# PanICT Project Final Report

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## Summary

The objective of the PanICT feasibility project was to prepare and complete a report which describes the establishment of a model framework for the collaborative networking of Universities, initially in the UK, Sweden and Germany, with the intention of providing a greater opportunity to create an enhanced preponderance of qualified individuals in the ICT sector and encourage the increased portability of high level qualifications across Europe.

Using the Career-Space job profiles as a starting point, the project has demonstrated the feasibility of the establishment of a framework for the collaborative networking of Universities and has extended the model to embrace all forms of training providers. The project offers a 'Passport to Industry' as the record of achievement of an individual as they strive to gain entry to the Industry and as a structure for continued professional development and career progression within it. The passport encourages mobility and the gaining of ability in the specific skills for their target job profile or cluster of profiles, from one or more academic institution and from training providers. All information relating to their ability coming together in the passport record. Both technical skills and behavioural skills are included in the passport.

To enable competence in behavioural skills that fall outside already defined key skills to be assessed, a proposal for a complete set of behavioural skills competence level descriptors is offered. These level descriptors provide a quantifiable means of determining the competence of complex, higher-level behavioural skills.

For completeness a list of pilot implementation projects is included as suggestions for an implementation phase.

## Contents

## Glossary

| | |
|---|---|
| BCS | British Computer Society |
| CPD | Continuing Professional development |
| DSP | Digital Signal Processing |
| EPC | Engineering Professors Council |
| HE | Higher Education |
| ICEL | International Co-operation Europe Ltd. |
| ICT | Information and Communications Technology |
| IEE | Institute of Electrical Engineers |
| LTSN | Learning and Teaching Support Network |
| NTO | National Training Organisation |
| PDR | Professional Development Record |
| QAA | Quality Assurance Agency |
| RF | Radio Frequency |
| SFIA | Skills Framework for the Information Age |
| UK | United Kingdom |

# 1 Introduction

### *Project aim*

The primary aim of the project, as stated at the outset is to:

> *Prepare and complete a report which describes the establishment of a model framework for the collaborative networking of Universities, initially in the UK, Sweden and Germany, with the intention of providing a greater opportunity to create an enhanced preponderance of qualified individuals in the ICT sector and encourage the increased portability of high level qualifications across Europe.*

### *Background and Overview*

The ICT industry forecasts a very serious and potentially economically damaging shortfall in qualified personnel over the next decade. The education system in its broadest sense needs to be mobilised to address this issue quickly and effectively. The maximisation of resources, both physical and intellectual within education is an imperative if it [education] is to have any chance of meeting the needs of this dynamic sector for high level skilled individuals.

To enhance this work a clear articulation by industry of the skills required is imperative, the identification of routes to the development of appropriately educated and trained personnel needs to be undertaken and the encouragement of students to enter the ICT industry is necessary.

The first need has been addressed by a number of industries and government supported initiatives to define cognitive frameworks for occupational knowledge, skills and understanding for key roles within the ICT sector. The European Skills Profiles Project [1] and the Skills Framework for the Information Age [2] are two of the more extensive such studies which provide a sound foundation for the definition of the required technical and transferable skills.

Progress towards identification of routes to the development of appropriately educated and trained personnel other than the currently available educational routes are however, less well developed. The primary objective of this project has been to outline a development leading to a pan-European framework that will facilitate the development of qualified personnel with minimal changes to the academic provision and which can be introduced within a very short time frame.

### *Project infrastructure*

The project has been managed by the e-skills NTO, the national training organisation for the information age and co-ordinated by contracted staff from the NTO in collaboration with a lead University in the UK, namely the University of York. The other Universities that participated in the project are:

- Southampton University

- University of Newcastle
- University of Northumbria
- Linköping University, Sweden
- University of Ulm, Germany
- University of Porto, Portugal

### *The basic project idea*

Using the development work of SFIA and Career-Space and in collaboration with ICT industry colleagues, generic job profiles within the industry will be mapped to course provision within the pilot Universities to enable a schematic map of 'fit'. It may be that one university provides the entire provision comprehensively. Where it does not a student within the confines of the 'Bologna Declaration' may identify the additional modules required from network university members. The student will complete the additional modules by following the course of study, 'on-line' in a virtual work environment or through an international placement. The Partner University will accredit the module achieved and this will count towards the required number of credits for the degree at the 'home' institution. In some cases, where provision is certified to be of a level and quality to count, the student may follow vendor courses, which are offered at industrial bases, such as the Cisco Academy, Thomson University or Microsoft for example, and be accredited by a relevant institution. Figure 1 illustrates the way in which this will work.

The central box of Figure 1 shows the ICT Industry job profiles, three are shown for diagrammatic simplicity. Each job profile is made up of a set of technical and behavioural skills, these are indicated by the cells in each job profile.

To the left of the central box is a box representing the academic programme provision of University A as panels comprising a number of modules in each programme. The programmes can be at first or second cycle.

Red arrows show where modules of the academic programme match or exceed the requirement of the ICT industry job profile skill (technical or behavioural). Hence where a student passes the academic module they can be deemed to have adequately met the requirements of the matching skill for that job profile. All the skills required for job profile 1 map to modules within one academic programme offered by University A hence success in that programme is deemed to have met the requirements of entry to the mapped job profile.

To the right of the ICT Industry central box are Universities B and C. Both universities offer degree programmes but neither have the complete mapping that University A offered. A student undertaking a programme of study at either university B or C does not therefore accumulate the necessary skills to satisfy job profile 3 as shown in Figure 1. The student can, however, attend University B as their main registered University but attend University C on a placement to gain the modules they require to fill the job profile. This is shown by the blue arrows (ringed 'Person Y') in Figure 1.

The notion of the idea is not limited to university academic provision but also embraces Continuing Professional Development training providers. The lower left block in Figure 1 shows three such training organisations. Person Z, who attended University C and gained competence in a number of the skills required for job profile 2 is, however, missing a number of skills. These are shown being developed by the certified training providers.

The basic model shown in Figure 1 therefore offers a very flexible set of routes in which the student can demonstrate they have accumulated the necessary competence in the required skills for the job profile or profiles they aspire to. The onus is placed on the student to accumulate the skills rather than on the Universities to adapt their programmes to ensure a 100% fit with the job profiles. This approach has the significant advantage in that it can be implemented immediately as changes to University curricula are, typically, a lengthy process of proposal, detailed planning and authorisation.

The model does not prevent any University deciding that it can or should provide 100% coverage of one or more job profiles. Indeed, other aspects of the PanICT project, as detailed later in this report, make clear the academic curriculum content required for each job profile and hence enable Universities to make quality provision decisions.

A model for the documentary record that an individual can use to demonstrate they have met the skills required for any of the job profiles is offered in the "Passport to Industry" section of this report.

### *PanICT in context*

The objective of the PanICT project is to build on the work undertaken by the Career-Space project to develop common curricula that align with the requirements and constraints of education systems across Europe. During the project, reference has also been made to SFIA, LTSN, etc. to maximise the compatibility of the outputs to existing works. This section offers a map and explanation to show how job profiles are created and how they link through the common curricula to individual portfolios and thence back to the job profiles.

### *The Career-Space project*

Figure 2 shows the route to job profiles.

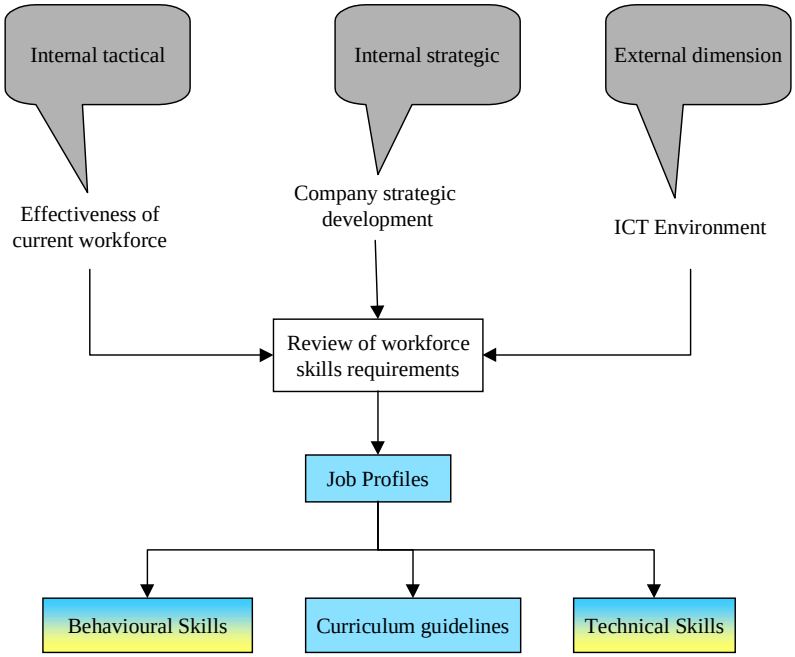


**Figure 2. How Job profiles are derived from organisational and environmental needs**

The three key inputs to the review of the current workforce skills requirements are:

- Effectiveness of the current workforce. Accepting that the current workforce has a determinable set of knowledge, skills and competencies an audit will determine current capability. This is the internal tactical input to the review process and places the 'where are we now' stake in the ground.
- Company strategic development. All the individual partners to the Career-Space consortium will have strategic plans for their enterprises. A map showing the direction they wish to go in based on their organisational aspirations and their view on the direction in which technology and the competitive environment is moving. This input represents the internal strategic input to the review process and identifies 'where do we want to go to'.
- The ICT environment is the business context within which all the Career-Space consortium partners are operating, the political, legal, economic, environmental, technological and sociological dimensions of the business playing field. This is the external input to the review process.

These three inputs have been used by the Career-Space consortium as a means of identifying the types of jobs required across the partners now and for the immediately forecastable future and the Industry skills gap.

The Career-Space project "was set up, co-ordinated by International Co-operation Europe Ltd., to put in place a clear framework for students, education institutions and governments that describes the roles, skills and competencies required by the ICT industry in Europe." [4]

For each of the job profiles the consortium have identified the key technical and behavioural skills required. These skills, together with a description of the meaning of each, are given in the skills profile document [4].

The Curriculum Development Working Group of the Career-Space project have also audited the academic provision across Europe and developed a set of curriculum guidelines that align with the job profiles and together with them provide the structural basis for pan-European common curricula for the ICT industry.

The technical and behavioural skills, along with a description of each together with the curriculum guidelines are the current outputs of the Career-Space project. It is these elements that the PanICT project has used as the platform upon which developments have been made.

### *The PanICT project*

It was originally proposed that the PanICT project would be established as a two-stage programme:

- Development Stage: During this stage the infrastructure, partners, mechanics and programme for the project will be established.
- Implementation Stage: This stage will establish a small pilot network that will collaborate on curriculum content and student 'exchanges', identify routes, both physical and virtual which students can follow to achieve the necessary knowledge skills and understanding required by job roles within the ICT industry.

A proposal would also be included for a follow-on project to address the development stage, the main tasks of which are:

1) Establish a small Project Steering Committee.
    a) This will comprise representation from the Department of Trade and Industry, e-skills NTO, a representative of the participating Universities and representatives from the ICT Industry and ICEL. It is anticipated that this group will meet only twice during the first stage of the project.

2) Identify and recruit the participant Universities.

   This will involve:

   a) Meeting the Deans of the various faculties' involved and identifying 'co-ordinator' contacts.

   b) Setting up lines of communication: primary amongst these will include the establishment of on-line mechanisms and teleconferencing facilities.

   c) Exchange of course information between partners.

   d) Exchange of information relating to how employability skills are developed and delivered within the curriculum.

   e) Willingness to discuss funding issues

   f) Identification of educational programme routes to ICT industry worthiness (matching to 'job' profiles using SFIA and Career Space Profiles).

3) Establishing and/or enhancing 'Industry/University interface development'.

4) Definition and gaining agreement for the 'Passport to Industry', a Record of Achievement (loosely based upon the formative work currently being undertaken in various forms within HE Progress File).

5) Identify the material development costs for:

   a) Course material not in on-line format.

   b) Software costs (where not available in – house [this may be sought as an industry contribution]) such as 'WebIT' and Lotus Learning Space.

6) Staff Training Costs, where this cannot be borne in-house e.g.:

   a) To enable use of on-line resources such as 'WebIT' or Lotus Learning Space.

   b) For the development of on-line discussion facilitation skills.

7) Identification of:

   a) Primary student cohort.

   b) On-line student costs (if any)

   c) Travel and subsistence costs where visits to 'donor' Universities are required.

8) Develop the methodology for the pilot implementation stage.

9) Set up the main administrative arrangements (secretarial etc – but kept to minimum) to essentially identify and manage the resource implications of the project.

10) Organisation and provision of a Stage One Seminar to finalise and agree the proposed methodology for the Second Stage – Implementation.

The outcomes of the project are to be the production of a report, which clearly delineates:

- The infrastructure of the pilot project.
- A clear representation of the Implementation Stage costs with project plans, Gantt analysis and critical path charts for the project.
- Statements of support and intent from the participating institutions, employers and other partners.

### *PanICT in reality*

The project has developed further than the original proposal in that a detailed set of common curricula have been developed to enable meaningful discussions to take place with the partner Universities in accreditation of modules. Additionally a detailed analysis of the behavioural skills has been undertaken and the framework for a "Passport to Industry" developed. This report details the outcomes of all these aspects of the project.

# 2 The link between job profiles and the common curricula

Figure 1 shows how the Career-Space job profiles are derived from the review of the current workforce skills and the demands of the organisation and the ICT Industry. The PanICT project has used this as the foundation for a common academic curriculum for each job profile. Figure 3 shows a proposed model that links job profiles through the academic process to personal progress files and continuing professional development.

PanICT project outcomes are shown in yellow. The project started by considering the technical skills in the Career-Space job profiles and producing an academic curriculum content for each. This content, detailed later in this report, is in a form designed to be compatible with typical University academic module content format in that it represents the indicative content required.

The behavioural skills in the Career-Space job profiles are more complex and lend themselves less easily to clear specification. The approach taken has been to decompose each skill into its 'core' behavioural skills and to propose a set of competence level descriptors for each.

The detailed technical skill curriculum content together with the behavioural skills competence level descriptors for the basic technical content of the common curriculum. To ensure a balanced curriculum results the generic guidelines for the common curriculum are used. These are detailed later in this report.

The inclusion of skills learning objectives and behavioural skills competence levels align the overall model with the general requirements of the Quality Assurance Agency for Higher Education in the UK and should align with other National quality initiatives.

The curriculum content can then be delivered to students via any of the routes to achievement of overall competence in a job profile described in Figure 1. The content delivery process links in learning theory and the learning and teaching infrastructure. The PanICT project has considered a number of potential projects that can foster transfer of teaching and learning between European academic institutions. These projects are described in section X of this report.

The GENIUS project, a recently European Union funded project within the e-Learning initiative, will also be focussing on this process to investigate new approaches to e-learning and new e-learning platforms.

Closely associated with content delivery, learning outcomes and competence levels is the assessment and verification processes. Inclusion of these models raises the visibility of the quality aspects of this part of the process and the best practices being identified and developed by projects such as the Learning and Teaching Support Network (LTSN).

Validation of learning modules leads to the student being able to certify that competence has been gained in the job profile skills. Recording of this achievement can be made in a number of ways. Specifically for the ICT industry the PanICT project has developed the "Passport to Industry", see section X of this report. Additional records of achievement at this stage include the Graduate Apprenticeship records and the Professional Development Record (PDR) offered by the Professional Institutions of which the IEE and BCS are the two major UK institutions for the ICT Industry.

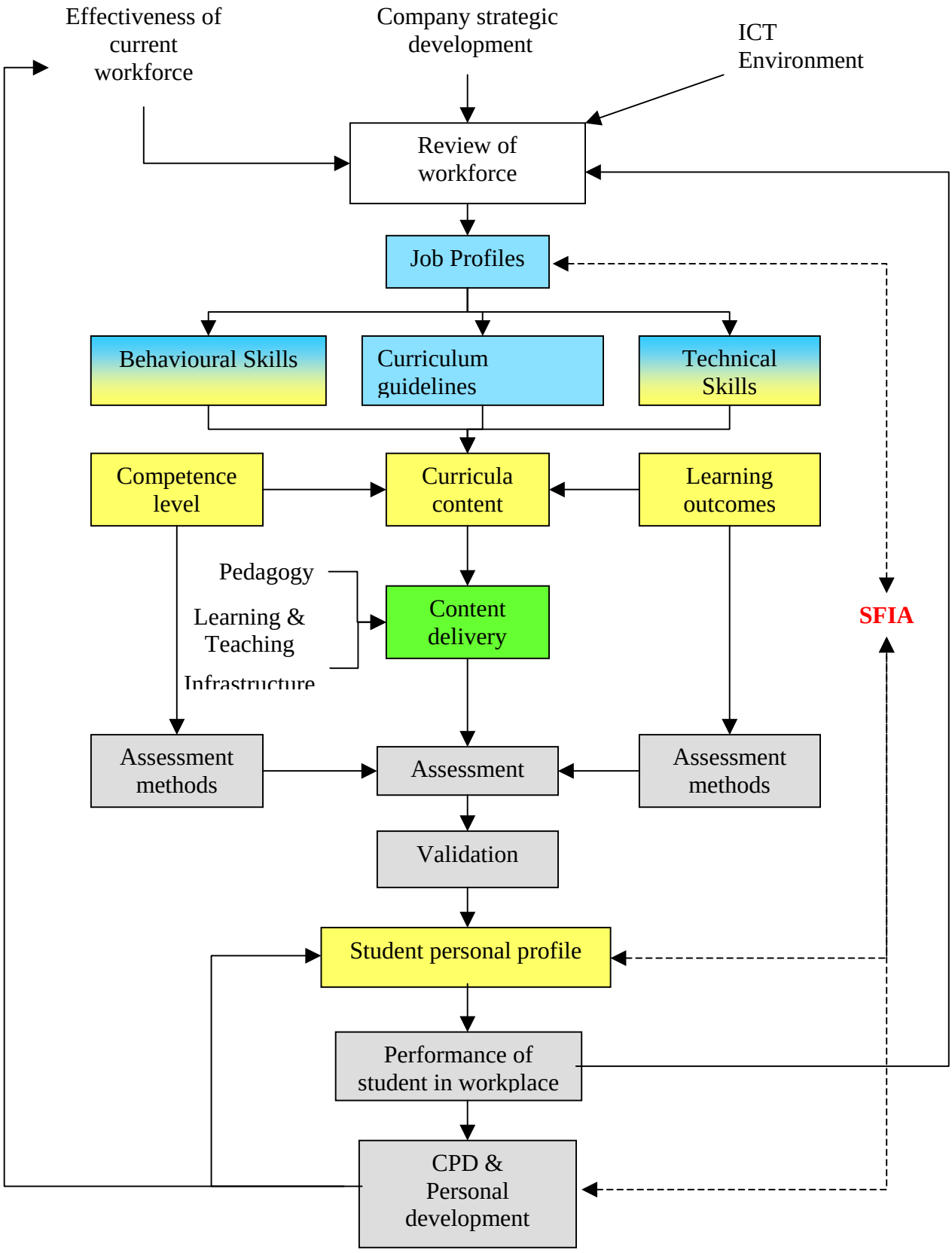


**Figure 3. How Job profiles link through curricula and performance to Industry feedback**

Performance of the student or individual in the workplace and any subsequent continued professional development and personal development leads to updates to the personal profile and to the overall effectiveness of the current industry workforce. This feedback loop is one of the routes by which the ICT industry can monitor and maintain current, the job profiles and skills content thereof.

