IIOTNET PROJECT

IIoT Body of Knowledge

WP4, Deliverable 4.2

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Introduction

This document sets out the core information that underpins the IIoT certification. Its purpose is to define the academic and professional knowledge that candidates, organisations and individuals must demonstrate to receive the IIoT certified status.

Each of these blocks describes the knowledge candidates are required to demonstrate, beginning with the most general information and progressing to the most specific level. There are recommended readings for each major area.

1. Objectives

The IIoT Body of Knowledge brings together as much relevant knowledge for professional development as possible in one place. It this sense, the IIoT Body of Knowledge as a certification programme defines the knowledge-base that IIoT professionals and practitioners need to be familiar with in order to do their jobs, and to enable them to attain this knowledge in a structured way. The certification programme defines the knowledge that candidates require in order to obtain the certification at both Basic and Advanced levels.

2. Description of the blocks

IIoT Body of Knowledge is structured in 7 blocks:

Structure of IIoT Body of Knowledge

Blocks	Title
BLOCK 00	Basics for the IIoT professional
BLOCK 01	Essential System Characteristics for the IIoT
BLOCK 02	Reference Architecture for the IIoT
BLOCK 03	Connectivity in the IIoT
BLOCK 04	Business Strategy and Innovation
BLOCK 05	Security in the IIoT
BLOCK 06	IIoT analytics

The progression from general to specific is broken down into blocks, topics and chapters. For example:

BLOCK 02: Reference Architecture for the IIoT

TOPIC 4. IIoT Business, Usage, Functional and Implementation Viewpoints

CHAPTER: Integration

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The structure of the blocks follows the process of design and implementation of IIoT models in the enterprise, starting with Block 00, which covers the business basics for the IIoT professional.

2.1. BLOCK 00 Business basics for the IIoT professional

Title	Business basics for the IIoT professional
Description	Block 00 prepares candidates for the remainder of the programme by reviewing and defining fundamental aspects of business management. The goal is to equip candidates with the essential tools they will require as they progress to more senior roles within their organisation.
Aim	The aim of this block is to enable applicants to map their existing knowledge and experience to the learning objectives of the IIoTNET certification. Block 00 covers the basic knowledge, skills and techniques that are pre-requisites for developing a career as an IIoT expert.
Input	Much of the input for this block will come from candidates' prior knowledge and experience.
Output	This introductory block will enable applicants to put their existing knowledge and skills in context, and to revise basic principles in readiness for completing the other blocks.
Topics	1. Information technology 2. Economics and International Business 3. General Management 4. Communication 5. Business Ethics 6. Business Strategy and Strategic Planning 7. Effective Management Decision Making 8. Risk Management 9. Leadership 10. Change Management

Topic 1 Information technology	
Chapter	Learning outcomes
Basic IT knowledge	• Use of operating systems for file management, word processing, spreadsheets, presentation software; • Data analysis and use of internet communication tools.

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ICT infrastructure	• Insights into structure and characteristics of computer infrastructure such as servers and clients, storage and networking equipment.

Topic 2 Economics and International Business	
Chapter	Learning outcomes
Macroeconomics	• Measuring national income; • Equilibrium in the economy.
Macro dynamics	• Inflation; • Economic growth; • Business cycles.
International economy	• Open macroeconomics; • Foreign exchange rate.
Basics of managerial economics	• Prices of goods and the quantities produced and consumed; • Government policies affecting prices and quantities; • Efficient market outcomes; • Types of competition.

Topic 3 General Management	
Chapter	Learning outcomes
Management policy and process	• Business process management (BPM) • Total quality management • Continuous improvement process
Introduction to business information systems	• ICT strategy • IT architecture and the design and use of ICT systems • Enterprise resource planning (ERP) systems • Business intelligence
Principles of organisational behaviour	• Human behavior in organizational setting; • Individual and group behavior.
Principles of human resource management	• Basic knowledge of human resource management

Topic 4 Communication	
Chapter	Learning outcomes
The concept of communication	• Communication channels; • Forms and types of communication;

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	• The role of the leader in ensuring communication; • Manager's social communicative competence; • Ethics in business communication; • Communication through technologies.
Corporate communication	• Internal communication; • Ability to address the audience; • Meaningful visual communication; • Media relations, investor relations, public relations; • How to build and protect corporate reputation; • Business reports; • Intercultural communication; • Methods for dealing with conflict.
Communication in crisis	• Crisis identification; • Crisis management; • Defining rules and responsibilities; • Communication training; • Crisis simulation.
Communication and negotiation in a dynamic international environment	• Digital and social media communication as a precondition for responsible management of an innovative organization; • Understanding and mastering strategies for interpersonal encounters, including conflict resolution, in multicultural environments; • Improving your global mind-set and negotiation skills.

Topic 5 Business Ethics	
Chapter	Learning outcomes
Ethics in Business	• Ethics, principles and moral values; • Social responsibility; • Appreciation of ethical concerns both at local and global level.
Business Ethics Principles	• Creating understandable and accurate information; • Ability to avoid conflicts of interest in professional relationships; • Resolving ethical dilemmas and making ethical decisions.
Corporate Ethics	• Influential factors on business ethics; • Code of Ethics and Code of Conduct; • Ethical leadership.

