent to discharge those responsibilities.

B.2 General considerations

All persons involved in any overall, E/E/PES or software safety lifecycle activity, including management activities, should have the appropriate training, technical knowledge, experience and qualifications relevant to the specific duties they have to perform.

The training, experience and qualifications of all persons involved in any overall, E/E/PES or software safety lifecycle activity, including management of functional safety activities, should be assessed in relation to the particular application

The following factors should be considered when assessing competence of persons to carry out their duties:

a) engineering knowledge appropriate to the application area;

b) engineering knowledge appropriate to the technology (for example electrical, electronic, programmable electronic, software engineering);

c) safety engineering knowledge appropriate to the technology;

d) knowledge of the legal and safety regulatory framework;

e) the consequences in the event of a failure of the E/E/PES safety-related system; the greater the consequences, the more rigorous should be the specification and assessment of competence;

f) the safety integrity level of the E/E/PES safety-related system; higher the safety integrity level, the more rigorous should be the specification and assessment of competence;

g) the novelty of the design, design procedures or application; the newer or more untried the designs, design procedures or application, the more rigorous should be the specification and assessment of competence;

h) previous experience and its relevance to the specific duties to be performed and the technology being employed, the greater the competence levels, the closer the fit should be between the competencies developed from previous experience and those required for the specific duties to be undertaken;

i) relevance of qualifications to specific duties to be performed.

The training, experience and qualifications of all persons involved in any overall, E/E/PES or software safety activity should be documented.

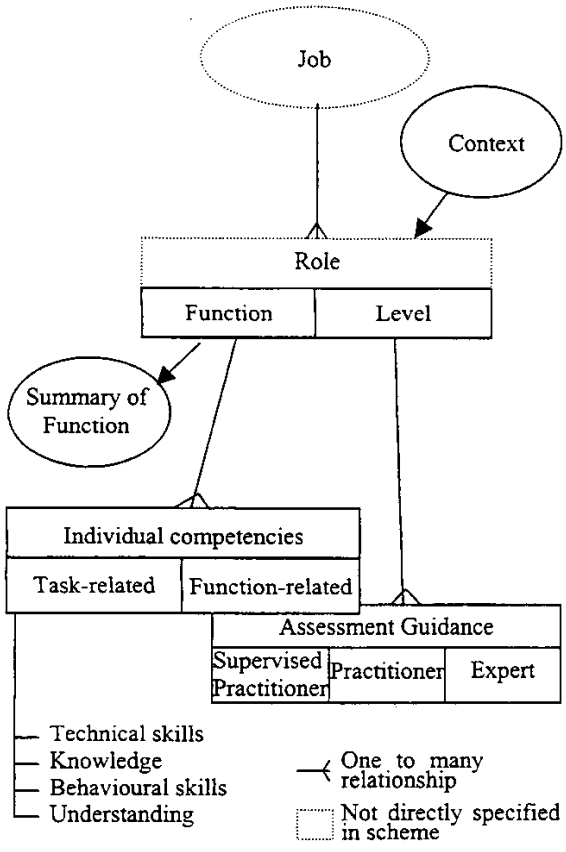
MODEL OF COMPETENCY FUNCTION

Safety-related Functions are a set of standards, which describe best practice for the execution of typical functions performed by professional safety-related engineers within a company.

Functions

The entry point for the model of competency is a function, which is defined as a logical aggregation of tasks typically performed by an individual in a company. For example, a function might be electronic hardware design, software coding or project management. The suite of functions has been chosen to match as closely as possible the functions typically undertaken by individuals developing system conformant with IEC 61508.

All Safety-related Functions are defined in generic terms. This is to ensure that Safety-related Functions are applicable across most industrial sectors, applications, technology, etc. Generic Safety-related Functions have two important benefits: proliferation of functions is avoided; and the problem of functions becoming obsolete is reduced.



Competency model

However, in general, actual competence can only be obtained within a particular context. Thus an understanding of context is an important aspect of any assessment of personal competence. Provision is made when making an assessment to record context information. This ensures an assessment is meaningful and also enables the transfer of the individual's competence to another environment.

