

The European Foundational ICT Body of Knowledge

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1 The need for a Foundational ICT Body of Knowledge

1.1 Europe’s ambition of strengthening the ICT Profession

The European Union has been actively promoting e-skills for more than a decade, with the European Commission establishing the European e-Skills Forum in March 2003. The purpose was to “foster an open dialogue between all relevant stakeholders and to catalyse actions with a view to helping to narrow the e-skills gap and to address e-skills mismatches.” This was followed in September 2007 by the Communication on “e-Skills for the 21st Century: Fostering Competitiveness, Growth and Jobs”.ⁱ

This Communication addressed concerns about an increasing lack of e-skills in the European workforce leading to a growing shortage of highly qualified ICT practitioners. This acts as a barrier to economic growth, competitiveness and employment. The main conclusion was that industry desperately needs highly skilled ICT practitioners and Europe needs **more young people** to become ICT practitioners to fulfil future increases in demand. It made a series of recommendations for a medium-term e-skills agenda (2007-2010).

A report for the European Commission in 2012 on ‘e-Skills and ICT Professionalism: Fostering the ICT Profession in Europe’ found that in the meantime and notwithstanding of the economic crisis the number of ICT practitioners required in Europe has continued to grow and will continue to do so.ⁱⁱ The demand for employees with ICT skills is growing by around 3% a yearⁱⁱⁱ, while the number of ICT graduates has fallen by 10% between 2006 and 2010^{iv}; If this trend were to continue, there would be up to 900 000 unfilled ICT practitioner vacancies in the EU by 2015^v.

In order to foster the growth of digital jobs in Europe and to improve ICT Professionalism this study proposed the concept of a ‘Framework for ICT professionalism’. This framework would consist of four building blocks which are also found in other professions: a body of knowledge (BOK); a competence framework; education and training; and a code of professional ethics.

A competence framework has already been established in the form of the European e-Competence Framework (e-CF)^{vi}. The other building blocks are still to be defined. The present report elaborates on the requirements for complying with the recommendation the BOK building block, i.e. establishing a “Foundational ICT Body of Knowledge”.

1.2 A ‘go-to’ reference to the requirements for the ICT professionals of tomorrow

At the moment, there is no authoritative source within the EU that defines and organises the core knowledge of the ICT discipline. An EU Foundational ICT Body of Knowledge is therefore needed to provide the basis for a common understanding of the foundational knowledge an ICT professional should possess^{vii}. Having a common way of referring to ICT knowledge, i.e. a ‘go-to’ point of reference, will facilitate communication among ICT practitioners and provide a baseline for competency models, certification programmes, educational programmes, and other workforce development initiatives^{viii}.

With this goal in mind, we defined a Foundational ICT Body of Knowledge as follows:

‘The European Foundational ICT Body of Knowledge is the base-level knowledge required to enter the ICT profession and acts as the first point of reference for anyone interested in working in ICT’.

The ultimate objective is to create a recognised and supported Foundational ICT Body of Knowledge that:

- Serves as an entry point to get into ICT for anyone contemplating a career in ICT and entering from other professions or wanting to digitise their current job;

- Facilitates communication between and understanding of ICT professionals in Europe in whatever sector they are active, thereby reducing risks and strengthening ICT professionalism;
- Increases the supply and pool of ICT professionals and enhances the image of ICT.

The European Commission and the research team of the report 'e-Skills: International Dimension and the impact of globalisation' have established cooperation with key stakeholders in other regions of the world sharing the same goals (e.g. in the US, Japan, Canada, Brazil, Australia etc.). This initiative aims to build on and strengthen that collaboration.

The definition of an **ICT Professional** is that developed in the research quoted previously **Error! Bookmark not defined.** as someone who should:

- Possess a comprehensive and up-to-date understanding of a relevant body of knowledge;
- Demonstrate on-going commitment to professional development via an appropriate combination of qualifications, certifications, work experience, non-formal and / or informal education;
- Adhere to an agreed code of ethics / conduct and / or applicable regulatory practices; and
- Through competent practice deliver value for stakeholders.

This definition, which was reviewed and widely accepted, reflects the importance of each of four building blocks that constitute the foundations of the Framework for ICT Professionalism.

1.3 Guidance for tomorrow's ICT professional

Information and Communication Technology is changing society. The degree to which ICT is pervasive in aspects of our social lives and working environment is ever increasing. ICT is ultimately the 21st century tool for the creation and implementation of specific solutions to meet customers' needs and realise business opportunities^{ix}. We are highly dependent on ICT, and therefore on ICT professionals, in every sector – from health and aviation to finance.

Some of the key challenges for the near future are to:

- Ensure that as many ICT professionals as possible have the necessary relevant knowledge, skills and competence to deliver professional products and service in today's digital economy;
- Improve the quality of the ICT profession;
- Close the ICT resource and skills gap;
- Enhance growth in digital jobs in Europe;
- Improve general ICT knowledge among professionals in other fields of expertise.

The nature of ICT jobs is also changing. It is no longer enough to merely be a technical expert. The industry needs professionals with a diversity of ICT knowledge and skills^x. ICT professionals are also required to understand the business, operational and HR management aspects. Industry is looking for multidisciplinary ICT professionals, dual thinkers (i.e. people who have a good understanding of both business and Technology) or T-shaped persons (see below). ICT is no longer a back office support tool or one department within a company but permeates all the layers and units of a company. ICT has moved itself to the forefront and become a key strategic asset in everyday (professional) life. Therefore, it is no longer sufficient only to have knowledge of one specific ICT domain.

The need for a broad IT systems viewpoint is essential, with the ability to understand the possibilities and constraints of the various technologies and to talk a common language with the diversity of people involved. This was expressed as a concept for the first time by David Guest in 1991^{xi} through the use of the T-shape metaphor, which has been widely adopted since.