Topic 6 Business strategy and strategic planning	
Chapter	Learning outcomes

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Introduction to strategic planning	• Planning and developing a strategy; • Business goals and objectives; • Financial considerations to be taken into account.
Organizational analysis	• Vision and mission; • Structure of the organization and the business activity; • Required resources.
External environment	• STEEPLE analysis; • Impact of technology; • Growths and evolution;
Implementation and evaluation of the strategy	• Implementation checklist; • Communication plan; • Team for evaluation and/or updating the strategy.

Topic 7 Effective Management Decision Making	
Chapter	Learning outcomes
Identifying problem	• Effective communication; • Assessing the scope and the nature of the problem to be resolved.
Gathering information	• Data sensing and collecting; • Sources of information.
Identifying alternatives	• Mapping alternative paths; • Weighing the evidence; • Choosing among the alternatives.
Taking action	• Analysis to action; • Team involvement; • Division of responsibility.
Reviewing and adjusting	• Identifying if the action has succeeded .

Topic 8 Risk Management	
Chapter	Learning outcomes
Identify the risks	• Types of risks; • Identifying risk.
Analyse the Risk	• Map risks to different documents, policies, procedures, and business processes; • Methods for risk analysis.
Evaluate or Rank the Risk	• Methods of risk evaluation.
Treat the Risk	• Strategies to eliminating, containing as well as treating the risk.

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Monitor and Review the Risk	• Formalizing management process; • Developing risk culture.
Risk Reduction	• Adjusting project plans, company processes and infrastructure.
Risk Sharing by different departments	• Customers; • Vendors,; • External organizations.

Topic 9. Leadership	
Chapter	Learning outcomes
Democratic Leadership	• Leader makes decisions based on the input of the team members; • Discussion about each option.
Strategic Leadership	• Intersection between a company's main operations; • Strategic thinking supports multiple types of employees at once.
Transformational Leadership	• Basic set of tasks and goals for a period of time; • Deadlines for reaching them
Coach-Style Leadership	• Nurturing individual strengths of each member in the team; • Similarities to strategic and democratic leadership.

Tropic 10. Change management	
Psychology of change	• Principles for managing change; • Managing the people's side of change.
Change management processes	• Managing organisational change; • Change management strategy; • Change management team.
Managing change	• Overcoming resistance; • Change management plan.

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2.2. BLOCK 01: Essential System Characteristics for the IIoT

Title	Essential System Characteristics for the IIoT
Description	Block 01 presents key system characteristics for the Industrial Internet of Things (IIoT). The goal is to understand what are the main concerns for the IIoT. The block also looks at integration and compatibility issues
Aim	The aim of this block is to familiarize the applicants with system characteristics and interoperability issues within the IIoT.
Input	Much of the input for this block comes from candidates' prior knowledge on characteristics of the IIoT systems and experience of their developing and deployment.
Output	This block will enable applicants to extend their existing knowledge and skills in the essential system characteristics of the IIoT and be able to address important IIoT key system concerns during the deployment of an industrial system.
Topics	1. Purpose and scope 2. Safety 3. Resilience 4. Integrability, Interoperability and composability 5. Data Management 6. Dynamic Composition and Automated Interoperability

Topic 1 Purpose and scope			
Chapter	Learning outcomes	Basic	Advanced
Purpose	• Key system concerns in industrial internet systems • Additional analysis to assist system architects	X	X
Scope	• Key concerns • System concerns • Functional domains	X	X

Topic 2	Safety		
Chapter	Learning outcomes	Basic	Advanced
Safety	• Considering and defining safety • Safety mechanisms • Support for independent functional safety features • Well-defined, verified and documented interfaces • Runtime monitoring and logging.	X	X

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Relationships with other concerns	• Role of reliability and resilience • Relationship between safety and security • Implications of dynamic composition and automated interoperability for safety		X

Topic 3	Resilience		
Chapter	Learning outcomes	Basic	Advanced
Resilience	• Considering and defining resilience • Coping with circumstances • autonomic computing notions	X	X
Dependence on resilience	• Mission planning; • Situation awareness; • Resource management; • Decide and assess.		X
Approaches and considerations	• Disconnected from authority; • Importance of Peer-to-peer communication; • Advantages of the hierarchical network; • Data and its transfer to information; • Planning and preparation; • Types of communication		X

Topic 4	Integrability, Interoperability and composability		
Chapter	Learning outcomes	Basic	Advanced
Assembling large systems	• Integrability, • Interoperability, • Composability, • Relation between composability, interoperability and integrability.		X
IIoT systems and components	• Transformation from automatic to autonomous • Constraints and assumptions for components • Impose framework to complete integrability, interoperability, and composability • Transform databases	X	X
Use of natural languages	• Information exchange with natural languages • World knowledge • Comprehend a context		X

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Topic 5 Data Management			
Chapter	Learning outcomes	Basic	Advanced
Data management	• Reduction and Analytics • Publish and Subscribe • Query • Storage, Persistence and Retrieval • Integration • Description and Presence • Data Framework • Rights Management	X	X
Reduction and Analytics	• Transmitting raw data over the networks • Administer data by reducing the volume or velocity		X
Publish and Subscribe	• Modern method for data exchange • Reliability, maintenance and resilience • Streaming data • Alarm and event • Command and control • Configuration • Scalable • Application-level data consumption model • Reliable control flow	X	X
Query	• Models for queries • The one-time query • The continuous query model • Selection of a subset of device-generated data, • Selective, usage-centric access to consolidated data		X
Storage and retrieval	• Defining storage, persistence and retrieval • Preserving time-stamping information • Replay • Support for simulations • Reliability in storage	X	X
Integration	• Available integration mechanisms • Integration across middleware and applications • Conventional ETL (Extract/Transform/Load)	X	X
Metadata, new data and models	• Types, format, structure and metadata of system data • Dynamic integration of application components		X