# 3 The Career-Space technical skills

### *Introduction*

The technical skills, as defined in the career-Space Generic Skills Profiles document have been considered from an academic module content point of view and a technical content, in academic terminology, proposed.

### *Technical skills academic content*

The proposed academic content of all the Career-Space technical skills are listed in Annex A, Analysis of the Career-Space technical skills.

# 4 The Career-Space behavioural skills

### *Introduction*

The behavioural skills as defined in the Career-Space Generic Skills Profiles are high level and often describe complex behaviours. In an attempt to derive a means of assessing an individual's level of competence in these skills each has been decomposed to the component skills that it is believed can be 'assessed' by means of a set of word pictures level descriptors. Each of these component skills represents a 'dimension' of the behavioural skill.

A number of the behavioural skills have common 'dimensions'. For example, the ability to communicate is required, or implied in a number of the Career-Space behavioural skills. These dimensions are repeated (shown in italics) in each of the behavioural skills to ensure each can stand alone and does not require complex cross referencing and 'piecing a jigsaw puzzle' together.

Use has been made of the SFIA framework for the identification of levels of competence in the dimensions of the behavioural skills. The SFIA framework identifies 7 levels of competence from level 1, 'follow' to level 7 'set strategy, inspire, mobilise'. In general it is proposed that entrants to the ICT industry are unlikely to be competent to levels above 5. Levels 6 and 7 are therefore not included for brevity.

The SFIA framework uses the term 'investigations' to describe activities undertaken. The term 'investigations' is retained in the word pictures and should be taken to mean projects, activities or tasks as appropriate.

In this section the Career-Space behavioural skills (Career-Space definition) is followed by a summary of the proposed dimensions. For each of the dimensions a set of word picture level descriptors for the levels considered appropriate for the dimension (not always a full set from 1 to 5) are then given.

### *Picturing competence in the behavioural skill*

Given that each Career-Space behavioural skill can be described by a set of 'dimensions' and that each 'dimension' has a set of word picture level descriptors, the best representation of competence in the behavioural skills is by way of a spoke-wheel diagram. An example of a four-dimension spoke-wheel diagram is shown in figure 4.

Each spoke represents one dimension of the behavioural skill. Competence in a dimension is indicated by a mark or cross on the spoke. The marks can be joined to show the competence profile of the skill. The figure shows a **hypothetical** example of a behavioural skill comprising four components. The desired competence profile for entry to the job profile is shown in red (the outer profile shape) while the student's current assessed competence is shown in blue (the inner profile shape). In two of the dimensions the student has been adjudged to be competent to the desired level. In two other dimensions the student has a competence below the desired level. The resulting gap is shown.

### *Detailed analysis of the Career-Space behavioural skills*

A detailed analysis of the Career-Space behavioural skills is given in Annex B, Analysis of the Career-Space behavioural skills, of this report.

# 5 Common curricula

### *Introduction*

As shown in Figure 3, the technical and behavioural skills and the Career-Space curriculum guidelines have been used to propose a set of common curricula. Each curriculum is a statement of the technical and behavioural skills content required by the ICT industry to enable an individual to meet the entry-level ability of the job.

The Career-Space curriculum working group concluded that it is expected that a student will only meet entry requirements of any job if, in addition to having gained a satisfactory level of achievement in the technical content described in the curriculum statement, they also achieve an first cycle qualification in their overall subject. This requirement is not currently clearly indicated in the draft passport but would be a simple additional checkbox.

### *Career-Space recommendations on curriculum design*

The Career-Space consortium, in its *Curriculum Development Guidelines* [3] makes the following general recommendations for ICT curricula:

- "ICT graduates need a solid foundation in technical skills from both the engineering and informatics cultures, with a particular emphasis on a broad systems perspective. They need training in team working, with real experience of team projects where several activities are undertaken in parallel. They also need a basic understanding of economics, market and business issues."
- "ICT graduates need to have good personal skills such as problem-solving abilities, awareness of the need for lifelong learning, readiness to understand fully the needs of the customer and their project colleagues, and awareness of cultural differences when acting in a global environment."
- "ICT curricula should consist of the following core elements:

  a) a scientific base of ~30%

  b) a technology base of ~30%

  c) an application base and systems thinking of ~25%

  d) a personal and business skills element of up to ~15%
- "The profiles can be clustered into three or four curricula as appropriate to the institution concerned."
- "The use of a series of core modules, followed by sets of area-specific modules and accompanied by a set of elective modules, is suggested as a flexible way to approach the design of new curricula."
- "… that practical experience of working in the ICT industry, of at least three months but ideally longer, should be an integral part of ICT curricula. An

additional three months minimum should be spent on project work applying what has been learnt form lectures, etc."

### *Draft example curriculum: Radio Frequency Engineering*

Annex C shows the proposed draft common curriculum for the Radio Frequency Engineering job profile.

# 6 Passport to the ICT Industry

### *Introduction*

This section provides the rationale behind the Passport to the ICT Industry and the process by which it has been developed.

### *Passport definition process*

Figure 5 shows the process employed to develop the Passport.

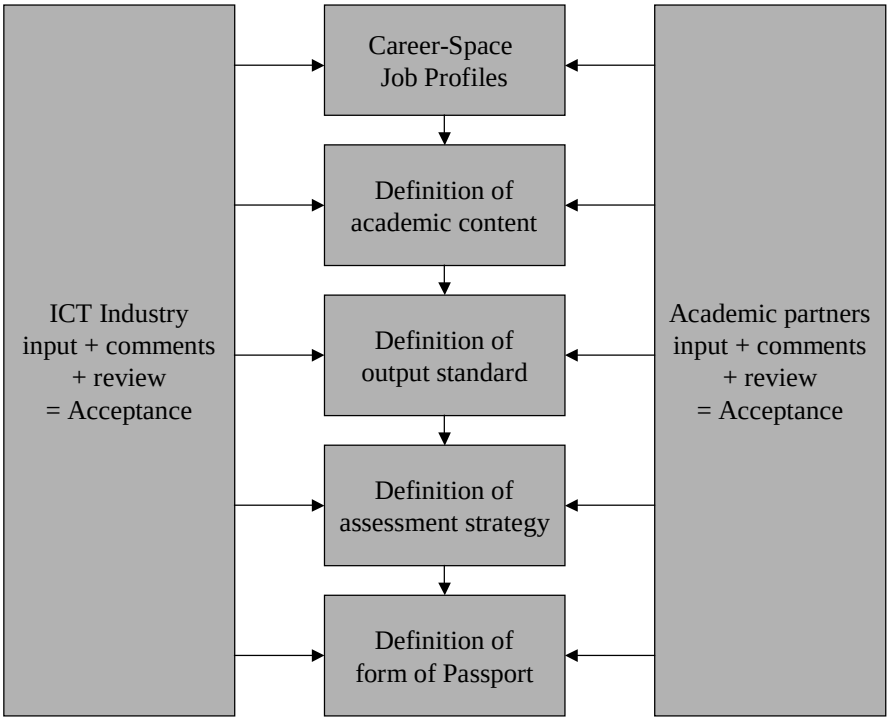


**Figure 5. Passport definition process**

The ‘definition of academic content’ is the statement of the content of each of the skills specified, see section 3, to the level of detail required by an academic institution to enable it to:

- either design a module or modules to cover the content
- or to assess where the required content is already included in its academic provision.

the academic content will be restricted to that which is necessary and sufficient to ensure any student achieves an acceptable level (for entry to the ICT Industry) in each skill.

The ‘definition of output standard’ is an articulation of the acceptable level of competence/ability in each skill, or component of underpinning academic content, required in the specific skill, for entry to the specific job profile.

The ‘definition of assessment strategy’ is a description of the assessment strategy required to ensure compatibility of standard across all academic institutions.

The ‘definition of the passport’ is a description of the form and supportive evidence required to ensure the *Passport to Industry* is meaningful and acceptable to all interested parties.

### *Definition of academic content*

The academic content of each skill is being developed, the latest version can be found on the PanICT web site and in Annex A, Analysis of the Career-Space Technical Skills.

### *Some thoughts on the assessment of content*

For the *Passport to Industry* to be meaningful, it needs to be transferable across all participating academic institutions and all industrial organisations. The achievement of this is clearly a challenging task.

Going back to basics, in the UK at least, it is common practice for undergraduate degrees to be awarded on the basis of a degree classification (first, upper second, lower second, etc.) and type of degree (masters, honours, etc.). These qualifications are *norm-referenced* and, to ensure a first from University A is equivalent to a first from University B requires a fairly well developed and robust cross-university normalisation system. In the UK this normalisation is achieved through the external examiner system.

The Career-Space job profiles are descriptors of requirements of ability, albeit in general terms. This points more towards the need for a *criterion* - or *competence* based specification of achievement and hence assessment approaches. If a low cost, quick implementation *Passport to Industry* is to be developed, reliance on a complex, international ‘external examiner’ style moderation system is considered inappropriate.

### *Specification the Passport to Industry assessment system*

Studies into the needs of assessment systems have been many-fold. One such study, reported in a 1992 paper issued by the UK Employment Department noted what a sound assessment system should exhibit. Based on this work, and others, the following is offered as a basis for the outline specification for an assessment system to underpin the passport to the ICT industry:

- The purpose of the assessment should be clear
- Learner outcome should be equivalent across all participating academic institutions
- The assessment system should provide the learner with clear visibility of their progress towards achievement of each module to enable them to plan further learning and development

- The assessment system should provide the tutor with clear visibility of the learner's progress to enable them to review progress and adjudge teaching effectiveness
- The assessment system should make clear what is being assessed and how judgements are reached
- Assessment will essentially assess what it claims to assess
- The assessment system will be credible and acceptable to tutors, learners and the ICT Industry
- An outcome will be clear records of attainment which are compatible with the *Passport to Industry*
- The system itself will be compatible with local quality assurance requirements and procedures

### *Structure of the Passport to the Industry*

For the Passport to the Industry to be a meaningful and usable document, it must be widely understood and widely accepted. An additional requirement is considered to be the need for it to be simple in concept and easy to interpret. There can be levels of detail behind the basic document supporting the overall claims of the student, but these overall claims should be very visible and easy to assess.

With this in mind, it is suggested that the Passport to Industry should be associated with a subset of the Career-Space job profiles and not attempt to be a single, panacea solution. This immediately raises the question of how to group or cluster the Job profiles. The clusters should be such that a student, following a generally flexible programme of study, can accumulate the technical and behavioural skills appropriate to the range of jobs their programme is likely to equip them to be able to do. A student who is fully equipped, i.e. has a complete passport to a software related job, is unlikely to simultaneously be fully equipped for an RF design job. That said, it is desirable to have only a small number of passport designs. A different passport for each job profile is considered a poor solution as it limits student flexibility. A degree programme is likely, in addition, to provide the necessary training and personal development for a student to be fully equipped for entry level into a small number of different job profiles.

An initial set of job profile clusters was arrived at through the use of a spreadsheet of Job profiles (columns) and technical skills (rows) with cells coloured where a job profile requires each technical skill. This spreadsheet approach enables technical skills and job profiles to be moved around quickly and easily by 'sorting' the matrix. A trial clustering of the job profiles into three, as shown below, results.

Networks

- Communications Network Design
- Data Communications Engineering
- RF Engineering

- Test and Implementation

Product Design

- Product Design
- DSP Applications Design
- Digital Design
- Multimedia Design

Software Systems

- Software Architecture and Design
- Software and Applications Development
- System Specialist
- Technical Support

These groupings could be used as the basis of a trial Passport to the Industry.

### *Levels of competence*

It is considered insufficient to simply state the skill and expect a tick against it to be meaningful. Two dimensions of 'tick' seem appropriate, firstly the level of achievement the student is aiming for and secondly the grade of achievement at that level. On the level of achievement, four levels are offered as a starting point:

- Entry

  Entry level is the lowest level of competence in the skill. It is the level at which the employer should expect the candidate to be able to undertake assigned tasks with guidance, probably step by step guidance.

- Basic

  Basic level is the entry level of competence at which the employer should expect the candidate to be able to undertake assigned tasks with a clear and straightforward set of objectives, once the task has been explained, in a straightforward and procedural approach. Creativity and lateral input should not be expected but may be observed by able candidates at this level.

- Advanced

  Advanced level is the level of competence at which the employer should expect the candidate to be able to undertake assigned tasks that are unclear and where constraints render the task such that there may be neither a clear end result or straightforward approach. Creative input from the candidate should be expected along with a broad understanding of the wider issues that impact the task.

- Expert

  Expert level is the competence level of the self-starter. The candidate who, from an overview of a problem area, will be able to formulate a task definition or set

of task definitions, and, where appropriate clarify objectives and methodologies to be adopted. High innovative input should be expected at this level together with the ability to decompose very complex systems into more manageable and assignable tasks.

These competence descriptors are simplistic and do not have the clear boundaries implied. It should be expected that there is blurring between them. They are included as the starting point for discussion.

### *Grade of achievement*

Within each of the above levels of achievement there are grades of competence. As might be expected from an individual building experience and competence there is progression from absolute beginner in a skill, in which they might best be characterised as 'weak' at 'entry level', to 'outstanding' at 'expert level'. To provide some gradation in the levels of achievement and to enable academic institutions to map achievements to ability, four grades of achievement are suggested:

- Weak

  Candidate has demonstrated the basic ability to undertake tasks or solve problems in this skill. Detailed additional advice and guidance should expect to be given to candidates with this grade of achievement.

- Average

  Candidate has demonstrated the ability to undertake straightforward tasks and problems in this skill. It should be expected that candidates can be assigned a task with the expectation that periodic monitoring will be required but that the task will be completed as specified.

- Good

  Candidate has demonstrated the ability to undertake more complex tasks and problems in this skill. It should be expected that the candidate can be assigned a task with the confidence that they will complete it with minimal guidance and that they will seek help when required. It should be expected that the candidate will exhibit a basic understanding of issues relating to the activity and how issues affect the activity being undertaken (the problem environment).

- Outstanding (very good/excellent)

  Candidates have demonstrated the ability to undertake more complex tasks and problems in this skill. It should be expected that the candidate will demonstrate a sound understanding of the wider issues of the activity or problem and complete the task taking due account of them.

These grades could be mapped across to academic assessment grades such as:

| Grade | 20 Point scale | Percentage | UK Degree Classification |
|---|---|---|---|
| Outstanding | 18 - 20 | 85 - 100 | Distinction |
| Good | 14 - 17 | 70 - 85 | First |
| Average | 10 - 13 | 50 - 70 | Second |
| Weak | 7 – 9 | 35 - 50 | Pass / Third |
| Fail | 0 – 6 | 0 - 35 | Fail |

It is important to recognise that any individual can have a score in more than one level box for any particular skill. For example, it might be judged that an individual might be grade 'good' at 'entry' level work but currently grade 'weak' in 'basic' level work. Developmental activities, for this individual, are likely to be aimed at the 'basic' level competence and would hence aim to increase their 'grade' of ability at the 'basic' level to the point where they are exposed to activities of an 'advanced' level (where they would, presumably, be starting again at the 'weak' grade).

The key point for the Academic / Industry interface is what constitutes the generally acceptable 'level' and 'grade' for entry to the profession. The definitions proposed in this section are offered as a starting point for wider debate.

### *Potential benefits of the passport*

#### For the student:

- A statement of the skills required for jobs they aspire to in the ICT industry.
- A statement of the level of competence required in each skill.
- A framework for the design and recording of their continued professional development.

#### For industry:

- A statement of the current competence of a job applicant or the incumbent of an existing post.
- Certification of the achievement of an individual in the skills and competences required of an ICT industry job.

### For the education providers:

- A detailed curriculum for each element of every ICT industry job profile.
- A set of competence level descriptors to enable students to be assessed against a commonly accepted standard.

### For audit bodies:

- A framework for the maintenance of currency of module content.
- A set of competence level descriptors as the basis for student assessment.
- A framework for verifying the effectiveness of student achievement.

### *Draft example passport: Radio Frequency Engineering*

Annex D shows the proposed draft passport for the Radio Frequency Engineering job profile.

# 7 Implementation projects

### *Introduction*

This section contains a description of the implementation phase projects identified during the feasibility stage of the PanICT project. A work breakdown structure and estimated project cost for each is shown in Annex E.

### *Passport to Industry*

Completion of the design and development of a 'passport' to industry that will sit alongside academic qualifications. The passport will provide a visual record, supported by evidence (possibly in portfolio form) of achievement of components of the Career-Space generic skills profiles.