The vertical line of the T represents the depth of related skills and expertise in a single field, whereas the horizontal bar is the ability to collaborate across disciplines with experts in other areas and to apply knowledge in areas of expertise other than one’s own. This model thus differs from another classic type: “I-shaped” – with a deep understanding of one specific discipline, but not necessarily of any other. In the current ICT environment, employers find themselves trying to do a “T” job with “I” people.

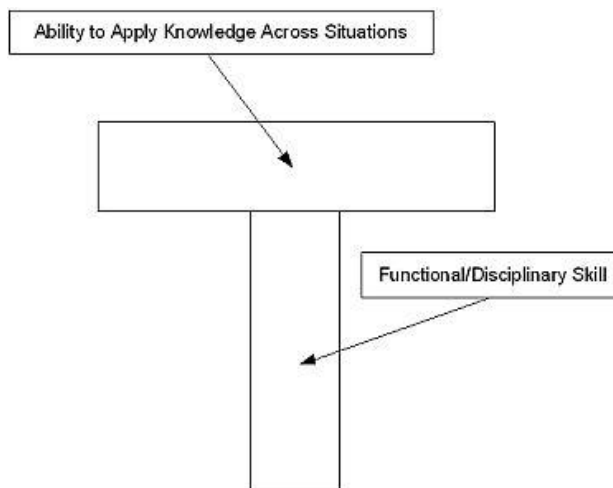


Figure 1: T-Shaped Skills Model^{xii}

However, a professional who combines specialisation in a specific ICT domain with relevant breadth of ICT knowledge is more easily employable and has a competitive position on the market. Given that there has in the past been a particular focus on depth, it is necessary to look more closely at the issue of breadth of knowledge. It is all a matter of creating the right balance between the two.

The objective is to create T-shaped persons with as much as possible the same elements in the horizontal bar. All ICT professionals should have the same DNA. It is however often the case that ICT professionals have much in common, but have different (job) profiles. The objective of a Body of Knowledge (BOK) is to define the ‘chromosomes’, or building blocks of the horizontal bar, in the ICT field and act as a guide to the breadth of ICT knowledge required.

The EU Foundational ICT Body of Knowledge thus aims to provide guidance for individuals, academia and industry, and hence contribute to developing tomorrow’s multidisciplinary ICT professionals.

1.4 Target audience and potential users

The EU Foundational ICT Body of Knowledge should provide the basis for a common understanding of the foundational knowledge an ICT professional should possess. Given this purpose and the different relevant stakeholders, one of the key aspects in approaching the Foundational ICT Body of Knowledge is the distinction between the target audience and the potential users.

The **target audience** defines for whom the Body of Knowledge has been developed. First of all, it consists of anyone interested in working in ICT and / or in understanding how to approach the ICT profession:

- Students and individuals who want to enter the ICT profession, to orient them to possible future careers;
- Individuals moving to ICT from other professions, to improve their awareness of the ICT domain.

The target audience is expected to use the Foundational ICT Body of Knowledge as part of an ICT professionalism framework together with the e-CF and the European ICT Profile Family tree. Entering the ICT profession, people should start from job profiles and move via e-competences to the Foundational ICT Body of Knowledge to obtain an overall understanding of ICT domain and professional requirements.

The **potential users** are those interested in using the Body of Knowledge as a point of reference for their own mission. This requires looking at how the Body of Knowledge can be used by education providers and training institutes, professional associations and the industry. A few examples of different uses of the Body of Knowledge are provided to explain this concept:

- Education providers: as a source of inspiration for curricula design and development;
- Professional Associations: to promote the Body of Knowledge to their members, ICT professionals;
- HR Department and Managers within industry with a need to understand the range of knowledge and the entry level required by ICT professionals in order to improve recruiting and people development processes (together with skills and competencies).

2 Design principles and approach of the Foundational ICT Body of Knowledge

2.1 Design Principles

The design principles establish the criteria for building the EU Foundational ICT Body of Knowledge and the requirements and expectations of stakeholders as to its development and maintenance. Building on principles and guidelines coming from existing ICT Bodies of Knowledge (i.e. ACS Body of Knowledge^{xiii}, IEEE SWEBOOK^{xiv}) and curriculum guidelines (i.e. Computer Science Curricula 2013 – ACM, the IEEE Computer Society^{xv}), the following design principles were defined:

- **Built on existing frameworks:** the structure should be derived from existing EU frameworks (the e-Competence Framework 3.0 and the related ICT Job Profiles);
- **Straightforward:** it should be written in a way that is comprehensible for existing and aspiring ICT professionals, especially young people entering or willing to enter the ICT profession;
- **Relevant:** it should address the needs of ICT professionals and European enterprises, including SMEs, and public administrations. The information provided to the user should be relevant to the user's task and context;
- **Flexible:** it should be able to adjust to technological change and new developments in the ICT profession, but it should provide a robust and solid foundation;
- **Objective:** the Foundational ICT Body of Knowledge should be inclusive. It should make reference to diplomas, certificates and training from different sources, whether these are open-source or vendor-specific.

These design principles provide a comprehensive view of how to construct the Foundational ICT Body of Knowledge to deliver its strategic objectives. They also ensure that the Foundational ICT Body of Knowledge will have a sound basis as they build on existing initiatives for ICT professionalism that provide the first reference point for developing the framework.

2.2 Approach

There are a vast number of Bodies of Knowledge in the ICT field, but there are overlaps and gaps. There is currently no global or European Body of Knowledge that is all-encompassing and which addresses all the ICT knowledge areas required by the industry^{xvi}. The landscape is very fragmented: in some cases several countries have a national ICT Body of Knowledge adapted to their national context which determines the core knowledge^{xvii}; in other cases specific organisations have drawn up a standardisation of the knowledge and skills necessary in isolated ICT fields or standards required for certification and accreditation of curricula for education^{xviii}.