To ensure consistency is achieved when using Safety-related Functions a summary of a function is provided. This tends to take the form of a brief description of responsibilities.

Task and Function-related competencies

For each Safety-related Function up to fifteen individual competencies are defined as "goal-orientated" statements. The up to fifteen individual competencies are chosen to be the most important competencies to perform the Safety-related Function to best practice.

To simplify assessment and avoid repetition, the competencies are divided into task and function-related competencies. Task competencies tend to be technical skills, whilst function competencies apply to the function as a whole, and tend to be knowledge, behavioural skills and understanding.

Assessment Guidance and Levels

For each individual competency, Assessment Guidance is provided for use when making an assessment of the competency of a person to perform a Safety-related Function. Assessment Guidance is given for three levels of competence, "Supervised Practitioner", "Practitioner" and "Expert".

A Supervised Practitioner has sufficient skill, knowledge and understanding to be able to work on tasks associated with the overall Safety-related Function without placing an excessive burden on the Practitioner or Expert supervising the work.

A Practitioner has sufficient skill, knowledge and understanding, and sufficient demonstrated experience of competency to be able to work on the overall Safety-related Function without the need for detailed supervision.

An Expert has sufficient understanding of why things are performed in certain ways, and/or will have demonstrated managerial skills, sufficient to be able to take overall responsibility for the performance of a Safety-related Function. An Expert keeps abreast of technology, application solutions, standards and regulatory requirements, particularly in rapidly evolving fields and is able to work in novel situations.

A person who has not achieved Supervised Practitioner level is termed a "Trainee".

Roles and Jobs

The combination of a function and the performance at a level is defined as a role. For example, an "expert software coder" would be a person who performs the role of software coding expertly. Typically a company would allocate roles to staff to perform functions at a level where the objectives of the organisation are met. This means that when an organisation specifies jobs for staff to perform, an organisation has to make a decision on what roles staff need to perform, and how those roles should be allocated to the staff.

For example, a small to medium enterprise might define the role of project manager as a person who is an expert at the function of software project management, a practitioner at the function of software architect and a supervised practitioner at the function of executive management.

The definition of jobs and their allocation to roles is outside the scope of the competency model.

Main features

By standardising on functions performed by individuals within companies rather than jobs, Safety-related Functions are generic in nature, stable, and applicable to must companies and situations.

By choosing a concept of level reflecting the degree of expertise by an individual to perform a function, a culture of excellence is encouraged. The use of concepts of levels associated with career advancement in a company hierarchy was rejected due to concerns over inhibiting the development of personal competence.

The use of a goal-orientated approach reflects current thinking. A good description of a graphical tool for use in a goal–orientated approach has been given by Kelly on a Goal Structured Notation (1).

The integration of Assessment Guidance with standards for personal competence has resulted in a competency scheme, which is both workable and relevant.

DERIVING A NEW COMPETENCY MODEL AND NEW DEVELOPMENTS

A new model for safety-related systems personnel

The competency model originated to specify the requirements for competency of professional engineers undertaking tasks on safety-related systems (2). Examples of such systems include those for air traffic control, railway signalling interlocking, and protection for process plants, failure of which could cause harm to humans.

The research undertaken to arrive at the competency model for safety-related engineering was in three stages: desk-based research of existing competency schemes; market research of suppliers and users of safety-related systems; and a trial of the proposed approach.

The desk-based research considered four main competency schemes: the Engineering Council proposals for a new system of engineering formation and registration (3); the early work on Engineering Occupational Standards for Higher Levels (4); the British Computer Society Industry Structure Model (5); and the Institution of Railway Signal Engineers Licensing Scheme (6).

Market research involved the consultation of more than sixty representatives of over thirty companies, actively involved in either the supply or operation of safety-related systems.

Several important conclusions were reached. Most companies recognised that the competence of their professional staff was a key factor in maintaining a competitive position. There was a strong requirement for a practical approach to improving the competence of the staff, which was cost effective and yielded a real return on investment. The National Vocational Qualification (NVQ) model for competence was not liked: the terminology was not easily understood and therefore inappropriate; the model with its decomposition into units and elements was too complex to efficiently perform assessments of personnel; and the five levels of competence as alternative pathways to academic attainment were not aligned to the needs of companies seeking to encourage a culture of excellence. Clearly, a new approach was necessary.

