DOMAIN DESCRIPTION

F U T U R E - P R O O F & C O M P R E H E N S I V E

PUBLISHED BY

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Composed by HBO-i Foundation

ISBN/EAN
978-90-834007-2-3

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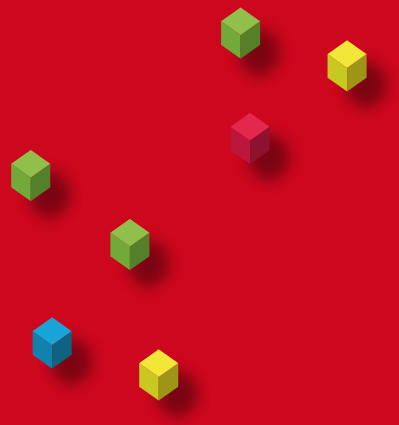
With thanks to all degree programmes, individuals and parties who contributed to this domain description in their pursuit of good ICT education.

FOREWORD



From the palm of our hands to the foundations of our cities, the impact of ICT cannot be ignored. More than a tool, ICT is the fabric of our modern world. And it affects everyone, private and business.

Problems or ambitions in any field look to ICT for solutions. Be it business developments or major social issues. With the rise of cybersecurity, data science and AI, the playing field is expanding considerably. And skills such as collaboration are indispensable for today's ICT professional.

In short, the world is changing and the role of ICT professionals is changing with it. That is why HBO-i developed this new version of the HBO-i domain description, in which all these developments have been given a place. As you are used to from HBO-i, this was done in close collaboration with the field.

I am convinced that this new domain description will help today's students prepare for a bright future. To meet the challenges that will soon be waiting for them. Ready to integrate, ready to innovate, ready for the future.

Maurice van Veghel
Chairman Advisory Board of HBO-i

CONTENTS

1. INTRODUCTION

The HBO-i domain description serves as a functional qualifications framework for universities of applied sciences and focuses on the starting proficiency of future ICT professionals. ICT plays a major role in virtually every aspect of societal, commercial and personal life. As well as being an important sector of economic activity itself, ICT is an invaluable driver of innovation in every knowledge-intensive domain in our society. The Netherlands has a great need for high-quality, trained ICT specialists, and the demand for ICT professionals continues to increase.

The ICT domain is expanding and deepening, and the number of specialisations and subdomains is increasing. To be able to respond to new applications, labour market issues, needs and innovations, the HBO-i domain description must be updated regularly.

ICT education is also evolving. For example, the number of associate degree and professional Master's degree programmes is growing. There is an increasing focus on professional skills, for example in the areas of ethics and sustainability. In addition, substantive developments necessitate changes in education. Examples include the movement of services and facilities to the cloud, the emergence of data science and artificial intelligence, and the increasingly essential concern for security.

1.1 WHAT IS IT?

The HBO-i domain description is a national framework for the exit qualifications for graduates of Dutch higher professional education (HBO) programmes in the ICT domain at the Associate, Bachelor's and Professional Master's degree level. The domain description is maintained by the HBO-i Foundation. Related to and inspired by international developments, frameworks and formats, the domain description is updated periodically in collaboration with the business community and is adopted by the Netherlands Association of Universities of Applied Sciences.

1.2 FOR WHOM IS IT INTENDED?

The domain description has been drawn up for various target groups. For higher professional education programmes in the ICT domain, it is a framework document from which programmes can derive their own programme profile, learning objectives and curricula. Explicit linkage of a programme's own programme profile to the domain description safeguards the content and exit level of the programme.
For businesses, the domain description provides insight into the exit level of graduates. Due to the variety of available ICT programmes, a generic domain description offers a stronghold to better understand the current skills of graduates.
For students, the domain description provides information on the competencies and professional tasks taught in the ICT programmes.

For adjacent domains, the fringes of this domain description mark the boundaries of the HBO-i domain. These fringes link to domains such as Engineering, Creative Technologies and Business Administration.

1.3 ABOUT HBO-i

The HBO-i Foundation is the umbrella organisation of ICT programmes at the higher professional education level in the Netherlands. The foundation is committed to the exchange of knowledge and transfer of information with regard to field-specific content and education. The foundation is also dedicated to increasing student intake through collective activities and products. This domain description is one of HBO-i's products.

1.4 DEVELOPMENT OF THE DOMAIN DESCRIPTION

Since 1994, HBO-i has provided an up-to-date framework document for affiliated programmes.
This HBO-i domain description is the fifth in a series in which the field-specific domain of ICT programmes is represented as a three-dimensional space with more or less orthogonal dimensions. This is also referred to as the 'cube.' The cube as a visualisation provides the opportunity to position degree programmes, programme profiles and professional profiles within the domain.

Compared to the previous domain description from 2018, this edition has changed in a number of aspects. For example, the field-specific topics have been updated. The professional skills needed to successfully perform field-specific professional ICT tasks have been further specified. In addition, the domain description indicates how these professional skills are connected to these professional tasks.
The model in this domain description was developed primarily to describe the supply side of Dutch ICT programmes at the higher professional education level. In addition, there are a large number of national and international models that describe educational and performance levels or identify and detail the professional field primarily from the demand side. How the domain description relates to these models and descriptions is explained in Chapter 4.

Because the digital world offers more opportunities than the paper format, the domain description is also accessible through digital channels. There is a PDF version as well as a website on which the cube and professional skills can be viewed from all angles. A dataset and an API that enable programmes to create their own detailing of the domain description are also available.

1.5 EXPLANATION, COORDINATION AND SUPPORT

This domain description was drawn up by representatives of the programmes affiliated with HBO-i. Feedback was provided by a large number of companies, by the HBO-i Advisory Council with representatives from industry associations and expert groups, and by members of professional field committees of affiliated programmes. Appendix 2 provides an overview of the organisations consulted.

2. THE MODEL

The domain description provides a systematic description of the professional field for which education is provided by the programmes within the HBO-i. This figure shows the model as a whole.

The cube describes the subject content in three dimensions:

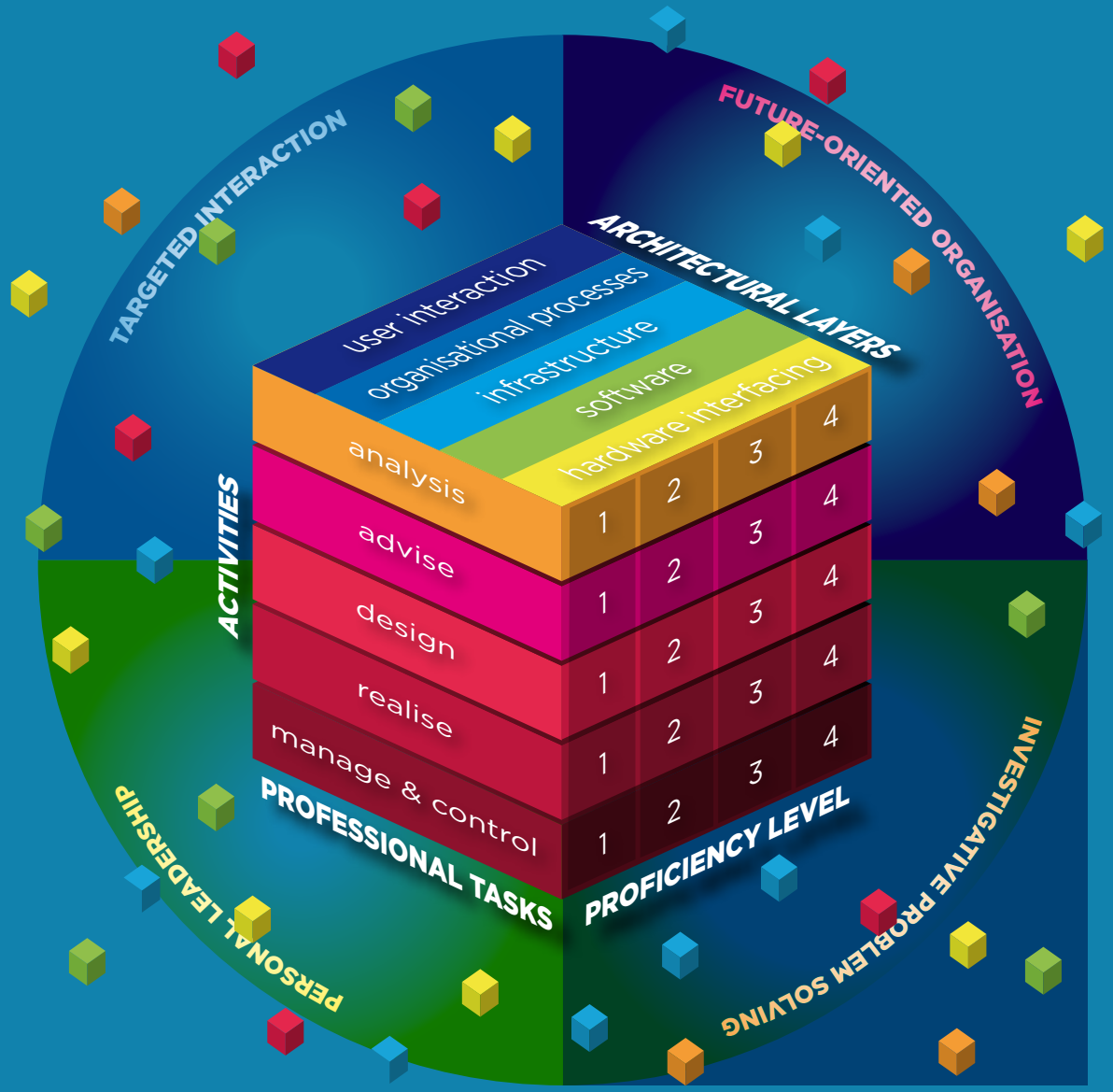
1. THE PROFICIENCY LEVELS
How complex are the content and context of the work?