The large number of Bodies of Knowledge related to ICT can be categorised in accordance with some key characteristics:

- **Scope:** generic Bodies of Knowledge which capture a large part of the IT domain and topic-specific Bodies of Knowledge which focus on a single IT area;
- **Approach:** Bodies of Knowledge that view the IT domain from different perspectives that reflect the education sector's or industry needs;

- **Purpose:** some Bodies of Knowledge may be intended to provide general guidance to curricula designers, while the objective of others is to certify professionals.
- **Target Audience:** Bodies of Knowledge which target different levels: students, practitioners or managers.

Measuring the generic Bodies of Knowledge against the criteria indicates that there is clear distinction to be made in the approach to structuring knowledge areas. These Bodies of Knowledge either structure the content taking an industry point of view with the future employability of students in mind or take a purely educational point of view.

Building on the existing models, the European Foundational ICT body of Knowledge has been developed in accordance with an approach that can be described as generic, industry-oriented and permissive:

- **Generic:** ICT is too vast for it to be possible for any single Body of Knowledge to cover it in a reasonable manner. However, the aim of the Foundational ICT Body of Knowledge is to provide the broad knowledge base required to enter the ICT profession;
- **Permissive:** coupled with the point above, the permissive approach means it is enough to use or know a sufficient part of the Body of Knowledge. This is the opposite of the exhaustive approach requiring the use or knowledge of the entire content of the Body of Knowledge;
- **Industry-oriented:** the Foundational ICT Body of Knowledge looks at ICT job profiles and competences to identify the knowledge required at base level. The ultimate objective is to provide the foundational knowledge people need to approach the ICT profession in a way that meets industry needs. With this aim, the Foundational ICT Body of Knowledge includes both managerial and technical knowledge covering the ICT business process, from planning to design to developing and managing technologies. This is in line with the need for “dual thinker” profiles and also reflects the logic of the ICT business processes as defined in the e-CF: ‘Plan, Build, Run, Enable and Manage’.

The structure of the Foundational ICT Body of Knowledge could be described as an ‘inverted T-model’, in which the horizontal axis shows the knowledge areas of the ICT domain running from a predominantly strategic to a predominantly technological perspective. The vertical axis corresponds to specific knowledge and skills an individual should develop to specialise in one domain. We can assume that any ICT professional wanting to go into a field different from that of their existing specialisation should come down to the horizontal bar (the base-level) and find a connection to other knowledge areas in order to expand their breadth of knowledge.

The Foundational ICT Body of Knowledge provides the base-level knowledge that ICT professionals require. However, considering the wide range of knowledge in the ICT field, it has to be intended as a “permissive model” where **every ICT professional will acquire as much breadth as possible** in terms of knowledge possession.

In addition to the dimension of ICT core knowledge defined above, the European Foundational ICT Body of Knowledge consists of a second dimension of complementary base-level knowledge required to enter the ICT profession. This dimension includes cross-cutting knowledge that cannot be considered purely in relation to one ICT knowledge area but can be referred to, at different levels, in relation to all core knowledge areas, i.e.:

- **Legal, ethical, social and professional practices:** including this knowledge in the Foundational ICT Body of Knowledge serves to provide key reference points for everyone interested in the ICT profession, as they are strongly linked to the definition of the ICT profession itself. Legal, ethical, social and professional practices need to be addressed at different levels at different stages of professional development. The very nature of professional work means that some knowledge and skills are best developed through experience and that an understanding of complex issues, such as ethics, grows with maturity. Further development will be provided at a full professional level through participation in certification programmes.

- **Soft skills:** including soft skills in the Foundational ICT Body of Knowledge provides a concrete contribution to the evolution of the ICT profession. Soft skills integrate the technical skills, providing a sound basis for developing “dual thinker” profiles, which are oriented towards team building, collaboration, negotiation, e-leadership, etc.
- **Emerging / disruptive technologies:** given the fast growth in the disruptive technologies of cloud, mobile, social and big data, which are predicted to constitute 40% of the global market and 98% of growth by 2020, and the expected creation of 4.4 million IT jobs globally to support big data – base- level knowledge should be provided to improve an understanding of these technologies and their impacts on business and society.

The BOK illustrated below and expanded on in the following sections presents the taxonomy of the high-level areas of knowledge that represent the base level that starting ICT professionals should understand. These knowledge areas are then broken down and described in further detail, including with a general definition of the knowledge area, a detailed list foundational knowledge, reference to the e-CF, potential job profiles and examples of specific Bodies of Knowledge, certification and training opportunities.

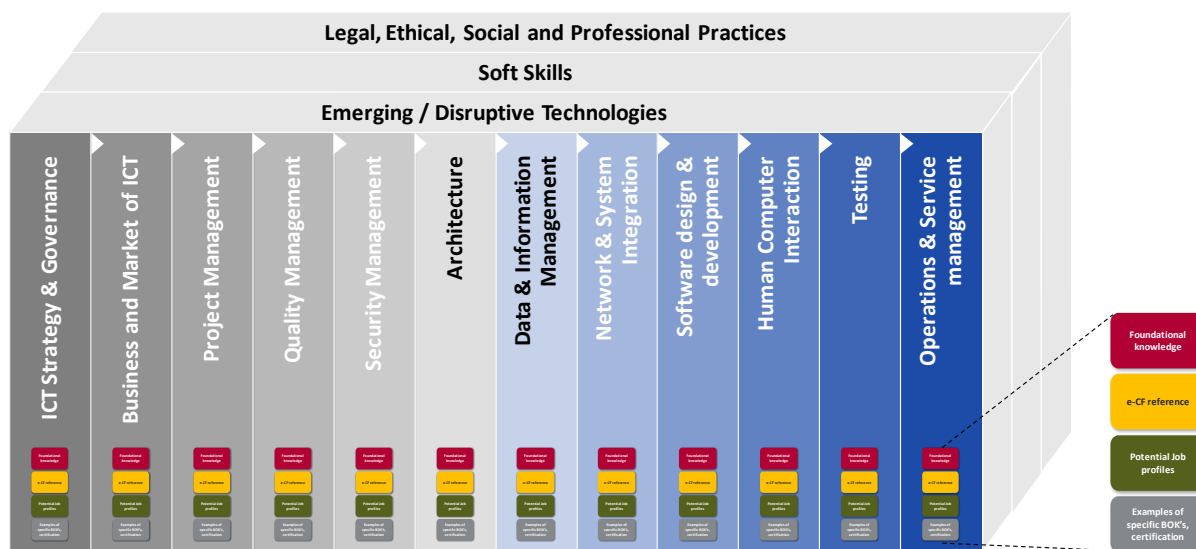


Figure 2: Taxonomy of Foundational ICT Body of Knowledge

This Body of Knowledge aims to develop the next generation of ICT professionals, e.g. young, rounded ICT professionals with a significant breadth of base-level knowledge of ICT that allows them to further specialise within a particular discipline.