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	• New data and communications • System management • New IIoT compositions		
Data Framework	• State and behavior • Diagnostic data, data update rates • Past and modern data frameworks • Data parameter monitoring • Traffic monitoring	X	X
Data ownership	• Track data ownership • Rights, access management, data protection • Data stewardship, • Out-sourcing in clouds • Regulatory and compliance requirements.		X

Topic 6 Dynamic Composition and Automated Interoperability			
Chapter	Learning outcomes	Basic	Advanced
Dynamic composition	• Service orientation • Dynamic integration of components • Situational awareness • Workload diversity • Complex relationships • Dynamic relationships.	X	X
Considerations	• Future capabilities • Models and implementation • Resources binding • Virtually centralized policy control • Service adaptability • Productivity	X	X
Functional components	• Integration contract management • Management of policies • Status monitoring • Addition and removal of system components • Management of links between interfaces	X	X

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2.3. BLOCK 02: Reference Architecture for the IIoT

Title	Reference Architecture for the IIoT
Description	Block 02 looks at the basic concepts and framework of Reference architectures for the IIoT. The goal is to present the candidates with the vocabulary and the standard-based frameworks, used for the description of business, usage, functional and implementation points of view in terms of a reference architectures.
Aim	The aim of this block is to give the applicants basic terms, knowledge and techniques and to make them understand the differences between business, usage, functional and implementation points of view.
Input	There is no need for prior knowledge on this topic.
Output	This block will enable applicants to understand the basic principles of creation and development of a reference architecture for the IIoT.
Topics	1. Purpose and scope 2. IIoT Reference Architecture Concepts 3. IIoT Architecture Framework 4. IIoT Business, Usage, Functional and Implementation Viewpoints 5. Example patterns of IIoT implementation

Topic 1 Purpose and scope			
Chapter	Learning outcomes	Basic	Advanced
Purpose	• Foundational framework for all other technical documents. • Reference architecture and why is it important. • Understanding concepts of reference architecture	X	X
Scope	• The Industrial Internet Architecture Framework (IIAF) and the Industrial Internet Reference Architecture (IIRA)		X

Topic 2 IIoT Reference Architecture Concepts			
Chapter	Learning outcomes	Basic	Advanced
Main concepts	• Definition and example of a reference architecture • A common vocabulary	X	X
Reference architecture for IIoT	• Broad industry applicability • Generic and at a high level of abstraction • Allowing refinement and revisions • Identifying technology gaps	X	X

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Topic 3	IIoT Architecture Framework		
Chapter	Learning outcomes	Basic	Advanced
Industrial Internet Architecture Framework – terms and concepts	• Conventions, principles and practices for description of IIoT architecture • Terms and concepts • Architecture frame, architecture representations • Viewpoints, stakeholders, model kinds	X	X
System architecture	• Identification and evaluation of concerns • Models of a representation • Developing system architecture		X

Topic 4	IIoT Business, Usage, Functional and Implementation Viewpoints		
Chapter	Learning outcomes	Basic	Advanced
Business viewpoint	• Concerns of stakeholders • Business vision, values and objectives • Return on investment, cost of maintenance and product liability • Achievement of the stated objectives.	X	X
Usage viewpoint	• Human activities delivering functionality • Implementation of key capabilities by IIoT systems • Activities of various units in regard to users	X	X
Functional viewpoint	• Functional components • Structure and interrelation • Interfaces and interactions • Support of activities in the system	X	X
Implementation viewpoint	• Technologies • Communication schemes • Lifecycle procedures • Price and timing issues • Issues on market focus • Regulation and compliances		X
Integration	• Integration of business, usage, functional and implementation levels • Revisions due to analysis • Inclusion of system concerns safety and security		X

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Topic 5	Example patterns of IIoT implementation		
Chapter	Learning outcomes	Basic	Advanced
Established architectural patterns	• Popular IIoT system implementations • Three-tier architecture pattern • Gateway-Mediated Edge Connectivity • Management architecture pattern • Layered data bus pattern	X	X
Three-Tier IIoT Architecture	• Edge, platform and enterprise tiers • Roles of the tiers in data flow processing • Control of the tiers during usage		X
Gateway-Mediated Edge Connectivity and Management	• Gateway-mediated edge connectivity • Management architecture • Connection to Internet/WAN • Need to reduce complexity		X
Layered Databus pattern	• Common architecture • Characteristics of the architecture/pattern • Best usage cases • Most popular applications		X

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2.4. BLOCK 03: Connectivity in the IIoT