### *Direct video supported lectures*

A network of real time, direct video links to aspects of course curriculum would be identified and established that any academic institution would be able to link to. For example:

- A direct video link into a semiconductor processing facility could be used, with or without a commentary from the source, as an illustration of semiconductor processing theory or practice.
- A direct video link to a production line could be used to inform and illustrate a lecture on production process theory.

### *Direct video industrial lectures*

Many academic institutions currently ask leading industrialists to give lectures to their local students. These lectures could be given without the industrialist leaving their home company through a direct video link. Alternatively a lecture given at one institution could be either directly relayed to others or be recorded for subsequent video streamed download from a central database of lecture material.

### *Virtual tutor exchange*

The academic equivalent of mentoring where an academic in one institution acts as the supervisor or tutor to a group in another institution, not necessarily in the same country. The tutor could act as a technical tutor or as a language tutor. Pastoral supervision is probably best left to a local supervisor.

### *International projects*

A project undertaken by students from different academic institutions as a team. Possibly employing Industrial idea or Industrial sponsorship or mentoring. Examples:

- Software Engineering project
- Embedded system

- Hardware project
- Engineering design process related project
- Management project

### *Student "Boot Camps"*

A meeting of students from different International academic institutions at which one or more new topics are raised. The meeting will form the starting point or 'bootstrapping' induction of the students into a new idea. Examples might include:

- Working in teams and JAVA in preparation for an International Software Engineering group project.
- Preparation for an International group project on culture.
- International bibliographic study project.
- Internationalisation project for a piece of software or an embedded system.

### *Academic Summer schools*

Opportunities for academics from different academic institutions to meet to discuss internationalisation, the issues, benefits, case studies, best practice, pedagogical issues and ideas, etc. The meetings could involve short presentations and poster sessions, almost as a mini-conference although with a stronger focus on networking and raising of new possible ideas for international co-operation.

### *Student/Student mentoring*

Senior students in one academic institution could mentor junior students in another institution. With an appropriate communications infrastructure this could easily cross National borders and enrich the student experience. This mentoring could be on technical subjects or language training and would involve more than email contact. The communication infrastructure would permit, as a minimum, real time video link between both parties with the ability to draw pictures as well as convey text.

### *Student/School Student mentoring*

Senior students in one academic institution could mentor students in schools within the same or different country. Such a scheme could enhance the image of engineering as a subject to be studied at University and could have an impact on the gender balance by targeting females for the mentor to provide role models and target female mentees as direct targets to influence. This scheme would require careful choice of mentor.

Mentoring would probably be most effective for Maths, Physics, Design Technology, etc.

### *Industrialist/Student mentoring (Global mentoring)*

Technical mentoring/advice made available 24hours per day by a network of Industrial people connected to a communications network. A student, anywhere, would make contact with the mentor by means of a real time, Internet channel. Ideally with video link so that face to face contact is made. Facility should allow either party to draw pictures to illustrate the problem, or move around text. Examples could be the design of circuits, solutions of mathematical equations, etc. care might need to be taken to ensure the mentoring system does not allow students to get answers to summative work set by their local Institution.

### *Central registry of Computer Based Learning material*

The detailed curriculum breakdown to component parts with learning objectives and output standards will enable a search and identification of currently available packages of adequate quality. These packages can be made available through a central database. Further a specification for new CAL package design or a set of design guidelines can be produced that will enable gaps in the curriculum coverage to be filled.

The specification or design guidelines can embrace design for disability to enhance inclusivity.

### *Communications infrastructure evaluation*

Many of the project ideas require an infrastructure to enable individuals to communicate effectively and in real time. A number of platforms are known to exist within the Industrial sector. This activity will be the evaluation of the platforms to determine which is the most appropriate.

# 8 Conclusions

The PanICT project is a feasibility study into the establishment of a model framework for the collaborative networking of Universities, initially in the UK, Sweden and Germany, with the intention of providing a greater opportunity to create an enhanced preponderance of qualified individuals in the ICT sector and encourage the increased portability of high-level qualifications across Europe. The project is based on the work undertaken by the Career-Space consortium and their defined ICT Industry job profiles.

To address this goal the technical skills of all the Career-Space job profiles have been examined and a detailed academic curriculum proposed for each. The detailed academic curriculum is of the form of a curriculum that underpins the technical skill described in the Career-Space skill and which a student would need to understand if they are to be deemed able in that technical skill.

The project has demonstrated that a common curriculum can be derived from the technical skills for the Career-Space job profiles. This detailed curriculum is well suited to form the basis of a model framework wherein academic institutions can design study programmes that will equip students with the skills required for entry to a specific job or clusters of jobs within the ICT industry. The framework can also be used as a vehicle for individual student module choice and career progression. The basic framework is encapsulated in the 'Passport to Industry', a document that sits alongside the academic qualification serving as a record of achievement for the individual student.

The passport is a list of skills required for one or a cluster of job profiles. The student studies these modules and collects evidence of ability in each. Claims of ability and references to the evidence are recorded on the passport.

Where students face module options in their academic programme, the passport can provide guidance as to which modules will contribute positively to their chosen career direction or maximise the flexibility of their overall programme. The passport can also be used by exchange students to inform their module choice, perhaps selecting modules that their host institution cannot offer but which their passport (their chosen career path) requires. In this way the passport becomes a record of achievement but also a personal development direction for the future.

Where a student, or employed individual wishes to chance career direction or progress up an organisational ladder, the passport can be updated to include the job profile and required skills, to show the skills 'gaps' that the individual requires to fill to have the ability to take on the new role. This use of the passport aligns well with the principles of the modern apprenticeship and with Professional Institution continued professional development schemes.

The Career-Space job profiles also include behavioural skills which are defined descriptively in the job profiles. The project investigated how these skills could be used within academic programmes and demonstrated that the behavioural skills can be decomposed to a set of fundamental personal effectiveness skills and proposes a spoke-wheel diagrammatic representation of each. To enable the competence of an individual

in each of these first level personal effectiveness skills to be assessed, sets of competence level descriptors have been designed. The design of the competence level descriptors is based on the SFIA framework hence it has been demonstrated that the framework can be used to derive a usable set of level descriptors for behavioural skills as well as technical skills.

The passport promotes social inclusion and learning access by opening up all forms of education and training. It facilitates the gaining of required skills through a broad range of methods and from a broad range of providers. The passport also promotes transference of module credit between education providers and hence aligns with the European Credit Transfer System. The passport encourages institutional inclusion both inter-institution and intra-institution as modules can be acquired from different faculties within or between institutions. The passport, together with the underlying technical skills descriptions and curriculum provide transparency to the requirements of entry to each job. This could be a useful step to addressing the shortage of females (currently less than 20% of ICT professionals) in the Industry.

Since the passport is not an academic qualification it will not require formal approval to be introduced. It will, however, require recognition and acceptance by the ICT industry. It is this that gives it value to both students and the industry. The significant advantage it offers is that its introduction can be swift and can be adopted by current and future HE students and current employees with equal ease. The passport relies on the certification of ability in technical and behavioural skills which, in some cases, may not align perfectly with the modular structure of HE programmes. The passport aligns with the QAA requirement to define learning outcomes for each module of study but requires the addition of levels of ability in the technical skills and levels of competence in the behavioural skills.

It is proposed that a passport, comprising the constituent skills, the levels of competence in them and the achievement of students in each, for any of the Career-Space job profiles is a practical way forward. Realisation can be in paper form or using a computerised metadata approach. In both cases the ability is present to allow interested parties to drill down into the detail to view what has been achieved, how it was achieved, the level of ability attained, in what context and who validated the outcome.

Finally a set of draft implementation projects are proposed that will increase the cooperation between Universities. The intention of these projects is to provide a greater opportunity for students to collect the necessary skills required for entry to the ICT industry and to experience multicultural education. By increasing interaction between Universities it is anticipated that mobility and portability of modules and qualifications will also be enhanced. A detailed work breakdown structure for each project has also be produced.

Overall the project has taken the Career-Space job profiles and demonstrated the feasibility of the establishment of a framework for the collaborative networking of Universities and has extended the model to embrace all forms of training providers. The project offers a ‘Passport to Industry’ as the record of achievement of an individual as they strive to gain entry to the Industry and as a structure for continued

professional development and career progression within it. The passport encourages mobility and the gaining of ability in the specific skills for their target job profile from one or more academic institution and from training providers. All information relating to their ability coming together in the passport record. Both technical skills and behavioural skills are included in the passport and a proposal for behavioural skills level descriptors is provided for completeness.

# 9 Recommendations

Based on the work undertaken during the PanICT feasibility study and the achieved outcomes, it is recommended that:-

## *9.1 Completion of common curricula*

The technical content of the profiles be completed and extended to include all job profile skills defined in the updates Career-Space generic ICT skills profiles handbook. Consideration should be given to identification of output standards for each module to enable module providers with clear guidance on required learning objectives. This will, in part, be completed as part of the EU funded *GENIUS* project.

A watching brief be established to monitor Career-Space developments and maintain the common curricula up-to-date.

## *9.2 Dissemination*

The outcomes of this report be disseminated widely amongst the Government, Academic and Industrial community through the final report, web site presence, seminars, conferences and journal papers. The following specific recommendations are made regarding dissemination of the findings:

### 9.2.1 Education Knowledge Resource

The establishment of an education knowledge resource in the form of a Higher Education Portal (he-it.com portal established by eSkills linked to HERO would be a suitable vehicle), providing a single point of access for Industry and Academia on matters relating to skills and education for the ICT Industry. The portal serving as one of the means of disseminating the technical and behavioural skills (including level descriptors) of the Career-Space curricula content and the Passport to the ICT Industry.

### 9.2.2 Industry/Academia Seminar

A seminar be organised to disseminate the outcomes of the project and to launch the portal. The target audience being Government, Academia and Industry.

## *9.3 Pilot 'Passport to Industry' trials*

The Passport to Industry be developed into a usable form with guidance notes for students, academia and Industry.

The Passport to the Industry be piloted in conjunction with the HE progress file and the Graduate Apprenticeship and discussions be held with Professional Institutions for compatibility with Continued Professional Development schemes.

Discussions be held with Industry regarding the incentive(s) that could be offered to individuals who complete the Passport for a particular job profile.

### *9.4 Output standards and level descriptors*

The SFIA model be reviewed for compatibility with the QAA and Engineering Professors Council output standards. The review should include consideration of module as well as programme level output standards.

### *9.5 Behavioural skills level descriptor mapping*

A review should be made into the mapping of the behavioural skills level descriptors to the general, vocationally-related and occupational sections of the QCA qualifications levels.

## References

[1] Career-Space, www.career-space.com

[2] “Introducing SFIA, Skills Framework for the Information Age”, www.sfia.org.uk

[3] “Generic ICT skills profiles”, Career-Space, 2205 EN, ISBN 9289600705

[4] “Curriculum Development Guidelines”, Career-Space, 2204 EN, ISBN 9-789289-600743

# Annex A.

# An analysis of the Career-Space technical skills

## Introduction

This document contains a proposal for the academic content of the Career-Space technical skills as described in the Career-Space Generic Skills Profiles.

## A/D Analogue/Digital

This is an unused skill in the Job profiles and therefore only serves as a definition of terminology.

## Applications Design Concepts

The requirement for operating systems; the virtual machine and resource management, Time sharing Systems; evolution and design, processes, process control and the scheduler; Inter-process communications: critical sections, semaphores, process synchronisation, deadlock; The scheduler process priorities, real time clock; Memory management policies, fragmentation, virtual memory; case examples: Unix and derivatives (e.g. Linux), MS-DOS, MS Windows.

Definition of real-time systems: Characteristics; examples. Real-time systems at the machine level: Virtual machines; processes; communication; synchronisation; memory management; scheduling; resource management. Design of real-time systems: Design methodologies; design and development tools; review of real-time programming languages. Case examples: Digital telephone exchange (System X) and Space Shuttle Primary Computer System. Definition and techniques: Faults, errors and failures; systems requiring fault tolerance; problems in the real world, key disciplines; minimisation of errors; design stages. Implementation techniques: Fault avoidance, fault tolerance, fault removal, fault forecasting; hardware systems, duplex, triple redundant systems; software systems, N-version programming, recovery blocks. Mathematical reliability models for hardware/software systems.

## Artistic Knowledge

The architecture of graphics systems; the facilities of a modern graphics environment, covering output primatives and management of input, and viewing in three dimensions. Modelling: creation and manipulation of hierarchical models, and specialised modelling techniques: physically based systems, curves and surfaces. Techniques for added realism: colour, lighting, and shading models. Discrete techniques: texture and bump maps, and compositin. Ray tracing and radiosity methods. Visualisation: isosurface algorithms, volume visualisation. Human Interface design: Input and output devices and interaction styles; rapid prototying based on story-boarding; psychology of human computer interaction. Evaluation techniques: co-operative evaluation; heuristic evaluation; cognitive walk-throughs. Visual

and haptic perception: eye, colour sensitivity, motion detection, pattern detection, visual acuity, reading, depth cues.

Light transmission, colour properties, filters, photography, graphics, perspective. The human eye, rods and cones, visual perception. Artistic aspects of static and dynamic visual art to guide the visual side of field recording. TV and video systems: cameras, receivers, video projectors, video standards: analogue and digital, digital TV, screen formats; In house video systems and video on demand. Video editing systems and video processors. Lighting and video controllers.

## Computer Programming

The following content is taken from ACM's and the IEEE's Computing Curricula 2001, Volume II Computer Science.

### *Introductory level:*

PR1 Programming Fundamentals: Fundamental programming constructs, algorithms and problem solving, fundamental data structures, recursion. PR2 Programming Languages; Overview of programming languages, introduction to formal languages, virtual machines, interpretation and compilation. PR3 Programming in one or more languages; At least one object oriented language (C++, Java) and preferably other languages in other paradigms (imperative - C, ADA, functional - Lisp, Haskell) and new script oriented languages (Java-script, Pearl). PR4 Concurrent programming; communication, synchronization. PR5 Programming Tools; using editors, debuggers, notation (UML) tools, documentation. PR6 Document description languages and Internet languages; XML, HTML

### *Intermediate level:*

PR7 Algorithms and complexity; more advanced data structures and algorithms, algorithm analysis, distributed algorithms. PR8 Programming in new other languages and paradigms; broadens the perspective of programming , programming paradigms and language design. PR9 Object oriented methods and design; notation and tools (UML), design patterns. PR10 Software engineering ; requirements, specification, software design, testing and validation, project management. PR11 Software project, larger programming task, teamwork, specification, design, testing

### *Advanced level:*

PR12 Program language design; type systems, models of execution control, memory management, compilers with formal languages, parsing, code optimization. PR13 Formal methods, verification, program semantics. PR14 Complexity analysis, P and NP, automata theory,

## Computing Systems Design

The bus, synchronous operation. Software interfacing, interface support devices and circuits. Polled interrupts and DMA driven interfaces. Further programming concepts: The use of stack to control nested procedures, and for parameter passing. The Von Neumann machine:

CPU design, instruction sets, introduction to assembly language, addressing modes related to the hardware.

Review of basic microprocessor architecture; input/output devices: keyboard, mouse, speech recognition and synthesis, joysticks; Coding information in computer systems: one's complement and two's complement arithmetic; Review of addressing modes: immediate, direct, indirect, multiple length instructions and addressing; Interrupts and DMA: CPU reaction to interrupts, interrupts in a multiple peripheral environment, types of interrupts, DMA overview, cycle and burst mode transfers, DMA controllers; Computer arithmetic : integer arithmetic, floating point arithmetic, overflow, underflow, condition codes; Memory management techniques: memory back switching, virtual memory, paging segmentation.

## Cost Modelling

The purpose of estimating within projects, including: Cost/benefit analyses; Cost estimates as a basis for project control; Costs that need to be included. Basic consting procedure. Introduction to cost estimating techniques including expert judgement, analogy, proce to win and algorithmic techniques such as COCOMO and Function Point Analysis. Basic rules of estimating. Introduction to software metrics. Risks to projects through poor estimation and their impact.

## Database Concepts

The following content is taken from ACM's and the IEEE's Computing Curricula 2001, Volume II Computer Science.

Introductory level: DB1 Principles of databases; data models (ER, relational, object oriented), transaction processing, security. DB2 Database query language; SQL, report generator DB3 Database systems; DB4 Application databases; hypertext and media, multimedia, information retrieval

Intermediate level: DB5 Storage structures; physical design, performance and optimization, recovery DB6 Distributed databases; DB7 Data mining;

## Digital Design Skills

The Field Programmable Gate Array (FPGA) and related architectures. The design cycle under CAD for these architectures. Design project using CAD environments, targeting. FPGAs: Pre and post route simulation circuit design using schematic captive and circuit modelling using VHDL.

## Electronics Theory and Know-How (analogue/digital)

Electronic Materials: Materials used in electronics: Metals, insulators, semiconductors; concept of conductivity; simple atomic structure and bonding between atoms; crystals; electronic band structure. Electrons and holes in intrinsic semiconductors: Properties and behaviour; controlling the conductivity in semiconductors: Doping with impurities. Current flow: The movement of charge carriers (electrons and holes) in semiconductors; simultaneous drift and diffusion currents; built-in fields and voltages; generation and recombination of minority carriers; the Continuity Equation.

The p-n junction: Structure and behaviour in equilibrium; energy band diagram. Current flow across a p-n junction; energy band diagrams under bias. Shockley diode equation; applications of the p-n junction in electronic devices: Rectifier, detector, photodiode; the bipolar transistor (BJT) -structure and principle of operation; 'Figures of Merit' for the BJT; current gain; equivalent circuit models for the BJT; applications of the models. Bipolar process: Buried collector BJT, indicate location of R's and C in equivalent circuit; capacitive effects in p-n junctions; depletion, diffusion, and the effects on ac models; Bipolar transistor advanced circuit models: Ebers-Moll model, application of Ebers-Moll model to practical transistors, charge control model, switching transistor circuit, higher order effects, base width modulation, SPICE transistor model and applications, derivation of hybrid p model, high frequency application of hybrid p model.