2. THE ACTIVITIES
What does an ICT professional do?

3. THE ARCHITECTURAL LAYERS
In what context does work take place?

The cube is filled with representative professional tasks. Around it are the four focus areas with professional skills required by an ICT professional.

The components of the model are detailed in the following sections. How each component relates to frameworks and standards is explained (see Chapter 4).



The domain description model

2.1 PROFICIENCY LEVELS

The first dimension of the HBO-i domain description is the proficiency level. This determines the programme level. Within the HBO-i domain, programmes and students can place an emphasis on different areas to suit their ambitions and the demands from the professional field. As a result, variation will occur in the level at which sub-areas are (or have to be) mastered.

The proficiency level is determined by the complexity of the context, the complexity of the content and the level of autonomy in carrying out the assignment. A proficiency level is achieved when two of the three facets are at the relevant level. For example: for the third proficiency level, the autonomy and complexity of the context may be at Level 3, while the complexity of the content is at Level 2. However, it is also possible for the complexity of the context and the content to be at Level 3 while autonomy is at Level 2. A higher proficiency level implies proficiency regarding the professional tasks at the underlying proficiency levels.

To enable comparability within that diversity, we distinguish four proficiency levels, in accordance with the definitions in the ZelCom model. (Bulthuis, 2013). The characterisation of proficiency levels in the overview below is consistent with the level description in Dimension 3 of the e-CF and the level classification described by the Expert Group on Protocol of the Netherlands Association of Universities of Applied Sciences (Andriessen et al., 2014).

RELATIONSHIP TO OTHER FRAMEWORKS

- e-CF: Dimension 3: proficiency level (NEN-EN 16234-1:2016, e.g. Annex B)
- Dimension 3 of the e-CF characterises context complexity at five levels
- SFIA: level of responsibility
- SFIA characterises complexity at seven levels.

ASSIGMENT AND PERFORMANCE		PROFICIENCY LEVEL			
		1. TASK-ORIENTED	**2. PROBLEM-ORIENTED**	**3. SITUATION-ORIENTED**	**4. PROFESSION-ORIENTED**
AUTONOMY		Works under general guidelines in an environment where unpredictable changes take place	Autonomously solves interactive issues that arise from project activities	Works autonomously to solve interactive problems. Has a positive effect on team performance	Coordinates and manages. Raises issues with many interacting factors
COMPLEXITY	**CONTEXT**	Structured - predictable context, problem defined, approach and solution known to client	Structured - unpredictable context, problem given, choice of approach and space for solutions limited	Structured - unpredictable context, vague problems, approach and solution space open	Unstructured multidisciplinary and/or specialised context
	CONTENT	A few basic concepts that build on prior education	Combination of several basic concepts and a few in-depth concepts that build on basic concepts	Combination of several concepts for delving deeper into and innovation in the local situation	New concepts for delving deeper and innovation that are transferable to other situations

2.2 ACTIVITIES

The second dimension of the professional tasks consists of the five activities 'analyse,' 'advise,' 'design,' 'realise' and 'manage & control.' These activities are based on the 'system and software development life cycle.' Every student in the HBO-i programme domain must be able to carry out these activities within their own professional context. In doing so, a variety of processes can be applied: from a more linear approach with clearly distinguished phases to agile approaches with an iterative process, in which different activities are carried out simultaneously. The 'manage & control' activity comprises the organisation and management of this process. This activity is listed last in the series of activities in order to be able to make a better correlation to the other activities. However, the performance of a professional task will often begin with 'manage & control.' Quality aspects, such as security, budget, time and sustainability, are of great importance for all activities.

The five activities are described below in relation to the e-CF, which is the most relevant international framework for this dimension.

ANALYSIS

The 'analysis' activity involves the analysis of processes, products and information flows in their interrelationship and context.

e-CF Dimension 1 (areas): the 'analyse' activity falls roughly within part of the 'Plan' area defined within Dimension 1.

ADVISE

The 'advise' activity involves advising on the organisation of processes and/or information for an ICT system to be newly developed, purchased or modified.

e-CF Dimension 1 (areas): the 'advise' activity falls roughly within part of the 'Plan' area defined within Dimension 1.

DESIGN

The 'design' activity involves designing an ICT system (or part thereof) based on requirements.

e-CF Dimension 1 (areas): the 'design' activity falls roughly within part of the 'Plan' area defined within Dimension 1.

REALISE

The 'realise' activity involves creating and testing an ICT system (or part thereof) based on a design.

e-CF Dimension 1 (areas): the 'realise' activity falls roughly within the 'Build' area defined within Dimension 1.

MANAGE & CONTROL

The 'manage & control' activity involves managing, monitoring and optimising the development, deployment and use of ICT systems.

e-CF Dimension 1 (areas): the 'manage & control' activity falls roughly/mainly within the 'Run' area defined within Dimension 1.

2.3 ARCHITECTURAL LAYERS

The third dimension of the professional tasks is formed by five architectural layers. These have been inspired by enterprise and software architecture models: User Interaction, Organisational Processes, Infrastructure, Software and Hardware Interfacing. Because the activities can concern different aspects of ICT systems, they can vary significantly in terms of content.
The architectural layers are intended to make this differentiation in content visible and reflect the breadth of the domain.

The order of the five architectural layers is not arbitrary. Each layer adds functionality or value to the underlying layer and uses 'services' from that layer: user interaction is unlocked through ICT-facilitated organisational processes built on a configured infrastructure composed of (programmed) hardware and software components that may be connected to hardware systems via hardware interfaces.

USER INTERACTION

The 'user interaction' architectural layer relates to the communication between the user or end user and the ICT system. This emphatically does not refer to interaction with users, as it takes place during the creation of an ICT system; after all, this takes place in each of the architectural layers.

ORGANISATIONAL PROCESSES

The 'organisational processes' architectural layer relates to the facilitation of organisational processes by means of ICT systems. This involves the functionality of the system as a whole (automated and non-automated components), viewed from the context of the organisational goals to be achieved.

INFRASTRUCTURE

The 'infrastructure' architectural layer concerns the entirety of ICT systems used to facilitate organisational processes. This involves making available, keeping available and configuring the traditional hardware infrastructure, and certainly also the software infrastructure.

SOFTWARE

The 'software' architectural layer concerns the development of various types of software. This concerns software that can be incorporated into an ICT infrastructure after delivery.

HARDWARE INTERFACING

The 'hardware interfacing' architectural layer concerns software that interacts with available hardware. This involves situations where the software must explicitly take into account the capabilities and limitations of the available hardware. In the description within this architectural layer, 'system' has been chosen as a generic, overarching term. Depending on the context, this can be further specified as 'embedded system,' 'industrial automation,' 'virtual system,' etc.