Title	Connectivity in the IIoT
Description	Block 03 prepares candidates for the understanding of the connectivity in IIoT. It provides the ability to exchange data between participants within and across functional domains (control, operations, information, applications, business).
Aim	The aim of this block is to help the applicants to understand the IIoT connectivity issues, to get acquainted with the stack model, to evaluate and determine the suitability of a connectivity technology for a particular system.
Input	Much of the input for this block will come from candidates' prior knowledge of communication technologies and protocols.
Output	This block will enable applicants to understand the basic data-sharing mechanisms to support the higher-level functions.
Topics	1. Purpose and scope 5. Stack model and architectural qualities 6. Connectivity standards and challenges 7. Connectivity functions and considerations 5. Transport layer 6. Assessing connectivity 7. Connectivity Standards

Topic 1 Purpose and scope			
Chapter	Learning outcomes	Basic	Advanced
Purpose	• The goal of understanding the IIoT connectivity is to allow data exchange in isolated systems, enabling data sharing and interoperability between components and subsystems.	X	X
Scope	• There is a wide spectrum of data models and functions specific to a particular industry, bellow which is the "internet" network layer, common across industries.	X	X

Topic 2Stack model and architectural qualities			
Chapter	Learning outcomes	Basic	Advanced
Connectivity Stack Model	• In the IIoT Connectivity Stack Model each layer is built over the layer below. The layers are: Framework, Transport, Network, Link and Physical	X	X

Architectural qualities	• Performance • Scalability • Reliability • Resilience • Security • Integration • Interoperability • Safety	X	X

Topic 3	Connectivity standards and challenges		
Chapter	Learning outcomes	Basic	Advanced
Connectivity standards	• New connectivity technologies - to be integrated with existing technologies, use of gateways • LPWAN, NB-IoT, LTE-M, 5G, Wi-Fi 6, Bluetooth 5	X	X
Connectivity challenges	• A connectivity technology can be universal but also can be suited to a particular application area. • Multiple connectivity technologies might be needed. No single connectivity standard across all domains for all industries.	X	X

Topic 4	Connectivity functions and considerations		
Chapter	Learning outcomes	Basic	Advanced
Connectivity functions	• Key connectivity framework functions: o data resource model, o publish-subscribe and request-reply data exchange patterns, o data quality of service, o data security, and o programming API. • Other functions and communication issues: o Data resource model (data objects) o Addressing o Data type o Data resource lifecycle o Exception handling	X	X
Considerations	• Choosing a connectivity framework: o System (peer-to-peer or broker),	X	X

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	○ Data (data-centric or device/app-centric), ○ Performance (real time or batch), ○ Scalability (data objects or applications), ○ Availability (redundancy and recovery), ○ deployment, ○ operational considerations. • The tradeoffs in each should be carefully evaluated.		

Topic 5 Transport layer			
Chapter	Learning outcomes	Basic	Advanced
Functions of transport	• Endpoint addressing (the messaging protocol), • Modes of communication (unicast, etc.), • Connection-oriented or connectionless, • Critical or non-critical data, • Timing and synchronization • Message security.	X	X
Network layer considerations	• Topology • Span • Segmentation	X	X

Topic 6 Assessing connectivity			
Chapter	Learning outcomes	Basic	Advanced
Business viewpoint	• Origin of the connecting system • Options and variants • Maturity and the state of development of the technology • Stability of the technology • Standards/organizational bodies behind it, open standard or not	X	X
Usage viewpoint	• Main concepts, architecture, and terminology • Technology options • Applications • Operation • Security • Safety (certified or not) • Gateways (are there)	X	X

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Functional viewpoint	• Data resource model • Addressing • Data type and data resource lifecycle • State management • Publish-subscribe • Request-reply • Discovery • Exception handling • Quality of Service (QoS) • Security • API and Governance	X	X
Implementation viewpoint	• Peer-to-peer or broker • Data-centric or device/application centric • Explicit or implicit governance • Data considerations • Performance considerations • Scalability considerations • Availability considerations • Deployment considerations • Network layer considerations	X	X

Topic 7 Connectivity standards			
Chapter	Learning outcomes	Basic	Advanced
Connectivity framework standards	• Data distribution service (DDS) • Hypertext Transfer Protocol (HTTP) • OPC Unified Architecture • One M2M • UDP and TCP transport • Constrained Application Protocol (CoAP) • MQTT • Fieldbus protocols –Profibus (Profinet), EtherNet/IP, Modbus & Modbus/TCP, HART & HART wireless.. Each has its vendors and customers	X	X

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2.5. BLOCK 04: Business Strategy and Innovation

Title	Business Strategy and Innovation
Description	Block 04 introduces the market context of the opportunities in the IIoT to develop business, creating innovations. The block presents a way to draw strategies that can help a business model, following the best practices and using the proper platforms.
Aim	The aim of this block is to look at the business models for the IIoT, and also at opportunities for development and production, and to get acquainted with the business models tools and ways to evaluate the business cases. Another aim is to carry out an impact and risk assessment.
Input	Much of the input for this block will come from candidates' prior knowledge on marketing, business models and innovation.
Output	This block will enable applicants to put their existing knowledge and skills in the context of the IIoT and innovations and will be able to identify and apply the best practices in the IIoT for business models, assessment and governance.
Topics	1. Purpose and scope 2. Market Context 3. IIoT Strategy 4. IIoT Business model innovation 5. IIoT Best practices and platforms

