Module by Module - Self Study Note Guide

Nokia Bell Labs 5G Certification Program

Nokia Bell Labs Industrial Automation Networks Course

Instructions

Research has shown that learning is most effective when understood from one's own personal perspective. As such, we have created this learning guide for you to use as a personal reference and study guide.

For each module, the guide starts with the objectives, potential exam topics, course topics, and then concludes with key takeaways. For each topic, space is provided for you to take notes, capture observations and insights, or simply create a study guide for reference in preparation for your certification exam.

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Exam Table

Exam Breakdown – The following table identifies the proportion of questions from each topic area that will appear on the certification examination.

Number of Questions: 60 Questions

Exam Time Limit: 90 Minutes

Topic	Percentage of Items on Exam
Industry's Business Imperative	8%
Evolving technology capabilities	8%
Applied Industry Solutions	15%
Access Enablers	20%
Network Enablers	20%
Digital Enablers	20%
The Decision Framework	8%

Unit 1 Module 1 – Industrial Automation Networks: Industry's Business Imperative

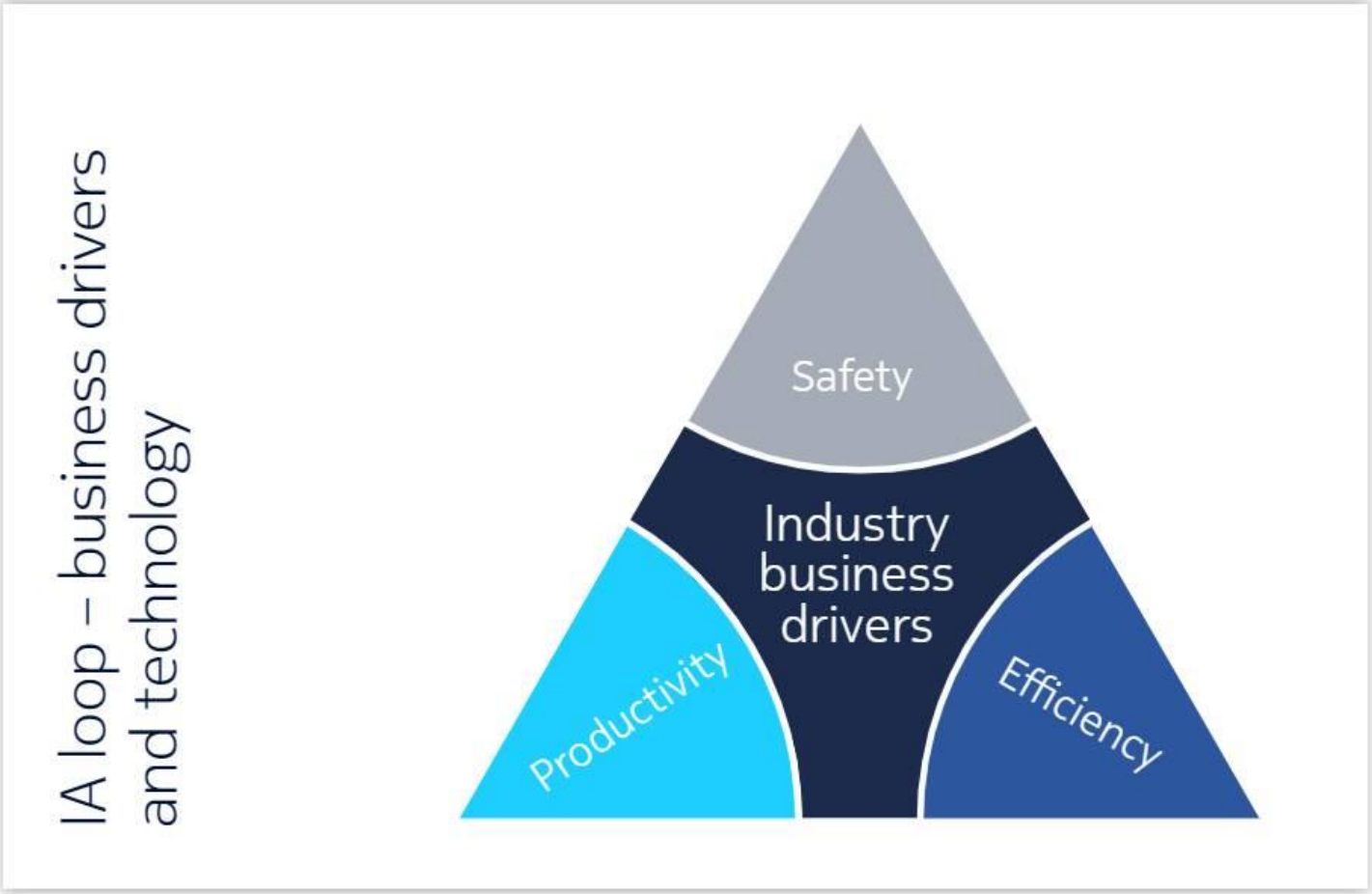
Key Objectives

Here are our learning objectives for this module.

- Define the scope of the overarching business imperatives driving Industrial Automation with a focus on Safety, Productivity, and Efficiency.
- Understand that the interdependency among these three drives industry value.

Potential Exam Topics: Industrial Automation Networks: Industry's Business Imperative

- The elements of the Industrial Triangle of Truth and the motto's associated with each element of the triangle and what the motto means.
- The business imperatives for safety, productivity and efficiency.
- The business drivers related to use cases focusing on manufacturing, emergency management systems, mining, and transportation.



Notes Section

Topic Names	Your Notes
Industrial Automation Networks: Industry's Business Imperative	Instructions. Type your notes in here. Box will expand to accommodate your text. Note: Select and Delete this comment.
Industry capitalizing on technology	
Industry 4.0	
Triangle of Truth	
Improving safety	
Improving productivity	
Improving efficiency	
Vertical impacts	

Additional Notes	

Key Take Aways:

Here are the key points to remember from this module.