A novel goal-orientated model of competency for professional engineers was proposed, which addressed the concerns of companies and incorporated the valid suggestions made. For this model twelve competency standards were drafted for functions undertaken by staff engaged on safety-related tasks. This model was validated in workshop trials and by extensive review. With minor change the model was adopted for use and the results published in 1999 by the IEE (7).

Extending the model to other disciplines and uses

The IEE recognised the potential of the new model of competency, particularly its use by other engineering disciplines, to improve its service to IEE members on professional development and to assist companies employing its members.

Assurance was required that the competency model could be applied to other engineering disciplines. Control Systems Engineering was chosen as an exemplar. Experts from companies actively involved in the supply and use of control and automation systems attended a workshop where a Facilitator captured their understanding. The Facilitator defined seventeen new functions, which were drafted as competency standards (8). Very few of the standards were specific to control systems engineering.

Assurance was also required that the competency model would be beneficial as a tool to the membership of the IEE when undertaking professional development. An internal report demonstrated how the existing IEE Professional Development Record could be modified to take advantage of the new standards (9). It was demonstrated that the competency standards filled an important gap, by setting high-level goals of best practice for a particular engineering topic, as an objective to be achieved by a member constructing a professional development programme. The problem of handling large amounts of information, when undertaking an assessment was of concern. The development of a Personal Computer tool for use by members could solve this problem.

Given the assurance, the competency model is being extended to cover other engineering disciplines undertaken by the membership of the IEE. In addition, a tool is under development for use by individual members undertaking a self-assessment of their competence.

REFERENCES

1. Kelly 1999, "A Six-Step Method for Developing Arguments in the Goal Structuring Notation (GSN)" Internal report, Department of Computer Science, University of York.

2. International Electrotechnical Commission 1998, "Functional safety of electrical / electronic / programmable electronic systems". IEC 61508.

3. Engineering Council 1995, "Competence and Commitment", ISBN 1 898126 1`6 X.

4. The Occupational Standards Council for Engineering 1999, "Engineering Occupational Standards for Higher Levels", Version 2.0.

5. British Computer Society, "Industry Structure Model (Release 3)"

6, Institution of Railway Signal Engineers, "IRSE Licensing Scheme".

7. Institution of Electrical Engineers 1999, "Safety, Competency & Commitment ", ISBN 0 85296 787 X

8. May 2001, "Using Professional Engineering Functions to Improve Company Competitiveness". Report to the Institution of Electrical Engineers, CF102/04/01.

9 . May 2001, "Supplement to the Professional Development Record". Report to the Institution of Electrical Engineers, rm010603.

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Personal competencies and the requirements of IEC 61508

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IEC61508 Requirements for Personal Competence

Management of functional safety - Part 1 Section 6

Requirement 6.2

……. the following should be considered:

6.2.1 h

the procedures for ensuring that applicable parties involved in any of the overall, E/E/PES or software safety lifecycle activities are competent to carry out the activities for which they are accountable

Note 1 - Annex B provides guidelines on the competence requirements of those involved in any overall, E/E/PES or software safety lifecycle activity

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IEC61508 Part 1 Annex B (informative)

B.1 Objective

This annex outlines considerations for ensuring that persons who have responsibilities for any overall, E/E/PES or software lifecycle activity are competent to discharge those responsibilities

B.2 General Considerations

All persons involved in any overall, E/E/PES or software safety lifecycle activity, including management activities, should have the appropriate training, technical knowledge, experience and qualifications relevant to the specific duties they have to perform

The training, experience and qualifications of all persons involved in any overall, E/E/PES or software safety lifecycle activity, including management activities, should be assessed in relation to the particular application

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IEC61508 Part 1 Annex B (continued)