3 Building blocks of the Foundational ICT Body of Knowledge

This Version 1.0 of the European Foundational ICT Body of Knowledge presents the **taxonomy** of high-level areas of knowledge that represent the base level starting ICT professionals should understand.

3.1 Introduction to Knowledge Areas

The following section presents 12 Knowledge Areas:

- ICT Strategy & Governance
- Business and Market of ICT
- Project Management
- Security Management
- Quality Management
- Architecture
- Data and Information Management
- Network and Systems Integration
- Software Design and Development
- Human Computer Interaction
- Testing
- Operations and Service Management.

Each Knowledge Area is further detailed, including a:

- Definition of the Knowledge Area;
- List of items required as foundational knowledge necessary under this Knowledge Area;
- List of references to the e-Competence Framework (dimension 4: knowledge);
- List of possible job profiles that require having an understanding of the Knowledge Area;
- List of examples of specific Bodies of Knowledge, certification and training possibilities.

The figures below summarise the content of each Knowledge Area.

ICT Strategy and Governance

ICT Strategy is about understanding how information systems can be managed to the best advantage of an organisation. In order to establish a sound business strategy, there is a need to know how information systems contribute to the operation of the organisation, explain the range of activities involved in information systems management, and evaluate different methods and approaches to solving information management problems.

An ICT Governance Framework is used to identify, establish and link the mechanisms for realising the potential of ICT. IT governance systematically involves everyone: board members, executive management, staff, customers, communities, investors and regulators^{xix}

a) Foundational knowledge required

- Introduction to organisations, structures and business functions
- The role of ICT within organisations and benefit realisation
- Information and content management
- Concept and theory of strategic planning
- International standards for corporate governance of information technology (ISO 38500)
- Foundations of IT value analysis and portfolio management
- Foundations of risk management
- Foundations of economics
- Foundations of ICT strategy design
- Information technology planning
- IT decision-making processes
- Communication systems

b) e-Competence Framework references

- A1 IS and Business Strategy Alignment
- A3 Business Plan Development
- C4 Problem Management
- E2 Project & Portfolio Management
- E3 Risk Management
- E7 Business Change Management
- E9 IS Governance

c) Examples of Job profiles envisioned

- CIO
- Business Information Manager
- Business Analyst
- ICT Consultant

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- Control Objectives for Information and related Technology (COBIT)
- Certified in the Governance of Enterprise IT (CGEIT)
- Lean
- Six Sigma
- ISO 38500

Business and Market of ICT

In essence, this is about how to fundamentally transform the way businesses consume and interact with IT^{xx}. It is necessary to gain insight into the business of ICT, the different applications of ICT in various sectors and its commercial value. An understanding is needed of how ICT can be used as a resource, how business transactions take place, and of the market principles and main components. Concepts of outsourcing, insourcing, offshoring, nearshoring, homeshoring and supply chain management that are specific to ICT should be highlighted in this Knowledge Area.

a) Foundational knowledge required

- Concepts of business and business models
- Foundations of market analysis and benchmarking
- Supply chain management: overview of the main supply chain models, including sourcing & shoring
- Concepts of e-procurement and e-sourcing
- Distribution and delivery models
- Business Process Management

b) e-Competence Framework references

- A3 Business Plan Development
- A7 Technology Trend Monitoring
- A9 Innovating
- D6 Channel Management
- D7 Sales Management
- D11 Needs Identification
- D12 Digital Marketing
- E7 Business Change Management

c) Examples of Job profiles envisioned

- Business Analyst
- Project Manager
- Supply Chain Manager
- Business Information Manager
- Account Manager
- ICT Consultant
- Enterprise Architect

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- BPM CBOK™ (Business Process Management Common Body of Knowledge – ABPMP)
- CBPP® (Certification Program, Certified Business Process Professional – ABPMP)
- Outsourcing Professional Body of Knowledge (OPBOK)

Project Management

Every IT project needs professional business managers capable of making effective and efficient project management decisions through the integration of specific knowledge, business understanding, and project management techniques supported by appropriate project management software. There will be a need to analyse both quantitative and qualitative data relating to project planning, to evaluate alternative strategies for executing projects, to use a range of electronic and non-electronic tools to create a project plan, to understand the people, processes and procedures around organising a project, including project contracts, risk management and people management.^{xxi}

a) Foundational knowledge required

- Project management principles and concepts
- Project planning, monitoring and control
- Cost / financial management (including budget planning, etc)
- Fundamentals of econometrics
- Project management methodologies and tools
- Change management

b) e-Competence Framework references

- A4 Product / Service Planning
- C4 Problem Management
- E2 Project and Portfolio Management

c) Examples of Job profiles envisioned

- Project manager
- CIO
- ICT Operations Manager

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- PRINCE2® Foundation, Practitioner (Projects IN Controlled Environments)
- IPMA certifications (International Project Management Association)
- PMI Certifications (PMP, CAMP, PgMP, PfMP, PMI-ACP, PMI-PBA, PMI-RMP, PMI-SP)