- There are three Industrial Automation business drivers: Safety, Productivity, and Efficiency. Which are represented in the Industrial “Triangle of Truth”. And there must be an element of interdependency among the three business imperatives
    - Safety – Do no harm to people, goods, and the environment. It is an undeniable business value of the outmost importance and should never be a matter of “either or” in concert with the other two business drivers. Safety is good business!
    - Productivity - Do more with the same. A foundational business driver that brings time savings, production increases or quality improvements, all at the same cost
    - Efficiency - Do the same with less. Also a foundational business driver that essentially entails optimal utilization of people and capital, and reduces production time and operations costs.
- Achieving optimal business value is dependent on the balance of Safety, Productivity, and Efficiency.

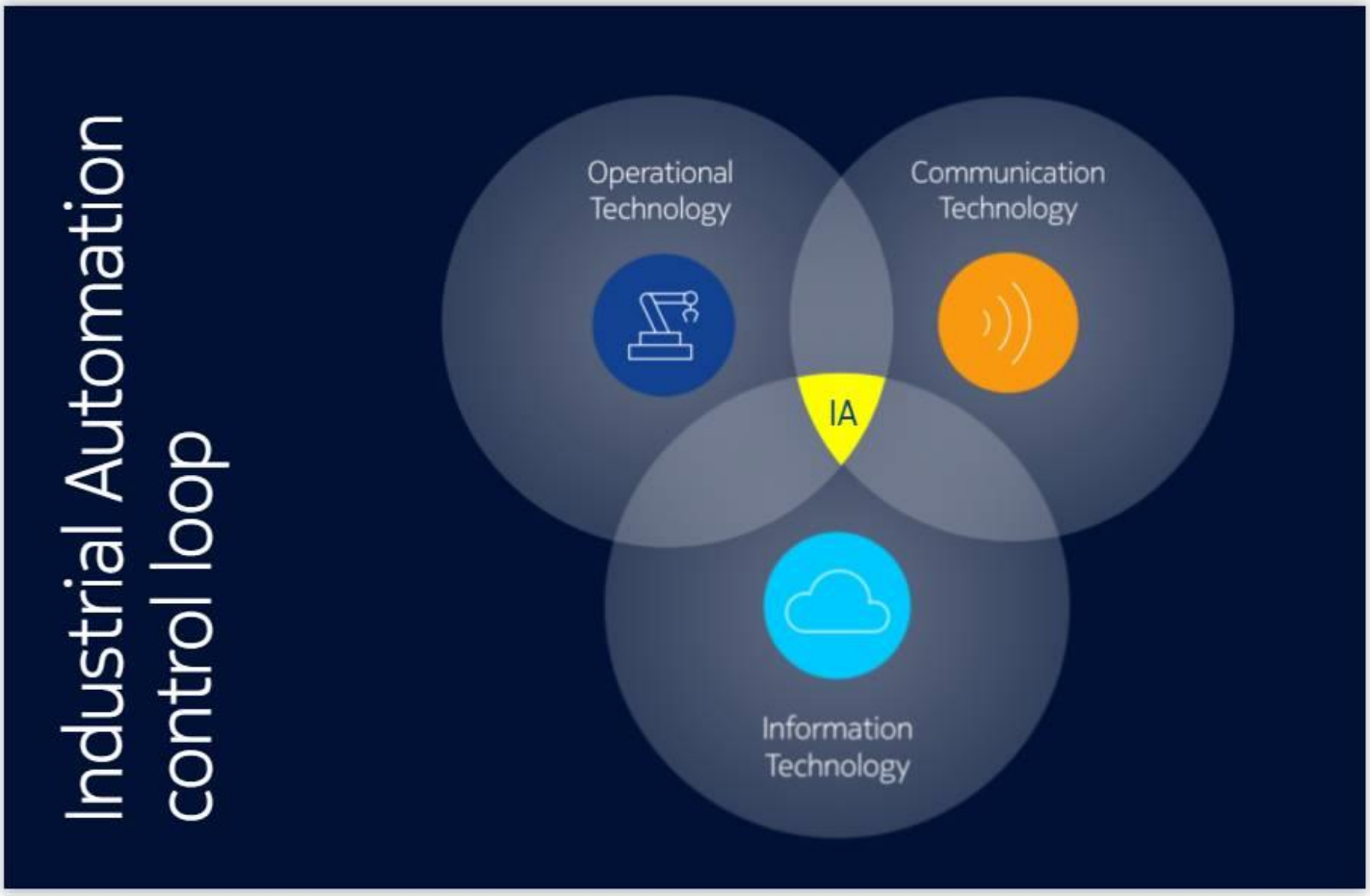
Unit 1 Module 2 - Evolving Technology Capabilities

Key Objectives

- Define, at a high level, how the combination of operational, information and communications technologies are addressing today's industry imperatives.
- Explain how these technologies work together, and are enhanced by 5G to drive additional industry value
- Articulate how the performance capabilities of 5G deliver that value through increased throughput, reduced latency and improved reliability.

Potential Exam Topics: Evolving Technology Capabilities

- The evolution of Operational, Information, and Communication technologies and the value they bring to Industrial Automation.
- The key enablers of industrial automation that have been produced by Operational, Information, and Communication technologies.
- The 5G performance capabilities that deliver value to Industrial Automation.



Notes Section

Topic Names	Your Notes
Evolving Technology Capabilities	Instructions. Type your notes in here. Box will expand to accommodate your text. Note: Select and Delete this comment.
Evolving Technology Capabilities	
The making of Industry 4.0	
OT for Industrial Automation	
IT for Industrial Automation	
CT for Industrial Automation	
Why a distributed cloud architecture?	
5G distributed cloud architecture	

Industry Automation requirements	
Progressive Throughput, Latency and Reliability	
3GPP Evolution	
Additional Notes	

Key Take Aways:

Let's sum up the key points to remember about this module.

- Industrial Automation relies heavily on the confluence of Operational, Information and Communications Technology.
- Operational Technologies have evolved over the past 200 years from simple human-reach to complex automation, and now generate significant amounts of valuable data for industry.
- Advanced Information Technology processing power and the cloud have allowed industry to harness that data to drive the analytics, machine learning and artificial intelligence services.
- 5G-based Communications Technology, in concert with OT data and advanced IT services delivers extreme throughput, low latency and ultra-reliable data transmission to drive Industrial Automation use cases.