Topic 1. Purpose and scope			
Chapter	Learning outcomes	Basic	Advanced
Purpose	• Framework for enterprise planning, using the IIoT concepts; • Accelerate decisions to deploy the IIoT technologies.	X	X
Scope	• Creating a detailed document that analyzes major business strategy for greater insight into topics; • Highlight steps for organizations considering deploying the IIoT initiatives.	X	X

Topic 2. Market Context			
Chapter	Learning outcomes	Basic	Advanced

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Opportunity for the IIoT	• Access to new and unified data requires a platform for improved decision-making by humans and machines; • A basis for more comprehensive business monitoring, insight and control, while increasing efficiency; • Look at the internal and external business factors aiming at the IIoT adoption; • Look at the influence and society impact;	X	X
Transform business models with IIoT	• IIoT transforms business models in all markets; • General business model and market transformation; • Unification of disparate business elements; • Enhanced development and production; • Increasing customer value.		X
Integrating data from information technology (IT) and operational technology (OT)	• Collaboration and cross-linkage between IT and OT; • Making informed and integrated business and operational decisions on the basis of all data.		X

Topic 3. Industrial IoT Strategy			
Chapter	Learning outcomes	Basic	Advanced
Defining the IIoT strategy for an enterprise before other activities	• The strategy reflects the extent to which the enterprise plans to shift toward IIoT and the speed of this shift • The strategy must be important, wide ranging and beneficial the enterprise's management.	X	X
Initiating the IIoT	• IIoT planning resembles the traditional planning and implementation approaches seen in IT and machine-to-machine (M2M) projects; • Including the IIoT as an item on executive-level agendas.	X	X
Management of the IIoT portfolio	• IIoT project portfolio must support sales and marketing activities, and overall business management;		X

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	• Identification, selection, and management for IIoT opportunities; • Budgetary tracking and roadmap management for IIoT initiatives.		

Topic 4. IIoT Business model innovation			
Chapter	Learning outcomes	Basic	Advanced
IIoT business models	• Optimization measures and business model innovation; • Investigating the shift from linear value chains to value creation within a network of stakeholders, both internal and external; • Follow a IIoT Business model builder;	X	X
Concepts	• Unlocking a wide variety of benefits; • Pursue cost and revenue optimization, operational efficiency, real-time business insight, new market and customer experience improvement, new services and societal improvements; • Production optimization; • New IIoT business models.	X	X
Preparation	• Selected ideas should be analyzed and documented; • Involve each of the contributing parties in the refinement of the planning cycle; • Draw a value-creation network for an IIoT solution.	X	X
Evaluation	• Business case calculation; • Business case challenges; • Impact and risk assessment.	X	X
Initiation	• Internal organizational setup; • Entering in arrangements of third party companies.		X

Topic 5. IIoT Best practices and platforms			
Chapter	Learning outcomes	Basic	Advanced

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IIoT Center of Excellence (CoE)	• Create and govern a unified IIoT strategy within the organization; • Identifying and applying best practices; • Enabling change management; • Rethinking business models; • Managing human resources; • IIoT maturity assessment; • IIoT governance.	X	X
Industrial IoT platform	• Identifying platform support requirements of an IIoT solution; • Define service groups; • Inventory of the IIoT platform service functions; • IIoT platform selection parameters; • Standards in the IIoT.	X	X

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2.6. BLOCK 05: Security in the IIoT

Title	Security in IIoT
Description	Block 05 prepares candidates to understand approaches and tools for secure Industrial Internet of Things (IIoT) systems. The block presents the basic characteristics of a secure system, and a number of specific aspects.
Aim	The aim of this block is to give an overall knowledge and experience to the very complex issue of security. The protection of an IIoT system has to be handled in a structured way.
Input	Much of the input for this block will come from candidates' prior knowledge and experience of security and security management.
Output	This block will enable applicants to understand and possibly apply a cybersecurity model that provides a proper level of security for endpoints, devices and processes within an organization. The block provides knowledge on security techniques and processes, their relation to important security objectives, and high-level requirements.
Topics	1. Purpose and scope 2. Essential System Characteristics 3. Specific Aspects of Securing the IIoT 4. Risk management and trust in the IIoT 5. Protecting Endpoints 6. Protecting Communications and Connectivity 7. Security Monitoring and Analysis 8. Security Configuration and Management

Topic 1 Purpose, scope and structure			
Chapter	Learning outcomes	Basic	Advanced
Purpose	• Security-related architectures, designs and technologies; • Procedures relevant to trustworthy Industrial Internet of Things (IIoT) systems; • Security characteristics, technologies and techniques.	X	X
Scope	• Security framework • Risks associated with security and privacy threats; • Technologies and processes for risk management.	X	X

Topic 2Essential System Characteristics			
Chapter	Learning outcomes	Basic	Advanced

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Defining essential system characteristics	• Essential IIoT system characteristics; • Properties of its various components and their interactions.	X	X
Security	• Condition of the system being protected from unintended or unauthorized access, change or destruction; • Secure behavior; • Elements for security of information and system assets.	X	X
Safety	• Safety as condition of the system; • Safety-assessment techniques; • Security analysis of the threat and threat-actor skills and capabilities.	X	X
Reliability	• Reliability of a system or component; • Understanding of the operational environment, the system's composition; • Establishing the likelihood of failure.	X	X
Resilience	• Resilience as a property of a system; • Designing the system so that failures are compartmentalized.	X	X
Privacy	• Privacy as a right of an individual or group; • Information protected or controlled from certain uses according to regulations and standards.	X	X
Trustworthy systems	• Trustworthiness as a degree of confidence in system performs as expected; • Importance of trustworthiness to each key system characteristic to a given deployment.	X	X