Quality Management

The ultimate mission of the IT quality function is to add value to the organisation as a whole and, in particular, to improve IT quality in every aspect, including applications and infrastructure. It includes both product / service quality and process quality. The scope of application of the quality models includes supporting specification and evaluation of software and software-intensive computer systems from different perspectives, i.e. those associated with their acquisition, requirements, development, use, evaluation, support, maintenance, quality assurance and control, and audit^{xxii}

a) Foundational knowledge required

- Quality principles
- Quality frameworks and ISO-9126
- Software quality management (including QM systems, methodologies for QM, quality audits)
- Fundamentals of quality analysis tools
- Procedural documentation production

b) e-Competence Framework references

- A2 Service Level Management
- D2 ICT Quality Strategy Development
- E5 Process Improvement
- E6 ICT Quality Management

c) Examples of Job profiles envisioned

- ICT Operations Manager
- Quality Assurance Manager
- Service Manager

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- ISO 9001: process quality
- ISO/IEC 15504 Information technology — Process assessment
- CMM (Capability Maturity Model)
- CMMI Practitioner Certifications
- CMMI Instructor Certifications
- CMMI Appraiser Certifications (SCAMPI)

Security Management

Information Security Management aims to ensure the confidentiality, integrity and availability of an organisation's information, data and IT services. It specifies requirements for the implementation of security controls customised to the needs of individual organisations or parts thereof^{xxiii}

a) Foundational knowledge required

- Introduction to security principles and concepts
- IT Security controls, plans and procedures
- Computer security (including firewalls and intrusion prevention systems, malicious software, cryptography, etc)
- Network security
- Computer forensics
- Business continuity management (e.g. security audit)
- Human behaviour / psychology

b) e-Competence Framework references

- B1 Application Development
- B6 Systems Engineering
- C2 Change Support
- C3 Service Delivery
- D1 Information security strategy development
- E8 Information security management

c) Examples of Job profiles envisioned

- ICT Security Manager
- ICT Operations Manager
- Systems Administrator
- ICT Security Specialist

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- CISM (Certified Information Security Management- ISACA)^{xxiv}
- ISM (Information Security Management – ITILv3)
- CREST (<http://www.crest-approved.org/>)
- EnCASE certification (<https://www.guidancesoftware.com/#>)
- CISSP (Certified Information Systems Security Professional)^{xxv}

Architecture

In information technology, architecture plays a major role in the aspects of business modernisation, IT transformation and software development, as well as other major initiatives within the enterprise. The architecture level represents the scope boundary and granularity of details the architectural activity should take into account, based on the organisation hierarchy and communication audience. It is classified in accordance with three different categories: enterprise architecture, solution architecture and system architecture. Each of these classifications varies in their implementation and design, depending on the contextual business scope, organisation structure and corporate culture^{xxvi}. The roles described below will only be taken by experienced professionals moving from related areas, so the underpinning foundational knowledge builds from those other areas.

a) Foundational knowledge required

(Note: The foundation knowledge mentioned below is very high level)

- Computer systems architecture
- Business architecture
- Data architecture
- Applications architecture
- Technical architecture
- Enterprise architecture

b) e-Competence Framework references

- A1 IS and business alignment
- A5 Architecture design
- A6 Application design
- B1 Application development
- B6 Systems engineering

c) Examples of Job profiles envisioned

(The roles described below will only be taken by experienced professionals moving from related areas, so the underpinning foundational knowledge builds on those other areas).

- IT Architect
- Business Architect
- Enterprise Architect
- System Architect
- System Analyst
- Solutions Architect

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- EABOK (Enterprise Architecture Body of Knowledge- MITRE)
- TOGAF ADM (Architecture Development Method The Open Group)
- Business Architects Association Architect (CBA)

Data and Information Management

Data management is the development, execution and supervision of plans, policies, programmes and practices that control, protect, deliver and enhance the value of data and information assets^{xxvii}. An understanding is required of how data is captured, represented, organised and retrieved from computer files and databases^{xxviii}.

a) Foundational knowledge required

- Information and data modelling
- Physical file storage techniques
- Database management systems (DBMS)
- Document, records and content management
- Reference and master data management
- Integrated data management

b) e-Competence Framework references

- A6 Application Design
- B1 Application Development
- B6 Systems Engineering
- C1 User Support
- D10 Information and Knowledge Management

c) Examples of Job profiles envisioned

- Business Information Manager
- Systems Architect
- Developer
- Test Specialist
- Database Administrator
- Systems Administrator
- Network Specialist

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- DAMA-DMBOK (Data Management BOK – DAMA International).
- Software Engineering Institute (SEI) Certification

Network & Systems Integration

This is about designing the computer networks that organisations rely on to access, share and store information^{xxix}. It is necessary to understand data communications and networking fundamentals. In addition, an insight should be gained into the process of linking different computing systems and software applications physically or functionally^{xxx}

a) Foundational knowledge required

- Introduction to network hardware and software
- Concepts and protocols (e.g. web standards and technologies)
- Network architecture
- Wireless and mobile computing
- Distributed systems
- Introduction to computer networking
- Network components and operating systems
- Systems architecture
- Smart systems development
- System infrastructure dimensioning
- Middleware
- Programming
- Telecommunication systems
- Multimedia and mobile computing components
- Principles of wireless communication
- Wireless networks and protocols
- OSI model layers
- Web technology
- Voice Over Internet Protocol (VOIP)

b) e-Competence Framework references

- A1 IS and Business Strategy Alignment
- A7 Technology Trends Monitoring
- B1 Application Development
- B2 Component Integration
- B4 Solution Deployment
- B6 Systems Engineering

c) Examples of Job profiles envisioned

- Network Specialist
- Digital Media Specialist
- ICT Consultant

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- WEBOK (Wireless Engineering Body of Knowledge – IEEE)
- SNABOK (System and Network Administration Body of Knowledge)

Software Design and Development

This is about is the application of engineering to the design, development, and maintenance of software^{xxxii}. It is necessary to understand how to develop or acquire software (information) systems that satisfy the requirements of users and customers. Knowledge of methodologies and processes for developing systems is also needed^{xxxiii}.