Unit 1 Module 3 - Applied Industry Solutions

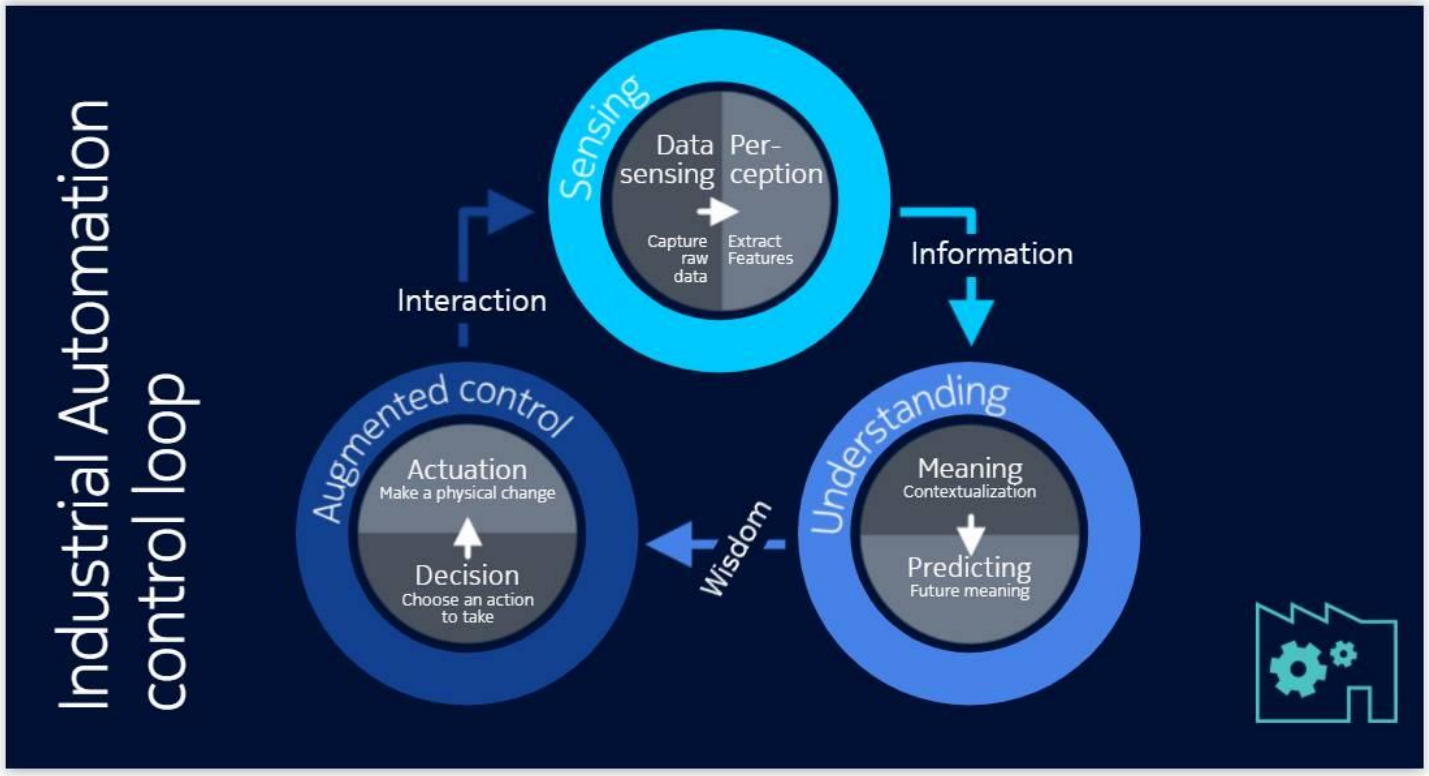
Key Objectives

Here are our learning objectives for this module.

- Map how innovative 5G solutions can be used to help industries solve challenges and create value.
  - Through observation and sensing to create data.
  - Through the analysis of the collected data to create understanding.
  - Through the application of that understanding to drive augmented control.

Potential Exam Topics: Applied Industry Solutions

- The stages of the Industrial Automation Control Loop.
- What is happening in the network at the Sensing, Understanding and Augmented Control phases of the loop.
- The technologies and types of devices that can help monitor moving equipment.
- 5G Enablers that help support emergency management systems.
- Application examples of the Industrial Control Loop.



Notes Section

Topic Names	Your Notes
Applied Industry Solutions	Instructions. Type your notes in here. Box will expand to accommodate your text. Note: Select and Delete this comment.
Industrial Automation control loop	
Sensing through observation	
5G Application Examples	
Understanding through Analysis	
Augmented control by taking decision	
IA Loop enabled by 5G	
Additional Notes	

Key Take Aways:

- Innovative 5G solutions can be used to help industry solve challenges and create value.

- The Industrial Automation Loop model incorporates 5G to:
  - Extract information through observation and sensing.
  - Create understanding through the analysis of that information.
  - Drive augmented control through the application of that understanding.

Unit 2 Module 2 - 5G Enablers for Industrial Automation: Access Enablers

Key Objectives

Here are our learning objectives for this module.

- Evaluate how select 5G RAN capabilities enable industrial applications.
- Describe how 5G NR positioning significantly improves accuracy and speed in industrial settings.
- Explain how 5G NR-Light delivers superior IoT performance for industrial applications. access.