Topic 3 Specific Aspects of Securing the IIoT			
Chapter	Learning outcomes	Basic	Advanced
Converging Information Technologies (IT) and Operational Technologies (OT)	• IT as computer and communication systems common across industries; • OT as a combination of hardware and software; • IT and OT involving complex merge of their key system characteristics; • Drivers and attitudes for convergence of IT and OT.	X	X

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Security evolution in IT and OT	• IT-centric security; • OT security and physical attacks; • Control on ”smart” appliances.	X	X
Regulatory requirements and standards in IT and OT	• Regulatory requirements in the field of IIoT; • External regulations that require compliance; • Audit, assurance and compliance requirements on both OT and IT to cover IIoT; • Standards that are not fragmented into IT and OT.	X	X
Cloud computing in IIoT	• Remote servers to store, manage and process data; • Architecture and security of cloud computing; • Communicating and storing data with a cloud system; • Shared third-party services affecting security and privacy.	X	X
Implications for securing IIoT	• Regulatory constraints to OT and IT safety and security systems and equipment; • Evaluation of attacks and threat models and security programs; • IT and OT integrated into an evolving landscape of endpoint, communication, monitoring and management.	X	X

Topic 4	Risk management and trust in the IIoT system		
Chapter	Learning outcomes	Basic	Advanced
Managing risk	• Safeguarding the investment in IIoT systems and protecting their operations from risk. • Functions of Risk Management: Risk Avoidance, Risk Mitigation, Risk Transferal, Risk Acceptance and Residual risk.	X	X
Security programs	• Range of technologies and activities essential to a comprehensive, robust security posture; • Essential program activities – Identify, Protect, Detect, Respond and Recover; • Periodic risk assessment; • Deployment of security solutions.	X	X
Risk assessments	• Process by which risk, including information security risk, is characterized • Physical consequences of errors and attacks, information systems risk		X

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	• Security model and mitigating the impact of many unplanned situations; • Identifying threats and consequences in the overall system and its implementation; • Cyber threats and attack methods.		
Communicating risk	• Communicating costs and benefits security risks and defensive postures to business decision makers; • Methods for communicating risk: Quantitative, Qualitative, and Systematic risk assessment		X
Metrics and Key Performance indicators	• Monitoring of reports on the security of IIoT systems during their life cycle • Security metrics: detected attack attempts, the breakdown of those attempts, incidents, close calls, policy violations, anomalies that have merited investigation. • Collecting metrics on remote terminal units and sensor outages; • Setting up a continuous feedback loop to identify areas of risk, improve security effectiveness, demonstrate compliance and provide inputs for effective decision making.		X

Topic 5 Protecting Endpoints			
Chapter	Learning outcomes	Basic	Advanced
Functional and implementation viewpoints	• Providing end-to-end security from the edge to the cloud; • Security implementation applied in multiple contexts; • IIoT systems resources and requirements for safety and real-time execution.	X	X
Security building blocks	• Core security functions; • Supporting functions; • Endpoint protection on devices at the edge and in the cloud; • Communications and connectivity protection implementing authentication and authorization of the traffic;	X	X

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	• Security monitoring and analysis and controlled security configuration management for all components of the system; • Security model and policy ensuring confidentiality, integrity and availability of the system throughout its lifecycle.		
Protecting endpoints	• Endpoints: edge devices, communications infrastructure, cloud servers or anything in between. • Requirements and hardware constraints for each endpoint; • Functions of Endpoint Protection.	X	X
Communications and connectivity protection	• Objectives: Physical security of the endpoint connectivity to the network, Protecting Information Flow in the Network, and Cryptographic Protection of communications between endpoints; • Functions of Communication and connectivity security.		X
Security monitoring and analysis	• Capturing data on the overall state of the system; • Monitoring: Endpoints & Communications, Secure Remote Logging, and Supply Chain; • Analyzing: Behavioral Analysis and Rule-Based Analysis • Actions: Proactive/Predictive, Reactive detection & Recovery and Root Cause/Forensics		X
Security configuration and management	• Control of changes to operational functionality of the system and security controls ensuring its protection: • Functions of Security configuration management.		X
Data protection	• Types of data to protect; • Data protection strategies.		X
From functional to implementation viewpoint	• Design principles of security capabilities: Economy of mechanism, Fail-safe defaults, Complete mediation, Open design, Separation of privilege, Least privilege, Least common mechanism, Psychological acceptability		X

Topic 6 Protecting Communications and Connectivity			
Chapter	Learning outcomes	Basic	Advanced

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Levels of protection	• Exchange of information among endpoints to facilitate component integration; • Types of information exchanged; • Cryptographic controls.	X	X
Cryptographic protection of communication and connectivity	• Security controls in communication and connectivity protocols • Information exchange among different actors within a system; • Security controls and mechanisms for protecting communication links; • Protecting exchanged content; • Connectivity standards and security; • Cryptographic protection for different communication and connectivity.	X	X
Information flow protection	• Information in motion; • Network data isolation; • Network segmentation; • Gateways and filtering; • Network firewalls; • Unidirectional gateways; • Network access control.	X	X
Security model and policies for protecting communications	• System components owned and deployed by one entity, but managed, maintained, or used by other entities; • Allowed and prohibited relationships between subjects and objects; • Communication & connectivity security policies; • Defining and enforcing of security policies.		X