2.4 PROFESSIONAL TASKS

The architectural layers are detailed in representative professional tasks. The set of professional tasks described has an illustrative function on the one hand and a framework-setting function on the other. This means that the professional tasks mentioned are illustrations and thus should not be interpreted as mandatory components of a programme. Together, these illustrations outline an overview framework for the combinations of activities, architectural layers and levels.

The professional tasks are divided into four proficiency levels for each architectural layer. Starting from a particular cell in the cube, it is easy to deduce a professional task of a higher or lower level by varying the autonomy or complexity of the professional task concerned.

USER INTERACTION

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
ANALYSIS	Identify the key elements of an external assignment, with clarification sought from the client, end users and experts	Benchmark functionality, user experience, accessibility, and other design aspects for a client	Analyse the end user, user interaction and user experience, both individually (physical, psychological and personal characteristics) and in a larger societal context (social, cultural, ethical and technological)	Analyse societal and/or domain-specific trends & opportunities and communicate about these at a strategic level with key stakeholders
	Identify client and end-user needs and translate these into ICT resources	Analyse existing products or services in relation to user needs and the client's core values	Analyse current and emerging interactive technologies	
	Explore existing interactive concepts, services and products	Identify relevant data visualisations for a dataset	Continuously evaluate the impact of the intervention on the user experience	
ADVISE	Advise on interaction design appropriate for the assignment, client, user needs and prior inventories	Provide reasoned, concrete recommendations on the interaction concepts and/or techniques to be used	Translate an analysis into strategic recommendations for the creation of user interaction, including recommendations for an appropriate design process	Extrapolate technological and societal trends and translate these into strategic-level design recommendations that include a vision of the user experience and the relationship between the user and the product/service
	Advise on interaction design based on a simple, self-performed or given usability analysis	Make proposals on creation choices, such as the technologies to be used, taking into account the professional context and end users	Advise which forms of data visualisation will have the desired effect for the client, taking into account quality requirements and ethical requirements	
		Advise on the objectives of current and subsequent iterations	Advise on interventions on the user experience in current and subsequent iterations	

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
DESIGN	Translate recommendations into a simple user interaction through a given interaction process, e.g. using a standard prototyping technique	Translate recommendations into a design of detailed user interaction with various prototyping techniques	Translate recommendations into a concrete and detailed user interaction design, appropriate for the project phasing, using an effective and reasoned design process	Design a user interaction, taking into account the client's long-term strategy and organisational objectives and anticipating relevant societal trends and technological developments
	Design a test with which essential interaction problems can be identified	Design tests with which iteration objectives are evaluated	Design a test strategy appropriate for the phase with which the objectives are evaluated from the perspective of the intended users	
	Design a visualisation of a simple data set	Apply an interaction design process under one's own direction in collaboration with stakeholders		
REALISE	Realise and test simple interactive products or services based on an interaction design, using standard tools, accessibility guidelines and/or corporate identity	Use various tools and techniques to realise and test one's own interaction design for interactive products or services for several types of end users	Realise, test and transfer the user experience of an interactive product, prototype, system or service based on the design with tools and techniques appropriate for the project phasing	Realise future-proof products, services or prototypes that are innovative and sustainable based on user interaction design and tools and techniques
		Realise a visualisation of a dataset for different types of end users		Validation of vision and strategy with key stakeholders
MANAGE & CONTROL	Record the most important decisions, results and insights related to the interaction design in an iterative process	Apply standards (interaction design guidelines, techniques and methods), fitting within the professional context	Monitor the core values and user experience of the product, organisation or service in every phase of the development and production process	From a user interaction perspective, manage a complex project at the strategic level while taking into account short and long-term goals and coordinating with all stake-holders involved
		Monitor and transfer the interaction design to the realised interactive product or service	Systematically and methodically record design choices for all stakeholders within a company	

ORGANISATIONAL PROCESSES

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
ANALYSIS	Analyse a single organisation, organisational process or process control at the operational level with associated data flows and (structured) data requirements	Analyse several operational and tactical organisational processes, including quality of the associated data and of the current and future ICT provision	Analyse the consequences of a (strategic) change in direction for organisational processes and the associated information provision	Conduct thorough, theoretically supported applied research into technological (interorganisational) process innovations
	Analyse bottlenecks and cause-and-effect relationships from the perspective of information provision	Analyse the relationship between bottlenecks and cause-effect relationships	Analyse (quantitatively and/or qualitatively) the current and future situation in the area of e.g. policy, strategy, alignment and architecture	
	Analyse available ICT options in the field	Establish ICT requirements based on the requirements of relevant stakeholders	Analyse the acceptance of and, if applicable, resistance to current and new technology and organisational processes	
ADVISE	Advise on improvements for a single organisational process in the area of organisation (structure), processes and structured data, taking into account the possibilities of ICT	Recommend coherent solutions to bottlenecks with regard to organisational structure, process structure and information provision	Advise on the organisation of and alignment between business and ICT (alignment and governance), taking into account the organisation's objectives	Advise on organisational and technological (interorganisational) process innovations, taking into account all relevant internal and external stakeholders, the societal context (people, society and organisation) and ethical and legal aspects
		Advise on new ICT options, including package selection and recommendations	Advise on a change management approach to the introduction of new, sustainable ICT options and organisational processes	
			Advise on solutions for structured and unstructured data, taking into account ethical and legal aspects	

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
DESIGN	Design a few organisational processes, a few data flows of structured data, the design of an organisational component and/or part of the information provision	Design coherent organisational processes: functional organisational structure, process management and information provision, taking into account security and privacy legislation	Design the architecture of organisational processes and/or control models, including associated proficiency by means of data solutions, information provision and change process	Evaluate and validate potential process innovations, based on data and other factors
	Draw up a simple data management plan	Design the interfaces for an application in the application landscape (mapping)	Design a change management approach with associated interventions	
	Draw up a simple implementation plan			
REALISE	Describe and draw up working instructions, job and role descriptions and procedures for a (modified) process	Implement the introduction and acceptance of procedures in conjunction with new or changed information provision and control	Implement the introduction and acceptance of changed organisational processes based on an implementation plan	Build and validate (prototypes of) new organisational processes and technological solutions for (inter-organisational) process innovations
	Test the alignment of organisational processes with the delivered information provision	Generate and validate a proof of concept of an application	Realise support for change among all relevant (internal) stakeholders	Realise broad support for change among all relevant internal and external stakeholders
		Set up a standard application		
MANAGE & CONTROL	Carry out maintenance on process documentation (e.g. business rules, principles and process models)	Set up, maintain and update (functional) management processes	Formulate and update principles, business rules and models of process architecture	Devise new organisational and technological solutions for the management of (interorganisational) process innovations
	Measure and monitor ICT processes using data	Measure and monitor organisational processes using data	Measure and monitor the organisation's strategic goals using data	
	Describe the need for change for a single sub-process	Identify the need for change of several operational and tactical organisational processes	Proactively identify the need for change in all organisational processes and initiate associated change processes	

INFRASTRUCTURE

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
ANALYSIS	Analyse a simple infrastructure according to a standard method and based on given quality requirements, e.g. security	Analyse the quality of an existing infrastructure and the services on it using common methods and standards	Analyse trends and best practices and translate these into desired or necessary developments in the enterprise infrastructure	Conduct thorough, theoretically supported and applied research on reference architectures, best practices and standards for cloud-agnostic enterprise infrastructures or high-performance computing in order to determine the maturity level at different organisations
		Analyse infrastructure-related incidents, problems and security threats	Perform a requirements impact or gap analysis for an enterprise infrastructure to establish quality requirements	
			Analyse technical options and privacy concerns of data management and processing systems	
ADVISE	Make recommendations on a setup of, or modifications to, a simple infrastructure	Advise on organisation and management of a (cloud-based) infrastructure with substantiated choices based on quality requirements, available technology and management methods	Advise on business justification and business-IT alignment of enterprise infrastructures, including management, security and privacy aspects, in relation to information and reference architectures	Advise on the architecture of an enterprise infrastructure or high-performance computing, including management, security and privacy aspects, in relation to information and reference architectures, innovation, societal and international developments
		Propose measures to improve the information security of an infrastructure	Advise on setting up the infrastructure for processing large amounts of data	
		Advise on the possible migration to or choice for e.g. a private, hybrid or public cloud	Advise on a cloud management platform for DevOps	