- Factors to be considered when assessing competence
  - engineering knowledge appropriate to the
    - application
    - technology
  - safety engineering knowledge appropriate to the technology
  - knowledge of the legal and safety regulatory framework
  - increased competence and assessment for
    - consequence
    - SIL
    - novelty of design
  - greater competence requires more related experience
  - qualifications must be relevant
- Training, experience and qualifications should be documented

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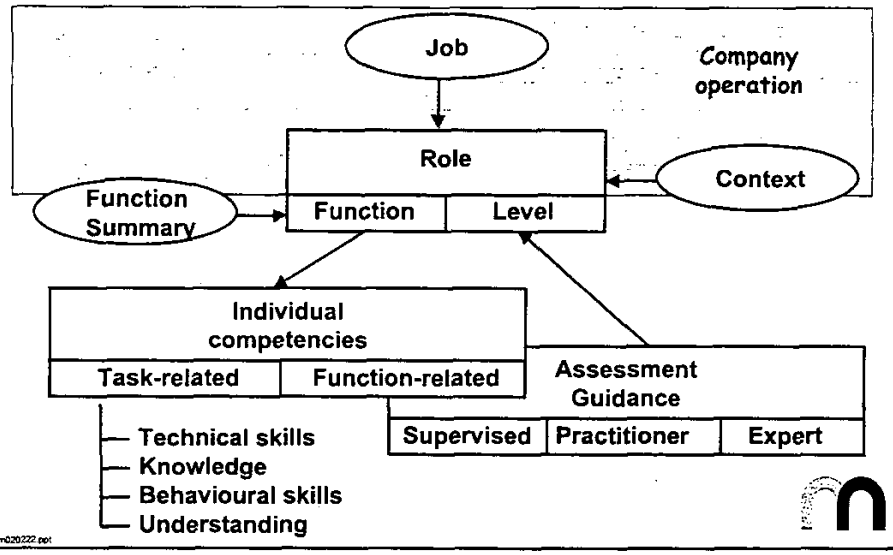
Competency Model of a Function



Examples of Task-related Competencies

CFM1 Realisation of a Safety Management Strategy

Identifies a corporate-wide approach to functional safety management and documents the approach in a Safety Management system, that both meets the requirements of functional safety and is appropriate to the organisation's environment.

CFM6 Handling safety incidents

Ensures that all incidents that could impact on functional safety are identified, investigated and necessary actions taken (including the updating of the Safety Management System and dissemination to all relevant staff), such that the immediate incident is resolved and its likelihood of re-occurrence is minimised.

Examples of Function-related Competencies

CFM14 Functional Safety Practices

Has a knowledge and understanding of functional safety practices, including application and technology appropriate to the organisation and the industry sector, necessary for the successful execution of the role.

CFM15 Professional standing and personal integrity

Has the professional standing to provide credible judgements that are generally acknowledged as authoritative, coupled with sufficient strength of character not to compromise sincerely held beliefs when under pressure.

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Assessment Guidance Information

CFM1 Realisation of a Safety Management Strategy Identifies a corporate-wide approach to functional safety management and documents the approach in a Safety Management system, that both meets the requirements of functional safety and is appropriate to the organisation's environment.		
Supervised Practitioner	**Practitioner**	**Expert**
Identifies relevant documentation relating to the company's methods and procedures and describes their key features.	*Has documented parts of a Safety Management System and illustrates, using corporate safety management procedures and audit reports, how existing company methods and procedures have been incorporated in to the Safety Management System.*	*Has developed at least one Corporate Safety Management System and has been involved in the development/ review of others. Identifies company methods and procedures which have had to be updated to meet new standards in functional safety assurance, and shows how the updated methods and procedures fit within the company safety management system.*

