

Appendix A: IEEE WCET Examination Specifications

Major Areas of Expertise

Area 1 (19-23%) - RF Engineering, Propagation, Antennas, and Signal Processing: Tasks and knowledge related to: antennas, RF engineering, transmission, reception, propagation, channel modeling, and signal processing.

Evaluate system performance and reliability; calculate path loss; evaluate the effects of different fading and empirical path loss models; calculate and evaluate the effects on the received signal of path-related impairments; determine parameters related to antennas or antenna arrays; generate and evaluate coverage and interference prediction maps; develop and analyze procedure to optimize the coverage of a radio; make RF system measurements.

Area 2 (19-23%) - Wireless Access Technologies: Tasks and knowledge related to wireless access networks, especially the physical, MAC, and link layers.

Analyze building blocks, multiple access, mobility management, and spectrum implications in wireless access system design; analyze design considerations to optimize capacity/coverage; design and analyze a wireless access system; analyze the required bandwidth for a wireless system and tradeoffs; analyze wireless access technology standards, their features, and evolution.

Area 3 (19-23%) - Network and Service Architecture: Tasks and knowledge related to network infrastructure, including core networks; service frameworks such as IMS; and application architectures such as voice, video streaming, and messaging. All-IP services architecture as in 3GPP Rel 6 and beyond, including Enhanced Packet Services (EPS) as in 3GPP Rel 8 LTE (Long Term Evolution) and EPC (Enhanced Packet Core).

Analyze service platforms, IP addressing schemes for various technologies; design and test quality of service (QoS); select and test a load-balancing scheme; analyze IP routing and ad hoc routing and mesh protocols; perform capacity planning, error tracking, and trace analysis; analyze the evolution of mobile networks to enable IP multimedia.

Area 4 (11-15%) - Network Management and Security: Tasks and knowledge related to fault, configuration, account, performance, maintenance, security management, management availability, and operation support systems (examples include network service assurance and provisioning).

Design a fault monitoring system and a performance monitoring system; develop/specify types and methods of alarm reporting; compute availability and reliability metrics; assess the potential impacts of known security attacks; plan corresponding solutions to known security attacks.

Area 5 (6-8%) - Facilities Infrastructure: Tasks and knowledge related to the specification, design, implementation, and operation of facilities and sites.

Determine power consumption; analyze electrical protection requirements and design the electrical protection layout for a wireless telecommunications facility; determine the required antennas for the facility and their positions; develop a specification for the required structure for a wireless base station facility; determine the required cable, antennas, and materials to implement an in-building wireless network; evaluate equipment compliance with industry standards, codes, and site requirements.

Area 6 (6-8%) - Agreements, Standards, Policies, and Regulations: Tasks and knowledge related to externally imposed compliance requirements and conformance testing, including interoperability.

Assess service and equipment quality; prepare specifications for purchasing services and equipment and evaluate the responses; verify compliance with regulatory requirements; select and analyze frequency assignments; perform standardized homologation tests as required by regulatory or standardization bodies; evaluate compliance with health, safety, and environmental requirements; perform conformance/interoperability analyses of systems and components; analyze the use of licensed vs. unlicensed spectrum; obtain licenses and permits.

Area 7 (8-12%) - Fundamental Knowledge: Basic knowledge that a wireless communications engineer would use in order to perform tasks across all domains.

Apply basic concepts related to electrical engineering, communications systems, and general engineering management.

Area 1 – RF Engineering, Propagation, Antennas, and Signal Processing

Tasks:

- T1.01 Calculate link budgets to evaluate system performance and reliability based on received signal level and fade margin (examples might include satellite, microwave link, base station to mobile station, wireless LAN and PAN); calculate path loss for various RF transmission systems (examples might include between isotropic or dipole reference antennas, base station to mobile station, base station to repeater, earth station to satellite, LOS/NLOS paths, and clutter losses).
- T1.02 Calculate the capacity of various multiple-antenna schemes, and analyze the tradeoffs involved in selecting from among alternative schemes (calculations might include analysis of pre-coding techniques).
- T1.03 Evaluate the effects of different fading models (examples might include Rayleigh and lognormal) and empirical path loss models on the received signal strength in various signal propagation environments (examples might include flat terrain, rolling hills, urbanized areas, and indoor environments [such as buildings or tunnels] with losses caused by walls, ceilings, and other obstructions).
- T1.04 Calculate and evaluate the effects on the received signal of path-related impairments, such as Fresnel Zone blockage, delay spread, and Doppler shift of a signal received by a moving receiver.
- T1.05 Calculate the polarization mismatch loss for various antenna systems (examples might include fixed microwave systems, cellular and mobile radio systems, and satellite systems).
- T1.06 Evaluate receive diversity gain for selection, equal gain, and maximal ratio diversity system configurations.
- T1.07 Determine parameters related to antennas or antenna arrays (examples might include pattern, beamwidth, gain, SAR-reduction features, distance from an antenna or array at which far field conditions apply, spacing, beam forming, tilt, and sectorization) and analyze the effects of these parameters on coverage.