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
DESIGN	Draw up specifications for a simple, e.g. cloud-based, infrastructure according to a standard method	Design an infrastructure by specifying techniques based on given requirements related to quality requirements such as availability, performance, scalability, security, privacy and sustainability	Design a cloud-agnostic enterprise infrastructure by specifying cloud techniques based on self-defined requirements within the frame-works of enterprise architecture, reference architectures and/or standards	Design cloud-agnostic enterprise infrastructures, including the processes, to achieve a higher maturity level
			Design a security operations centre (SOC) to prevent and resolve security incidents and issues	
REALISE	Set up, test and make available a simple infrastructure (or a proof of concept thereof)	Set up and test a cloud-based infrastructure (or a proof of concept thereof) using (cloud) techniques that meet the design and its requirements	Realise a cloud-agnostic infrastructure (or a proof of concept thereof) by specifying cloud techniques within the frameworks of enterprise architecture, reference architectures and/or standards	Apply maturity models in creating cloud-agnostic enterprise infrastructures
		Draw up and carry out a test plan for an infrastructure to test quality based on risks	Realise a cloud management platform for DevOps	
MANAGE & CONTROL	Set up and document standard management processes and working procedures for managing a simple, e.g. cloud-based, infrastructure	Implement management of technological developments related to the (cloud-based) infrastructure	Implement management processes for a cloud-agnostic enterprise infrastructure	Shape Business-IT alignment and IT governance in relation to a cloud-agnostic enterprise infrastructure
		Implement parts of management processes	Embed an updated infrastructure in the organisation	

SOFTWARE

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
ANALYSIS	Collect and validate functional requirements for a software system with one stakeholder according to a standard methodology and draw up acceptance criteria	Perform a requirements analysis for a software system with various stakeholders, taking into account sustainability aspects and other quality characteristics including security	Perform a requirements analysis for a software system with various stakeholders in a context of existing systems	Perform analysis on complex software-in-software systems to identify all non-functional requirements, including safety, security and privacy and their compliance with laws and regulations in order to arrive at best practices and updated ICT standards
	Perform an analysis of the functionality of an existing software system or component to determine the possibilities and impossibilities for adjustment	Perform an analysis to formulate and validate the functionality, security, design, interfaces, etc., of an existing software system or existing component	Define acceptance criteria based on quality characteristics and a performed risk analysis including sustainability, security and privacy aspects and accessibility	
	Analyse whether a given data set provides information for a given application	Assess the quality of a data set including descriptive statistics and visualisations		
ADVISE	Make recommendations on specific requirements of a software system based on research into existing, similar systems	Advise on purchase and selection of software components during the development of a software system based on functionality and cost	Advise on the selection of a data architecture for a data solution, made up of existing and new data sources, with cost aspects and quality requirements such as availability, performance, security and scalability playing a role	Define a vision regarding future technology in alignment with stakeholders and in compliance with laws and regulations on security and privacy aspects
		Advise on a component of an architecture or a limited software system	Advise on the application of new technologies (such as machine learning and artificial intelligence) as well as their impact on aspects such as sustainability, security and privacy	
			Advise on setting up a software development process, including the testing and release process	

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
DESIGN	Realise a design for a software system, including a database, with modelling techniques according to a standard method	Draw up a design for a software system, taking into account the use of existing components and libraries	Draw up a software architecture for a software system, made up of existing and new systems, taking into account multiple stakeholders and quality requirements	Draw up a reusable software architecture for (cross-platform) software systems made up of existing and new (cloud-based) systems, taking into account multiple stake-holders, quality characteristics and compliance with laws and regulations
	Draw up test scripts for end user/acceptance tests	Apply design quality criteria taking into account sustainability and other aspects such as privacy, large amounts of data and use on various devices	Draw up a test strategy for system and compliance testing	Design a software system or framework for solving a generic class of problems
		Establish the quality of the design, e.g. by testing or prototyping, taking into account the formulated quality characteristics	Design the data architecture and model architecture including a test strategy for the data and machine learning models	
		Prepare test designs according to a given test strategy		

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
REALISE	In a structured manner, build, test and make available a simple software system that works with structured data and meets basic quality requirements	Build a software system consisting of several subsystems, using existing or generated components and be able to reason the choice made	Build, test and make available a scalable software system that ties in with existing systems, optionally in the cloud, according to a designed or generated architecture with substantiated use of frame-works	Build and make available a (self-learning) software system based on a model, algorithm or data with scientifically proven correct operation and providing answers to ethical questions
	Draw up and carry out (automated) unit tests	Integrate software components into an existing software system, monitoring aspects including integrity, security and system performance	Draw up and perform regression, integration and system tests and evaluate, process and follow up on the results	Draw up and carry out (reusable) compliance tests
		Draw up and carry out (automated) unit and UI tests	Refactor an existing application using design patterns	
MANAGE & CONTROL	Set up and use a management system to support software development in teams	Manage and use a development environment to support software development in teams, including e.g. continuous integration (CI) as an option	Carry out configuration, change and release management in coordination with infrastructure management, making CI/CD a possibility	Develop or further develop methods and techniques for the software development process with the aim of improving the effectiveness and quality of the software system as well as reducing the costs and lead time of the software development process
		Apply methods and techniques to manage a software development process and ensure its quality	Set up and evaluate a development environment with CI/CD support	

HARDWARE INTERFACING

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
ANALYSIS	Collect quality requirements and acceptance criteria for a system, e.g. an embedded or other technical system or subsystem based on a domain analysis	Perform a requirements analysis for a system or subsystem, including hardware and software, taking into account domain aspects and relevant quality characteristics including security, safety and sustainability	Perform a requirements analysis in coordination with stakeholders for a distributed system taking into account quality requirements including timing, resource use, performance, security and security networks, safety and other relevant non-functional requirements. (e.g. with machine learning components)	Conduct research on emerging technologies, e.g. machine learning, for application in distributed systems
	Describe the (physical) architecture of a system, e.g. an embedded or other technical system or sub-system	Perform a protocol analysis	Draw up an acceptance test plan and an integration test plan based on the quality requirements	Conduct research on security, safety, privacy and sustainability aspects within emerging technologies
	Describe the applicability of actuators and sensors	Draw up an acceptance test for a system using the quality requirements		
ADVISE	Provide a substantiated technical recommendation for a simple system (or part thereof)	Provide a technical recommendation for the architecture of a system (or part thereof) including the hardware and software components, based on the requirements analysis	Provide a technical recommendation on a distributed system to be realised, including hardware and software components and interfaces based on the requirements analysis and in relation to reference architectures, innovation and international developments and standards	Provide a technical recommendation on the application of emerging technologies to realise a distributed system
	Make recommendations for the initial structure and functionality of a given system or subsystem, in terms of both hardware and software	Advise on linking hardware systems and software components	Advise on setting up a development and testing process	Advise on future-oriented setup of distributed systems
				Define vision for technology roadmap and align this with key stakeholders

ACTIVITIES	PROFICIENCY			
	LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
DESIGN	Design a system (or part thereof), e.g. an embedded or other technical system, based on given hardware	Methodically design a system (or part thereof) based on requirements with self-selected hardware and software components	Design a distributed system including determination of relevant hardware and software components based on the quality requirements including non-functional requirements such as timing, resource use, maintainability, safety and security	Design distributed systems using hardware synthesis and/or artificial intelligence
	Design a simple protocol	Integrate a hardware interface in an application (e.g. an application driver)	Design a protocol for reliable production and transmission of large amounts of data	Design a distributed system using machine learning components including determination of actuators, sensors, circularity, carbon footprint, timing, resource use and performance.
REALISE	Write software for a designed system (or part thereof) equipped with actuators and sensors	Realise a designed system (or part thereof) and use software to realise the interfaces with hardware components	Realise a distributed system or part thereof based on a given design, including the relevant quality requirements	Realise a complete system using hardware synthesis (VHDL) or artificial intelligence
	Test a realised system (or part thereof)	Write and test designed systems (or parts thereof) and hardware interfaces (e.g. application driver software)	Draw up and implement an acceptance procedure for a realised system	Realise a complete system with machine learning elements including network, hardware and system software
MANAGE & CONTROL	Install and use a development and testing platform for the purpose of hardware/software, including tools	Assess a given development environment based on quality requirements	Set up and use version control, release management, teamwork support and automated testing for hardware and software systems	Lead co-design teams for the management of the hardware, software and synthesis creation process, including the development environment
		Monitor, report on and assess a given test development environment		

2.5 PROFESSIONAL SKILLS

Professional skills are inextricably linked to the professional tasks performed by an ICT professional. Professional performance of tasks is task and context-specific: it requires professional behaviour with respect to stakeholders and the delivery of appropriate, relevant professional products that are consistent with the demands of the organisation, with careful consideration in relation to societal issues.