Basic concepts and components: Charge, current, power, signals, resistance, capacitance, inductance and mutual inductance; ideal and non-ideal voltage and current sources - both independent and dependent. Linearity: Kirchhoff's laws; the Principles of Proportionality and Superposition. Equivalent Circuits: Thevenin and Norton equivalents for circuits containing both dependent and independent sources. Frequency Domain Analysis: complex representation of sinusoidal signals; phasors, reactance, susceptance and impedance; magnitude and phase response; decibels, Bode plots, poles and zeros. Time Domain Analysis: Differential equations of simple circuits; solution using the method of undetermined coefficients; transient response of first and second-order circuits; the effects of damping.Power in ac circuits: The Power Transfer Theorem. Conjugate matching; real, reactive, and apparent power; power factor and power factor correction. Tuned Circuits: Resonance in simple LCR circuits; determination of resonant frequency, Q-factor, bandwidth and dynamic impedance.

Analogue Filters: The approach to filter design: The notion of approximation, synthsis nad realisation as the essential parts of the design process. Approximations to ideal filter amplitude response: Butterworth, Chebychev and Elliptic. Synthesis: Darlington insertion loss technique for resistively terminated LC filters. Active filter synthesis; Sallen and Key, Rauch, Ring-of-three configurations. Realisation: Impedance level denormalisation. Realisation of lowpass, highpass, bandpass and bandstop filters. Appropriate technologies. Active filter design: Single, dual and multi-amplifier biquads, effect of tolerances and amplifier limitations. Lowpass to highpass/bandpass. Use of design tables. Delay equalisation and realisation. Digital Filters: Introduction to Digital Signal Processing; the sampling theorem, aliasing, the anti-alias filter, the reconstruction filter. Digital filter design: concepts, structure, symbols, mathematical notation; the moving average filter; impulse response, frequency response, the discrete-time Fourier transform, linear phase, nonrecursive filter design by the Fourier method, windowing. Introduction to the z transform: relationships between Fourier, Laplace and z transforms, the pole-zero z plane plot, generating a recurrence expression, simple recursive filter design; notch filter, bandpass filter/comb filter combination.

Bipolar Transistors: Introduction to the transistor: The requirement for the transistor, bipolar devices; DC operation and biasing; DC and AC load lines, gm; investigation of the circuit building blocks; common-emitter and common-collector configurations, differential amplifier, current sources; simple models; Miller effect. Power Transistors: Bipolar and MOS power transistors; safe-operating area, heat sinks requirements and thermal stability,

power amplifiers, classes A, B, AB, and C, single-ended and push-pull circuits, class B design. T and pi transistor models - gain and impedance variation with current at LF, frequency response, hybrid parameters, fT, Miller Effect, common base and cascode. Difference amplifier - differential and common mode gain. Current sources/mirrors (Wildar/Wilson) – Early voltage, active loads, O/P impedance, calculation of Voltage Offsets. Output stages: Class A - Emitter follower + current source; I/P and O/P impedance, transfer characteristics and distortion. (Complementary output stages, Class B, Class A/B). Some Op-Amp circuits - effect of feedback on I/P and O/P impedance and stability/compensation. Application circuits including Adder and D to A; Integrator - Triangular Waveform generator; Schmitt Trigger and Logarithmic Amplifier.

Operational Amplifiers: Introduction to signals; operational amplifiers; ideal voltage amplifiers; the virtual earth, introduction to feedback; integrators and differentiators. Filters; bandwidth, Bode plots; bias currents; offset voltages; performance specification; voltage gain; input impedance; output impedance. The monolithic operational amplifier - internal construction and circuit topologies.

Switch mode power supplies.

Introduction to: Boolean logic, logic gates, the truth table, the timing diagram, binary numbers, binary addition, hexadecimal, ASCII, BCD, 7-segment displays, noise margins, error detection, error correction, combinational logic design, Boolean algebra methods, the K-map, canonical forms, cellular logic, 2's complement arithmetic. S-R, D-type flip-flops; latching: sequential logic design. Logic elements as electronic components; logic families; design and characteristics; bipolar logic, MOS logic families, MSI logic device and the problems of testability; Multiplexers; demultiplexers; and examples of their application, problems associated with noise and digital interfacing. Timing diagrams.LSI devices: Simple array devices: PLA, FPGA. Counters, cascading asynchronous and synchronous designs. Memory structures: Static and dynamic memory; applications. Tri-state logic.Finite state designs: simple examples using FSM. Microcoded structures; advanced finite state machine design.
Introduction to circuit noise: Introduction to noise and noise models for circuit design, sources of noise, voltage and current noise models, noise temperature, noise figure, the effect of bandwidth, noise build-up in systems, kTB and their uses.

The design process: An introduction to electronic product design, establishing needs and specifications, system design, costs and product development, tolerance design, design for the physical environment, design for reliability, design for manufacture, design for inspection and test, quality in the design process.

## Hardware Knowledge

The basic elements of the computer: CPU, memory, I/O busses, interface circuits. Hardware features: Serial and Parallel outputs, keyboards, mice, interupts, polling, memory devices, power supply requirements, disk, tape, CD and DVD drives, internal busses including PCI. Hardware performance measures.
An introduction to electronic product design, costs and product development, tolerance design, design for the physical environment, design for reliability, design for manufacture, design for inspection and test, quality in the design process.

## Integration Concepts

## Mathematics

Basic understanding of arithmetic including meaning of decimals, fractions, percentages. Basic understanding of algebra including the abilty to simplify, substitute into and solve simple first order equations. Understanding of and ability to recognise basic geometric shapes including parallelograms, triangles, polygons. Be able to apply Pythagoras (and its converse) to triangles. Be able to determine the tangent to curve. Basic understanding of trigonometry including solving right-angled triangles for side lengths and angles and radians. Basic understanding of functions including trigonometric, logarithmic and exponential. Ability to combine two periodic signals. Understand contradictory and insufficient equations and ill-conditioning.
Basic understanding of normal, log-log, log-linear, polar and Bode graphs including the equations of straight lines, gradient and the ability to sketch a curve from its equation. Ability to interpret data.

Solve quadratic equations by factorisation and by formula.

Basic understanding of probability and statistics including the meaning and ability to calculate the mean, mode, median, percentiles and standard deviation.

Ability to manipulate matrices including addition, subtraction, multiplication, inverses and their use in the solution of simultaneous equations. Definition and properties of matrices and determinants. Determine the inverse of a matrix and use matrices to find the solution of sets of equations. Understand the The Gaussian elimination algorithm. Understand the circuit network applications of matricies.

Basic understanding of series including sigma notation for sums of n2 and n3, and the Maclaurin expansions for arithmetic, geometric and binomial series. Series expansions of exp, sin, cos and log. Taylor series expansions.

Ability to differentiate products, quotients, a function of a function, exponentials, logarithmic functions and determine turning points of a simple nature. Understand partial differentiation, the chain rule, mixed derivatives, total differential, implicit differentiation, geometrical and practical significance.

Ability to integrate linear equations and trigonometric functions, understand constants of integration and be able to integrate using standard forms and by substitution, partial fractions, parts and solve indefinite and definite integrals.

Understand the Argand diagram, modulus-argument, and exponential forms of complex numbers and be able to add, multiply, divide, find the modulus of and the solution of quadratic equations. Understand vectors including position vector, scalar product and their use in 3-D geometry. Understand the exponential form of complex numbers, De Moivre's theorem, roots of a complex number, rotations and phasors and hyperbolic functions. Basic vector calculus, differentiation of vectors, vector fields, scalar fields, line integrals, surface integrals, volume integrals.

Understand first and second order differential equations including forming, solution by separation, exponential decay and initial and boundary conditions. Solving high order

differential equations and understanding transient and steady state components, forced damped harmonic oscillator and resonance of dynamic systems.

Basic understanding of errors including coping with inconsistent results and ill-conditioning

Multivariable tools: 3-dimensional visualisation, solid angle, 3-dimensional co-ordinate systems (Cartesian, polar, spherical, cylindrical), changing between co-ordinate systems, double integrals, triple integrals, change of variables, Jacobians.

Fourier: Applications of signal processing, the transform approach. Signal analysis and synthesis, Fourier series; trigonometric form, exponential form; generalised orthogonal functions; waveform symmetries; odd and even functions, half-wave symmetry, Parseval's theorem, power spectra, Fourier transform, direct application, use of tables. Linear, time-invariant systems; frequency response, impulse response; convolution, deconvolution, cross-correlation, autocorrelation, energy spectra, the psuedo-random binary sequence; spread spectrum communications, system identification.

Laplace: Definitions, integral definition, the inverse transform; functions and operations; Transform of simple time functions, transform of operations - differentiation and integration; transients in circuits and systems, notion of system functions derived from differential equations describing a system, analysis of simple circuits; Laplace models for circuit components, inverse transformations through the partial fraction expansion. Poles and zeros, pole/zero description of a system, the impulse response and its relationship to stability, assessment of the system behaviour from the pole/zero plot; initial and final value theorems, derivations and applications of these important theorems; shifting theorems, the derivation and application of the first and second shifting theorems in the determination of the Laplace transforms of complex time waveforms; convolution.

## Networking Concepts and Architectures

Overview, protocols: ISO OSI and TCP/IP. Network topologies, connection-based and reliable protocols, switching, streaming and packet-based networks. Flow control and error control schemes. Detecting errors: checksum, CRCs. Multiple access schemes: definition, examples. Physical Layer considerations: cables and equalisation, coding schemes. IEEE Project 802 and the LLC. Bridging LANs. Linking LANs to the Internet. The Internet: IP Addresses: classes, and classless addressing. Routing: RIP and OSPF. Names and DNS. UDP and TCP. The future: IPv6.

Voice, video and data traffic: grades of service, characteristics and traffic modelling. Circuit-switched networks and blocking. Erlang and Engset distributions. Packet-switched networks and queuing theory. Network capacity and discard strategies. Congestion control. Priority. Overview and historical perspectives. Basic elements of a typical optical communications system. Fundamental system topologies (coherent and direct detection). Optical sources and transmitters for optical communications. Optical detectors and receivers for optical communications. Optical fibres and cables. Fundamental system limitations (bandwith and

Overview of satellite communications and services; orbits & coverage; link budgets and system trade-offs. Access techniques (FDMA, TDMA); Spread Spectrum; CDMA. Packet transmission, PRMA, Hybrid schemes. Satellite system engineering and payload design. VSAT systems & networks; military satcoms; LEO satellite systems. Overview of cellular radio systems; frequency re-use. Modulation & coding. Propagation effects; channel models;

shadowing & multipath. Diversity and equalisation. Cellular system planning; interference. Power control techniques. Fixed Wireless Access case studies. Overview and development of mobile systems (including GSM, IS-95, UMTS, GPRS, EDGE).

## Reliability Engineering

What is reliabiltiy? Definitions of types of failure. Mean Time Between Failure and Mean Time To Repair. Failure pattern during life. Constant failure rate. Exponential and Product laws of reliability. Testing and confidence levels. Stressed and Unstressed reliability prediction techniques. Reliability models for practical devices. System redundancy and parallel circuits. Stress policy and de-rating. Thermal design. Design for reliabiltiy principles.

EMC and Electric and Magnetic fields. Conducted and Radiated interference. Sources of electromagnetic interference. Units and measurements. Classification of noise into narrowband and broadband. Common EMC specifications.

## RF Circuit Design

Distributed Circuits: The Smith chart and stub matching methods; the use of scattering, and transmission matrices for microwave components; single stage amplifier design; microstripline design; directional couplers:network analysers.

Design of low noise small signal amplifiers; broadband small signal amplifiers incorporating feedback for optimum input and output impedance; the theory and design of low phase noise oscillators; frequency synthesisers; power amplifiers; mixers; filters.

## RF Design Methods

## RF Design Tools

Introduction to HP/EESOF Series IV software.

## RF Theory

Component models including: biopler transistors, FETs, diode detectors, printed and wirewound inductors, surface mount resistors and capacitors; S, Y, Z parameter definition, conversion manipulation and calculation; Noise measurement techniques.

Electromagnetism: Review of free space electrostatics; Gauss' Law; electric flux density; dielectric materials - dielectric polarisation; boundary conditions for electric fields at interfaces; dielectrics in capacitors; energy in electric field; Laplace/Poisson Equations; Computer solutions of electrostatic fields; review of free space magnetostatics; magnetic materials; magnetic flux density; boundary conditions for magnetic fields at interfaces; magnetic circuits; inductance and energy in magnetic fields; Ampere's Law; Faraday's Law. Displacement current; Maxwell's Equations. Electromagnetic Waves: Vector wave equation for free space; solutions of the wave equation in free space; energy flow - the Poynting vector; wave polarisation - linear, circular, elliptical; vector wave equation for media;

solutions of the wave equation in media; special solution - perfect dielectrics, conductors, lossy dielectrics.

Antennas: General properties of antennas and antenna systems, near, Fresnel and far-field regions. Impedance, radiation resistance. Radiation from current elements (simple treatment). Dipole and monopole antennas (descriptive treatment). Arrays and Array factor. Aperture field and far-field relationships. Uniformly illuminated rectangular and circular apertures. Illustration of practical field tapers. Paraboloidal antennas, configurations, feed optimisation.

Introduction to Electromagnetic Compatibility.

Radio Propagation: Free space propagation. Basic link budgets. Introduction to propagation in the earth's atmosphere from ELF to EHF. Guided waves. Ground waves and Millington's method. Scattering. Effects of the ionosphere and sky waves. Space waves: refraction and the 4/3 Earth radius; reflection and the Rayleigh criterion; diffraction, clearance criteria and rounded obstacles. Fading channels: Two-ray, Rayleigh, Ricean, Gaussian and Log-Normal fading, physical origins. System availability and outage.

Receiver topologies; direct detection, trf, super-regenerative, superheterodyne (single, dual and multi-conversion); direct conversion (Zero IF) receivers. Performance indices; sensitivity, selectivity, noise and strong signal performance, dynamic range, co-channel, adjacent channel rejection, suprious responses and blocking. Modulation and modems. Transmit architectures. Chipsets for wireless communications, partition of functions. Wireless system examples; GSM, TETRA, UMTS, Wireless LAN and Bluetooth. Signal detection and matched filtering. Spread Spectrum & CDMA. Synchronisation and phase locked loops. Digital down conversion and software radio.

## RF Theory

Component models including: biopler transistors, FETs, diode detectors, printed and wirewound inductors, surface mount resistors and capacitors; S, Y, Z parameter definition, conversion manipulation and calculation; Noise measurement techniques.

Electromagnetism: Review of free space electrostatics; Gauss' Law; electric flux density; dielectric materials - dielectric polarisation; boundary conditions for electric fields at interfaces; dielectrics in capacitors; energy in electric field; Laplace/Poisson Equations; Computer solutions of electrostatic fields; review of free space magnetostatics; magnetic materials; magnetic flux density; boundary conditions for magnetic fields at interfaces; magnetic circuits; inductance and energy in magnetic fields; Ampere's Law; Faraday's Law. Displacement current; Maxwell's Equations. Electromagnetic Waves: Vector wave equation for free space; solutions of the wave equation in free space; energy flow - the Poynting vector; wave polarisation - linear, circular, elliptical; vector wave equation for media; solutions of the wave equation in media; special solution - perfect dielectrics, conductors, lossy dielectrics.

Antennas: General properties of antennas and antenna systems, near, Fresnel and far-field regions. Impedance, radiation resistance. Radiation from current elements (simple treatment). Dipole and monopole antennas (descriptive treatment). Arrays and Array factor. Aperture field and far-field relationships. Uniformly illuminated rectangular and circular

apertures. Illustration of practical field tapers. Paraboloidal antennas, configurations, feed optimisation.

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Receiver topologies; direct detection, trf, super-regenerative, superheterodyne (single, dual and multi-conversion); direct conversion (Zero IF) receivers. Performance indices; sensitivity, selectivity, noise and strong signal performance, dynamic range, co-channel, adjacent channel rejection, suprious responses and blocking. Modulation and modems. Transmit architectures. Chipsets for wireless communications, partition of functions. Wireless system examples; GSM, TETRA, UMTS, Wireless LAN and Bluetooth. Signal detection and matched filtering. Spread Spectrum & CDMA. Synchronisation and phase locked loops. Digital down conversion and software radio.

## Statistical Analysis

Statistics: Mean, Standard Deviation, Histograms, frequency distributions. Discrete and continuous random variables. Probability theory, discrete random variables, continuous random variables and the probability density function, special distributions, the Central Limit Theorem;

## Software Engineering

The following content is taken from ACM's and the IEEE's Computing Curricula 2001, Volume II Computer Science. This definition of software engineering is not the traditional one, this is more computer system oriented, more systems engineeringSoftware Engineering)

Introductory level: SE1 Operating systems; principles, organization, scheduling and dispatch, memory management, file system, introduction to networking SE2 Real time principles; real time operating system, scheduling, fault tolerance, SE3 Software engineering; requirements, specification, software design, testing and validation, project management (overlapping with Programming) SE4 Structure of component libraries (API's)

Intermediate level: SE5 Component based computing, design patterns SE6 Building component libraries SE7 Distributed systems, communication and applications, distributed objects (CORBA) SE8 Real time, formal methods, specification and verification

## Systems Design and Architecture

Principles and processes of requirements engineering. Specification document design; The language of Availability, Reliability and Maintainability, Design for Manufatcure, Design for Test, System security, User Interface Design.

## Systems Development Methods

Overview of formal methods. Introduction to Z: basic schema notation, schema operators, state and operations. Use of formal method tools such as CADiZ, Formaliser or Z/EVES. The software development process from requirement analysis to implementaiton and roll-out.

## Systems Development Tools

## Systems Management Concepts

Systems management tasks: system monitoring, fault management, performance management, configuration management: procedures and industrial tool support, security management. Maintenance and modifications: fault reporting and action procedures, upgrades and reconfiguration, capacity planning. Risk management: risk identification, analysis and prioritisation. Roll of the backup and recovery strategy. Risk management strategies.