- T1.08 Determine appropriate antenna location at base station sites to prevent inter-system and intra-system interference effects, taking into account required radiation patterns and mutual coupling effects.
- T1.09 Generate and evaluate coverage and interference prediction maps (examples might include maps for cellular, mobile radio, and WLAN systems).
- T1.10 Develop and analyze a procedure to optimize the coverage of a radio system using propagation modeling and "drive test" measurements.
- T1.11 Develop a block diagram of an RF system (examples might include cellular, land mobile, and WLAN) employing standard modules (examples might include filters, couplers, circulators, and mixers) and/or using lumped or distributed matching networks, microstrips, and stripline.
- T1.12 Make and analyze RF system measurements (examples might include swept return loss to determine antenna system performance, transmitter output power [peak or average, as appropriate], signal-to-noise ratio at a receiver front end, and co-channel and adjacent-channel interference for specific types of signal spectra).

Knowledge of:

- K1.01 different types of losses (examples might include transmission line loss, antenna gain, connector losses, and path loss)
- K1.02 procedures to calculate antenna gain and free space path loss
- K1.03 statistical fading models and distance-power (path loss) relationships in different propagation environments
- K1.04 the effects of outdoor terrain and indoor structures such as walls, floors, and ceilings on signal propagation
- K1.05 common deterministic, statistical, and empirical propagation models (examples might include free space, Okumura, Longley-Rice, and ray-tracing) and software modeling tools (examples might include EDX Signal, ATDI, PathLoss, and similar radio network planning tools) used to implement them
- K1.06 topographical maps and digital terrain databases
- K1.07 indoor and outdoor coverage calculation and verification techniques
- K1.08 E_s/N_0 , E_b/N_0 , RSSI, NF, and other system parameters
- K1.09 the relationship between receiver noise figure, noise temperature, and receiver sensitivity and the relationship between sensitivity under static conditions and the degradation of effective receiver sensitivity caused by signal fading in different propagation conditions
- K1.10 external noise sources and their impact on the S/N ratios of received signals, and techniques for measuring the impact of external noise
- K1.11 basic antenna system design and use including antenna types (examples might include omnidirectional, panel, parabolic, dipole array, indoor antennas), antenna patterns, gain and EIRP, EIS, ERP, TIS, TRP, antenna size, antenna polarization, receive and transmit diversity, antenna correlation coefficients (examples might include MIMO antenna systems), and proper antenna installation to provide for coverage, interference mitigation, and frequency reuse

- K1.12 adaptive antenna methods and techniques, including null-steering, selection diversity, optimal-ratio combining, adaptive antennas, spatial multiplexing, space-time coding, and MIMO techniques
- K1.13 subscriber unit, mobile, and device antennas and their performance characteristics, including SAR-reduction characteristics
- K1.14 use of test equipment such as network analyzers, spectrum analyzers, and TDRs
- K1.15 co-channel and adjacent channel interference analysis and measurement methods and techniques; multi-user detection and interference-cancellation schemes and their limitations
- K1.16 filters, power dividers, combiners, and directional couplers
- K1.17 signal processing techniques, including matched filtering, adaptive filtering, adaptive equalization, and Rake processing

Area 2 – Wireless Access Technologies

Tasks:

- T2.01 Analyze multiple access schemes for various technologies.
- T2.02 Analyze spectrum implications in wireless access system design (examples might include applications, TDD/FDD, inter-modulation, LOS/NLOS, coverage/capacity).
- T2.03 Analyze design considerations and perform system design to eliminate coverage holes and to optimize capacity/coverage in urban/indoor areas.
- T2.04 Design and analyze a wireless access system (examples might include AP placement and channel selection) according to given bandwidth requirements, coverage, and other considerations.
- T2.05 Test devices with respect to interference issues in various operating environments (examples might include TDMA, CDMA, WCDMA, WLAN, 802.15).
- T2.06 Perform interference analysis (examples: co-site interference in TDMA, CDMA, WCDMA, WLAN, 802.15, and GSM; effect of interference on capacity in cellular, WLAN, WAN, ad hoc and sensor networks).
- T2.07 Compute the required bandwidth for a wireless system given certain network conditions (examples might include BER, flow count, and protocols in use).
- T2.08 Analyze the tradeoffs (examples might include bandwidth versus BER) of various error detection and correction techniques.
- T2.09 Analyze the tradeoffs and capacity implications of mitigation techniques for time-varying channels, including channel estimation; time- and frequency-recovery and tracking; modulation/demodulation; pre-coding; and power control schemes (examples: scheduling algorithms, bandwidth versus power efficiency analysis).
- T2.10 Calculate frequency re-use factor.
- T2.11 Design fundamental elements/attributes of wireless network systems (examples might include cellular, 802.16, WLAN, and satellite).

- T2.12 Analyze the steps involved in the process of handover/handoff for various wireless systems (examples might include UMTS, CDMA2000, 802.16, and WLAN).
- T2.13 Analyze the tradeoff between the size of a paging area and the location update frequency.

Knowledge of:

- K2.01 multiple access and multiplexing schemes (examples might include TDMA, CDMA, OFDMA, FDMA, and SDMA)
- K2.02 technology standards and their evolution (examples might include WCDMA, CDMA2000, LTE, 802.11, 802.15, and 802.16)
- K2.03 error detection and correction, ARQ, HARQ, Turbo Coding, link-adaptation, modulation/demodulation, and pre-coding techniques
- K2.04 objectives of channel-estimation and power-control schemes and their operation
- K2.05 handover/handoff/mobility management, including inter-technology handover/handoff
- K2.06 paging functions
- K2.07 the major components of a wireless network topology
- K2.08 LEOS, MEOS and geostationary satellites, their bands, and their usage for broadcasting

Area 3 – Network and Service Architecture

Tasks:

- T3.01 Analyze service platforms including service enablers (examples might include messaging, positioning, and location), service creation/delivery (examples might include Open Service Access and Parlay), and service-oriented architecture (SOA). Design and engineer various VAS (CRBT, SMS, VMS, Alerts, etc.) services on wireless network CORE. Design optimum network services for data traffic.
- T3.02 Analyze IP addressing schemes for various technologies (examples might include Mobile IP, ROburst Header Compression [ROHC] as in VoIP over HSPA or LTE, IPv4, and IPv6).
- T3.03 Design and test quality of service (QoS) (examples might include design and plan for adequate resources, selecting priority schemes, prioritization of differentiated services, queuing strategies, mapping of QoS classes between network and transport layers and call admission control) for VoIP and IMS-based services. Calculate Capacity and Grade of Service (GOS) for a cellular network e.g., GSM/WCDMA/LTE networks. Provision QoS for different applications per 3GPP standards, e.g. through QCI, ARP, etc. for LTE/EPC networks.
- T3.04 Select and test a load-balancing scheme.
- T3.05 Analyze IP routing (examples might include interpreting an IP routing table).

- T3.06 Analyze ad hoc routing and mesh protocols, and suitability for various deployment scenarios.
- T3.07 Perform capacity planning using traffic engineering principles.
- T3.08 Perform error tracking and trace analysis on protocol control messages for specific systems.
- T3.09 Analyze the evolution of mobile networks to enable IP multimedia services (including circuit-switched to packet-switched network evolution).
- T3.10 Analyze intra- and inter-domain roaming (examples might include roaming within a country or in different countries in 3GPP networks). Analyze service continuity across domains (e.g., VoIP in LTE and circuit-switched voice in GSM/W-CDMA networks).
- T3.11 Analyze the functioning of TCP/IP major transport protocols (examples might include TCP, UDP, and RTP) in the context of wireless communications and limitations of PING/Ack.
- T3.12 Develop a simple block diagram-level design for a network operations center (examples might include digital cellular, web-based mobile content, multimedia broadcast, and SMS).