a) Foundational knowledge required

- Software elements of a computer system
- Software architecture
- Object-oriented design
- User interface design
- Software design process
- Concept of developing requirements (including types and analysis techniques)
- Programming languages and protocols
- Iterative software development
- Concept of system integration

b) e-Competence Framework references

- A6 Application Design
- B1 Application Development
- B2 Component Integration
- B4 Solution Deployment
- B6 Systems Engineering
- C1 User Support

c) Examples of Job profiles envisioned

- Systems Analyst
- Systems Architect
- Developer
- Test Specialist
- Systems Administrator
- Network Specialist

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- SWEBOK v3.0 (Software Engineering Body of Knowledge – IEEE Computer Society)
- IEEE - Certified Software Development Professional
- CompTIA (Computing Technology Industry & Association)
- Vendor certifications (Microsoft, Cisco, IBM, etc.)
- OMG Certified UML® Professional (OCUP)
- Application Services Library (ASL)
- OPEN CITS (Open Group Certified IT Specialist)

Human-Computer Interaction

Human-computer interaction (HCI) as defined by the Association for Computing Machinery (ACM) is “a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them”. It requires an understanding of the importance of the user in developing ICT applications and systems, and involves developing a mindset that recognises the importance of users, their work practices and organisational contexts. Topics covered could include user-centred design methodologies, interaction design, ergonomics, accessibility standards and cognitive psychology^{xxxiii}.

a) Foundational knowledge required

- Models and theories of human-computer interaction (HCI)
- Interaction design basics
- HCI in the software process
- Modelling rich interaction
- Groupware, ubiquitous computing and augmented realities
- Hypertext, multimedia, and the world wide web

b) e-Competence Framework references

- A5 Architecture design
- A6 Application design
- A9 Innovating
- B1 Application development
- B2 Component integration
- D11 Needs identification

c) Examples of Job profiles envisioned

- System Architect
- Developer
- Digital Media Specialist
- Test Specialist
- Network Specialist

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- Usability Body of Knowledge (<http://www.usabilitybok.org/>)

Testing

Software testing is an investigation conducted to provide stakeholders with information about the quality of the product or service under test^{xxxiv}. Software testing can also provide an objective, independent view of the software to allow the business to appreciate and understand the risks of software implementation^{xxxv}. Test techniques include, but are not limited to, the process of executing a programme or application with the intent of finding software bugs (errors or other defects)^{xxxvi}. Or software component.

a) Foundational knowledge required

- Definition and concepts of structured testing
- Testing principles
- Testing types, methods & techniques
- Life cycle testing

b) e-Competence Framework references

- B2 Component Integration
- B3 Testing
- B4 Solution Deployment
- E8 Information Security Management

c) Examples of Job profiles envisioned

- Developer
- Test Specialist
- Systems Administrator
- Digital Media Specialist

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- OPENCITS (Open Group Certified IT Specialist)
- ISTQB (International Software Testing Qualifications Board)()
- TMAP (Test Management Approach) ()

Operations & Service Management

ICT Operations and Service Management deals with the ongoing operation of ICT in an organisational context and includes frameworks for structuring the interactions of ICT technical personnel with business customers and users^{xxxvii}. The area is concerned with the “back office” or operational concerns of the organisation and could be referred to as “operations architecture” or “operations management”. The objective of IT Operations and Service Management is to ensure the effective and efficient implementation and maintenance of the ICT infrastructure in accordance with organisational rules, processes and standards.

a) Foundational knowledge required

- Basic concepts of service management (including the concept of service and service level agreement)
- Key principles and models
- Service management processes (including design, transition, delivery and improvement of services)
- Service management standards (including ISO 20000)
- Contract management

b) e-Competence Framework references

- A2 Service Level Management
- A4 Product / Service Planning
- C3 Service Delivery
- C4 Problem Management
- D1 Information Security Strategy Development
- D2 ICT Quality Strategy Development
- D8 Contract Management
- D11 Needs Identification

c) Examples of Job profiles envisioned

- Service Manager
- Project Manager
- ICT Operations Manager
- Service Desk Agent
- Network Specialist
- Technical Specialist
- Account Manager

d) Examples of specific Bodies of Knowledge, certification and training possibilities

- ITIL((Information Technology Infrastructure Library)
- ASL (Application Services Library)
- COBIT (Control Objectives for Information and related Technology)

3.2 Introduction to cross-cutting Knowledge Areas

As pointed out in the previous section, there are certain knowledge dimensions that are cross-cutting and apply to each of the 11 Knowledge Areas described above. Every ICT professional entering the ICT domain should have gained insight into these aspects. The three knowledge dimensions are described separately below and are:

- Soft Skills
- IT Legal, Ethical, Social and Professional practices
- Emerging and Disruptive Technologies.

Soft Skills

Soft skills are personal attributes that describe an individual’s ability to interact with others. Soft skills complement hard skills to enhance an individual’s relationships, job performance and career prospects. Unlike hard skills, which tend to be specific to a certain type of task or activity, soft skills are broadly applicable^{xxxviii}.