## Technology, Component and Material Knowledge

## Technical Documentation

## Testing

Hardware testing: Device, module, sub-system and system testing. Design for test: system partitioning for ease of testing, closed loop systems (analogue and digital), built in test facilities, boundary-value analysis, equivalence partitioning, error guessing. Test methods: Continuity and device testing, In-circuit testing, Functional testing. Type approval and Production testing, surrogate testing. Test strategies: Designing test strategies and plans, process yield models and test documentation (plans, records, reports). Use of ATE and its impact on test data recording.

# Annex B.

# Analysis of the Career-Space behavioural skills

## Introduction

The behavioural skills as defined in the Career-Space Generic Skills Profiles are high level and often describe complex behaviours. In an attempt to derive a means of assessing an individual's level of competence in these skills each has been decomposed to the component skills that it is believed can be 'assessed' by means of a set of word pictures level descriptors. Each of these component skills represents a 'dimension' of the behavioural skill.

A number of the behavioural skills have common 'dimensions'. For example, the ability to communicate is required, or implied in a number of the Career-Space behavioural skills. These dimensions are repeated (shown in italics) in each of the behavioural skills to ensure each can stand alone and does not require complex cross referencing and 'piecing a jigsaw puzzle' together.

Use has been made of the SFIA framework for the identification of levels of competence in the dimensions of the behavioural skills. The SFIA framework identifies 7 levels of competence from level 1, 'follow' to level 7 'set strategy, inspire, mobilise'. In general it is proposed that entrants to the ICT industry are unlikely to be competent to levels above 5. Levels 6 and 7 are therefore not included for brevity.

The SFIA framework uses the term 'investigations' to describe activities undertaken. The term 'investigations' is retained in the word pictures and should be taken to mean projects, activities or tasks as appropriate.

In this section the Career-Space behavioural skills (Career-Space definition) is followed by a summary of the proposed dimensions. For each of the dimensions a set of word picture level descriptors for the levels considered appropriate for the dimension (not always a full set from 1 to 5) are then given.

### *Picturing competence in the behavioural skill*

Given that each Career-Space behavioural skill can be described by a set of 'dimensions' and that each 'dimension' has a set of word picture level descriptors, the best representation of competence in the behavioural skills is by way of a spoke-wheel diagram. An example of a four-dimension spoke-wheel diagram is shown in figure 1.

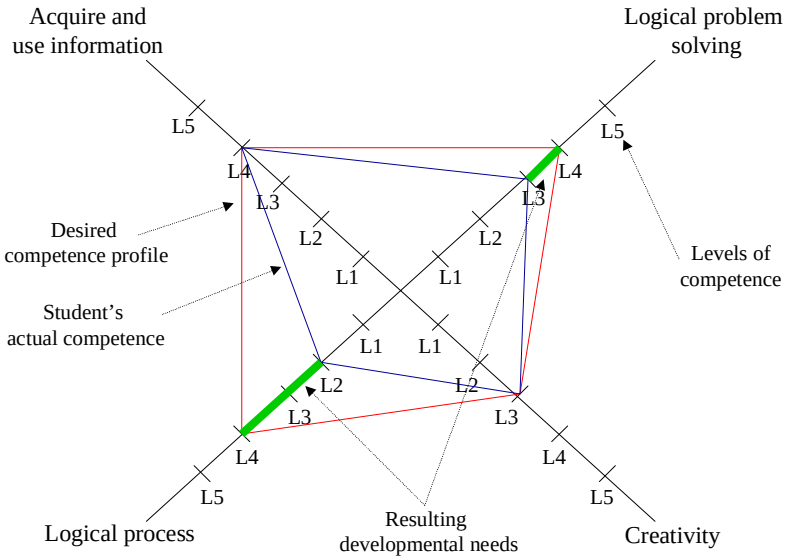


**Figure 1. Example behavioural skill profile.**

Each spoke represents one dimension of the behavioural skill. Competence in a dimension is indicated by a mark or cross on the spoke. The marks can be joined to show the competence profile of the skill. The figure shows a **hypothetical** example of a behavioural skill comprising four components. The desired competence profile for entry to the job profile is shown in red (the outer profile shape) while the student's current assessed competence is shown in blue (the inner profile shape). In two of the dimensions the student has been adjudged to be competent to the desired level. In two other dimensions the student has a competence below the desired level. The resulting gap is shown

## ‘Analytical’

### *Career-Space definition*

“Able to acquire information and identify missing information. Able to look logically at a technical situation to solve problems and create new and innovative solutions. Prepared to use facts, data, measurements and a logical process to carry out a job. Often tools and methodologies will exist to assist with this analytical work and a high degree of proficiency would be expected in the use of these.”

### *Summary of dimensions for the skill*

1. Acquire and use information
2. Problem solving
3. *Managing risk*
4. *One-to-one communication*
5. *Obtain information from others*
6. *Acquire information and compare with need*
7. Creativity

### *Word picture level descriptors*

- Acquire information and compare with need

Level 1: Can only acquire information under close supervision and close direction. Expected to seek guidance when unable to locate a specific document or source.

Level 2: Can acquire information under routine supervision where the sources of information are generally available. Expected to be able to resolve problems such as locating information by author, title or source.

Level 3: Can search information given a general subject area and would be expected to use multiple sources to search broadly. Determines when it is appropriate to seek help form retrieval specialists.

Level 4: Determines what information is required to support own investigations, plans the retrieval and the sources to be used.

Level 5: Determines what information is required to support own and team investigations and delegates objectives and assignments to subordinates.

- Logical problem solving

Problem solving is a Career-Space defined behavioural skill in its own right, it is assumed that there is no difference, as far as the ICT roles are concerned, between ‘problem solving’ and ‘logical problem solving’.

Level 2: With routine supervision can identify simple problems and solve them by adopting a prescribed problem solving approach.

Level 3: With general supervision can identify problems in own investigations and follow an agreed problem solving approach to resolve them.

Level 4: Can identify and anticipate problems associated with own investigations and can gather relevant information and solve complex problems.

Level 5: Can identify and anticipate problems associated with own and team investigations and can gather relevant information and solve complex problems.

- Managing risk

Level 2: Working under routine supervision, can perform a risk assessment of a well defined activity.

Level 3: Working under general supervision can perform a risk assessment of own work to a given set of quantification criteria and, with guidance, can produce contingency plans for agreed risks.

Level 4: Can perform a full risk management role for own investigations including risk assessment, prioritisation and contingency planning. Can set personal objectives and assignments to ensure risks are minimised.

Level 5: Can perform a full risk management role for own and team investigations including risk assessment, prioritisation and contingency planning. Can set objectives and assignments to subordinates to ensure risks are minimised.

- Ability to convey technical matters to technical and non-technical audiences in one-to-one interactions (face-to-face and by phone)

Level 1: Working under close supervision and guidance, can follow prescribed interviewing approach.

Level 2: Can ask appropriate questions and give answers within a general framework to specified individuals.

Level 3: Can recognise that one-to-one contact is necessary and, under general supervision can make contact, ask appropriate questions and make appropriate answers.

Level 4: Determine when and with whom and about what a one-to-one contact is appropriate to support own investigations and plans approach, timing, rapport building, questioning, listening and answering style.

Level 5: Determines information needs to support own and team needs and delegates objectives and assignments to subordinates.

- Ability to obtain information from others

Level 1: Working under close supervision and guidance can ask specific questions to gain specific information.

Level 2: Can ask questions of specified individuals on a given subject to gain information.

Level 3: Can recognise that others hold useful information and, under general supervision, can ask appropriate questions and interpret answers to gain information.

Level 4: Determine when and who holds useful information to support own investigations and plans approach, rapport building, questioning and listening style to gain information.

Level 5: Determine information needs to support own and team needs and delegates objectives and assignments to subordinates.

- Acquire information and compare with need

Level 1: Can only acquire information under close supervision and close direction. Expected to seek guidance when unable to locate a specific document or source.

Level 2: Can acquire information under routine supervision where the sources of information are generally available. Expected to be able to resolve problems such as locating information by author, title or source.

Level 3: Can search information given a general subject area and would be expected to use multiple sources to search broadly. Determines when it is appropriate to seek help form retrieval specialists.

Level 4: Determines what information is required to support own investigations, plans the retrieval and the sources to be used.

Level 5: Determines what information is required to support own and team investigations and delegates objectives and assignments to subordinates.

- Creativity

Level 1: Can only implement a creativity activity such as a brainstorming session under close supervision and close direction. Expected to seek guidance when faced with an unexpected problem or situation.

Level 2: Can plan and implement a creativity activity such as a brainstorming session, given a specific problem area, under routine supervision. Expected to be able to resolve problems such as identifying and reserving required resources such as a room for the activity.

Level 3: Can plan and implement a creativity activity such as a brainstorming session given a specific problem area. Determines when it is appropriate to seek help form retrieval specialists.

Level 4: Determines when a creativity activity will beneficially support own investigations, plans the activity and implements the appropriate technique.

Level 5: Determines when a creativity activity will beneficially support own and team investigations and delegates objectives and assignments to subordinates.

## ‘Attention to detail’

### *Career-Space definition*

“Able to produce accurate work, even when under pressure. For critical information checks the accuracy of information before using it or passing on to others.”

### *Summary of dimensions for the skill*

1. Produce accurate work under pressure
2. Devising self checking methods

### *Word picture level descriptors*

- Produce accurate work under pressure

Level 1: Working under close supervision can complete a simple investigation such that the result is technically accurate. Expected to seek guidance in unexpected situations.

Level 2: Working under routine supervision can complete a simple investigation such that the result is technically accurate. Expected to be able to resolve difficulties.

Level 3: Working under general supervision can complete a complex investigation under pressure such that the result is technically accurate.

Level 4: Can complete a small range of simultaneous, complex investigations such that the results are technically accurate.

Level 5: Can manage the completion of a range of simultaneous, complex investigations under pressure by self and team, such that the results are technically accurate.

- Devising self checking methods

Level 1: Working under close supervision and guidance can recognise that errors may have crept into own investigation and that results need to be checked.

Level 2: Working under routine supervision can devise checking methods for straightforward investigations.

Level 3: Working under general supervision can devise checking methods for complex investigations.

Level 4: Can recognise the need to devise checking methods and devise and employ methods appropriate to own investigations.

Level 5: Can recognise the need to devise checking methods and devise and employ methods appropriate to own and team investigations and set objectives and assignments to subordinates appropriately.

## ‘Commitment to Excellence’

### *Career-Space definition*

“Has a passion for succeeding in assigned tasks and to produce work of the highest quality. Will adjust working time to meet the demands of the business. Meets own commitments and ensures the completion of own tasks. Is responsible and can be relied upon.”

### *Summary of dimensions for the skill*

1. Personal commitment to quality
2. Personal effort to achieve and meet deadlines

### *Word picture level descriptors*

- Personal commitment to quality

Level 1: Working under close supervision can undertake specific takss to specific instructions.

Level 2: Working under routine supervision can undertake general tasks to a specified quality standard.

Level 3: Can recognise the need for a quality approach and can manage own investigations to meet given quality standards.

Level 4: Determines quality approach within organisational policy and practices appropriate to won investigations and plans, monitors and executes work to this quality standard.

Level 5: Determines quality standards within organisational policy and practices, of won and team investigations and delegates objectives and assignments to subordinates.

- Personal effort to achieve and meet deadlines

Level 1: Working under close supervision will meet given deadlines.

Level 2: Working under routine supervision can motivate self to meet given deadlines.

Level 3: Can recognise the need to meet given business demands and can motivate self to achieve.

Level 4: Determines deadlines and effort required for own investigations and can plan, delegate and motivate self to succeed.

Level 5: Determines deadlines and effort required for own and team investigations and can plan, delegate and motivate self and team to succeed.

## ‘Communication’

### *Career-Space definition*

“Able to communicate effectively face to face, on the phone, in writing and via presentations. Knows when to abstract complex technical concepts and describe in terms meaningful and relevant to technical and business managers and to other non-technical people. Also knows how to obtain the maximum understanding from other people. Is able to build a network of contacts who can provide information and assistance.”

### *Summary of dimensions for the skill*

1. One-to-one communication
2. Written communication
3. Public presentation
4. Obtain information from others
5. Develop and build relationships for networking purposes

### *Word picture level descriptors*

- Ability to convey technical matters to technical and non-technical audiences in one-to-one interactions (face-to-face and by phone)

Level 1: Working under close supervision and guidance, can follow prescribed interviewing approach.

Level 2: Can ask appropriate questions and give answers within a general framework to specified individuals.

Level 3: Can recognise that one-to-one contact is necessary and, under general supervision can make contact, ask appropriate questions and make appropriate answers.

Level 4: Determine when and with whom and about what a one-to-one contact is appropriate to support own investigations and plans approach, timing, rapport building, questioning, listening and answering style.

Level 5: Determines information needs to support own and team needs and delegates objectives and assignments to subordinates.

- Ability to convey technical matters to technical and non-technical audiences in writing

Level 1: Can produce a report on a specific problem under close step by step supervision. Expected to seek guidance at each stage.

Level 2: Can produce a report on a specific subject under routine supervision. Expected to be able to resolve problems such as sourcing an appropriate

computer and word-processing software. Report structure and scope expected to be prepared in conjunction with supervisor.

Level 3: Can produce a report on a specified subject to a given specification. General supervision is available and the report would be expected to be checked. Determines when it is appropriate to seek help.

Level 4: Can produce a report on an aspect of own work to a technical or non-technical audience.

Level 5: Determines when a report would be appropriate and can plan an event and delegate assignments to subordinates.

- Ability to make presentations to convey technical matters to technical and non-technical audiences

Level 1: Can produce a presentation on a specific problem under close step by step supervision. Expected to seek guidance at each stage.

Level 2: Can produce a presentation on a specific subject under routine supervision. Expected to be able to resolve problems such as sourcing an appropriate computer and presentation software. Presentation storyboard expected to be prepared in conjunction with supervisor.

Level 3: Can produce a presentation on a specified subject to a given specification with appropriate audio/visual support. General supervision is available and the presentation would be expected to be checked. Determines when it is appropriate to seek help.

Level 4: Can produce a presentation on an aspect of own work to a technical or non-technical audience with appropriate audio/visual support and defend through questioning.

Level 5: Determines when a presentation would be appropriate and can plan an event and delegate assignments to subordinates.

- Ability to obtain information from others

Level 1: Working under close supervision and guidance can ask specific questions to gain specific information.

Level 2: Can ask questions of specified individuals on a given subject to gain information.

Level 3: Can recognise that others hold useful information and, under general supervision, can ask appropriate questions and interpret answers to gain information.

Level 4: Determine when and who holds useful information to support own investigations and plans approach, rapport building, questioning and listening style to gain information.

Level 5: Determine information needs to support own and team needs and delegates objectives and assignments to subordinates.

- Ability to develop and build relationships for networking purposes

Level 1: Able to register contacts when presented with them. Purely reactive approach.

Level 2: Can develop a small network under routine supervision and guidance. Would be expected to be reactive in developing network.

Level 3: Can recognise the need to develop a network and, given specific instructions and general supervision, can develop a network of useful contacts.

Level 4: Determine networking needs to support own investigations and position and can plan, maintain and proactively develop a network of useful contacts..

Level 5: Determine networking needs to support own and team investigations and delegates objectives and assignments to subordinates.

## 'Creative'

### *Career-Space definition*

"The ability to create images and visions to help explain concepts and put ideas across in exciting and though provoking ways."

### *Summary of dimensions for the skill*

1. Create images and visions

### *Word picture level descriptors*

Level 1: Working under close supervision can develop images and visions given guidance and a specific aspect of work.

Level 2: Working under routine supervision can devise images and visions to help explain concepts of specific aspects of own work.

Level 3: Can recognise the place of images and visions to help explain concepts to others and can, under general supervision, devise and communicate them to others.

Level 4: Determines when it is beneficial to create images and visions to help explain concepts and aspects of own investigations and can devise and communicate them to others..

Level 5: Determines when it is beneficial to create images and visions to help explain concepts and aspects of own and team investigations and can set related objectives and assignments to subordinates.

## ‘Customer Orientation’

### *Career-Space definition*

“Is focussed on what is best for the customer, always lets customer needs, consistent with business profitability, drive actions and decisions.”

### *Summary of dimensions for the skill*

1. Focus on customer needs
2. Awareness of impact of customer needs on business

### *Word picture level descriptors*

- Focus on customer needs

Level 1: Working under close supervision can recognise customer needs and be guided into taking account of them in own work.

Level 2: Working under routine supervision can appreciate customer needs and how they impact on own investigations.

Level 3: Recognises the need to focus on customer needs and, working under general supervision, can communicate appropriately with the customer.

Level 4: Determines the degree of customer focus appropriate to own investigations and how customer needs can best be satisfied. Will communicate with customer appropriately.

Level 5: Determines the degree of customer focus appropriate to own and team investigations and how it will be achieved, set objectives and delegates appropriate assignments to subordinates. Will communicate with customer appropriately.

- Awareness of impact of customer needs on business

Level 1: Working under close supervision can recognise the impact customer needs have on own work and be guided into making due allowance for them.

Level 2: Working under routine supervision can recognise the impact customer needs have on own work and can make due allowance for them.

Level 3: Recognises the impact customer needs have on business operations related to own work and, working under general supervision, can make due allowance for them.

Level 4: Determines how business operations related to own investigations is impacted by customer needs and can plan and act appropriately.

Level 5: Determines how business operations related to own and team investigations is impacted by customer needs and delegates objectives and assignments to subordinates appropriately.

## ‘Decision Making’

### *Career-Space definition*

“The ability to make timely decisions based on adequate but often incomplete information.”

### *Summary of dimensions for the skill*

1. Decision making

### *Word picture level descriptors*

Level 1: Working under close supervision can take decisions relating to straightforward aspects of won work in situations where information is complete. Expected to seek guidance in unexpected situations.

Level 2: Working under routine supervision can take decisions relating to aspects of own work in situations where information is complete. Can recognise that information can be incomplete but would be expected to escalate decision making in such situations.

Level 3: Working under general supervision can make decisions relating to aspects of own work in situations where information is incomplete. Determines when the problem should be escalated to a higher level.

Level 4: Can determine information needs for, and timing of decisions in own investigations, recognising incomplete information situations and setting appropriate personal objectives to enable decisions to be made.