Topic 7 Security Monitoring and Analysis			
Chapter	Learning outcomes	Basic	Advanced
Monitoring	• Aggregating and storing data from running IIoT systems; • Security analytic tools; • Monitoring parameters; • Monitoring related to the model of attack incidents and security and privacy policies; • Monitored data.	X	X

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Incident prevention, detection, analysis and response	• Security analytics for actionable conclusions incorporated into automated incident response plans; • Security analytics prior, during and after an incident.	X	X
Security monitoring and analytics	• Purposes of security monitoring; • Types of security analytics systems.		X
Capturing and storing data for analysis	• Logging and event monitoring; • Distinction between operational monitoring and security monitoring; • Capturing and monitoring security data • Sources of monitoring data.		X
Security data protection	• Security policy and regulatory challenges for gathering, communicating and storing sensitive data for monitoring and analysis; • Prohibited monitoring; • Protecting sensitive data.		X
Special considerations for monitoring	Security model and privacy policy considering • Greenfield vs brownfield systems; • Supply chain integrity monitoring		X

Topic 8 Security Configuration and Management			
Chapter	Learning outcomes	Basic	Advanced
Managing changes	• Updates to policy, firmware and software; • Periodic security compliance reports; • Security objectives of the system to be managed.	X	X
Secure operational management vs security management	• Operational management as configuration of the operational functionality of the system and its endpoints; • Security management as security controls on an endpoint; • Integrity and confidentiality of changes made to operational elements of the system.	X	X
Security communication channels	• Data channel and control channel with management as its sub-channel; • The control channel enforcing policy on the data channel;	X	X

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	• Security configuration channel and security monitoring channel.		
Secure operational management	• Configuring and controlling the IIoT system and its components; • Trustworthiness of the system; • Safety implications that traverse operational management systems.	X	X
Security management	• Security policy management; • Policy authoring and definition; • Policy assignment and delivery.	X	X
Endpoint configuration and management	• Activating and enforcing configured endpoint policy settings; • Implementing new security controls; • Secure software patching and firmware update.		X
Communication configuration and management	• Security management and control of network communications; • Applying policy at the communicating endpoints, or at intermediary communications devices.		X
Identity management	• Attributes for identification; • Identity management in endpoint security and its role for authentication and authorization; • Standards and recommendations for identity management.		X
Security model change control	• Lifecycle transitions over the lifetime of an endpoint; • Changing security model for each endpoint depending on its lifecycle state; • Enrollment and credential management phases of security model change control.		X
Configuration and management data protection	• Security management maintains the consistency of security over time, and must not interfere with operational processes. • Sharing security metadata with operation management systems; • Security data conforming to the requirements of the specific network; Control of metadata updates to the management server.		X
Security model and policy for	• Review of the security model and updates of organization policy hierarchy;		X

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change management	• Setting access rights to networks to match the directives from the regulatory policy; • Adjustments to machine policy for security control settings, configurations and security controls; • Controlling and tracking policy updates with an audit trail.		

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2.7. BLOCK 06: IIoT analytics

Title	IIoT analytics
Description	Block 06 gives understanding of the next-generation level of integration and its practical outcomes for the end users. When applied to machine and process data, the analytics provides new insights and intelligence to optimize decision-making significantly and enable intelligent operations leading to transformational business outcomes and social value. This block is for the IIoT system architects and business leaders looking to successfully deploy industrial analytic systems
Aim	The aim of this block is to enable applicants to understand the combinations of various fields like mathematics, computer science and engineering, which are at the basics of analytics. The block covers the business, usage, functional and implementation viewpoints of analytics, issues like AI and Big Data, methods and modeling and characteristics and functions related to analytics.
Input	Much of the input for this block will come from candidates' prior knowledge and experience of analytics tools and methods.
Output	This block will enable applicants to enhance and improve their existing knowledge and skills in the field of IIoT analytics
Topics	1. Purpose and scope 2. Business Usage and Functional Viewpoints 3. Implementation Viewpoint 4. Artificial Intelligence and Big Data 5. Analytics Methods and Modeling 6. System Characteristics and Crosscutting Functions

Topic 1 Purpose and scope of IIoT analytics			
Chapter	Learning outcomes	Basic	Advanced
Purpose	• Systematic analysis of IIoT systems; • Guidance and assistance in IIoT Analytics Systems;	X	X
Scope	• Concepts; • Components of analytical system; • Characteristics; • Services in an industrial setting.	X	X

Topic 2 Business, Usage and Functional Viewpoints

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Chapter	Learning outcomes	Basic	Advanced
Business viewpoint and process analytics	• Identification of stakeholders; • Their business vision, values and objectives; • Business and regulatory context; • Creating business value; • Performance bottlenecks; • Meeting the demand from sales and profit targets; • Needed information; • Gathering data from machines; • Processes optimization.	X	X
Strategic business analytics	• Data and analytical strategies; • Accountability for processes; • System's operational states, performance and environment; • Identifying and analyzing emerging information patterns; • Industrial system assessments under varied conditions.		X
Analytic system users and their viewpoint	• Concerns of expected system usage; • Sequences of activities involving human or logical users; • System's intended functionality; • Stakeholders involved in the specification of the analytics system.	X	X
Analytic users' relationships	• Standards and innovations in sensor and computer technology, extending analytics to machines across the globe; • Analytics algorithms and techniques, including machine learning; • Analytics insights automatic application to operational efficiency of machines.		X