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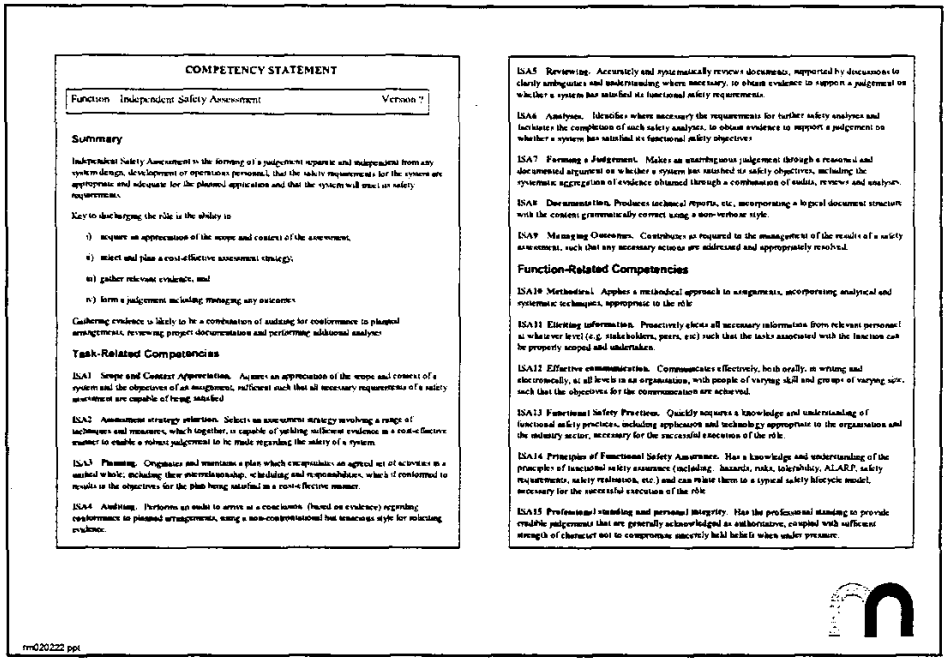

COMPETENCY STATEMENT

Function: Independent Safety Assessment — Version ?

Summary

Independent Safety Assessment is the forming of a judgement separate and independent from any system design, development or operations personnel, that the safety requirements for the system are appropriate and adequate for the planned application and that the system will meet its safety requirements.

Key to discharging the role is the ability to:

i) acquire an appreciation of the scope and context of the assessment;

ii) select and plan a cost-effective assessment strategy;

iii) gather relevant evidence; and

iv) form a judgement, including managing any outcomes.

Gathering evidence is likely to be a combination of auditing for conformance to planned arrangements, reviewing project documentation and performing additional analyses.

Task-Related Competencies

ISA1 Scope and Context Appreciation. Acquires an appreciation of the scope and context of a system and the objectives of an assignment, sufficient such that all necessary requirements of a safety assessment are capable of being satisfied.

ISA2 Assessment strategy selection. Selects an assessment strategy involving a range of techniques and measures, which together, is capable of yielding sufficient evidence in a cost-effective manner to enable a robust judgement to be made regarding the safety of a system.

ISA3 Planning. Originates and maintains a plan which encapsulates an agreed set of activities in a unified whole, including their interrelationship, scheduling and responsibilities, which if conformed to results in the objectives for the plan being satisfied in a cost-effective manner.

ISA4 Auditing. Performs an audit to arrive at a conclusion (based on evidence) regarding conformance to planned arrangements, using a non-confrontational but tenacious style for soliciting evidence.

ISA5 Reviewing. Accurately and systematically reviews documents, supported by discussions to clarify ambiguities and understanding where necessary, to obtain evidence to support a judgement on whether a system has satisfied its functional safety requirements.

ISA6 Analyses. Identifies where necessary the requirements for further safety analyses and facilitates the completion of such safety analyses, to obtain evidence to support a judgement on whether a system has satisfied its functional safety objectives.

ISA7 Forming a Judgement. Makes an unambiguous judgement through a reasoned and documented argument on whether a system has satisfied its safety objectives, including the systematic aggregation of evidence obtained through a combination of audits, reviews and analyses.

ISA8 Documentation. Produces technical reports, etc, incorporating a logical document structure with the content grammatically correct using a non-verbose style.

ISA9 Managing Outcomes. Contributes as required to the management of the results of a safety assessment, such that any necessary actions are addressed and appropriately resolved.

Function-Related Competencies

ISA10 Methodical. Applies a methodical approach to assignments, incorporating analytical and systematic techniques, appropriate to the role.