IT organisations aim to employ individuals possessing both hard and soft skills. However, the demand for the latter is increasing, especially for those in IT leadership roles. This demand arises because there is a perceived “soft skills gap,” or lack of these skills, among many IT staff, as well as an increasing need to align IT with business goals

a) Foundational Knowledge required:

- Basics of written and verbal skills
- Communication and relationship management
- Networking
- Negotiation and conflict management
- Teamwork
- Leadership and people management
- Decision-making
- Time management

b) Reference to existing Bodies of Knowledge

- The ICT Profession Body of Knowledge – Australian Computer Society (ACS)
- Guide to the Common Body of Knowledge for Computing and IT (CBOK) – Canadian Information Processing Society (CIPS)

c) Reference to European e-Competence Framework 3.0::

- D9 Personnel Development
- E4 Relationship Management

IT Legal, Ethical, Social and Professional practices

- a) Legal, ethical, social and professional practices provide a comprehensive reference to professional conduct. Knowledge included in this area should provide an overview of practices designed to ensure the highest level of ethical conduct, standards of practice and integrity with respect to the ICT professional activities.
- b) **Foundational Knowledge required:**
- History of computing and the ICT discipline
 - Privacy and civil liberties, intellectual property and legal issues
 - Contracts and liability
 - Fundamental ethical notions (virtues, duty, responsibility, harm, benefit, rights, respect and consequences)
 - Basic ethics theories
 - ICT-specific ethical issues
 - Workplace health and safety
 - Environmental and sustainability issues (Energy Informatics and /or Green IT)
- c) **Reference to existing Bodies of Knowledge and frameworks:**
- ACM code of ethics
 - IEEE code of ethics
 - CIPS code of ethics
 - Institute for the Certification of Computing Professionals – Code of ethics
 - CPSR – Computer Professionals for Social Responsibilities
 - BCS LSEPI (Legal, social, ethical and professional issues)
- d) **Reference to European e-Competence Framework 3.0:**
- A1 IS and Business Strategy Alignment
 - A8 Sustainable Development
 - D8 Contract Management
 - D10 Information and Knowledge Management
 - D12 Digital Marketing

Disruptive Technologies

A disruptive technology is one that displaces an established technology and shakes up the industry or a ground-breaking product that creates a completely new industry^{xxxix}. Harvard Business School professor Clayton M. Christensen coined the term disruptive technology. In his 1997 best-selling book, “The Innovator’s Dilemma,” Christensen separates new technology into two categories: sustaining and disruptive. Sustaining technology relies on incremental improvements to an already established technology. Disruptive technology lacks refinement, often has performance problems because it is new, appeals to a limited audience, and may not yet have a proven practical application.

a) Foundational Knowledge required:

- Cloud computing
- Mobile computing
- Big data and analytics
- Social media
- Internet of things

b) Reference to existing Bodies of Knowledge and frameworks

- The ICT Profession Body of Knowledge – Australian Computer Society (ACS)
- SWEBOK v3.0 – Guide to the Software Engineering Body of Knowledge – IEEE Computer Society
- Enterprise ITBOK Guide Framework – IEEE Computer Society

c) Reference to European e-Competence Framework 3.0:

- A1 IS and Business strategy alignment
- A7 Technology Trend Monitoring
- A9 Innovating.

4 Reference to European frameworks

The European Foundational ICT Body of Knowledge includes different knowledge areas of the ICT domain ranging from a strategic to a technological perspective. Each knowledge area provides reference to the e-Competence Framework and to possible job profiles. This function of referencing is one of the key strengths of the model – as it allows for anyone to understand what comes next. Base-level knowledge is required to start an ICT job, after which one has to further develop specific knowledge, competencies and skills to grow and explore a career path.

Building on e-CF 3.0, examples of knowledge Dimension 4 has been assessed and elaborated in order to define Knowledge Areas. The matrix below shows the link between e-CF and Knowledge Areas:

KNOWLEDGE AREAS	e-CF																																							
	IS and Business Strategy Alignment	Service Level Management	Business Plan Development	Product/ Service Planning	Architecture Design	Application Design	Technology Trend Monitoring	Sustainable Development	Innovating	Application Development	Component integration	Testing	Solution Deployment	System engineering	User support	Change support	Service Delivery	Problem Management	Information security strategy development	ICT quality strategy development	Channel Management	Sales Management	Contract Management	Personnel development	Information and knowledge management	Needs identification	Digital marketing	Project and Portfolio Management	Risk Management	Relationship Management	Process Improvement	ICT Quality Management	Business Change Management	Information Security Management	IS Governance					
ICT Strategy & Governance	X		X															X																	X	X				
Business and Market of ICT			X			X	X														X	X				X	X								X					
Project Management				X														X									X													
Security Management										X				X		X	X		X																	X				
Quality Management		X																		X											X	X								
Architecture	X				X	X				X				X																										
Data and Information Management						X				X				X	X											X														
Network and Systems Integration	X					X				X	X		X	X																										
Software Design and Development						X				X	X		X	X	X																									
Human Computer Interaction					X	X			X	X	X																X													
Testing											X	X	X																								X			
Operations and Service Management		X		X												X	X	X	X					X		X														
Soft Skills																								X					X											
IT Legal, Ethical, Social and Professional practices	X						X																X		X		X													
Disruptive Technologies	X					X	X																																	

The set of job profiles listed in Knowledge Areas are derived from the European ICT Professional Profiles (CWA 16458), which have to be intended as representative ICT Profiles covering the full ICT Business process.

The process of mapping European ICT job profiles against Knowledge Areas took place in three key steps:

- Step 1. Building on e-CF dimension 4 (example of knowledge), Knowledge Areas have been defined and associated to competences dimension 2 (competences)

- Step 2. Looking at ICT job profiles, required competences from e-CF have been identified
- Step 3. Competences from e-CF, associated to Knowledge Areas, have been further associated to ICT job profiles

The matrix below is the result of this process and is not intended to be exact but it provides a reference to link Knowledge Areas within European Foundational ICT Body of Knowledge with the other European Frameworks (e-CF and European ICT Professional Profiles)

KNOWLEDGE AREAS	ICT JOB PROFILES																						
	Chief Information Officer	Business Information Manager	ICT Operations Manager	Quality Assurance Manager	ICT Security Manager	Project Manager	Service Manager	Business Analyst	Systems Analyst	Enterprise Architect	Systems Architect	Developer	Digital Media Specialist	Test Specialist	Database Administrator	Systems Administrator	Network Specialist	Technical Specialist	Service Desk Agent	Account Manager	ICT Consultant	ICT Security Specialist	
ICT Strategy & Governance	X	X						X														X	
Business and Market of ICT		X				X		X		X										X	X		
Project Management	X		X			X																	
Security Management			X		X										X								X
Quality Management			X	X			X																
Architecture		X						X	X	X													
Data and Information Management		X									X	X		X	X	X	X						
Network and Systems Integration													X				X					X	
Software Design and Development								X		X	X		X	X	X	X	X						
Human Computer Interaction										X	X	X	X				X						
Testing												X	X	X		X							
Operations and Service Management			X			X	X										X	X	X	X			

5 Glossary

The glossary needs to be aligned with the e-CF glossary which is currently under revision.