The professional skills have been formulated within four focus areas, each with its own focus: Future-oriented Organisation, Investigative Problem Solving, Personal Leadership and Targeted Interaction. Each focus area is subdivided into three competencies. The descriptions are based on the Dublin descriptors (Appendix 4) and the HBO standard (Higher Professional Education Council (HBO-raad), 2009). Each higher proficiency level implies proficiency in the skills at the lower proficiency levels. This makes it possible for the skills to be developed over the course of the programme. For example, at Proficiency Level 1, a lot instruction is required, while at Level 3, students can figure out for themselves how the assignment relates to factors of interest.

FUTURE-ORIENTED ORGANISATION

Within future-oriented organisation, the environment in which ICT work takes place is key. The focus here is on the working method in relation to the assignment and the context factors that influence the work and/or the products to be developed or further developed.

INVESTIGATIVE ABILITY

Within investigative ability, questions related to the assignment are key. The emphasis in this theme is on critical thinking and working methodically with substantiated choices.

PERSONAL LEADERSHIP

Personal leadership focuses on the development of the individual in relation to the context in which he/she operates. This includes attention to proactive action based on information obtained in order to shape further personal and professional development.

TARGETED INTERACTION

Communication and collaboration play a key role in targeted interaction. Both the form and content of communication and collaboration aspects are important in this.

RELATIONSHIP TO OTHER FRAMEWORKS

e-CF: Dimension 3: proficiency level (NEN-EN 16234-1:2016, e.g. Annex B)
Dimension 3 of the e-CF characterises levels based on autonomy, context complexity and behavioural competencies.

QF-EHEA
Characterises the level in terms of professional skills for ‘assessment,’ ‘learning skills’ and ‘communication.’

SFIA: level of responsibility
SFIA characterises the levels based on autonomy, complexity, professional skills (business skills) and influence.

FOCUS AREA	COMPETENCY	DESCRIPTION
FUTURE-ORIENTED ORGANISATION	**Organisational context**	You identify various environmental factors (e.g. societal developments such as sustainability and/or inclusion issues) that may affect the elaboration of the assignment and take further steps on the basis of this
	Ethics	You weigh social and ethical aspects (such as sustainability and inclusion) in the (applied) technological and professional context and include these in professional actions
	Process management	You organise and realise the assignment (e.g. a project assignment) based on defined requirements and ensure sustainable embedding of the delivery in the organisation
INVESTIGATIVE ABILITY	**Methodical problem approach**	You identify relevant issues and/or options, identify what knowledge is lacking and plan follow-up research steps in a structured and critical manner, choosing methods appropriate for the issue at hand
	Research	You conduct research with an open attitude in a substantiated, pragmatic, structured and critical manner
	Solution	You apply the information obtained from research within the context of the issue and make proposals based on the information obtained. In doing so, you remain critical and open to alternative ideas and working methods
PERSONAL LEADERSHIP	**Entrepreneurial mindset**	You work in a targeted manner and act deliberately on new opportunities/initiatives, involving collaborative partners (e.g. team members, stakeholders, civil society organisations)
	Personal development	You substantiate your degree programme and career choices and make well-founded adjustments to your own learning development (e.g. through reflection and/or feedback)
	Personal profiling	You regularly evaluate personal ambitions and qualities in relation to the desired positioning in the professional field and take appropriate action on this
TARGETED INTERACTION	**Partners**	You actively maintain relationships with relevant collaborative partners (e.g. team members, clients, end users, civil society organisations and/or other stakeholders)
	Communication	You deliberately and purposefully tailor your communications to the target group or groups
	Collaboration	You collaborate in a conscious and constructive manner and in the appropriate form, taking responsibility for your part in the collaboration (e.g. in interdisciplinary and/or intercultural contexts) and the end result

2.6 RELATIONSHIP BETWEEN ACTIVITIES AND PROFESSIONAL SKILLS

There is a relationship between the professional tasks performed by an ICT professional and the professional skills. The value of an ICT application is thus dependent on its contribution to the organisation or organisational unit for which it is intended.

Appendix 3 outlines how professional ICT tasks and professional skills can interact. It illustrates which competencies from the professional skills may be applicable for each activity.

3. APPLICATION

The HBO-i domain description describes the entire domain of HBO-i programmes. It thus forms a framework within which each programme, each programme profile and each specialisation can position itself. Because the model provides a broad framework, the model can also be applied to link education and professional practice.

3.1 CURRICULUM DEVELOPMENT AND JUSTIFICATION

With the introduction of the Bologna Accord (2005) and subsequent additions, European higher education has four consecutive degrees: Associate degree (Ad), Bachelor (B), Master (M) and Doctor of Philosophy (PhD). The Dublin descriptors (Appendix 4) describe the level of those degrees as accepted in Europe. Nationally, this is safeguarded through the Netherlands Qualifications Framework (NLQF). The national level of the Bachelor's degree is described in the HBO standard.

Programme profiles derived from the domain description include the Dublin descriptors and the HBO standard. Therefore, when students satisfy the programme profile, they also satisfy both the Dutch and internationally accepted level of the degree concerned. The overview on the next page shows the interrelationship between these and other relevant frameworks.

PROFICIENCY LEVELS OF VARIOUS FRAMEWORKS

NLQF Qualifacation	**BASIC EDUCATION 1**	**MBO 1 BE 2 ...**	**MBO 2 BE 3 ...**	**MBO 3**	**MBO 4 HAVO**	**VWO**	**ASSOCIATE DEGREE**	**BACHELOR**	**MASTER**	**PHD**
NLQF Level	**Entry**	**1**	**2**	**3**	**4**	**4+**	**5**	**6**	**7**	**8**
QF EHEA Cycle				**2**			short	1	2	3
EQF Level		1	2	3	4		5	6	7	8
e-CF Dimension 3: proficiency level				e1			e2	e3	e4	e5
SFIA Level of responsibility				1			2	3	4	7
HBO-i Proficiency level				1			2	3	4	

NLQF Netherlands Qualification Framework
QF EHEA Framework of Qualifications for the European Highert Education Area
EQF European Qualifications Framework
e-CF European e-Competence Framework, NEN-EN 16234-1: 2026
SFIA Skills Framework for the Information Age
HBO-i Domain description

3.2 PROGRAMME LEVELS

A key question concerning a programme profile is whether it fits the level of the corresponding degree, e.g. a Bachelor's degree. Each programme profile consists of a programme-specific combination of professional tasks combined with professional skills, in a way that reflects the Dublin descriptors and HBO standards. The combination of professional tasks should have sufficient breadth and depth. Some programmes are relatively narrow in terms of variety of professional tasks, but have many professional tasks at the highest level. Other programmes are relatively broad in terms of variety of professional tasks, but have fewer professional tasks at the highest level. In addition, in both cases, autonomy, complexity and professional skills are at a corresponding level.

ASSOCIATE DEGREE (AD)

An associate degree programme is a job-specific, task-oriented programme at the operational-tactical level. A corresponding programme profile in the HBO-i model therefore usually has a field-specific focus on an architectural layer at Level 2. The professional skills are delved into more deeply at the tactical level of action. Compared to the first two years of a Bachelor's programme, there is a more specialised, field-specific orientation and a specific task-based orientation of the associated professional skills.

BACHELOR (B)

A Bachelor's programme trains for positions at the tactical-strategic level. A corresponding programme profile is often focused on one or more architectural layers at Level 3. The breadth or depth of a profile determines the exit level in other architectural layers. The professional skills prepare students, often from the very beginning of a programme, to eventually function at the tactical-strategic level in a multidisciplinary context.

PROFESSIONAL MASTER (M)

A Professional Master's programme prepares students for complex professional practice, multidisciplinary work, coordination and control for the purpose of innovation of the ICT profession and functioning at the strategic level. The corresponding programme profile delves deeper to Level 4. In addition, this may also explicitly involve delving deeper to – and connecting with – an area of application. In the professional skills, we see emphases in the area of coordination, innovation and specialisation.