ISA11 Eliciting information. Proactively elicits all necessary information from relevant personnel at whatever level (e.g. stakeholders, peers, etc) such that the tasks associated with the function can be properly scoped and undertaken.

ISA12 Effective communication. Communicates effectively, both orally, in writing and electronically, at all levels in an organisation, with people of varying skill and groups of varying size, such that the objectives for the communication are achieved.

ISA13 Functional Safety Practices. Quickly acquires a knowledge and understanding of functional safety practices, including application and technology appropriate to the organisation and the industry sector, necessary for the successful execution of the role.

ISA14 Principles of Functional Safety Assurance. Has a knowledge and understanding of the principles of functional safety assurance (including: hazards, risks, tolerability, ALARP, safety requirements, safety realisation, etc.) and can relate them to a typical safety lifecycle model, necessary for the successful execution of the role.

ISA15 Professional standing and personal integrity. Has the professional standing to provide credible judgements that are generally acknowledged as authoritative, coupled with sufficient strength of character not to compromise sincerely held beliefs when under pressure.

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List of Functions

CFM	Corporate Functional Safety Management
PSM	Project Safety Assurance Management
SRM	Safety-Related System Maintenance and Modification
SRP	Safety-Related System or Services Procurement
ISA	Independent Safety Assessment
HRA	Safety Hazard and Risk Analysis
SRS	Safety Requirements Specification
SV	Safety Validation
SAD	Safety-Related System Architectural Design
SSR	Safety-Related System Software Realisation
SHR	Safety-Related System Hardware Realisation
HF	Human Factors Safety Engineering

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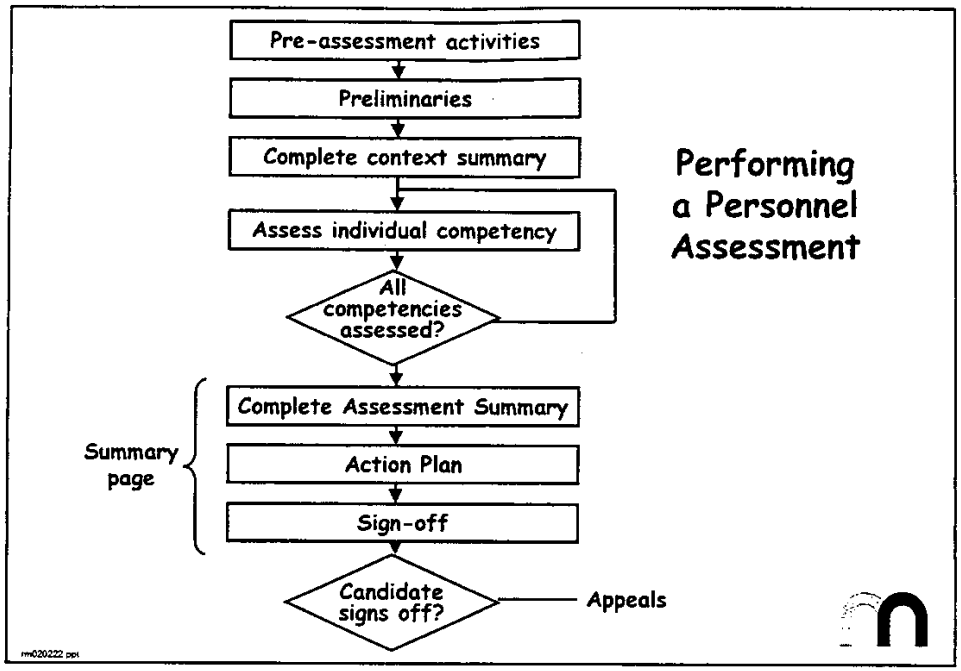