Potential Exam Topics: 5G Enablers for Industrial Automation: Access Enablers

- The 5G RAN enablers and their impact to Industry.
- Enablers that improve throughput and reduce interference
- mMIMO & Beamforming's
  - Impact on Industry
  - Ideal frequency depending on size and number of antennas
  - The most appropriate bands to use Beamforming
- Unlicensed bands
- Device to Device and Vehicle to Everything Communications
- Converged Frequencies
- IAB
  - What it is and how it's used within Industry Automation.
  - What it can solve and its constraints
- Sidelink
- URLLC
  - Factors that can improve latency
  - Transmission Time Interval
  - Reliability
- 5G Frequency Ranges
- NR Positioning
- NR Light

Notes Section

Topic Names	Your Notes
5G Enablers for Industrial Automation: Access Enablers	Instructions. Type your notes in here. Box will expand to accommodate your text. Note: Select and Delete this comment.
Access Enablers: RAN Enablers	
mMIMO Beamforming	

IAB	
Sidelink	
URLLC	
Access Enablers: NR Positioning	
Access Enablers: NR-Light	
Additional Notes	

Key Take Aways:

- 5G RAN Enablers provide unique benefits, in particular:
  - mMIMO and Beamforming helps increase capacity for machines and applications
  - Extended Frequencies enable a mix of 5G coverage and capacity solutions
  - Integrated Access & Backhaul enables lower cost, and faster high-density deployments
  - Sidelink enables device peer-to-peer communication
  - URLLC enables critical, time sensitive applications
- Leveraging UL-AoA, DL-AoD and Multi-RTT, NR Positioning will provide increasing levels of positioning accuracy below 1 meter.
- NR-Light will allow IoT devices to deliver significant amounts of data, provide latency from 10 – 30 milliseconds, and last longer between charges.

Unit 2 Module 3 – Industrial Automation Networks: Network Enablers

Key Objectives

- Articulate how Edge Cloud improves automation by bringing the application closer to the devices, reducing latency, and increasing reliability and security.
- Explain how 5G network slicing enables end-to-end quality-of-service differentiation to support unique eMBB, URLCC, mMTC applications with specific performance requirements.
- Understand how 5G integrates into a Time-Sensitive Network to support wireless communications for a range complex industrial application.
- Describe the different deployment options for Non-Public and Non-Terrestrial Networks and the use-cases applicable to each.

Potential Exam Topics: Industrial Automation Networks: Network Enablers

- Key Functions of Cloud Orchestration
- The function of a vertical slice
- The components of Network Isolation
- What comprises Network Slice Identification Assistance Information (S-NSSAI)
- Use Cases for Time-Sensitive Networking (TSN)

- Definition of Time-Sensitive Networking (TSN)
- Aspects of Network Slice isolation
- Characteristics of Edge, Metro and Core Cloud
- Scenarios for NPN deployment

Notes Section

Topic Names	Your Notes
Industrial Automation Networks: Network Enablers	Instructions. Type your notes in here. Box will expand to accommodate your text. Note: Select and Delete this comment.
Network Enablers: Edge Cloud	
Distributed Cloud Architecture	
Network Enablers: Slicing	
Network Slicing Isolation	
Network Enablers: TSN	
5G Integration with TSN	
Network Enablers: NPN NTN	
Additional Topics	

Key Takeaways:

- 5G-enable edge clouds bring control and processing very close to industrial machines—but not in them—helping reduce cost, reduce latency, improve coordination and increase speed.
- Slicing enables differentiated QoS from device to application by creating virtual network instances in order to guarantee performance requirements for specific applications as well as isolate traffic and resources as needed.
- 5G can seamlessly integrate in TSN and provide synchronized, deterministic wireless communication, and, in combination with URLLC can help deliver a max of 10 ms end-to-end latency for critical industrial applications.
- Non-Public and Non-Terrestrial networks allow for local, regional and nationwide private industrial networks that are secure and can deliver discrete, sliced applications, while at the same time leveraging different levels of integration with a public network as needed.

Unit 2 Module 4 - Industrial Automation Networks: Digital Enablers

Key Objectives

- Describe how Digital Twins allow industry to reduce costs and improve efficiencies by simulating a physical asset using a virtual copy to enable real-time visualization and autonomous optimization and testing.
- Articulate the role machine learning and artificial intelligence play within industry to provide better monitoring, prediction and automation.
- Map how Self Organizing Networks help control the cost and improve the quality of industrial networks through self-configuring, -optimizing and –healing.
- Define how industrial networks are protected from bad actors and malicious threats through end-to-end, well-orchestrated and fully automated 5G network cybersecurity.

Potential Exam Topics: Industrial Automation Networks: Digital Enablers

- The definition of a Digital Twin
- The elements that constitute a Digital Twin
- Key elements of Machine Learning and Artificial Intelligence.
- The SON feature categories
- Key purposes of 5G cybersecurity
- Typical security issues in an industrial network.
- Definition and examples of clustering

Notes Section

Topic Names	Your Notes
Industrial Automation Networks: Digital Enablers	Instructions. Type your notes in here. Box will expand to accommodate your text. Note: Select and Delete this comment.
Digital Enablers: Digital Twin	
Digital Twin Composition	
Digital Twin enabled 5G Planning	
Digital Enablers: AI/ML	
Machine Learning concepts	
AI/ML Industrial Automation Scenarios	

Digital Enablers: SON	
SON variants	
SON Feature Categories	
Cybersecurity	
Purpose of 5G Security	
Additional Topics	

Key Takeaways:

- Digital Twins collect data from industrial systems, applies the data to digital models that represent the physical asset, and provides interfaces for real-time visualization and autonomous optimization and testing.
- Artificial Intelligence and Machine Learning are digital tools that help industrial applications digitally learn from real-time experience to help model, predict and ultimately automate functions and processes.
- Self-Organizing Networks self-configuring, optimizing and healing attributes allow industry to better plan, deploy and manage complex 5G networks.
- Machine-learning-enabled 5G cybersecurity allows industry to protect networks through scalable controls, well-integrated Defense in Depth systems, and end-to-end security orchestration and automation.