3.3 EDUCATIONAL PLANNING AND IMPLEMENTATION

In educational implementation, the model can play a role in the programmes offered and student choice. The programmes offered can range from a standard programme with set learning outcomes to fully demand-driven education. The domain description model can play a role in both cases. The model can be used to position a standard programme within the entire domain. In the case of more demand-driven programmes, the model can indicate the elective component and identify the relationship between the components. In assessment, the model is particularly useful in the case of individual study paths and competencies acquired elsewhere (accreditation of prior learning, APL) are involved. This can be done by relating criteria to the model with reference to professional tasks and associated performance indicators.

3.4 CONNECTION TO THE PROFESSIONAL FIELD

The professional field has provided input on the establishment of the professional tasks and professional skills by means of a critical review. The model supports a two-way connection to the professional field. On the one hand, this takes place from the professional field to the programme, as the model represents professional profiles for programmes and students. This makes it clear to both a programme and an individual student what goal they are working towards. On the other hand, from the programme to the professional field, the profile of alumni can be depicted in job vacancies to highlight the suitability of candidates.

The relationships established in this domain description with other (international) frameworks support the possibility of connecting education and the professional field, i.e. the supply and demand sides. A concrete example of this is the connection between the HBO-i model and the e-CF through the ‘ICT Professional Profiles’ described in the e-CF.

3.5 PURPOSE AND SCOPE

The domain description provides ICT programmes with a framework and a de facto standard with which they can describe their content, tasks and competencies, position their programmes in the domain, and set up, organise and validate their education. The model offers the possibility of setting up the programme broadly or specifically, with a solid foundation and room to offer specialisations and respond to current developments while maintaining position and profile. As a result, students and employers know what to expect from a recent Associate, Bachelor’s or Master’s graduate of a particular programme. It is up to the programmes themselves to describe specific knowledge, skills and behaviour within a context based on the framework in order to arrive at competencies and their own BOKS (Body of Knowledge and Skills). Programmes have the space to position themselves within the model, and students can develop into fully competent professionals.

4. CONTEXT

The domain description does not stand on its own. It fits into a context of national and international frameworks and Bodies of Knowledge and Skills. These formed the context in the development of the domain description. They also form the context for educational development, student and/or professional. Some are well-known and frequently used. Others are useful for specific sub-areas. Still others determine the level of education, sometimes legally.

4.1 FRAMEWORKS

In the ICT domain, the international nature of the labour market is an important aspect in training professionals, recruiting staff and planning careers. A variety of initiatives have been taken in Europe and worldwide, aimed at making descriptions of the ICT profession more transparent. These initiatives vary in aspects such as terminology, basic principles and areas of application. A number of national and international frameworks are relevant to the HBO-i domain description.

The HBO-i domain description is based on national and international frameworks for determining the level and on specific ICT frameworks.

FRAMEWORK FOR QUALIFICATIONS OF THE EUROPEAN HIGHER EDUCATION AREA (QF-EHEA)

The framework for qualifications of the European Higher Education Area (QF-EHEA) is intended to benefit the international comparability in the context of qualifications provided by higher education. It has by now been implemented in 48 countries, including the Netherlands. With the introduction of the Bologna Accord in 2005, European higher education offers three consecutive degrees: Bachelor's, Master's and PhD. The Dublin descriptors describe the internationally accepted levels of these degrees, as well as the short cycle within the Bachelor's degree. In the Netherlands, under the Higher Education (Quality in Diversity) Act, the Associate degree (Ad), which corresponds to the level of the short cycle, has existed structurally since 1 September 2013.

Structure
The whole structure consists of five descriptors, referred to as the Dublin descriptors. These are described at four qualification levels, called cycles. The first cycle – short cycle – actually only forms part of the first cycle.

Relevance to the HBO-i domain description
The first three levels define the exit level in general terms for each Associate degree, Bachelor's degree and Master's degree, respectively. They help form the normative framework for those levels for countries concerned. It thus forms the concrete, general substantive context of Levels 2 to 4 of the HBO-i domain description.

EUROPEAN QUALIFICATIONS FRAMEWORK FOR LIFELONG LEARNING (EQF-LLL)

The European Qualifications Framework for Lifelong Learning (EQF-LLL) was designed to enable comparison of qualifications and qualification levels in a European context. To this end, it describes learning outcomes in terms of knowledge, skills and competencies. The scope is broader than that of the QF-EHEA since the EQF covers not only higher education but also the underlying levels.

Structure
The EQF provides an indication of complexity and depth and distinguishes eight levels.

Relevance to the HBO-i domain description
Levels 5 to 8 define the exit level in general terms for each Associate degree, Bachelor's degree and Master's degree, respectively. Level 4 defines the underlying international level. They help form the normative framework for those levels for countries concerned. It thus forms the concrete, general substantive context of all four levels of the HBO-i domain description. This is particularly important because of its direct relationship to the level classification in the e-CF.

NETHERLANDS QUALIFICATIONS FRAMEWORK (NLQF).

The Netherlands Qualifications Framework (NLQF) is intended to unambiguously standardise the various programme levels in the Netherlands. It provides an overview of the different forms of education based on level in relation to each other. In the context of European cooperation, it functions as the National Qualification Framework (NQF) for the Netherlands. Thus, it relates educational qualifications regulated by the Dutch national government to the overarching European framework EQF. This makes it possible to compare Dutch programmes with programmes in other European countries that have also provided an NQF.

Structure
The NLQF has ten levels, to which qualifications such as 'Bachelor' are related. The numbering is completely parallel to that of the EQF.

Relevance to the HBO-i domain description
The NLQF shows the Associate degree, Bachelor's and Master's levels relevant to HBO-i in the Netherlands (Figure 3). It also positions these in relation to prior and subsequent levels, which are relevant to intake and graduation rates, respectively. The NLQF is also the linking pin to international frameworks such as the Dublin descriptors and EQF, and thus to e-CF and SFIA, for example. This makes it possible, when using an element from the HBO-i domain description, to also identify elements of the same level from other frameworks. In this way, the specific knowledge from those frameworks can be used as support when using the HBO-i domain description.

MBO PROGRAMME DOMAIN INFORMATION AND COMMUNICATION TECHNOLOGY

Senior secondary vocational education (MBO) qualification files determine the content of MBO programmes and are established substantively by the Minister of Education, Culture and Science. Accordingly, what each ICT-related MBO qualification consists of is also defined.

Structure
Within senior secondary vocational education, a distinction is made between (qualification) files, qualifications, basic components, profile components and elective components. "The qualification file describes the requirements that a student must satisfy in order to obtain their degree. Each file contains one or more qualifications, and each qualification leads to a diploma. [...] A qualification file consists of a basic component and one or more profile components. [...] Electives are an addition to the qualification and complete the programme." Qualification files and qualifications have a CREBO code (CREBO: Central Register of Vocational Courses)

Each qualification file falls within a market segment, which in turn falls under a sectoral committee. The 'ICT and Creative Industry' sectoral committee is relevant in this case. The market segments 'Arts and Entertainment' (501), 'Communication, Media and Design' (502) and 'ICT' (503) fall within that sectoral committee.

Relevance to the HBO-i domain description
A substantial proportion of the students entering an ICT programme in higher professional education have a senior secondary vocational education as their prior education. The MBO qualification files provide insight into prior knowledge for each prior programme. The MBO qualification files are being updated at around the same time as the HBO-i by the Foundation for Cooperation on Vocational Education, Training and the Labour Market (SBB).

EUROPEAN E-COMPETENCE FRAMEWORK (E-CF)

In 2001, several large ICT companies expressed concern about the shortage of ICT workers in the labour market. This prompted the creation of the CEN ICT Skills Workshop in 2003. A further inventory of ICT profiles within Europe took place in 2006, showing how profile descriptions differ in terms of basic principles, model and purpose, for example SFIA (United Kingdom), AITTS (Germany) and CIGREF (France). This prompted the development of the European e-Competence Framework (e-CF), which was first published in September 2008. The third version was published in 2013. The framework was adopted as a Dutch standard (NEN-EN 16234-1) in 2016.

Developed for the business community and human resource management, the e-CF uses proficiency levels for the entire breadth of job profiles in the ICT field, thus including domains such as human resource management and sales management.

Structure
The e-CF consists of four dimensions:
- Dimension 1: five e-competence areas, derived from the ICT business processes plan, build, run, enable and manage
- Dimension 2: a collection of 32 e-competencies
- Dimension 3: five proficiency levels, related to the six highest EQF levels
- Dimension 4: examples of knowledge and skills related to the e-competencies.