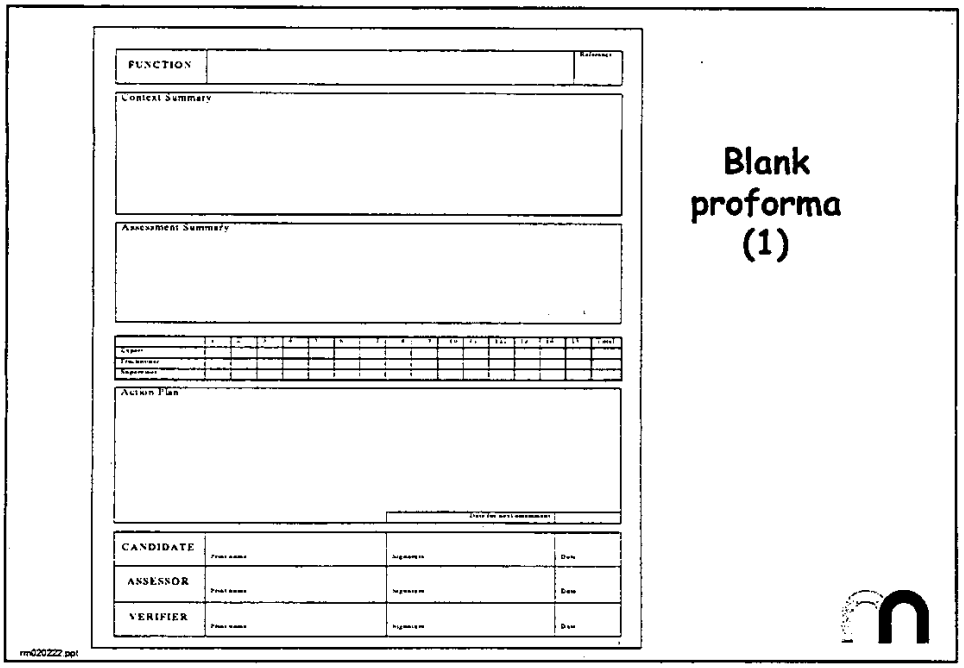

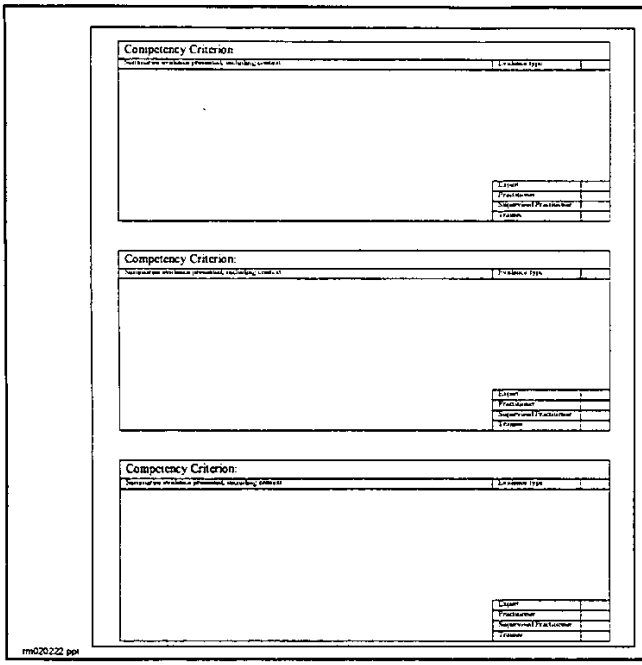

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Company use of Competency Standards

- Understanding "best practice" through a functional description of the activities undertaken by the engineering staff of a company
- Improving the competency of the workforce to undertake professional engineering tasks
- Selecting and assembling competent teams to undertake projects
- Motivation of staff through a professional approach to personnel development of individual members
- Provision of standards against which recruitment strategies can be planned