Level 5: Can determine information needs for, and timing of decisions in own and team investigations, recognising incomplete information situations and setting appropriate objectives and assignments to subordinates to enable the team to make decisions.

## ‘Flexibility and Self Learning’

### *Career-Space definition*

“The ICT industry today is one of the fastest changing industries of all time. This makes it both an exhilarating and demanding environment to work. Products that everyone was using two years ago are replaced with alternative products. Ways of working that are common today will disappear tomorrow. To survive, and enjoy the experience, you will have a flexibility attitude, be willing to acquire and learn new skills, new knowledge and new ways of working. Sometimes this will be achieved by formal education and sometimes by self-study and research.”

### *Summary of dimensions for the skill*

1. Flexibility

### *Word picture level descriptors*

Level 1: Working under close supervision can be guided to undertake activities in new ways.

Level 2: Working under routine supervision can accept need to be flexible in methods of working and propose areas of self-development appropriate to current investigations.

Level 3: Working under general supervision can recognise need to be flexible in methods of working and propose areas of self-development appropriate to current investigations and professional development.

Level 4: Can determine the knowledge, skills and working methods needed in own investigations and professional development. Can plan and set appropriate objectives to develop and modify own working methods.

Level 5: Can determine the knowledge, skills and working methods needed in own and team investigations and professional development. Can set appropriate objectives and assignments to subordinates to develop and modify team working methods.

## 'Information Handling'

### *Career-Space definition*

"With e-mail, the World Wide Web and company Internets the volume of information available significantly exceeds anyone persons capability to absorb it. Information handling skills are therefore needed to identify what is important and what is urgent and to be able to categorise information for easy retrieval."

### *Summary of dimensions for the skill*

1. Identification of importance and urgency of information
2. Categorising information for easy retrieval

### *Word picture level descriptors*

- Identification of importance and urgency of information

Level 1: Working under close supervision can be guided to appreciate the difference between importance and urgency and can, be guided on the appropriate action to be taken.

Level 2: Working under routine supervision understands the difference between importance and urgency and can, with guidance, decide on the appropriate action to be taken.

Level 3: Working under general supervision can decide where on the information/urgency grid information relating to own investigations lies and

how it should be dealt with. Determines when to escalate decisions to a higher level.

Level 4: Determines where on the information/urgency grid information relating to own investigations lies and how it should be dealt with.

Level 5: Determines where on the information/urgency grid information relating to own and team investigations lies and how it should be dealt with. Can set appropriate objectives and assignments to subordinates.

- Categorising information for easy retrieval

Level 1: Working under close supervision can establish and maintain an information storage system.

Level 2: Working under routine supervision can propose, establish and maintain an information storage system.

Level 3: Working under general supervision can determine an information storage system for own area of work and establish and maintain it.

Level 4: Determines how information relating to won investigations should be categorised. Can set appropriate objectives to establish and maintain an effective retrieval system.

Level 5: Determines how information relating to won and team investigations should be categorised. Can set appropriate objectives and assignments to subordinates to establish and maintain an effective retrieval system.

## 'Initiative'

### *Career-Space definition*

"Able to recognise when action is required, will take control of the situation and implement or propose a course of action. Does not wait to be prompted."

### *Summary of dimensions for the skill*

1. Taking initiative

### *Word picture level descriptors*

Level 1: Working under close supervision is expected to need guiding to act in all but the most obvious situations.

Level 2: Working under routine supervision recognises when obvious actions need to be taken but is expected to need guiding to act in less obvious situations.

Level 3: Working under general supervision recognises when action is needed and, with support, takes control of the situation and acts appropriately.

Level 4: Determines when action relating to own investigations is required and takes appropriate proactive action.

Level 5: Determines when action relating to own and team investigations is required and takes proactive action setting appropriate objectives and assignments to subordinates.

## 'Leadership'

### *Career-Space definition*

"At the personal level capable of making decisions and recognising and managing conflict situations. Able to command the support of a team and carry out their decisions to completion. Willing to challenge existing processes and proposals. Able to create and sell a vision of the future which others are keen to follow."

### *Summary of dimensions for the skill*

1. Decision making
2. Recognising and managing conflict
3. Teamwork
4. Willingness to challenge existing processes and proposals
5. Able to create and sell a vision of the future

### *Word picture level descriptors*

- Decision making

Level 1: Working under close supervision can take decisions relating to straightforward aspects of won work in situations where information is complete. Expected to seek guidance in unexpected situations.

Level 2: Working under routine supervision can take decisions relating to aspects of own work in situations where information is complete. Can recognise that information can be incomplete but would be expected to escalate decision making in such situations.

Level 3: Working under general supervision can make decisions relating to aspects of own work in situations where information is incomplete. Determines when the problem should be escalated to a higher level.

Level 4: Can determine information needs for, and timing of decisions in own investigations, recognising incomplete information situations and setting appropriate personal objectives to enable decisions to be made.

Level 5: Can determine information needs for, and timing of decisions in own and team investigations, recognising incomplete information situations and setting appropriate objectives and assignments to subordinates to enable the team to make decisions.

- Recognising and managing conflict

Level 3: Working under general supervision recognises most conflict situations and can, with guidance, manage and resolve them.

Level 4: Recognises and can manage conflict situations relating to own investigations and sets appropriate objectives to deal with them.

Level 5: Recognises and can manage conflict situations relating to own and team investigations and sets appropriate objectives and assignments to subordinates to deal with them.

- Teamwork

Level 3: Recognises the role different team members play in a team investigation and the need to motivate and support team members in the achievement of the team goal, sometimes at the expenses of personal gains.

Level 4: Able to harness the different team contributions through co-ordination, motivation and support to lead when given a formal leadership position.

Level 5: Able to bring together a number of individuals through co-ordination, motivation and support to lead them in a complex investigation without a formal leadership position.

- Willingness to challenge existing processes and proposals

Level 3: Working under general supervision propose appropriate changes to existing processes and practices and, given authority, to plan and change them.

Level 4: Determine when it is appropriate to challenge existing processes and practices relating to own investigations and set personal objectives to modify and re-embed the changes into the quality system.

Level 5: Determine when it is appropriate to challenge existing processes and practices relating to own and team investigations and set objectives and assignments to modify and re-embed the changes into the quality system.

- Able to create and sell a vision of the future

Level 3: Working under general supervision devise and propose a vision of the future of own areas of interest.

Level 4: Devise and sell a vision of the future of own areas of interest to higher, peer and lower levels of management and the external community as appropriate.

Level 5: Devise and sell a vision of the future of own and team areas of interest to higher, peer and lower levels of management and the external community as appropriate.

## ‘Managing Risk’

### *Career-Space definition*

“Considers the possible consequences of action or inaction and puts contingency plans in place to minimise negative consequences. Ensures appropriate levels of management are aware of major areas of risk.”

### *Summary of dimensions for the skill*

1. Managing risk
2. One-to-one communication
3. Obtain information from others

### *Word picture level descriptors*

- Managing risk

Level 2: Working under routine supervision, can perform a risk assessment of a well defined activity.

Level 3: Working under general supervision can perform a risk assessment of own work to a given set of quantification criteria and, with guidance, can produce contingency plans for agreed risks.

Level 4: Can perform a full risk management role for own investigations including risk assessment, prioritisation and contingency planning. Can set personal objectives and assignments to ensure risks are minimised.

Level 5: Can perform a full risk management role for own and team investigations including risk assessment, prioritisation and contingency planning. Can set objectives and assignments to subordinates to ensure risks are minimised.

- Ability to convey technical matters to technical and non-technical audiences in one-to-one interactions (face-to-face and by phone)

Level 1: Working under close supervision and guidance, can follow prescribed interviewing approach.

Level 2: Can ask appropriate questions and give answers within a general framework to specified individuals.

Level 3: Can recognise that one-to-one contact is necessary and, under general supervision can make contact, ask appropriate questions and make appropriate answers.

Level 4: Determine when and with whom and about what a one-to-one contact is appropriate to support own investigations and plans approach, timing, rapport building, questioning, listening and answering style.

Level 5: Determines information needs to support own and team needs and delegates objectives and assignments to subordinates.

- Ability to obtain information from others

Level 1: Working under close supervision and guidance can ask specific questions to gain specific information.

Level 2: Can ask questions of specified individuals on a given subject to gain information.

Level 3: Can recognise that others hold useful information and, under general supervision, can ask appropriate questions and interpret answers to gain information.

Level 4: Determine when and who holds useful information to support own investigations and plans approach, rapport building, questioning and listening style to gain information.

Level 5: Determine information needs to support own and team needs and delegates objectives and assignments to subordinates.

## 'Negotiation'

### *Career-Space definition*

"Can communicate with others to come up with a course of action which meets the needs and objectives of all parties. Not concerned with winning an argument for its own sake but producing a solution which meets the needs of the situation and the individuals involved."

### *Summary of dimensions for the skill*

1. Negotiation
2. One-to-one communication
3. Obtain information from others

### *Word picture level descriptors*

From the above description the following set of sub-skills has been extracted, for each sub-skill the KUSA attributes are shown. The description suggests that 'analytical' skill is a skill with four components:

- Negotiation

Level 3: Working under general supervision can identify when negotiation is required in relation to own work and, with guidance, can reach a win-win solution. Is aware of the stages and tactics of negotiation but requires advice and guidance to be successful.

Level 4: Determine when negotiation is required in relation to own investigations and able to consider the interests of all involved parties to reach win-win situations.

Level 5: Determine when negotiation is required in relation to own and team investigations and able to consider the interests of all involved parties and guide the team to reach win-win situations.

- Ability to convey technical matters to technical and non-technical audiences in one-to-one interactions (face-to-face and by phone)

Level 1: Working under close supervision and guidance, can follow prescribed interviewing approach.

Level 2: Can ask appropriate questions and give answers within a general framework to specified individuals.

Level 3: Can recognise that one-to-one contact is necessary and, under general supervision can make contact, ask appropriate questions and make appropriate answers.

Level 4: Determine when and with whom and about what a one-to-one contact is appropriate to support own investigations and plans approach, timing, rapport building, questioning, listening and answering style.

Level 5: Determines information needs to support own and team needs and delegates objectives and assignments to subordinates.

- Ability to obtain information from others

Level 1: Working under close supervision and guidance can ask specific questions to gain specific information.

Level 2: Can ask questions of specified individuals on a given subject to gain information.

Level 3: Can recognise that others hold useful information and, under general supervision, can ask appropriate questions and interpret answers to gain information.

Level 4: Determine when and who holds useful information to support own investigations and plans approach, rapport building, questioning and listening style to gain information.

Level 5: Determine information needs to support own and team needs and delegates objectives and assignments to subordinates.

## ‘Persuasiveness’

### *Career-Space definition*

“Able to convince others of the effectiveness of the proposals presented in a friendly and constructive way. Demonstrates other necessary attributes simultaneously (e.g. teamwork).”

### *Summary of dimensions for the skill*

1. Ability to convince others in a friendly and constructive way
2. Teamwork

### *Word picture level descriptors*

From the above description the following set of sub-skills has been extracted, for each sub-skill the KUSA attributes are shown. The description suggests that ‘analytical’ skill is a skill with four components:

- Ability to convince others in a friendly and constructive way

Level 3: Working under general supervision in terms of approach, can convince others of the merit of proposals relating to a given aspect of own work.

Level 4: Determine the most effective method of convincing others of the merit of proposals relating to own investigations and be able to convince higher, peer and lower management and external audiences.

Level 5: Determine the most effective method of convincing others of the merit of proposals relating to own and team investigations and be able to convince higher, peer and lower management and external audiences.

- Teamwork

Level 3: Recognises the role different team members play in a team investigation and the need to motivate and support team members in the achievement of the team goal, sometimes at the expenses of personal gains.

Level 4: Able to harness the different team contributions through co-ordination, motivation and support to lead when given a formal leadership position.

Level 5: Able to bring together a number of individuals through co-ordination, motivation and support to lead them in a complex investigation without a formal leadership position.

Possible associated skills - Communications: Presentation & Report Writing

## ‘Planning and Organising’

### *Career-Space definition*

“When given a task, is able to determine and document, the best approach and the time required to carry it out. Approaches the task in an organised and professional way and highlights revisions to the plan in timely manner, based on the work already done and new factors. Ensures that the work is carried out in a way that conforms to the rules of the organisation. Delivers on time and works equally effectively on multiple tasks when necessary.”

### *Summary of dimensions for the skill*

1. Planning and organising

### *Word picture level descriptors*

Level 1: Working under close supervision can produce a plan for a single, simple investigation and with close direction and monitoring, complete each task. Expected to seek guidance in unexpected situations.

Level 2: Working under routine supervision can produce a plan for a single, simple investigation and, with reference to supervisor in difficult situations can set own objectives that will ensure the plan is completed to deadline and in accordance with the organisations policies and practices.

Level 3: Working under general supervision can produce a plan for a single, complex investigation and set own objectives that will ensure the plan is completed to deadline and in accordance with the organisations policies and practices.

Level 4: Can produce a plan for a range of projects covering own investigations, document the plans and produce a set of personal objectives that will ensure the plans are achieved to deadline and in accordance with the organisations policies and practices.

Level 5: Can produce a plan for a range of projects covering own and team investigations, document the plans, communicate them to team and produce a set of objectives and assignments that will ensure the plans are achieved to deadline and in accordance with the organisations policies and practices.

## ‘Problem Solving’

### *Career-Space definition*

“We are all faced with problems every day. Problem solving in this context relates specifically to technology or process related problems and is not just the ability to analyse the cause of the problem, design an appropriate workable solution and implement the solution but also to be able to anticipate potential problems and prevent them from occurring. To be skilful in this area you will be proficient in gathering relevant information but also in assessing the quality and accuracy of the information.”

### *Summary of dimensions for the skill*

1. Problem solving
2. Managing risk
3. One-to-one communication
4. Obtain information from others
5. Acquire information and compare with need

### *Word picture level descriptors*

- Problem solving

Level 1:

Level 2: With routine supervision can identify simple problems and solve them by adopting a prescribed problem solving approach.

Level 3: With general supervision can identify problems in own investigations and follow an agreed problem solving approach to resolve them.

Level 4: Can identify and anticipate problems associated with own investigations and can gather relevant information and solve complex problems.

Level 5: Can identify and anticipate problems associated with own and team investigations and can gather relevant information and solve complex problems.

- Managing risk

Level 2: Working under routine supervision, can perform a risk assessment of a well defined activity.

Level 3: Working under general supervision can perform a risk assessment of own work to a given set of quantification criteria and, with guidance, can produce contingency plans for agreed risks.

Level 4: Can perform a full risk management role for own investigations including risk assessment, prioritisation and contingency planning. Can set personal objectives and assignments to ensure risks are minimised.

Level 5: Can perform a full risk management role for own and team investigations including risk assessment, prioritisation and contingency planning. Can set objectives and assignments to subordinates to ensure risks are minimised.

- Ability to convey technical matters to technical and non-technical audiences in one-to-one interactions (face-to-face and by phone)

Level 1: Working under close supervision and guidance, can follow prescribed interviewing approach.

Level 2: Can ask appropriate questions and give answers within a general framework to specified individuals.

Level 3: Can recognise that one-to-one contact is necessary and, under general supervision can make contact, ask appropriate questions and make appropriate answers.

Level 4: Determine when and with whom and about what a one-to-one contact is appropriate to support own investigations and plans approach, timing, rapport building, questioning, listening and answering style.

Level 5: Determines information needs to support own and team needs and delegates objectives and assignments to subordinates.

- Ability to obtain information from others

Level 1: Working under close supervision and guidance can ask specific questions to gain specific information.

Level 2: Can ask questions of specified individuals on a given subject to gain information.

Level 3: Can recognise that others hold useful information and, under general supervision, can ask appropriate questions and interpret answers to gain information.

Level 4: Determine when and who holds useful information to support own investigations and plans approach, rapport building, questioning and listening style to gain information.

Level 5: Determine information needs to support own and team needs and delegates objectives and assignments to subordinates.

- Acquire information and compare with need

Level 1: Can only acquire information under close supervision and close direction. Expected to seek guidance when unable to locate a specific document or source.

Level 2: Can acquire information under routine supervision where the sources of information are generally available. Expected to be able to resolve problems such as locating information by author, title or source.

Level 3: Can search information given a general subject area and would be expected to use multiple sources to search broadly. Determines when it is appropriate to seek help form retrieval specialists.

Level 4: Determines what information is required to support own investigations, plans the retrieval and the sources to be used.

Level 5: Determines what information is required to support own and team investigations and delegates objectives and assignments to subordinates.

## ‘Professional Attitude’

### *Career-Space definition*

“Approaches tasks and colleagues in a responsible and professional manner demonstrating attributes which are considered appropriate to the situation and job. Understands what is required in this respect and is able to modify attitudes to meet varying situations. Can be relied upon to produce quality results efficiently that bring credit to themselves, their team and their company. Takes ownership and responsibility for work items and is tenacious in work through or round problems. Works efficiently and effectively to produce a quality result.”

### *Summary of dimensions for the skill*

1. Professional attitude
2. Flexibility
3. Takes ownership and responsibility

### *Word picture level descriptors*

- Professional attitude towards tasks

Level 2: Working under routine supervision can undertake activities and ensure completion to required quality standards on time.

Level 3: Working under general supervision can complete investigations in an appropriate manner with due attention being paid to the wider business issues to ensure completion to required quality standards on time.

Level 4: Can be trusted to ensure own investigations are approached in an appropriate manner with due attention being paid to the wider business issues to ensure completion to required quality standards on time.

Level 5: Can be trusted to ensure own and team investigations are approached in an appropriate manner with due attention being paid to the wider business issues to ensure completion to required quality standards on time.

- Flexibility

Level 1: Working under close supervision can be guided to undertake activities in new ways.

Level 2: Working under routine supervision can accept need to be flexible in methods of working and propose areas of self-development appropriate to current investigations.

Level 3: Working under general supervision can recognise need to be flexible in methods of working and propose areas of self-development appropriate to current investigations and professional development.