Knowledge of:

- K3.01 IMS (IP multimedia subsystems) and its architecture, including session control and switching plane; knowledge of different VAS in wireless domain
- K3.02 VoIP/IP-multimedia protocols
- K3.03 wireless service enablers evolution, including call processing architecture/framework, feature development/enhancement, as well as applications such as presence, location, etc. policy rules, decisions, charging and enforcement
- K3.04 location and positioning techniques
- K3.05 load balancing principles in the context of wireless communications, and methods to avoid single point of failure through active/active or active standby, and concept of self organizing networks (SON)
- K3.06 IP routing and mobile IP networking and addressing schemes including WLAN systems. IP evolution in wireless access - backhaul and packet core connectivity
- K3.07 error tracking and trace analysis techniques for dropped cells, access failures and other network related problem reports
- K3.08 circuit switched and packet switched data and packet cellular networks and the differences between them; knowledge of various data capable technologies - 1xRTT, EVDO, GPRS/EDGE, LTE
- K3.09 roaming and roaming controls
- K3.10 TCP/IP including transport protocols including WLAN systems
- K3.11 Access Point Name and its functionality
- K3.12 heterogeneous architecture for single-hop and multi-hop wireless networks

Area 4 – Network Management and Security

Tasks:

- T4.01 Design a fault monitoring system (examples might include using SNMP TRAP/NOTIFICATION, and using 2G OAM&P standards at Network Element Layer [NEL], Equipment Management Layer [EML], and Network Management Layer [NML]).
- T4.02 Design a performance monitoring system (examples might include using SNMP GET/SET and performance measurement on radio layer, BTS and RNC, usage and traffic analysis and accounting, monitoring SAACH frame error rate in 3GPP networks).
- T4.03 Develop/specify types and methods of alarm reporting for an installation, and other OAM&P.
- T4.04 Compute availability and reliability metrics from both the “network performance” and “system designer” perspectives (related to equipment failure).
- T4.05 Assess the potential impacts of known security attacks on wireless systems (examples might include virus, worm, DoS, network sniffing, flooding and impersonation; additional examples might include SIM/USIM card cloning, attempting bank transaction using prepaid cellular handsets, integrity of SMS, multi subscription of USIM card etc).
- T4.06 Plan corresponding solutions to known security attacks (examples might include stolen SIM card, stolen PIN, use of different handsets using the same SIM card etc).
- T4.07 Monitor, log, and audit security-related data (including tasks such as streaming system logs to third party box for analysis and reporting).
- T4.08 Analyze security vulnerabilities and prepare/recommend corrective actions; develop comprehensive test plan for network security testing.
- T4.09 Design and plan a migration to a new network management scheme (including impacts on OSS, BSS, and billing); design proper access levels (user management) and its implementation.
- T4.10 Analyze wireless accounting and billing schemes including inter-operator accounting.
- T4.11 Design and establish VPN communications from client to host.

Knowledge of:

- K4.01 quality of service (QoS) monitoring and control
- K4.02 fault management
- K4.03 configuration management including licensing mechanisms, feature addition/integration, system initialization and installation, policy-based management, role-base access control, level of security offered OTA by standard cellular and wireless systems, and architectures for service management
- K4.04 authentication, authorization, and accounting (AAA) principles and mechanisms and APN security; CAVE, A3/A8 and other authentication algorithms - separating mobile from subscription data; cellular authentication schemes based on HLR, VLR, SIM card
- K4.05 types of security attacks on wireless networks (examples might include use of stolen SIM card, fraudulent techniques to use handsets in non-designated areas)

- K4.06 protocols to secure wireless networks (examples might include Application Security, Web security and Secure Socket Layer, VPN, RADIUS, DIAMETER, HLR/VLR and encryption methods based on cellular algorithms), and Self Organizing/Optimizing networks for next generation networks
- K4.07 security-violation events logging and monitoring, attempts towards billing fraud, SIM card manipulation and detection, etc. and different security testing tools
- K4.08 security issue management and resolution (examples might include management of A-key, OTAP and HLR/VLR updates, monitoring handoff and reauthentication during call)
- K4.09 network management protocols (examples might include simple network management protocol [SNMP], network scanning for BTS identification, interface measurements, data quality measurements, video quality measurements, verification of test mobile phones, acquisition of calibration data for planning tools)
- K4.10 performance metrics pertinent to various access networks (examples might include Carrier to Interface (C/I) matrix; recommended changes to neighbor list to ensure appropriate cell handovers and others)
- K4.11 IP security, Encapsulation Security Payload (ESP), Internet Key Exchange, and digital signature; root authentication keys in removable UIM, Data Subscriber Authentication - DSA over the air interface
- K4.12 MIB, RMON, and Internet Control Messaging Protocol (ICMP)
- K4.13 intrusion detection systems, DDoS attacks, and traceback techniques; GSM security IMSI/TMSI, RAND, SRES-HLR and AuC checking methods, network controlled policies, on-line and off-line charging for pre-paid subscribers
- K4.14 operational process models (examples might include ITIL and eTOM); writing A-key into mobile – manual and over-the-air procedures
- K4.15 hot billing during call, hot billing after call, and similar cases
- K4.16 OTAP (Over the air provisioning methods), USIM (Universal SIM) card architecture, Kasumi security algorithm
- K4.17 mobile money transaction methods, near-field communications and security