The e-CF identifies five levels of proficiency in the workplace and integrates three facets into that proficiency in the competency definition:

- Autonomy: ranges between 'responding to instructions' and 'making personal choices'
- Behaviour: represents an observable outcome of attitude and ranges between 'the ability to apply' and 'the ability to conceive'
- Context: ranges between 'structured - predictable' situations and 'unpredictable - unstructured' situations.

Relevance to the HBO-i domain description
The four proficiency levels of the domain description correspond to proficiency levels e-1 to e-4 of Dimension 3 of the e-CF. This enables appropriate enrichment and/or broadening to take place at all levels of the domain description if desired, using the e-CF.

SKILLS FRAMEWORK FOR THE INFORMATION AGE (SFIA)

The Skills Framework for the Information Age (SFIA) describes the skills required of professionals with respect to levels of responsibility in ICT. The framework has been adopted by organisations and individuals in nearly two hundred countries and has been available in Version 6 (SFIA6) since 2015.

Structure
SFIA6 has the following main structure:

- Skills: Strategy and Architecture, Change and Transformation, Development and Implementation, Delivery and Operation, Skills and Quality, Relationship and Engagement
- Levels of responsibility: 1 Follow, 2 Assist, 3 Apply, 4 Enable, 5 Ensure, advise, 6 Initiate, influence, 7 Set strategy, inspire, mobilise
- Attributes: autonomy, influence, complexity, business skills.

Relevance to the HBO-i domain description
As far as professional tasks are concerned, SFIA can be used for inspiration for those components that the domain description does not address substantively. For proficiency levels and professional skills, SFIA provides enrichment with regard to how they can be interpreted or carried out.

Proficiency Levels 1 to 3 correspond to SFIA Levels of Responsibility 1 to 3 . For Proficiency Level 4 of the domain description, this is somewhat less straightforward. The SFIA Levels of Responsibility 4 to 7 do not necessarily coincide with certain levels of proficiency of the e-CF.

EDISON DATA SCIENCE FRAMEWORK

The Data Science Competence Framework (CF-DS) is a cornerstone component of the EDISON Data Science Framework (EDSF, also referred to as Edison). The CF-DS provides a basis for the Data Science Body of Knowledge (DS-BoK) and Model Curriculum (MC-DC) definitions, and also for the definition and certification of Data Science Professional Profiles. The CF-DS incorporates many of the underlying principles of the e-CF 3.0 that have been used to define data science competencies. In turn, this made it possible to offer expansions of the new e-CF4.0 version (published as CEN EN 16234-1, 2019) with the Data Science competencies. The CF-DS and DSPP have also adopted the classification structure of the European Skills, Competences, Occupations (ESCO) Framework. Corresponding information is provided in the corresponding documents CF-DS and DSPP.

Relevance to the HBO-i domain description
Data plays an increasing role in society. In the ICT domain, there is an increasing emphasis on collecting and processing large amounts of data, and using advanced techniques to make analyses or predictions. The 2018 domain description did not provide sufficient guidance for education in the field of data science and especially applied data science. The Applied Data Science addendum, added to the 2018 domain description in late 2019, uses the EDSF published by the European Union in 2017. It is a very extensive system of documents that are not directly useful in education, but do provide substantive guidance.

This addendum has been updated according to the latest version of the EDSF and included in this domain description in its entirety.

NIST

NIST is the National Institute of Standards and Technology of the United States Department of Commerce. The NIST Cyber Security Framework helps companies of all sizes better understand, manage and reduce their cybersecurity risks and protect their networks and data.

Relevance to the HBO-i domain description
The NIST Cyber Security Framework provides a framework to describe professional tasks that are part of the practice of all ICT professionals, not just for cybersecurity specialists.

4.2 BODIES OF KNOWLEDGE AND SKILLS (BOKS)

The content of the HBO-i domain description covers the essential parts of the ICT field for Dutch HBO programmes in the ICT domain.
In the field-specific detailing, an appropriate level of abstraction was chosen by means of a set of representative professional tasks. Nevertheless, the domain description is based on a broad background of professional knowledge from the programmes involved and sources used. For effective use of the domain description this background information is required in practice, to achieve field-specific broadening and deepening on the one hand, and to clarify concepts and their content on the other. The current bodies of knowledge and skills can provide this. They are generally open standards, established in a broad committee and by means of a controlled process. For the interpretation and detailing of parts of the domain description, they can provide the necessary additional background with broad support.

The overview of bodies of knowledge and skills is not exhaustive. The sources mentioned are considered starting points through which programmes can find their way.

ISO/NEN/IEC/IEEE STANDARDS

Various organisations set standards in the ICT field, according to standardised open processes. Such standards usually provide the rationale for certain parts of the field. For example, they define concepts and processes. Two of the best known standards are the SWEBOK and the software life cycle process.
The various sources are listed in Appendix 6.

APPENDICES

APPENDIX 1.

OVERVIEW OF HIGHER PROFESSIONAL EDUCATION PROGRAMMES IN ICT

As of mid-2023, the public ICT programme domain includes the following programmes in the Central Register of Higher Education Study Programmes (CROHO):

ASSOCIATE DEGREE

Ad IT Service Management (80024)

Ad Informatica (Information Technology) (80075)

Ad ICT Service Management (80083)

Ad Software Development (80130)

Ad ICT-Beheer (ICT Service Management) (80071)

Ad ICT (80152)

Ad Cybersecurity (80156)

Ad ICT Internet of Things (80155)

BACHELOR

B HBO-ICT (30020, 81033)

B Technische Informatica (Computer Science) (34475)

B Informatica (Information Technology) (34479)

B Business IT & Management (39118)

B Applied Data Science & Artificial Intelligence (39309)

PROFESSIONAL MASTER

M Applied Artificial Intelligence (49157)

M Master of Applied IT (45293)

M Master Software Engineering (45294)

APPENDIX 2.

ORGANISATIONS CONSULTED

A
ACA IT-Solutions
Achmea
Acknowledge
Acolad Digital
Actemium
Allardata
Alten
ASML
Atos
Axians

B
Betty Blocks
Bosch Rexroth
Brand Encounters
Brunel
Byont

C
Capgemini
CGI
Chimpworks Games
Chipsoft
Cimsolutions
City of Amsterdam
CM.com
Coffee IT
Connect FRL
Cre8ion Lab
Croonwolters
Ctouch
Cytosmart

D
D-centralize
DAF Trucks
Data place datacenters
Deloitte
Dual Inventive

E
Ecodorp Boekel
Elkerliek
Embedded Fitness
Endava
Enversed
Eurofiber
EvenTix
Eviden
EY

F
Freshheads
Furgo
Future Bytes

G
Galaxy Grove
Game Solutions Lab
Games for Health

H
Happy Horizon
Hyster-Yale

I
IAS B.V.
ICT Group
Indicia
Infosupport
Informa
InMotion VR
Innobeweeglab
Intrige.communicatie
iO
IT-topdogs
It's language

J
Jugo

L
Luca Allodi

M
Manus
MKB Cybercampus
Mobeye
Municipality of Eindhoven

N
Networkpeople
Neways
Northwave

O
OpenRemote
Ordina

P
Partout
Peercode
Philips
Plainwater

R
Rabobank
Remoticom

S
Sigmasolutions
Simac
Sioux
Sogeti
StudyPortals
Sue
Swis

T
Thales
TaxModel
TweeKracht

V
Valtech
Vanderlande

W
Wanted5
Whitehats

Z
ZiuZ

APPENDIX 3.