Unit 3 Module 1 - Industrial Automation Networks: The Decision Framework

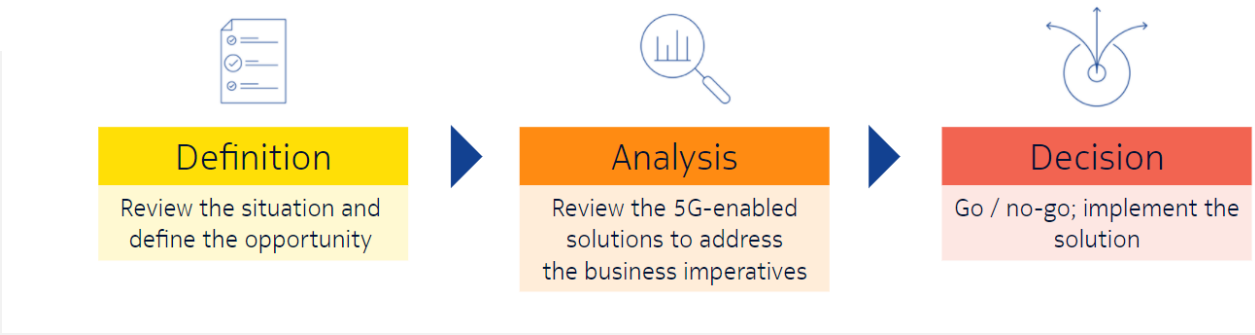
Key Objectives

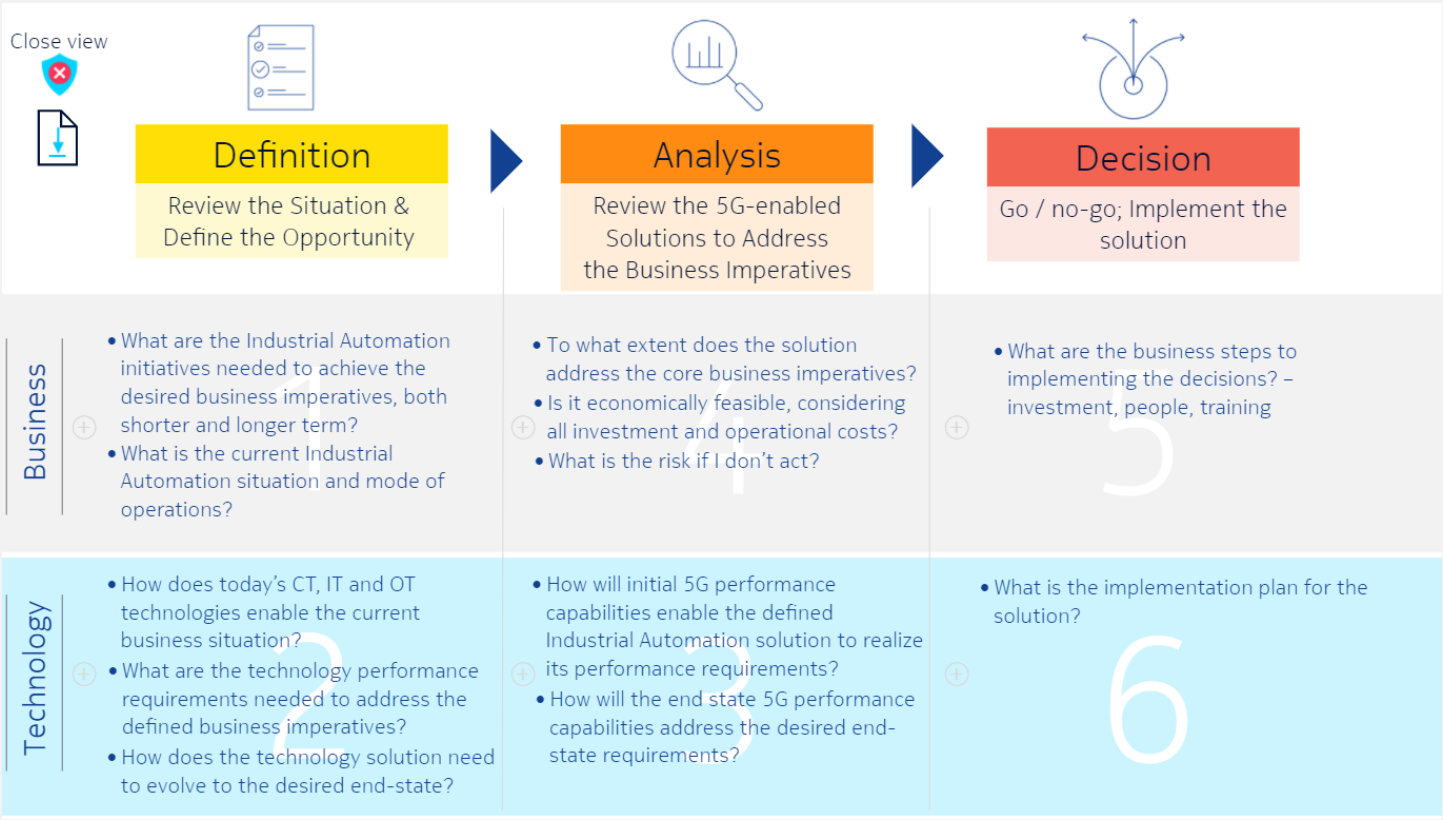
- Illustrate the different stages of the decision framework for evaluating 5G-enabled industrial automation solutions, from both a business and technology perspective
- Articulate the specific issues to address at each stage of the decision framework, from both perspectives, that matter most when evaluating 5G-enabled industrial automation solutions
- Consider how to apply the steps of the decision framework to plan and select 5G-enabled Industrial Automation solutions to address business imperatives.

Potential Exam Topics: Industrial Automation Networks: The Decision Framework

- The stages of the decision framework and what takes place at each stage.
- The types of questions asked by the business and technology job roles during each stage of the decision framework.

The IA decision framework stages





Notes Section

Topic Names	Your Notes
Industrial Automation Networks: The Decision Framework	Instructions. Type your notes in here. Box will expand to accommodate your text. Note: Select and Delete this comment.
Introduction to the Decision Framework	

The decision framework stages	
The perspective of the key job roles	
5G decision framework description	
Additional Notes	

Key Takeaways:

- The Decision Framework is a repeatable, structured way to make decisions about applying 5G to Industrial Automation.
- It consists of three major phases
  - Definition
  - Analysis
  - Decision.
- It reflects the perspective and key issues that both business and technology industry decision makers would address at each phase of the decision process.
- When applying the framework, short and long-term business imperatives need to be defined, capability gaps in the current industrial automation solutions need to be evaluated and proposed short and long-term solutions need to be analyzed and validated for feasibility.