Area 5 – Facilities Infrastructure

Tasks:

- T5.01 Determine the power consumption of a unit of communications equipment (examples might include tower amplifier modules, pressurization systems for waveguides).
- T5.02 Determine the power consumption for a facility containing communications equipment (examples might include base station amplifier racks, microwave system rack etc.).
- T5.03 Design a DC power plant to support the facility for a given required reserve time.
- T5.04 Analyze the electrical protection requirements (includes grounding/earthing, bonding, shielding, and lightning protection) and design the electrical protection layout for a wireless telecommunications facility.

- T5.05 Design a wireless communication facility layout plan with considerations for heating, air conditioning, ventilation, and structural issues.
- T5.06 Determine the required antennas for the facility, including specification of the antenna system from RAN to Antenna. Identify and size common types of antenna, amplifiers, and cable for a given scenario.
- T5.07 Determine the required antenna positions on a structure (examples might include towers located in remote/extreme conditions such as mountain tops, arctic areas, etc.).
- T5.08 Design the waveguide/transmission line layout between the communications electronics and the antenna(s).
- T5.09 Coordinate with other users when implementing a communications system in a shared location.
- T5.10 Develop a specification for the required structure for a wireless base station facility based on the required antenna sizes and elevations above ground.
- T5.11 Determine the required cable, antennas, distributed antenna systems, and materials to implement an in-building wireless network.
- T5.12 Determine the required number of racks on which to mount the equipment and the rack layout and placement, taking into account the maintainability of the equipment.
- T5.13 Evaluate equipment compliance with industry standards, codes, and site requirements such as NEBS/ETSI specifications as well as ANSI, IEC, local/city regulations, right of way, and other applicable standards.
- T5.14 Design a site-specific alarm and surveillance system.

Knowledge of:

- K5.01 procedures to determine the power consumption of wireless communications equipment (examples might include satellite earth station facility, ship/small island based facility, etc.)
- K5.02 how to determine the power required to support a site (examples might include solar and wind based support for tower sites, considerations of bird nests, heated radome, etc.)
- K5.03 the application of AC and DC power systems (examples might include urban towers based on roof tops, tunnels and bridges)
- K5.04 the application of alternative energy sources to wireless communications facilities (examples might include use of solar, wind power, or bio-mass in rural areas)
- K5.05 heating, ventilation, and air conditioning (HVAC) requirements
- K5.06 equipment racks, rack mounting spaces, and related hardware
- K5.07 electrical protection (including grounding/earthing, bonding, shielding, and lightning protection)
- K5.08 basic waveguides and transmission lines (examples might include elliptical waveguides, multiple cables runs, pressurization and sealing of connectors, etc.)
- K5.09 tower specifications and standards (examples might include wind load calculation based on Effective Plate Area, alignment kits, and elevation angle measurements)
- K5.10 physical security requirements

- K5.11 alarm and surveillance systems
- K5.12 effects of environmental exposure (examples might include corrosion, temperature, and UV susceptibility)
- K5.13 NEBS/ETSI specifications as well as ANSI, IEC, and other applicable standards, codes, and other relevant site-specific requirements
- K5.14 where to find expertise in structural engineering, fire suppression, and other building systems

Area 6 – Agreements, Standards, Policies, and Regulations

Tasks:

- T6.01 Assess service and equipment quality and recommendations to standardization bodies for new requirements/features.
- T6.02 Prepare specifications for purchasing services and equipment, and evaluate the responses, including relevant country-specific standards (examples might include preparing request for proposals for introducing new services/licenses and evaluating submitted proposals for implementation of universal services projects).
- T6.03 Verify compliance with regulatory requirements (examples might include licensing, standards, rules, and regulations).
- T6.04 Select and analyze frequency assignments.
- T6.05 Perform standardized homologation tests as required by regulatory or standardization bodies.
- T6.06 Evaluate compliance with health, safety, and environmental requirements.
- T6.07 Perform conformance/interoperability analyses of systems and components, including self organizing and self optimizing networks for NGN.
- T6.08 Analyze the use of licensed vs. unlicensed spectrum.
- T6.09 Obtain and draft licenses and permits where required, including software, hardware, product licenses (open source, GNU, IP, patent laws), as well as dispute settlement.
- T6.10 Perform market analysis, study of market indicators, and pricing of telecom services.

Knowledge of:

- K6.01 regulatory requirements and telecom laws (examples might include international, national, and local); emerging standards and network evolution (examples might include convergence of networks, IMT-advanced); regulatory pillars (examples might include transparency, free competition) and mandates (examples might include consumer protection, universal service); international organizations and corresponding structure and functions (examples might include the role of ITU and its subdivisions)
- K6.02 spectrum licensing (examples might include leasing options, primary and secondary assignments in license)

- K6.03 spectrum characteristics, availability, and management including formal methods of measurements to report non-compliance to regulatory bodies
- K6.04 local and site-specific rules/codes (examples might include the National Electric Code in the US and analogous codes in other countries) and engineering regulations (examples might include when engineering work needs to be sealed by a Professional Engineer)
- K6.05 electrical and RF safety (examples might include UL, EC, CSA, and IEEE C.95)
- K6.06 frequency assignment databases and online tools (examples might include verification of registered users in the area, experimental bands and their usages)
- K6.07 modulation anomalies (examples might include cross modulation, modulation products, harmonics, and quantization impact)
- K6.08 health, safety, and environmental issues (examples for RF safety might include SAR limits for different countries [e.g., American limits vs. European limits for accepted SAR-values] and their different ways to measure it)
- K6.09 equipment type approval processes/requirements
- K6.10 how to identify and locate appropriate industry technical standards, applicable codes, and other pertinent requirements
- K6.11 cost calculation models

Area 7 – Fundamental Knowledge

Knowledge related to electrical engineering

- K7.1 fundamental AC/DC circuit analysis
- K7.2 mathematics including linear algebra, probability, statistics, and Boolean arithmetic
- K7.3 operation of complex test instruments, including oscilloscopes, spectrum analyzers, network analyzers, TDRs, and signal generators
- K7.4 frequency spectrum and Fourier transforms
- K7.5 basic printed circuit board design considerations
- K7.6 transmission theory and lines, antennas, and basic electromagnetic wave theory and applications
- K7.7 power calculations (examples might include dB, dBm, and dBx)
- K7.8 basic concepts of queuing theory and traffic analysis
- K7.9 basic signal processing (examples: analog and digital processing; quantization; linear filtering theory, concepts, and design)
- K7.10 basic concepts related to optical communications
- K7.11 basic electronic system-level block diagrams
- K7.12 basic power supply design

Knowledge related to communication systems

- K7.13 basic communications and information theory (analog and digital)
- K7.14 basic telephony (including signaling, switching, and transmission)
- K7.15 noise impairments
- K7.16 basic EMI, EMC, and interference
- K7.17 frequency allocations and reuse
- K7.18 modulation techniques for analog (examples might include AM, FM, and PM)
- K7.19 modulation techniques for digital (examples might include FSK, PSK, and QAM)
- K7.20 wireless multiple-access schemes (examples might include FDMA, TDMA, CDMA, and variants)
- K7.21 basic satellite communications
- K7.22 digital data transmission formats (examples might include E1/T1 and OC-n/SDH)
- K7.23 basic components of RF circuitry
- K7.24 basic RF circuit design, including filter design
- K7.25 basic RF coupling, radiation, and antenna theory concepts
- K7.26 measurements for RF circuits and sub systems, such as output power, receiver sensitivity, noise figure, linearity performance, and spectral performance

Knowledge of general engineering management:

- K7.27 project management methods and processes
- K7.28 fundamental engineering economics
- K7.29 design and configuration for ease of maintenance
- K7.30 documentation and configuration control schemes
- K7.31 IEEE Code of Ethics