CONNECTION BETWEEN ICT COMPETENCIES AND PROFESSIONAL SKILLS

ACTIVITY	PROFESSIONAL SKILLS COMPETENCIES	EXPLANATION
ANALYSE The 'analyse' activity involves the analysis of processes, products and information flows in their interrelationship and context.	**Methodical problem approach** **Research** **Organisational context** **Partners**	Methodical problem solving and research fit with analysis, as analysis requires defining the problem, arriving at a formulation of the problem and choosing appropriate methods in your problem solving. Understanding of the organisational context is needed in order to make the formulation of the problem relevant and to delineate it. This helps in selecting the most appropriate method of analysis. Coordination with relevant collaborative partners is necessary to perform the analysis and make matters transparent.
ADVISE The 'advise' activity involves advising on the organisation of processes and/or information for an ICT system to be newly developed, purchased or modified.	**Solution** **Ethics** **Organisational context** **Communication**	To arrive at a recommendation, it is necessary to turn results from an analysis into conclusions, from which the recommendations follow logically. Therefore, the professional skill 'solution' fits well with advising; after all, it involves interpreting information within the context of the issue in order to present proposals that tie in with the problem and fit the organisation. For this reason, the organisational context is important within the advise competency. Since a recommendation may potentially have social and ethical implications (such as sustainability and inclusion), the ethics competency is appropriate here. The impact of the implications should be communicated properly, tailored to the stakeholders. Therefore, communication is an important competency in advising.
DESIGN The 'design' activity involves designing an ICT system (or part thereof) based on specifications	**Communication** **Entrepreneurial mindset** **Process management**	During the design phase, coordination with stakeholders is important in order optimise the design. Communication is therefore an important competency in the entire process. Since design often takes place in coordination with various stake-holders, it is important to have an entrepreneurial mindset: working purposefully and taking initiative in terms of (product) components or an approach to arrive at a design, in which collaborative partners remain involved. Since the implications of a chosen direction often become clear during the design phase, setting priorities (e.g. through a minimal viable product, or MVP) is important. And understanding the organisational implications requires good process management so that the design is achievable and satisfies the preconditions, and there are prospects regarding the embedding of the final product (resulting from the design) in the organisation.

ACTIVITY	PROFESSIONAL SKILLS COMPETENCIES	EXPLANATION
REALISE The 'realise' activity involves creating an ICT system (or part thereof) based on a design.	**Process management** **Entrepreneurial mindset** **Collaboration**	Process management is very important in creation. After all, the organisation of work within preconditions with consideration for sustainable use within the organisation remains key. This can involve various tasks during building, such as delivering a prototype, validating a final product and/or taking care of the transfer. During the creation phase, ICT professionals often work on products with several people. This makes cooperation important. Indeed, the effectiveness of cooperation benefits product quality and the completion of the creation phase. At the same time, taking the initiative constructively (e.g. based on solving problems that emerge during the creation phase) remains important, tying in with an entrepreneurial mindset.
MANAGE & CONTROL The 'manage & control' activity involves managing, monitoring and optimising the development, deployment and use of ICT systems.	**Process management** **Organisational context**	Within Manage & Control, it is important that the implementation of products proceeds properly and to ensure proper care and quality assurance after implementation. This corresponds to process management, where the sustainable embedding of materials within the organisation is important, in line with preconditions. Of course, attention to the organisational context remains important; after all, environmental factors can change and alter requirements, as a result of which new or already developed products need to be optimised.

APPENDIX 4.

DUBLIN DESCRIPTORS

DUBLIN DESCRIPTOR	CYCLES		
	SHORT	**1**	**2**
KNOWLEDGE AND UNDERSTANDING	Has demonstrable knowledge and understanding of a field of expertise, building on general secondary education; typically functions at the advanced textbook level; has a knowledge base for a professional field or profession, for personal development and for further study to complete the first cycle (Bachelor's).	Has demonstrable knowledge and understanding of a field of expertise, building on and exceeding the level achieved in secondary education; typically functions at a level at which, with the support of specialist textbooks, there are some aspects that require knowledge of the latest developments in the field.	Has demonstrable knowledge and understanding, based on the knowledge and understanding at the Bachelor's level and which exceed and/or deepen it, as well as providing a basis or opportunity to make an original contribution to the development and/or application of ideas, often in a research setting.
APPLICATION OF KNOWLEDGE AND UNDERSTANDING	Is able to apply knowledge and understanding in professional contexts.	Is able to apply his/her knowledge and understanding in such a way that it shows a professional approach to his/her work or profession, and also has competencies for drawing up and deepening arguments, and for solving problems in the field of expertise.	Is able to apply knowledge, understanding and problem-solving skills in new or unknown circumstances within a broader (or multidisciplinary) context related to the field of expertise; is able to integrate knowledge and deal with complex subject matter.
ASSESSMENT	Has the ability to identify and use data to determine a response to clearly defined, concrete and abstract problems.	Is able to collect and interpret relevant data (usually in the field of expertise) with the aim of forming an opinion that is partly based on weighing relevant social, scientific or ethical aspects.	Is able to formulate judgements based on incomplete or limited information, taking into account the social and ethical responsibilities associated with the application of one's knowledge and judgements.
LEARNING SKILLS	Has the learning skills to enter into a follow-up programme that requires a certain degree of autonomy.	Has the necessary learning skills to enter into a follow-up study programme that assumes a high level of autonomy.	Has the learning skills that enable him/her to enter into a follow-up study programme of a largely self-directed or autonomous nature.
COMMUNICATION	Can communicate with peers, supervisors and clients about understanding, skills and work activities.	Is able to convey information, ideas and solutions to an audience consisting of specialists or non-specialists.	Is able to clearly and unambiguously convey conclusions, as well as the knowledge, motives and considerations underlying them, to an audience of specialists or non-specialists.

APPENDIX 5.

AFFILIATED INSTITUTIONS

The HBO-i Foundation is the umbrella organisation of ICT programmes at the higher professional education level in the Netherlands. The institutions affiliated with the HBO-i are listed below.

- Avans University of Applied Sciences
- Ede Christian University of Applied Sciences
- Fontys University of Applied Science
- The Hague University of Applied Sciences
- Hanze University of Applied Sciences Groningen
- Inholland University of Applied Sciences
- University of Applied Sciences Leiden
- Rotterdam University of Applied Sciences
- HU University of Applied Sciences Utrecht
- HZ University of Applied Sciences
- Amsterdam University of Applied Sciences
- HAN University of Applied Sciences
- Windesheim University of Applied Sciences
- NHL Stenden University of Applied Sciences
- Saxion University of Applied Sciences
- Zuyd University of Applied Sciences


avans hogeschool
CHE CHRISTELIJKE HOGESCHOOL EDE
Fontys
DE HAAGSE HOGESCHOOL
HAN_UNIVERSITY OF APPLIED SCIENCES
Hanzehogeschool Groningen University of Applied Sciences
Hogeschool van Amsterdam
Hogeschool Leiden
HOGESCHOOL ROTTERDAM
HOGESCHOOL UTRECHT
hogeschool Windesheim
UNIVERSITY OF APPLIED SCIENCES
inholland hogeschool
NHL STENDEN hogeschool
SAXION HOGESCHOOL
ZUYD

APPENDIX 6.

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- IEC en NEN, ISO and information and communication technology, IEC, ISO and information communication technology
- IEC, IEC – International Electrotechnical Commission
- IEEE, IEEE – Institute of Electrical and Electronics Engineers
- INCITS, INCITS – InterNational Committee for Information Technology Standards
- ISO, ISO – International Organization for Standardization
- ISO/IEC Software life cycle processes, ISO/IEC 12207:2017 - Systems and software engineering, Software life cycle processes
- MBO qualification file It systems and devices, level 4: Expert IT systems and devices
- MBO qualification file Software development, level 4: qualification Software developer
- National Coordination Point of the Netherlands Qualification Framework Schematic overview of generic classification of government-regulated qualifications in NLQF and EQF. http://www.nlqf.nl/images/downloads/Schema_def_05052015.jpg (accessed: 1 September 2023)
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- SWEBOK, ISO/IEC TR 19759:2015 - Software Engineering, Guide to the software engineering body of knowledge (SWEBOK)

APPENDIX 7.

ABBREVIATIONS

A

API	Application programming interface
APL	Accreditation of prior learning

B

BOKS	Body of Knowledge and Skills

C

CEN	Comité Européen de Normalisation
CF-DS	Data Science Competence Framework
CI/CD	Continuous integration and continuous delivery
Crebo	Central Register of Vocational Courses
CROHO	Central Register of Higher Education Study Programmes

E

e-CF	European e-Competence Framework
EDSF	EDISON Data Science Framework
EQF	European Qualifications Framework
EQF-LLL	European Qualifications Framework for Lifelong Learning

H

Hbo	Higher professional education

M

Mbo	Senior secondary vocational education

N

NLQF	Netherlands Qualification Framework
NQF	National Qualification Framework

Q

QF-EHEA	Framework for Qualifications of the European Higher Education Area

S

SFIA	Skills Framework for the Information Age
SOC	Security operations center
SWEBOK	Software engineering body of knowledge

V

VHDL	Very High speed integrated circuit hardware Description Language