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Functional viewpoint	Functional components in industrial analytics system: • Internal structure and interrelations; • Relation and interactions with external elements; • Support the usages and activities of the overall system • Analytics objectives and constraints; • Five functional domains: control, operations, information, application and business; • Deploying industrial analytics functionality throughout the IIoT architecture; • Capabilities needed for successful industrial analytics solutions.	X	X
Communication of analytic results	• Presenting in a compelling and understandable format; • Charts, graphs, and recommended actions; • Means for humans to interact with the results; • Summary and drill down into the evidence supporting recommendations.		X

Topic 3 Implementation Viewpoint			
Chapter	Learning outcomes	Basic	Advanced
Design considerations	• Technologies needed to implement functional components; • Communication schemes; • Lifecycle procedures; • Scope of performing analytics; • Response time and reliability; • Bandwidth and Capacity; • Security; • Volume, velocity and variety; • Temporal correlation; • Compliance in terms of national security.	X	X
Analytics capacity considerations	• Functionality for industrial analytics; • Information technology and elasticity to provide the required capacity; • Elasticity as a degree to adapt to workload changes;		X

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	• Capacity to avoid affecting profitability; • Operational technology ensuring determinism with engineered capacity; • Determinism as supporting computation and transmission of data between connected devices and applications within a predetermined time; • Response time for work request.		
Analytics deployment models	• Analytics deployed closer to the I/O at the edge; • Predictions deployed in the cloud; • Types of analytics; • Deploying analytics on monitoring devices; • Process of deployment.		X
Data pre-processing, transformation and curation	• Data preparation of messy data; • Simplifying and clarifying data dimensions; • Time dimension in historical data; • Data transformation in machine learning to simplify complexities.		X

Topic 4 Artificial Intelligence and Big Data			
Chapter	Learning outcomes	Basic	Advanced
Big data analytics	• Cutting across information technology and operational technology, data and roles through Big data analytics; • Computational systems and networks designed around the data. • "5V" model of Big Data – volume, velocity, variability, veracity and variety. • Features of machine and operational data; • Big data application scenarios and purposes; • Big data analytics functions; • Multi-typed input data from a large quantity of sensors or machines; • Types of queries and analyses for data mining; • Requirements for analytics functions in an industrial environment.	X	X

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Artificial intelligence (AI)	• Improving analysis efficiency and accuracy in industrial analytics through AI; • Analytics algorithms and frameworks used in IIoT; • Machine learning (ML) and Deep learning (DL); • Deploying a machine-learning model; • Supervised and unsupervised analytics methods and algorithms; • Deep learning algorithms; • Deep learning and neural networks; • Training data for Deep-learning algorithms; • Convolutional and recurrent deep-learning algorithms.		X

Topic 5 Analytics Methods And Modeling			
Chapter	Learning outcomes	Basic	Advanced
Analytic methods and algorithms	• Streaming analytics responding to events in a timely manner; • Managing large data throughput, latency, reliability and security; • Batch analytics on available data; • The lambda architecture as pattern in industrial analytics; • Aggregating data sources in streaming analytics and complex event processing (CEP); • Time windows are a common construct of stream processing and CEP; • Preprocessing the data into a form that it can be analyzed; • Analytics in the cloud and at the edge; • Functions of master/batch/serving layer analytics; • Designing analytics for master/batch/serving layer.		X
Analytics model building	• Collecting and preparing data; • Selecting algorithms; • Machine-learning algorithms; • Data used to train the model;		X

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	• Comparing the performance of algorithms and selecting the best one; • Cross-validation for testing the performance of a model; • Performance metrics.		

Topic 6 System Characteristics and Crosscutting Functions			
Chapter	Learning outcomes	Basic	Advanced
Safety	• Dependencies and requirements for collection, storage, and communication of data to other parts of the industrial processes; • Security expectations for authentication and authorization; • Data management expectations for information models; • Connectivity expectations for reliable data synchronization between the IIoT system tiers; • Processing of industrial analytics results and confirming that they are in the expected range; • Engaging a human in the loop to review anomalies.	X	X
Security	• Concept of in-depth defense; • Data management components encrypting sensitive data; • Connectivity protocols performing the same functions for data-in-motion; • Configuring security domains to protect and manage access to industrial analytics processes and data.	X	X
Data management	• Static and dynamic characteristics of the IIoT assets tracked over time to gain insight; • Collecting and storing data in their rawest form and tracking important anomalies; • Asset types in industrial ecosystem; • Semantics for meaningful information; • Data origin as attribution of the data sources.	X	X

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Connectivity	• The industrial internet as a distributed architecture by design; • Producing raw data geographically separate from where the resulting information delivers business value; • Connectivity within a tier and across tiers of IIoT system; • Local access to data and processing; • Applications depending on resources across multiple tiers; • Incorporate multiple vendors in a deployment; • Synchronizing the mechanisms for industrial analytics components; • Response time within a tier and across tiers.	X	X

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