Level 4: Can determine the knowledge, skills and working methods needed in own investigations and professional development. Can plan and set appropriate objectives to develop and modify own working methods.

Level 5: Can determine the knowledge, skills and working methods needed in own and team investigations and professional development. Can set appropriate objectives and assignments to subordinates to develop and modify team working methods.

- Takes ownership and responsibility

Level 1: Working under close supervision accepts responsibility for activities undertaken.

Level 2: Working under routine supervision accepts ownership of investigations and responsibility for activities undertaken.

Level 3: Working under general supervision recognises and accepts ownership of investigations and responsibility for investigations.

Level 4: Takes ownership and responsibility for own investigations in terms of methods adopted, quality of results obtained, problem solving and development and maintenance of working relationships.

Level 5: Takes ownership and responsibility for own and team investigations in terms of methods adopted, quality of results obtained, problem solving and development and maintenance of working relationships.

## 'Relationships'

### *Career-Space definition*

"Every job in the Information Technology and Telecomms industry requires an ability to work effectively with our people. In general the more senior the position the more the need to work with a wider range and type of person. For some job roles junior roles only require effectively relationships with a small team of colleagues, e.g. some Product Design roles. In other roles such as IT Business Consultancy the ability to form relationships quickly and easily with a wide range of customer people including managers, financial analysts, personnel specialists as well as technical practitioners. If relationships is identified as a core expertise for the role then you will be expected to be able to establish effective business relationships with team members, customers and other colleagues. You will have good communication skills, be able to listen effectively to others and be confident in seeking advice when appropriate. You will quickly develop a network of contacts and be ready to share information and ideas."

### *Summary of dimensions for the skill*

1. Establish business relationships
2. One-to-one communication
3. Develop and build relationships for networking purposes

### *Word picture level descriptors*

- Establish business relationships

Level 1: Able to recognise that contact with individuals in differnet business functions is necessary. Working under close supervision, can deal with simple specific issues when presented with them.

Level 2: Working under routine supervision can discuss issues relating to the broader business issues of own work when presented with them.

Level 3: Recognises the need to communicate with individuals in other business functions in order to complete own work and can, build rapport with individuals when approached by them.

Level 4: Recognises the need to communicate with individuals in other business functions in order to complete own work and will seek out appropriate individuals, build rapport and maintain an effective working relationship.

Level 5: Recognises the need to communicate with individuals in other business functions in order to complete own and team investigations and will seek out appropriate individuals, build rapport and maintain an effective working relationship.

- Ability to convey technical matters to technical and non-technical audiences in one-to-one interactions (face-to-face and by phone)

Level 1: Working under close supervision and guidance, can follow prescribed interviewing approach.

Level 2: Can ask appropriate questions and give answers within a general framework to specified individuals.

Level 3: Can recognise that one-to-one contact is necessary and, under general supervision can make contact, ask appropriate questions and make appropriate answers.

Level 4: Determine when and with whom and about what a one-to-one contact is appropriate to support own investigations and plans approach, timing, rapport building, questioning, listening and answering style.

Level 5: Determines information needs to support own and team needs and delegates objectives and assignments to subordinates.

- Ability to develop and build relationships for networking purposes

Level 1: Able to register contacts when presented with them. Purely reactive approach.

Level 2: Can develop a small network under routine supervision and guidance. Would be expected to be reactive in developing network.

Level 3: Can recognise the need to develop a network and, given specific instructions and general supervision, can develop a network of useful contacts.

Level 4: Determine networking needs to support own investigations and position and can plan, maintain and proactively develop a network of useful contacts..

Level 5: Determine networking needs to support own and team investigations and delegates objectives and assignments to subordinates.

## 'Strategy and Planning'

### *Career-Space definition*

"Able to take a broad and long-term view of what needs to be done in a particular situation and translate it into detailed actions."

### *Summary of dimensions for the skill*

1. Take strategic view and produce plans
2. One-to-one communication
3. Written communication
4. Public presentation

### *Word picture level descriptors*

- Take strategic view and produce plans

Level 3: Working under general supervision can propose long term strategy and detailed plans to support own investigations.

Level 4: Can produce a long term strategy and detailed plans for own investigations and communicate to upper, peer and lower management and, where appropriate, external audiences.

Level 5: Can produce a long term strategy and detailed plans for own and team investigations and communicate to upper, peer and lower management and, where appropriate, external audiences.

- Ability to convey technical matters to technical and non-technical audiences in one-to-one interactions (face-to-face and by phone)

Level 1: Working under close supervision and guidance, can follow prescribed interviewing approach.

Level 2: Can ask appropriate questions and give answers within a general framework to specified individuals.

Level 3: Can recognise that one-to-one contact is necessary and, under general supervision can make contact, ask appropriate questions and make appropriate answers.

Level 4: Determine when and with whom and about what a one-to-one contact is appropriate to support own investigations and plans approach, timing, rapport building, questioning, listening and answering style.

Level 5: Determines information needs to support own and team needs and delegates objectives and assignments to subordinates.

- Ability to convey technical matters to technical and non-technical audiences in writing

Level 1: Can produce a report on a specific problem under close step by step supervision. Expected to seek guidance at each stage.

Level 2: Can produce a report on a specific subject under routine supervision. Expected to be able to resolve problems such as sourcing an appropriate computer and word-processing software. Report structure and scope expected to be prepared in conjunction with supervisor.

Level 3: Can produce a report on a specified subject to a given specification. General supervision is available and the report would be expected to be checked. Determines when it is appropriate to seek help.

Level 4: Can produce a report on an aspect of own work to a technical or non-technical audience.

Level 5: Determines when a report would be appropriate and can plan an event and delegate assignments to subordinates.

- Ability to make presentations to convey technical matters to technical and non-technical audiences

Level 1: Can produce a presentation on a specific problem under close step by step supervision. Expected to seek guidance at each stage.

Level 2: Can produce a presentation on a specific subject under routine supervision. Expected to be able to resolve problems such as sourcing an appropriate computer and presentation software. Presentation storyboard expected to be prepared in conjunction with supervisor.

Level 3: Can produce a presentation on a specified subject to a given specification with appropriate audio/visual support. General supervision is available and the presentation would be expected to be checked. Determines when it is appropriate to seek help.

Level 4: Can produce a presentation on an aspect of own work to a technical or non-technical audience with appropriate audio/visual support and defend through questioning.

Level 5: Determines when a presentation would be appropriate and can plan an event and delegate assignments to subordinates.

## ‘Teamwork’

### *Career-Space definition*

“Demonstrates a strong desire to see the team achieve its agreed goals. Prepared to support team members and team decisions at expense of own goals. Recognises the value of having diverse attitude, skills, experiences and views and prepared to ensure they are harnessed when appropriate.”

### *Summary of dimensions for the skill*

1. Teamwork

### *Word picture level descriptors*

Level 3: Recognises the role different team members play in a team investigation and the need to motivate and support team members in the achievement of the team goal, sometimes at the expenses of personal gains.

Level 4: Able to harness the different team contributions through co-ordination, motivation and support to lead when given a formal leadership position.

Level 5: Able to bring together a number of individuals through co-ordination, motivation and support to lead them in a complex investigation without a formal leadership position.

## ‘Technical Orientation and Interest’

### *Career-Space definition*

“Is excited by finding out how things work. Applies technical understanding to solve business problems. Willing and excited by performing technical and analytical tasks in the IT and telecommunications area.”

### *Summary of dimensions for the skill*

1. Technical orientation and interest

### *Word picture level descriptors*

Level 2: With guidance will investigate the general IT field.

Level 3: Proactively investigates the general IT field.

Level 4: Proactively investigates the general IT field and can take ideas from one technical area and apply them innovatively to own work.

Level 5: Proactively investigates the general IT field and can take ideas from one technical area and apply them innovatively to own and team investigations.

# Annex C.

# Draft Common Curriculum for Radio Frequency Engineering

## Introduction

This document details a draft common curriculum for the Career-Space job profile 'Radio Frequency Engineer'. It is a statement of the technical content of the programme that is required by the ICT industry to enable a graduate of the programme to meet the ***entry level ability*** for the job of Radio Frequency Engineer. The content described herein is not a complete academic curriculum. It is expected that a student will only meet the entry requirements if, in addition to having gained a satisfactory level of achievement in the technical content described herein, they also achieve an undergradate qualification in their overall subject.

Meeting the ICT Industry entry requirements for the job of Radio Frequency Engineer, in summary, requires:

*[Need to introduce the balance across the Engineering Science, Fundamental knowledge and Behavioural, etc.]*

Statements confirming an acceptable ability in all the technical content described in this curriculum

**and**

A pass, of acceptable level, in the overall undergraduate programme

**Technology, Component, Material Knowledge and Thermal Design**

***Learning outcomes***

The student should be able to:

Select the appropriate component technology for a given circuit or system.

Select an appropriate material …

Consider the thermal aspects of a radio frequency circuit design and specify an appropriate solution to deal with circuit heat dissipation.

***Suggested underpinning behavioural skills***

Discussion, Analytical, teamwork,

***Example academic content***

Component types: Axial, Radial, Chip, Surface Mount, etc. Active and passive component handling. Static considerations. Hazardous materials handling. Materials for Printed Circuit Boards, heat sinks, enclosures, etc. Technologies for circuit and system realisation. Technologies for rapid prototyping, production, assembly, test.

Conduction, convection and radiation. Heat dissipation in active and passive components. Thermal effects including runaway. Cooling and heatsinks including airflow and heat exchangers. Thermal resistance. Derating policy. Thermal modelling tools.

**Radio Frequency Theory**

***Learning outcomes***

The student should be able to:

Apply fundamental and contemporary radio frequency theory to enable them to design communication equipment and sensor components and systems.

***Suggested underpinning behavioural skills***

***Example academic content***

Component models including: bipolar transistors, FETs, diode detectors, printed, chip and wirewound inductors, surface mount resistors and capacitors; S, Y, Z parameter definition, conversion manipulation and calculation; Noise analysis and measurement techniques.

Electromagnetism: Review of free space electrostatics; Gauss' Law; electric flux density; dielectric materials - dielectric polarisation; boundary conditions for electric fields at interfaces; dielectrics in capacitors; energy in electric field; Laplace/Poisson Equations; Computer solutions of electrostatic fields; review of free space magnetostatics; magnetic materials; magnetic flux density; boundary

conditions for magnetic fields at interfaces; magnetic circuits; inductance and energy in magnetic fields; Ampere's Law; Faraday's Law. Displacement current; Maxwell's Equations. Electromagnetic Waves: Vector wave equation for free space; solutions of the wave equation in free space; energy flow - the Poynting vector; wave polarisation - linear, circular, elliptical; vector wave equation for media; solutions of the wave equation in media; special solution - perfect dielectrics, conductors, lossy dielectrics.

Antennas: General properties of antennas and antenna systems, near, Fresnel and far-field regions. Impedance, radiation resistance. Radiation from current elements (simple treatment). Dipole and monopole antennas (descriptive treatment). Arrays and Array factor. Aperture field and far-field relationships. Uniformly illuminated rectangular and circular apertures. Illustration of practical field tapers. Paraboloidal antennas, configurations, feed optimisation.

Introduction to Electromagnetic Compatibility: Sources of EMI, EMI propagation mechanisms including radiation and conduction. Susceptibility and emissions. Units of measurement. EMC standards and regulations. EMC design principles.

Radio Propagation: Free space propagation. Basic link budgets. Introduction to propagation in the earth's atmosphere from ELF to EHF. Guided waves. Ground waves and Millington's method. Scattering. Effects of the ionosphere and sky waves. Space waves: refraction and the 4/3 Earth radius; reflection and the Rayleigh criterion; diffraction, clearance criteria and rounded obstacles. Fading channels: Two-ray, Rayleigh, Ricean, Gaussian and Log-Normal fading, physical origins. System availability and outage.

Receiver topologies; superheterodyne (single, dual and multi-conversion); direct conversion (Zero IF) receivers. Performance indices; sensitivity, selectivity, noise and strong signal performance, dynamic range, co-channel, adjacent channel rejection, suprious responses and blocking. Modulation and modems. Transmit architectures. System partitioning of functions. Modern wireless system examples. Signal detection and matched filtering. Spread Spectrum & CDMA. Synchronisation and phase locked loops. Digital down conversion and software radio.

**Testing**

Test instruments including: spectrum analyser, vector voltmeter, signal generators, network analyser, reflectometer, time-domain reflectometer. Measurement accuracy. Meaning of precision. Errors and uncertainty. 1- and 2-port measurement systems. Noise measurement. Calibration. Environmental test issues. Test strategies for development, type approval and production.

**Reliability Engineering**

Definitions. Mean Time Between Failures and Mean Time To Repair. Reliability prediction including unstressed and stressed predictions. De-rating policies. Failure

Modes and Effects Critical Analysis and Fault Tree Analysis. Reliability testing including accelerated life testing.

**RF Design Tools**

Introduction to industry standard software packages. Models and their limitations. Libraries. Schematic entry. Simulation and optimisation. Design targets. Yield analysis. Tolerance analysis.

**Electronics Theory and Know-How (analogue/digital)**

**Electronic Materials:** Materials used in electronics: Metals, insulators, semiconductors; concept of conductivity; simple atomic structure and bonding between atoms; crystals; electronic band structure. Electrons and holes in intrinsic semiconductors: Properties and behaviour; controlling the conductivity in semiconductors: Doping with impurities. Current flow: The movement of charge carriers (electrons and holes) in semiconductors; simultaneous drift and diffusion currents; built-in fields and voltages; generation and recombination of minority carriers; the Continuity Equation.

**The p-n junction:** Structure and behaviour in equilibrium; energy band diagram. Current flow across a p-n junction; energy band diagrams under bias. Shockley diode equation; applications of the p-n junction in electronic devices: Rectifier, detector, photodiode; the bipolar transistor (BJT) -structure and principle of operation; 'Figures of Merit' for the BJT; current gain; equivalent circuit models for the BJT; applications of the models. Bipolar process: Buried collector BJT, indicate location of R's and C in equivalent circuit; capacitive effects in p-n junctions; depletion, diffusion, and the effects on ac models; Bipolar transistor advanced circuit models: Ebers-Moll model, application of Ebers-Moll model to practical transistors, charge control model, switching transistor circuit, higher order effects, base width modulation, SPICE transistor model and applications, derivation of hybrid p model, high frequency application of hybrid p model.

**Basic concepts and components:** Charge, current, power, signals, resistance, capacitance, inductance and mutual inductance; ideal and non-ideal voltage and current sources - both independent and dependent. Linearity: Kirchhoff's laws; the Principles of Proportionality and Superposition. Equivalent Circuits: Thevenin and Norton equivalents for circuits containing both dependent and independent sources. Frequency Domain Analysis: complex representation of sinusoidal signals; phasors, reactance, susceptance and impedance; magnitude and phase response; decibels, Bode plots, poles and zeros. Time Domain Analysis: Differential equations of simple circuits; solution using the method of undetermined coefficients; transient response of first and second-order circuits; the effects of damping.Power in ac circuits: The Power Transfer Theorem. Conjugate matching; real, reactive, and apparent power; power factor and power factor correction. Tuned Circuits: Resonance in simple LCR circuits; determination of resonant frequency, Q-factor, bandwidth and dynamic impedance.

**Analogue Filters:** The approach to filter design: The notion of approximation, synthsis nad realisation as the essential parts of the design process. Approximations to ideal filter amplitude response: Butterworth, Chebychev and Elliptic. Synthesis: Darlington

insertion loss technique for resistively terminated LC filters. Active filter synthesis; Sallen and Key, Rauch, Ring-of-three configurations. Realisation: Impedance level denormalisation. Realisation of lowpass, highpass, bandpass and bandstop filters. Appropriate technologies. Active filter design: Single, dual and multi-amplifier biquads, effect of tolerances and amplifier limitations. Lowpass to highpass/bandpass. Use of design tables. Delay equalisation and realisation. Digital Filters: Introduction to Digital Signal Processing; the sampling theorem, aliasing, the anti-alias filter, the reconstruction filter. Digital filter design: concepts, structure, symbols, mathematical notation; the moving average filter; impulse response, frequency response, the discrete-time Fourier transform, linear phase, nonrecursive filter design by the Fourier method, windowing. Introduction to the z transform: relationships between Fourier, Laplace and z transforms, the pole-zero z plane plot, generating a recurrence expression, simple recursive filter design; notch filter, bandpass filter/comb filter combination.

**Bipolar Transistors:** Introduction to the transistor: The requirement for the transistor, bipolar devices; DC operation and biasing; DC and AC load lines, gm; investigation of the circuit building blocks; common-emitter and common-collector configurations, differential amplifier, current sources; simple models; Miller effect. Power Transistors: Bipolar and MOS power transistors; safe-operating area, heat sinks requirements and thermal stability, power amplifiers, classes A, B, AB, and C, single-ended and push-pull circuits, class B design. T and pi transistor models - gain and impedance variation with current at LF, frequency response, hybrid parameters, fT, Miller Effect, common base and cascode. Difference amplifier - differential and common mode gain. Current sources/mirrors (Wildar/Wilson) – Early voltage, active loads, O/P impedance, calculation of Voltage Offsets. Output stages: Class A - Emitter follower + current source; I/P and O/P impedance, transfer characteristics and distortion. (Complementary output stages, Class B, Class A/B). Some Op-Amp circuits - effect of feedback on I/P and O/P impedance and stability/compensation. Application circuits including Adder and D to A; Integrator -Triangular Waveform generator; Schmitt Trigger and Logarithmic Amplifier.

**Operational Amplifiers:** Introduction to signals; operational amplifiers; ideal voltage amplifiers; the virtual earth, introduction to feedback; integrators and differentiators. Filters; bandwidth, Bode plots; bias currents; offset voltages; performance specification; voltage gain; input impedance; output impedance. The monolithic operational amplifier - internal construction and circuit topologies.