Industry Acronyms

The following Industry relevant acronyms may be referenced during the course and on the certification exam. You should become familiar with these terms as the acronym may be used on the certification exam.

Acronym	Meaning
3GPP	3rd Generation Partnership Project
4IR	Fourth Industrial Revolution
5G	5th generation wireless technology
5G GM	5G Grand Master
5G VN	5G Virtual Network
5G-AN	5G Access Network
5G-BRG	5G Broadband Residential Gateway
5GC	5G Core Network
5G-CRG	5G Cable Residential Gateway
5G-EIR	5G-Equipment Identity Register
5G-GUTI	5G Globally Unique Temporary Identifier
5GLAN	5G Local Area Network
5GNR	5G New Radio

5G-RG	5G Residential Gateway
5GS	5G System
5G-S-TMSI	5G S-Temporary Mobile Subscription Identifier
5GTTH	5G to the home
5QI	5G QoS Identifier
A2P	Application-to-person
ACL	Acces List Control
ADM	Add-drop multiplexer
ADS	Advanced Defense Systems
ADSL	Asymmetric digital subscriber line
AF	Application function
AGV	Automated Guided Vehicle
AI	Artificial intelligence
AI/ML	Artificial Intelligence/Machine Learning
AKA	Authentication and key agreement
AMF	Access and mobility management function
AMR	Autonomous Mobile Robot
AN	Access Network
ANR	Automatic Neighbour Relation
API	Application Programing Interface
AR	Augmented reality
AS	Access Stratum
ASIC	Application-specific integrated circuit
ASICS	Application-Spesific Integrated Circuit
ATC	Automated Train Control
ATO	Automated Train Operation
ATSSS	Access Traffic Steering, Switching, Splitting
ATSSS-LL	ATSSS Low-Layer
AuC	Authentication center
AUSF	Authentication server function
AVVO	Advanced Vital Vehicle Operation
BBU	Base Band Unit
BGP	Border gateway protocol
BMCA	Best Master Clock Algorithm
BPaaS	Business Processes as as Service
BSF	Binding Support Function
BTS	Base transceiver station
BVLOS	Beyond Visual Line of Sight
BWP	Bandwidth Part
C2R	Command and Control Room
CA	Carrier Aggregation
CAG	Closed Access Group
CAPEX	Capital Expenditure

CAPIF	Common API Framework for 3GPP northbound APIs
CCAP	Converged cable access platform
CCPA	California Consumer Privacy Act
CCTV	Closed-Circuit TeleVision
CDI	Composable Disaggregated Infrastructure
CHF	Charging Function
CI/CD	Continous Integration/Continous Delivery
CN	PDB Core Network Packet Delay Budget
CNCF	Cloud Native Computing Foundation
CNF	Cloud Native function
CNI	Cloud-Native Network Interface
CoMP	Coordinated Multi-Point
CP	Control Plane
CPE	Customer premise equipment
CPRI	Common public radio interface
CPU	Central processing unit
C-RAN	Cloud RAN or Centralized RAN
CSFB	Circuit Switched Fall back
CSI	Cloud-Native Storage Interface
CSMF	Communication Service Management Function
cSON	Centralized Self-Organizing Network
C-SON	Centralized Self-Organizing Network
CSP	Communication service provider
CT	Communication Technology
CTI	Co-operative Transport Interface
CU	Centralized unit
CU-CP	Centralized Unit - Control Plane
CUPS	Control and user plane separation
CU-UP	Centralized Unit - User Plane
CWDM	Coarse wavelength division multiplexing
D2D	Device to Device communication
DC	Data center
DÉCOR	Dedicated core network
DevOps	Development Operations
DevSecOps	Development Security Operations
DL	Downlink
DL-AoD	Downlink Angle of Departure
DN	Data network
DNAI	DN Access Identifier
DNN	Data Network Name
DoS	Denial of service
DRB	Data Radio Bearer
DRX	Discontinuous Reception

DSCP	Differentiated service code point
DSL	Digital subscriber line
dSON	Distributed Self-Organizing Network
D-SON	Distributed Self-Organizing Network
DSP	Digital Service Provider
DSS	Dynamic Spectrum Sharing
DS-TT	Device-side TSN translator
DU	Distributed unit
DWDM	Dense wavelength division multiplexing
E2E	End-to-End
EAP	Extensible authentication protocol
EBI	EPS Bearer Identity
ECMP	Equal-cost multi-path
eCPRI	Enhanced Common Public Radio Interface
eLTE	Evolved long-term evolution
EMA	Emergency Management Agency
eMBB	Enhanced mobile broadband
EMS	Element Manager System
EMS	Emergency Management System
eMTC	Enhanced machine-type communication
EN-DC	E-UTRAN New Radio Dual Connectivity
EPC	Evolved packet core
ePDG	Evolved Packet Data Gateway
EPS	Evolved Packet System
eSIM	Embedded Subscriber Identity Module
ETSI	European Telecommunications Standards Institute
EUI	Extended Unique Identifier
E-UTRAN	Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access
eVPN	Ethernet virtual private network
FAR	Forwarding Action Rule
FCAPS	Fault Configuration Accounting Performance Security
FCC	Federal Communications Commission
FDM	Frequency Division Multiplexing
FIP	Floating IP
FMS	Fleet Management System
FN-BRG	Fixed Network Broadband RG
FN-CRG	Fixed Network Cable RG
FN-RG	Fixed Network RG
FPGA	Field-Programmable Gate Array
FQDN	Fully Qualified Domain Name
FR	Frequency range
FRMCS	Future Railway Mobile Communication System
FTTH	Fiber to the home