End notes

- i See: <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52007DC0496&from=EN>
- ii See: http://ec.europa.eu/enterprise/sectors/ict/files/eskills/ict_professionalism_report_en.pdf
- iii See: http://ec.europa.eu/europe2020/pdf/themes/12_digital_agenda_ict.pdf
- iv See: <http://careerstalk.org/blog/2013/09/16/thinking-about-a-career-developing-apps/>
- v See: http://ec.europa.eu/europe2020/pdf/themes/12_digital_agenda_ict.pdf
- vi See: <http://www.ecompetences.eu/>
- vii ICT literacy is defined as being familiar with the fundamental information technology concepts and having the ability to utilise computers and related technology efficiently. One of the components is computer literacy. One way of becoming computer literate is to take the European Computer Driving Licence (<http://www.ecdl.org/>).
- viii “e-Skills and ICT Professionalism: Fostering the ICT profession in Europe”;
http://ec.europa.eu/enterprise/sectors/ict/files/eskills/ict_professionalism_report_en.pdf
- ix Career Space Consortium (2001), p. 12. See: <http://people.ac.upc.es/toni/papers/CurriTEng.PDF>
- x See: <http://is2.lse.ac.uk/asp/aspecis/20040092.pdf>; www.ictc-ctic.ca/Outlook_2011/index_en.html
- xi The term is now widely used and first appeared in 3The hunt is on for the Renaissance Man of computing, in The Independent, September 17, 1991
- xii <http://coevolving.com/blogs/index.php/archive/t-shaped-professionals-t-shaped-skills-hybrid-managers/>
- xiii See: http://www.acs.org.au/__data/assets/pdf_file/0007/7792/The-ICT-Profession-Body-of-Knowledge.pdf
- xiv See: <http://www.computer.org/portal/web/swebok> ;
<http://www.computer.org/portal/web/guest/home>
- xv See: <http://www.acm.org/education/CS2013-final-report.pdf>
- xvi IEEE (Institute of Electrical and Electronics Engineers) is currently drafting an Enterprise IT BOK with the objective of creating a formal, certified, recognised and respected common source of information about enterprise IT. This Enterprise IT BOK is to become a common yardstick for what constitutes an IT Enterprise professional and a common IT language.
- xvii http://www.acs.org.au/__data/assets/pdf_file/0007/7792/The-ICT-Profession-Body-of-Knowledge.pdf;
<http://www.cips.ca/?q=system/files/BOK.pdf>
- xviii <http://www.nioc2013.nl/wp-content/uploads/2013/05/NIOC2013-BOK-hbo-ict-BeckersMischa.pdf>
- xix See: ISO 9001 Quality Management Systems).
- xx See: <http://www.baselinemag.com/c/a/Business-Intelligence/14-Delivery-Models-Transforming-IT/>)
- xxi See Greenwich University, Project Management Undergraduate Course:
http://www2.gre.ac.uk/study/courses/ug/bus/n106/courses?sq_content_src=%2BdXJsPWh0dHAIM0ElMkYlMkZuZWxzbnZ3JlMmFjLnVrJTJGcGxzJTJGY3JzZSUyRnVvZ3dlYnNpdGUucF9jcnNISW5mbyUzRnRlcml0lMOQyMDUwMDAlMjZzdWJqJTNEQlVtSSUyNmNyc2UIM0QxNTk1JTl2Y29kZSUzRCZhbGw9MQ%3D%3D)
- xxii ISO/IEC 25010:2011
- xxiii See: Information Security Management – ITILv3
- xxiv See: <http://www.isaca.org/Certification/CISM-Certified-Information-Security-Manager/Pages/default.aspx>
- xxv See: <https://www.isc2.org/cissp/default.aspx>
- xxvi See: <http://www.infoq.com/articles/admit-architecture-framework>
- xxvii See: <http://www.dama-dmbok.org/>
- xxviii Australian Computer Society Body of Knowledge:
http://www.acs.org.au/__data/assets/pdf_file/0007/7792/The-ICT-Profession-Body-of-Knowledge.pdf
- xxix See: http://www.webopedia.com/TERM/I/it_network_engineer.html
- xxx Gilbert Held, (2000), Understanding Data Communications, From Fundamentals to Networking, 3rd Edition
- xxxi ACM (2007). “Computing Degrees & Careers”
- xxxii Australian Computer Society Body of Knowledge:
http://www.acs.org.au/__data/assets/pdf_file/0007/7792/The-ICT-Profession-Body-of-Knowledge.pdf

- xxxiii Australian Computer Society Body of Knowledge:
http://www.acs.org.au/_data/assets/pdf_file/0007/7792/The-ICT-Profession-Body-of-Knowledge.pdf
- xxxiv Cem Kaner, (2006), 'Exploratory Testing'. Florida Institute of Technology, Quality Assurance Institute
Worldwide Annual Software Testing Conference, Orlando, FL, available:
<http://www.kaner.com/pdfs/ETatQAI.pdf>
- xxxv See: <http://cignetinc.com/services/testing-services/software-testing/>
- xxxvi SWEBOK Guide Chapter 5
- xxxvii Australian Computer Society Body of Knowledge:
http://www.acs.org.au/_data/assets/pdf_file/0007/7792/The-ICT-Profession-Body-of-Knowledge.pdf
- xxxviii WhatIs.techtarget.com – <http://whatis.techtarget.com/>
- xxxix WhatIs.techtarget.com – <http://whatis.techtarget.com/>