**Switch mode power supplies.**

**Introduction to Logic circuits:** Boolean logic, logic gates, the truth table, the timing diagram, binary numbers, binary addition, hexadecimal, ASCII, BCD, 7-segment displays, noise margins, error detection, error correction, combinational logic design, Boolean algebra methods, the K-map, canonical forms, cellular logic, 2's complement arithmetic. S-R, D-type flip-flops; latching: sequential logic design. Logic elements as electronic components; logic families; design and characteristics; bipolar logic, MOS logic families, MSI logic device and the problems of testability; Multiplexers; demultiplexers; and examples of their application, problems associated with noise and digital interfacing. Timing diagrams. LSI devices: Simple array devices: PLA, FPGA. Counters, cascading asynchronous and synchronous designs. Memory structures: Static

and dynamic memory; applications. Tri-state logic. Finite state designs: simple examples using FSM. Microcoded structures; advanced finite state machine design.

**Introduction to circuit noise:** Introduction to noise and noise models for circuit and systems, sources of noise, voltage and current noise models, noise temperature, noise figure, the effect of bandwidth, noise build-up in systems, kTB and their uses.

**The design process:** An introduction to electronic product design, establishing needs and specifications, system design, costs and product development, tolerance design, design for the physical environment, design for reliability, design for manufacture, design for inspection and test, quality in the design process.

**Radio Frequency Circuit Design**

Distributed Circuits: The Smith chart and stub matching methods; the use of scattering, and transmission matrices for microwave components; single stage amplifier design; microstripline design; directional couplers.

Design of low noise small signal amplifiers; broadband small signal amplifiers incorporating feedback for optimum input and output impedance; the theory and design of low phase noise oscillators; frequency synthesisers; power amplifiers; mixers; filters.

**Radio Frequency Design Methods**

Design specifications. Design procedures and rules. Use of ideal and real components in designs. Parasitic components. Partitioning and interconnection strategies. Enclosure design. Approaches to prototyping. Engineering changes.

**Thermal Design**

***Learning outcomes***

The student should be able to:

Consider the thermal aspects of a radio frequency circuit design and specify an appropriate solution to deal with circuit heat dissipation.

***Example academic content***

Conduction, convection and radiation. Heat dissipation in active and passive components. Thermal effects including runaway. Cooling and heatsinks including airflow and heat exchangers. Thermal resistance. Derating policy. Thermal modelling tools.

# Annex D

# Draft Passport for the RF Engineering Skills Profile

### Achievement summary - Technical skills

| Technical skills | Level | Achievement | Evidence |
|---|---|---|---|
| Thermal Design | Entry | | |
| | Basic | | |
| | Advanced | | |
| Reliability Engineering | Entry | | |
| | Basic | | |
| | Advanced | | |
| Technology, Component and Material Knowledge | Entry | | |
| | Basic | | |
| | Advanced | | |
| Radio Frequency Circuit Design | Entry | | |
| | Basic | | |
| | Advanced | | |
| Radio Frequency Design Methods | Entry | | |
| | Basic | | |
| | Advanced | | |
| RF Design Tools | Entry | | |
| | Basic | | |
| | Advanced | | |
| Electronics Theory and Know-How (analogue/digital) | Entry | | |
| | Basic | | |
| | Advanced | | |
| Testing | Entry | | |
| | Basic | | |
| | Advanced | | |

## Achievement summary - Behavioural skills

| Career-Space Behavioural skill | Dimensions | Competence Level | Evidence |
|---|---|---|---|
| Creative | Create images and visions | | |
| Analytical | Acquire and use information | | |
| | Problem Solving | | |
| | Managing Risk | | |
| | One-to-One Communications | | |
| | Obtain information from others | | |
| | Acquire information and compare with need | | |
| | Creative | | |
| Teamwork | Teamwork | | |
| Communication | One-to-one communication | | |
| | Written communication | | |
| | Public presentation | | |
| | Obtain information from others | | |
| | Develop and build relationships for networking purposes | | |
| Professional Attitude | Professional attitude | | |
| | Flexibility | | |
| | Takes ownership and responsibility | | |
| Problem Solving | Problem Solving | | |
| | Managing risk | | |
| | One-to-one communication | | |
| | Obtain information from others | | |
| | Acquire information and compare with need | | |
| Initiative | Taking initiative | | |
| Managing Risks | Managing risk | | |
| | One-to-one communication | | |

| | | | |
|---|---|---|---|
| | Obtain information from others | | |
| Flexibility and Self Learning | Flexibility | | |
| Committment to Excellence | Personal commitment to quality | | |
| | Personal effort to achieve and meet deadlines | | |
| Customer Orientation | Focus on customer needs | | |
| | Awareness of impact of customer needs on business | | |

## Nomenclature:

### Technical Skill 'Levels'

- Entry

  Entry level is the lowest level of competence in the skill. It is the level at which the employer should expect the candidate to be able to undertake assigned tasks with guidance, probably step by step guidance.

- Basic

Basic level is the entry level of competence at which the employer should expect the candidate to be able to undertake assigned tasks with a clear and straightforward set of objectives, once the task has been explained, in a straightforward and procedural approach. Creativity and lateral input should not be expected but may be observed by able candidates at this level.

- Advanced

  Advanced level is the level of competence at which the employer should expect the candidate to be able to undertake assigned tasks that are unclear and where constraints render the task such that there may be neither a clear end result or straightforward approach. Creative input from the candidate should be expected along with a broad understanding of the wider issues that impact the task.

- Expert (Expert level is not shown on the above grid)

  Expert level is the competence level of the self-starter. The candidate who, from an overview of a problem area, will be able to formulate a task definition or set of task definitions, and, where appropriate clarify objectives and methodologies to be adopted. High innovative input should be expected at this level together with the ability to decompose very complex systems into more manageable and assignable tasks.

### Technical Skills 'Achievement'

- Weak (aspirational)

  Candidate has demonstrated the basic ability to undertake tasks or solve problems in this skill. Detailed additional advice and guidance should expect to be given to candidates with this grade of achievement.

- Average

  Candidate has demonstrated the ability to undertake straightforward tasks and problems in this skill. It should be expected that candidates can be assigned a task with the expectation that periodic monitoring will be required but that the task will be completed as specified.

- Good

  Candidate has demonstrated the ability to undertake more complex tasks and problems in this skill. It should be expected that the candidate can be assigned a task with the confidence that they will complete it with minimal guidance and that they wil lseek help when required. It should be expected that the candidate will exhibit a basic understanding of issues relating to the activity and how issues affect the activity being undertaken (the problem environment).

- Outstanding (very good/excellent)

  Candidates have demonstrated the ability to undertake more complex tasks and problems in this skill. It should be expected that the candidate will demonstrate a sound understanding of the wider issues of the activity or problem and complete the task taking due account of these them.

### Technical Skills 'Evidence'

Reference to the page or logical location for evidence to support the achievement claim for each level of each skill completed.

### Behavioural Skill Level

Column 1 shows the Career-Space behavioural skill. Column 2 shows the 'dimensions' of the skill, column 3 the competence level achieved in each dimension and column 4 the reference to the page or logical location for evidence to support the achievement claim. The competence level achieved is one of 7 levels with level 7 being the most competent as described below:

- Level 1 - Follow

  Works under close supervision. Uses little discretion. Expected to seek guidance in unexpected situations.

- Level 2- Assist

  Works under routine supervision. Uses minor discretion in resolving problems or enquiries. Works without frequent reference to others.

- Level 3- Apply

  Works under general supervision. Uses discretion in identifying and resolving complex problems and assignments. Specific instruction is usually given and work is reviewed at frequent milestones. Determines when problems should be escalated to a higher level.

- Level 4- Enable

  Works under general direction within a clear framework of accountability. Substantial personal responsibility and autonomy. Plans own work to meet given objectives and processes.

- Level 5- Ensure, advise

  Works under broad direction. Full accountability for own technical work or projects/supervisory responsibilities. Receives assignments in the form of objectives. Establishes own milestones, team objectives and delegates assignments. Work is often self-initiated.

- Level 6- Initiate, influence

  Has defined authority and responsibility for a significant area of IS work, including technical, financial and quality aspects. Establishes organisational objectives and delegates assignments. Accountable for actions and decisions taken by self and subordinates.

- Level 7- Set strategy, inspire, mobilise

  Has authority and responsibility for all aspects of a significant area of IS work, including policy formulation and application. Is held fully accountable for actions taken and decisions made, both by self and subordinates.

# Annex E

# Implementation project plans

| *Action* | *Description* | *Project Work Breakdown Structure* | *Subject(s)* |
|---|---|---|---|
| ***Passport to Industry*** | Design and development of a 'passport' to industry that will sit alongside academic qualifications. The passport will provide a visual record, supported by evidence (possibly in portfolio form) of achievement of components of the Career-Space generic skills profiles. | • Design passport, produce draft<br>• Investigate possibility of electronic storage of records and portfolio<br>• Gain agreement for principle of the passport amongst academic partners<br>• Gain commitment from Industry to provide a 'benefit' to students who complete passport.<br>• Circulate draft design for comments<br>• Incorporate feedback, produce final draft | |
| ***Detailed curriculum content*** | Starting with the generic Career-Space job profiles and knowledge of academic curricula, decompose the job profiles down to academically meaningful modules to include academic content and, if possible, definition of output standard required. | • Decompose Career-Space generic profiles down to academic modules.<br>• Identify clear module and sub-module descriptions.<br>• Identify learning objectives for each component.<br>• Identify output standards for each component.<br>• Gain agreement from academic partners that output standards can be measured and are reasonable.<br>• Gain agreement from Industry that output standards are understandable and meaningful. | |
| ***Student "Boot Camps"*** | A meeting of students from different International academic institutions at which one or more new topics are raised. The meeting will form the starting point or | • Define course objectives<br>• Establish course guidelines and plan | |

| | | | |
|---|---|---|---|
| | 'bootstrapping' induction of the students into a new idea. Examples might include:<br>• Working in teams and JAVA in preparation for an International Software Engineering group project.<br>• Preparation for an International group project on culture.<br>• International bibliographic study project.<br>• Internationalisation project for a piece of software or an embedded system. | • Define measures of student success<br>• Define optimum timing and duration<br>• Establish requirements for course tutors<br>• Identify suitable course tutors<br>• Brief course instructors/tutors<br>• Plan course facilities, handouts, etc.<br>• Establish a model personal specification for the students (allowing for academic level)<br>• Identify students<br>• Design student briefing notes<br>• Brief students before departure<br>• Establish venue requirements and identify suitable venue<br>• Arrange student travel, insurance, subsistence, visa and medical requirements | |
| ***International projects*** | A project undertaken by students from different academic institutions as a team. Possibly employing Industrial idea or Industrial sponsorship or mentoring. Examples:<br>• Software Engineering project<br>• Embedded system<br>• Hardware project<br>• Engineering design process related project<br>• Management project | • Scope out suitable project<br>• Define learning objectives<br>• Define measures of student success<br>• Define assessment method(s)<br>• Identify possible Industrial interest<br>• Define project in academic terms<br>• Define individual and group student performance metrics | |

| | | | |
|---|---|---|---|
| | | • Define and scope supervision mechanism and remit<br>• Define group communication infrastructure<br>• Establish appropriate group communications infrastructure<br>• Define optimum timing and duration<br>• Establish a model personal specification for the students (allowing for academic level)<br>• Brief students<br>• Brief instructors/tutors<br>• Identify students<br>• Define local facility requirements | |
| ***Academic Summer schools*** | Opportunities for academics from different academic institutions to meet to discuss internationalisation, the issues, benefits, case studies, best practice, pedagogical issues and ideas, etc. The meetings could involve short presentations and poster sessions, almost as a mini-conference although with a stronger focus on networking and raising of new possible ideas for international co-operation. | • Define course objectives<br>• Establish course guidelines and plan<br>• Define measures of student success<br>• Define optimum timing and duration<br>• Establish requirements for course tutors<br>• Identify suitable course tutors<br>• Brief course instructors/tutors<br>• Plan course facilities, handouts, etc.<br>• Establish a model personal specification for the students (allowing for academic level)<br>• Identify students<br>• Design student briefing notes | |

| | | | |
|---|---|---|---|
| | | • Brief students before departure<br>• Establish venue requirements and identify suitable venue<br>• Arrange student travel, insurance, subsistence, visa and medical requirements | |
| ***Student/Student mentoring*** | Senior students in one academic institution could mentor junior students in another institution. With an appropriate communications infrastructure this could easily cross National borders and enrich the student experience. This mentoring could be on technical subjects or language training and would involve more than email contact. The communication infrastructure would permit, as a minimum, real time video link between both parties with the ability to draw pictures as well as convey text. | • Define learning objectives<br>• Define scope of mentoring scheme<br>• Define the 'rules' and operating principles<br>• Identify optimum timing and duration or frequency of contact<br>• Define the role of the link person in each academic institution<br>• Establish a model personal specification for the mentor<br>• Identify academic institutions that wish to take part in the scheme<br>• Establish a link person within each academic institution<br>• Define group communication infrastructure<br>• Establish appropriate group communications infrastructure<br>• Identify suitable mentors and mentees<br>• Arrange initial meeting between mentors and mentees and brief on scope and rules. | |
| ***Student/School Student mentoring*** | Senior students in one academic institution could mentor students in schools within the same or different country. Such a scheme could enhance the image of engineering as a subject to be studied at University and could have an impact on the gender balance by | • Define scope of mentoring scheme<br>• Define the 'rules' and operating principles<br>• Identify optimum timing and duration or frequency of | |

| | | | |
|---|---|---|---|
| | could have an impact on the gender balance by targeting females for the mentor to provide role models and target female mentees as direct targets to influence. This scheme would require careful choice of mentor.<br><br>Mentoring would probably be most effective for Maths, Physics, Design Technology, etc. | contact<br>• Define the role of the link person in the school and the academic institution<br>• Establish a model personal specification for the mentor<br>• Identify schools that wish to take part in the scheme<br>• Establish a link person within the school and the academic institution<br>• Define group communication infrastructure<br>• Establish appropriate group communications infrastructure<br>• Identify suitable mentors and mentees<br>• Arrange initial meeting between mentors and mentees and brief on scope and rules. | |
| ***Industrialist/Student mentoring***<br><br>***(Global mentoring)*** | Technical mentoring/advice made available 24hours per day by a network of Industrial people connected to a communications network. A student, anywhere, would make contact with the mentor by means of a real time, Internet channel. Ideally with video link so that face to face contact is made. Facility should allow either party to draw pictures to illustrate the problem, or move around text. Examples could be the design of circuits, solutions of mathematical equations, etc. care might need to be taken to ensure the mentoring system does not allow students to get answers to summative work set by their local Institution. | • Define scope of mentoring scheme<br>• Define the 'rules' and operating principles<br>• Identify optimum timing and duration or frequency of contact<br>• Define the role of the Industrial mentor<br>• Establish a model personal specification for the mentor<br>• Identify organisations that wish to take part in the scheme<br>• Identify suitable persons within the organisation<br>• Define communication infrastructure<br>• Ensure each person has the appropriate communications infrastructure | |

| | | | |
|---|---|---|---|
| ***Direct video supported lectures*** | A network of real time, direct video links to aspects of course curriculum would be identified and established that any academic institution would be able to link to. For example:<br>• A direct video link into a semiconductor processing facility could be used, with or without a commentary from the source, as an illustration of semiconductor processing theory or practice.<br>• A direct video link to a production line could be used to inform and illustrate a lecture on production process theory. | • Define purpose and objective of scheme<br>• Identify possible video subjects<br>• Identify/define equipment requirements<br>• Provision equipment and link to communications infrastructure<br>• Plan video recording event<br>• Document link in for useable to others, post to database | |
| ***Virtual tutor exchange*** | The academic equivalent of mentoring where an academic in one institution acts as the supervisor or tutor to a group in another institution, not necessarily in the same country. The tutor could act as a technical tutor or as a language tutor. Pastoral supervision is probably best left to a local supervisor. | • Define purpose and objective of scheme<br>• Identify possible video subjects<br>• Identify/define equipment requirements<br>• Provision equipment and link to communications infrastructure<br>• Plan video recording event<br>• Document link in for useable to others, post to database | |
| ***Direct video industrial lectures*** | Many academic institutions currently ask leading industrialists to give lectures to their local students. These lectures could be given without the industrialist leaving their home company through a direct video link. Alternatively a lecture given at one institution could be either directly relayed to others or be recorded for subsequent video streamed download from a central database of lecture material. | • Define purpose and objective of scheme<br>• Identify possible video subjects<br>• Identify/define equipment requirements<br>• Provision equipment and link to communications infrastructure<br>• Plan video recording event<br>• Document link in for useable to others, post to database | |

| | | | |
|---|---|---|---|
| ***Central registry of Computer Based Learning material*** | The detailed curriculum breakdown to component parts with learning objectives and output standards will enable a search and identification of currently available packages of adequate quality. These packages can be made available through a central database. Further a specification for new CAL package design or a set of design guidelines can be produced that will enable gaps in the curriculum coverage to be filled.<br><br>The specification or design guidelines can embrace design for disability to enhance inclusivity. | • Define data dictionary<br>• Estimate database size<br>• Define hardware & software requirements<br>• Provision hardware & Software<br>• Design database and link to Internet<br>• Populate database | |

## Additional project components.

| *Action* | *Description* | *Project Work Breakdown Structure* | *Subject(s)* |
|---|---|---|---|
| ***Communications infrastructure evaluation*** | Many of the project ideas require an infrastructure to enable individuals to communicate effectively and in real time. A number of platforms are known to exist within the Industrial sector. This activity will be the evaluation of the platforms to determine which is the most appropriate. | • Define the requirement, specify selection criteria and measures (including financial terms and conditions)<br>• Identify available platforms<br>• Negotiate terms and conditions of evaluation<br>• Evaluate platforms against criteria and measures<br>• Select most appropriate platform<br>• Establish the platform in each pilot Institution<br>• Provide training in use of the platform for each academic institutuion. | |
| ***Project management*** | Overall project management of the EU project. Including programme plan management, income (in terms of in kind benefits) and expenditure tracking,. | | |
| ***Dissemination*** | Management of the dissemination requirements of the contract. | | |
| ***Data and infrastructure management*** | Management of project documents, teaching resource databases and communications infrastructure | | |