FTTx	any broadband network architecture using optical fiber to provide all or part of the local loop used for last mile
FWA	Fixed Wireless Acces
g.fast	a DSL protocol
GDP	Gross domestic product
GDPR	General Data Protection Regulation
GEO	Geostationary Earth Orbit
GFBR	Guaranteed Flow Bit Rate
GM	General Motors
GMLC	Gateway Mobile Location Centre
gNB	gNodeB
GNSS	Global Navigation Satellite System
GoA	Grade of Automation
GPGPU	General Purpose Graphical Processing Unit
GPON	Gigabit Passive Optical Network
GPSI	Generic Public Subscription Identifier
gPTP	generic Precision Time Protocol
GPU	Graphics processing unit
GSM A	GSM Association
GSM-R	GSM-Rail
GUAMI	Globally Unique AMF Identifier
GW	Gateway
HAP	High Altitude Platforms
HARQ	Hybrid Automatic Request
HD	High Definition
HDR	High Dynamic Range
HEO	Highly Elliptical Orbits
HLR	Home location register
HMI	Human-Machine Interface
HPLMN	Home public land mobile network
HR	Home Routed (roaming)
H-SON	Hybrid Self-Organizing Networks
HSS	Home subscriber server
http/2	HyperText Transfer Protocol version 2
HW	Hardware
IA	Industrial Automation
IaaS	Infrastructure as a Service
IAB	Integrated access and backhaul
ICP	Internet content provider
ICT	Information and Communications Technology
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force

IIOT	Industrial IOT
IKE	Internet key exchange
IMEI/TAC	IMEI Type Allocation Code
IMSI	International mobile subscriber identity
IMT	International Mobile Telecommunications
IOT	Internet Of the Things
IP	Internet Protocol
IPSec	Internet protocol security
IPUPS	Inter PLMN UP Security
IPX	Internetwork packet exchange
IS to IS	Intermediate system to intermediate system
I-SMF	Intermediate SMF
IT	Information technology
ITU	International Telecommunications Union
ITU-T	ITU-telecommunication
I-UPF	Intermediate UPF
KPI	Key Performance Indicator
KVM	Kernel-based Virtual Machine
LAA	Licensed Assisted Access
LADN	Local Area Data Network
LAN	Local area network
LBO	Local Break Out (roaming)
LCM	Life Cycle Management
LEO	Low Earth Orbits
LiDAR	Light Imaging Detection and Ranging
IIoT	Industrial Internet of Things
LMF	Location Management Function
LoA	Level of Automation
LOS	Line of SIght
IoT	Internet of Things
LPP	LTE Positioning Protocol
LPWA	Low-Power Wide-Area
LRF	Location Retrieval Function
LTE	Long-term evolution
LTE-M	Long-term evolution machine-type communication
MAA	Massive antenna array
MAC	Medium Access Control
MANO	Management and network orchestration
MBB	Mobile broadband
MCX	Mission Critical Service
MDBV	Maximum Data Burst Volume
MEC	Mobile Edge Computing
MEO	Medium Earth Orbits

MES	Manufacturing Execution Systems
MFBR	Maximum Flow Bit Rate
MICO	Mobile Initiated Connection Only
MIMO	Multiple Input Multiple Output
MiTM	Man in the middle
ML	Machine learning
MI MO	Multiple-input multiple-output
MME	Mobility management entity
mMIMO	Massive multiple input multiple output
mMTC	massive Machine Type Communications
mmW	millimeterwaves
mmWaves	millimeterwaves
MNO	Mobile network operator
MOCN	Mobile operator core network
MPLS	Multi-Protocol Label Switching
MPS	Multimedia Priority Service
MPTCP	Multi-Path TCP Protocol
MR	Mixed Reality
MRO	Maintenance - Repair - Operation
MSC	Mobile Switching Center
MT	Mobile Termination
MTC	Machine-type communication
MU-MI MO	Multiple-user multiple-input multiple-output
MVNO	Mobile virtual network operator
MW	Microwaves (transmission)
N3IWF	Non-3GPP InterWorking Function
N5CW	Non-5G-Capable over WLAN
NaaS	Network as a Service
NAI	Network Access Identifier
NAS	Non Access Stratum
NASA	National Aeronautics and Space Administration
NAT	Network Address Translation
NB-IoT	Narrowband Internet of Things
NEBS	Network Equipment Building System
NEF	Network exposure function
NESAS	Network element security assurance scheme
NF	Network function
NFMF	NF Management Function
NFV	Network Functions Virtualization
NFV MANO	Network Function Virtualization Management and Orchestration
NFV-0	Network function virtualization orchestration
NFV-I	Network function virtualization infrastructure
NFV-MANO	Network Functions Virtualization-Management and orchestration

NFVO	NFV orchestration
NG RAN	New generation radio access network
NGAP	Next Generation Application Protocol
NG-RAN	Next Generation Radio Access Network
NID	Network identifier
NLRI	Network layer reachability information
NOC	Network Operation Center
NPN	Non-Public Network
NR	New radio
NR-DC	New Radio Dual Connectivity
NRF	Network repository function
NR-U	New Radio Unlicensed
NS	Network service
NSA	Non-standalone
NSI	Network Slice Instance
NSMF	Network Slice Management Function
NSSAA	Network Slice-Specific Authentication and Authorization
NSSAI	Network Slice Selection Assistance Information
NSSF	Network slice selection function
NSSI	Network Slice Subnet Instance
NSSMF	Network Slice Subnet Management Function
NSSP	Network Slice Selection Policy
NTN	Non-Terrestrial Network
NVP	Network visibility poisoning
NW	Network
NWDAF	Network data analytics function
NW-TT	Network-side TSN translator (Time Sensitive Networking Bridge)
O&M	Operation and Maintenance
OAM	Operation Administration and Maintenance
Oauth	Open authentication
OLT	Optical Line Termination
ONT	Optical Network Transmitter
ONU	Optical Network Unit
OPEX	Operational Expenditure
OS	Operating system
OSPF	Open shortest path first
OT	Operational Technology
OTP	One-time password
PaaS	Platform as a Service
PC	Personal Computer
PCE	Path computation engine
PCF	Policy control function
PCI	Physical Cell Identification