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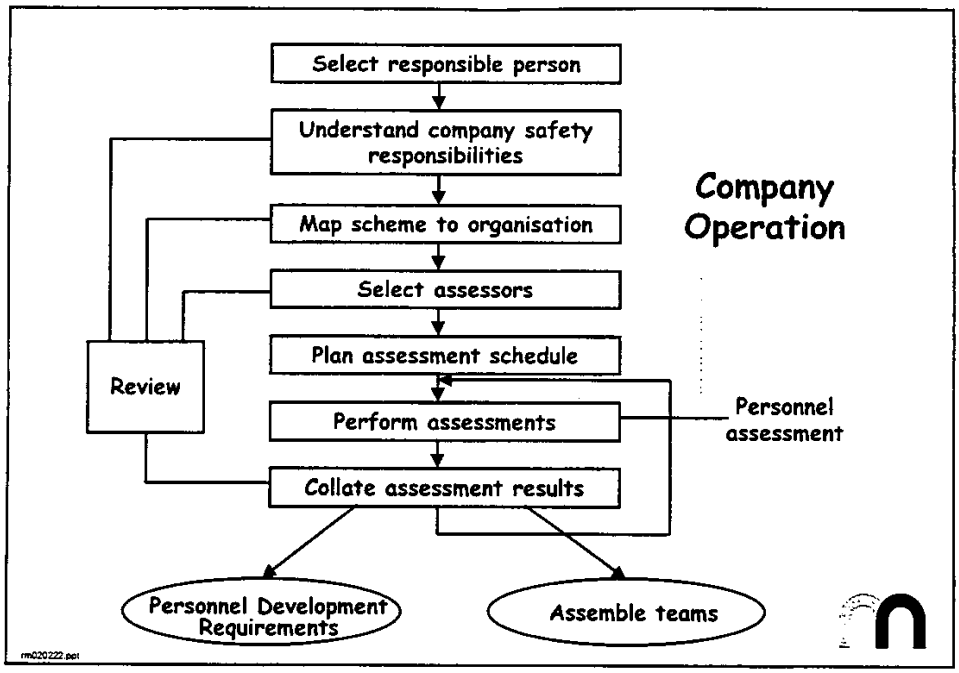

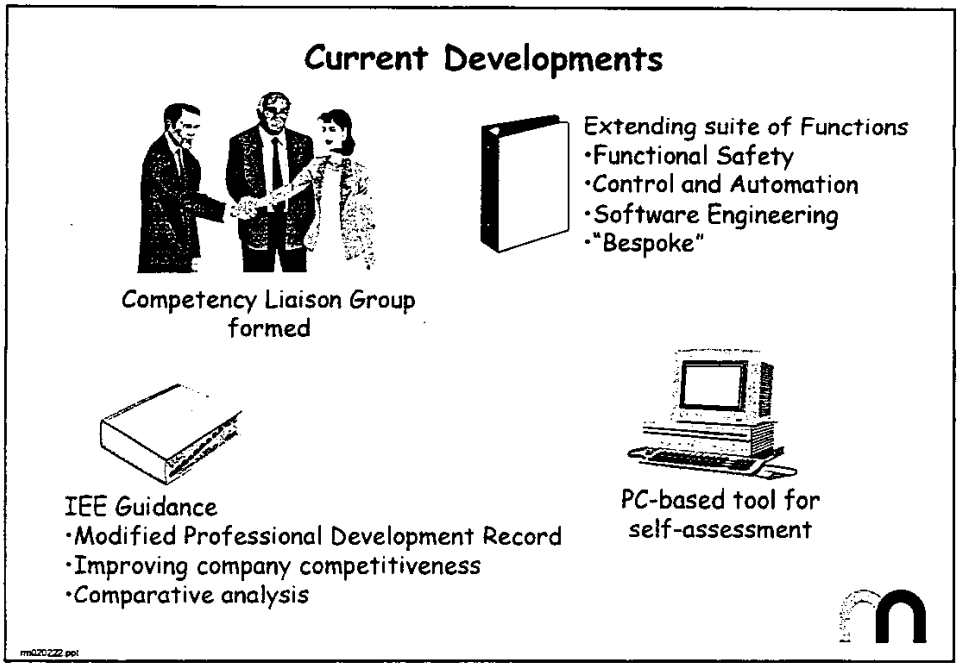

Two quotations [1]

The only rule I have in management is to ensure that I have good people - really good people - and that I grow good people, and that I provide an environment where good people can produce.

Knowledge is the raw material of software development, and it is software engineers who transform knowledge into software products ... Improving technology and process alone is not enough in the most knowledge-intense industry in history. Improving a software organisation requires continual improvement of its people and of the conditions that empower their performance.

[1] Source: Curtis, Hefley and Miller, People Capability Maturity Model, SEI Carnegie Mellon University, 1995

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