PCRF	Policy and Charging Rules Function
PCS	Probabilistic constellation shaping
PDB	Packet Delay Budget
PDCP	Packet Data Convergence Protocol
PDR	Packet Detection Rule
PDU	Protocol Data Unit
PEI	Permanent Equipment Identifier
PER	Packet Error Rate
PFD	Packet Flow Description
PGW	Packet Data Network Gateway
PGW-C	Packet Data Network Gateway - Control
PGW-U	Packet Data Network Gateway -User
PHY	Physical layer
PLC	Programmable Logic Controller
PLMN	Public land mobile network
PNF	Physical network function
PNI-NPN	Public Network Integrated Non-Public Network
POM	Production and Operations Management
PON	Passive Optical Network
PPD	Paging Policy Differentiation
PPF	Paging Proceed Flag
PPI	Paging Policy Indicator
ProSe	Proximity Services
PSA	PDU Session Anchor
PSTN	Public switched telephone network
PTP	Precision Time Protocol
QFI	QoS Flow Identifier
QoE	Quality of Experience
QoS	Quality of Service
RACS	Radio Capabilities Signalling optimisation
RAM	Random access memory
RAN	Radio access network
RF	Radio frequency
RG	Residential Gateway
RHF	Redundancy Handling Function
RIC	RAN Intelligent Controller
RIM	Remote Interference Management
RLC	Radio Link Control
RMG	Rail Mounted Granty cranes
ROADM	Reconfigurable optical add-drop multiplexer
RQA	Reflective QoS Attribute
RQI	Reflective QoS Indication
RRC	Radio Resource Control

RSN	Redundancy Sequence Number
Rt	Realtime
RTT	Round-Trip Time
RU	Radio Unit
SA	Standalone
SaaS	Service/Software as a Service
SA-NPN	Standalone Non Public Network
SBA	Service Based Architecture
SBI	Service Based Interface
SCAS	Security assurance specification
SCP	Service Communication Proxy
SCS	Subcarrier Spacing
SD	Slice Differentiator
SDAN	Software defined access network
SDAP	Service Data Adaptation Protocol
SDM	Spatial Division Multiplexing
SDN	Software Defined Network
SD-WAN	Software-Defined Wide Area Network
SEAF	Security Anchor Functionality
SECAM	Security assurance methods
SEPP	Security Edge Protection Proxy
SGW	Serving Gateway
SIDF	Subscription identifier de-concealing function
SIM	Subscriber Identity Module
SLA	Service level agreement
SMF	Session management function
SMSF	Short message service function
SN	Sequence Number
SNPN	Stand-alone Non-Public Network
S-NSSAI	Single network slice selection assistance information
SOAR	Security orchestration automation and response
SOC	Service Operation Center
SOHO	Small Office Home Office
SON	Self-Organizing Networks
SR	Segment routing
SR-TE	Segment routing-traffic engineering
SSB	Synchronization Signal Block
SSC	Session and Service Continuity
SSCMSP	Session and Service Continuity Mode Selection Policy
SSID	Service Set Identifier or network name
SSM	Synchronization Status Messaging
SST	Slice/Service Type
SUCI	Subscription Concealed Identifier

SUPI	Subscription permanent identifier
SV	Software Version
SW	Software
TAM	Total Addressable Market
TCO	Total cost of ownership
TDM	Time Division Multiplexing
TEU	Twenty-foot equivalent unit
TLS	Transport layer security
TNAN	Trusted Non-3GPP Access Network
TNAP	Trusted Non-3GPP Access Point
TNGF	Trusted Non-3GPP Gateway Function
TNL	Transport Network Layer
TNLA	Transport Network Layer Association
TRP	Transmission-Reception Point
TRX	Transceiver
TSC	Time Sensitive Communication
TSCAI	TSC Assistance Information
TSN	Time Sensitive Networking
TSN-FRER	Time Sensitive Networking Frame Replication for Reliability
TSN-GM	TSN Grand Master
TSP	Traffic Steering Policy
TT	TSN Translator
TTI	Transmission time interval
TWIF	Trusted WLAN Interworking Function
UAS	Unmanned Aerial Systems
UCMF	UE radio Capability Management Function
UDM	Unified data management
UDR	Unified data repository
UDSF	Unstructured data storage function
UE	User equipment
UL	Uplink
UL CL	Uplink Classifier
UL-AoA	Uplink Angle of Arrival
UPF	User plane function
URLLC	Ultra Reliable Low Latency Communication
URRP-AMF	UE Reachability Request Parameter for AMF
URSP	UE Route Selection Policy
V2I	Vehicle-to-Infrastructure
V2N	Vehicle-to-Network
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-everything
vApp	Virtual Application

vDAA	Virtualized Distributed Access Architecture
VDSL	Very high speed digital subscriber line
VID	VLAN Identifier
VIM	Virtual Infrastructure Manager
VIP	Virtual IP
VLAN	Virtual Local Area Network
VM	Virtual machine
VNF	Virtual Network Function
VNFM	VNF management
VNF-M	Virtualized network function manager
VOD	Video on demand
VoIP	Voice over internet protocol
VPLMN	Visited public land mobile network
VPN	Virtual Private Network
VR	Virtual reality
vRAN	Virtualized RAN
VVWC	Voltage, Var and Watt Control
VXLAN	Virtual eXtensible LAN
W-5GAN	Wireline 5G Access Network
W-5GBAN	Wireline BBF Access Network
W-5GCAN	Wireline 5G Cable Access Network
W-AGF	Wireline Access Gateway Function
WAN	Wide area network
WDM	Wavelength division multiplexing
WFA	Wireless Fixed Access
Wifi	Wireless Fidelity
WLAN	Wireless LAN
WTTA	Wireless to the antenna
WWC	Wireline-wireless convergence
xDSL	any Digital subscriber Line technology
XG-Cable	10 Gbit/s capable fiber
XG-Fast	(or XG-PON or 10G-PON) 10 Gbit/s Passive Optical Network
XGS-PON	Symmetric 10 Gigabit Passive Optical Network
X-Haul	or Any-haul - comprehensive transport solution front, mid and backhaul.
XML	eXtensible Markup Language
YAML	Yet Another Markup Language
ZSM	Zero touch network & Service Management (from ETSI)

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