The following is a listing of each topic considered necessary in the education of workers performing installation, maintenance and repair of mobile and fixed radio communications systems. Also included are topics on additional frequencies used in telecommunications field, wireless industry best practices, and digital communication technologies. There are 22 general categories. This COMPETENCY listing is the identification of each individual subject in which the technician must be knowledgeable and skilled.

Technicians seeking the Wireless Communications Electronics Technician as a Certified Electronics Technician specialty are also required to have a basic education in fundamental electronics. That basic knowledge is assessed in the Associate CET examination (or the GCT1 examination). The Wireless Communications (WCM) serves as a journeyman option for the Associate CET (or the GCT1).

1.0 RADIO THEORY
1.1 Describe electromagnetic transmission and reception theory
1.2 List common radio frequency bands
1.3 Identify the basic block diagram sections of a radio transmitter and a receiver
1.4 Define bandwidth in terms of the FCC’s requirements for various private, commercial and public safety frequency allocations
1.5 List the functions of receiver stages
1.6 Describe frequency tuning or channel switching methods
1.7 Explain what propagation can be expected in the various bands

2.0 COMPONENTS, TERMINOLOGY AND SYMBOLS
2.1 Identify the components below, their symbols and usages:
   2.1.1 Microphones and speakers
   2.1.2 Rotary encoders
   2.1.3 Inductance, Reactance and Capacitance
   2.1.4 Transistors
   2.1.5 Integrated Circuits
   2.1.6 Special IC circuits
   2.1.7 Relays and thyristor switches
   2.1.8 Motors and generators
   2.1.9 Fuses & circuit breakers
   2.1.10 Batteries
   2.1.11 Power supply components
   2.1.12 Softpots
   2.1.13 Common types of electronic displays

3.0 SATELLITE – DATA – TELECOMMUNICATIONS
3.1 Explain the applications pertaining to two-way radio for the following:
   3.1.1 Satellite
   3.1.2 GPS (Global Positioning System)
   3.1.3 High speed telephone
   3.1.4 Telecommunications
3.2 List potential interference to or from items listed above in 3.1

4.0 MOBILE SYSTEMS
4.1 Describe basic simplex operation
4.2 Explain how mobile relay – simplex/duplex works
4.3 Compare remote control and manual control systems
4.4 Define RF link and explain its purpose
4.5 List common RF transmission band assignments or allotments pertinent to commercial and private radio communications
4.6 List competing services encountered by radio workers
4.7 List common frequencies and bands used for Public Safety services
4.8 Explain paging systems communications
4.9 Describe trunking (single/multi-site)
4.10 Compare conventional single and multi-site communications systems
4.11 Define simulcast systems and list their purposes
4.12 Define satellite voting systems and show how they are used
4.13 Compare wireless data systems with two-way voice communications
4.14 Describe CTCSS (Continuous Tone Coded Squelch System) squelch operation
4.15 Define and list how DCSS (Digitally Coded Squelch Signaling) is used
4.16 Explain the differences between point-to-point and point-to-multipoint transmissions
4.17 Describe the function of a repeater

5.0 COMMERCIAL RADIO NETWORKS
5.1 Describe the operational characteristics of two-way radio communications systems
5.2 List technical characteristics of working communications systems
5.3 Explain programming characteristics of system receivers and transmitters
5.4 Describe the concepts used in trunking radio systems

6.0 BLOCK DIAGRAMS – SCHEMATICS - FLOW CHARTS
6.1 Identify diagram symbols used in communications radio service
6.2 Explain how to trace power and signal paths in a radio receiver and transmitter
6.3 Describe the purpose of and be able to locate schematic test points
6.4 Estimate normal signals and voltages expected at schematic locations
6.5 Describe the purpose of flow charts

7.0 BASIC ANALOG CIRCUITS
7.1 Describe basic AC and DC radio power supplies
7.2 Explain the function of different types of amplifiers including RF and IF stages
7.3 Identify a basic audio amplifier circuit
7.4 Compare AM and FM audio detectors
7.5 Explain AVC (Automatic Volume Control) and AGC (Automatic Gain Control) circuits and their operation
7.6 Explain how various modulators are used in transmitters
7.7 Explain what each of the components of a transmitter power output circuit does
7.8 Identify the circuit for an operational amplifier and explain its operation
7.9 Define gain and explain how it is measured
7.10 Define bi-directional amplifier and explain where they are used
7.11 Explain the purpose and concept of PLL (phase locked loop) and VCO (voltage controlled oscillator) circuits

8.0 HAND TOOLS AND SOLDERING
8.1 Identify soldering tools and accessories
8.2 List proper equipment care routines
8.3 Identify the proper soldering sequence
8.4 Visually identify proper and improper soldering techniques
8.5 Identify the proper desoldering sequence
8.6 Identify the qualities of a good solder joint
8.7 Know the differences between available solder alloys
8.8 Describe flux and explain its purposes
8.9 Describe cold – defective solder joints and list reasons they occur
8.10 Describe methods of replacing surface mount components
8.11 Describe wire wrap reconnection precautions
8.12 Explain how hot air bonding equipment is used
8.13 Define RoHS (Restriction of Hazardous Substances) and explain its purpose
8.14 Describe various solder leads (gull wing, j-leads, ball grid array)
9.0 COMPUTER AND DIGITAL CIRCUITS
9.1 Identify the symbols for digital gates and their truth tables
9.2 Compare common memory devices used in radio communications
9.3 Explain how tuning is accomplished in radio receivers and transmitters
9.4 Describe how microprocessor controls are used in radio
9.5 Compare RAM (Random Access Memory), PROM (Programmable Read Only Memory), EEPROM (Electronically Erased Programmable Read Only Memory), ROM (Read Only Memory)
9.6 Describe how DACs (Digital to Analog Converter) and ADCs (Analog to Digital Converter) are used
9.7 Define modems and explain their purposes
9.8 List the types of drivers used in Wireless Communication applications
9.9 Describe TTL (Transistor - Transistor Logic) and CMOS (Complementary Metal Oxide Semiconductor) outputs

10.0 COMPUTER APPLICATIONS
10.1 Describe the use of the following in Wireless Communications applications:
   10.1.1 Word processing reports, databases, spreadsheets
   10.1.2 Internet
   10.1.3 Parts, literature, product information/ordering via Internet
   10.1.4 Explain how to access troubleshooting and diagnostics software
   10.1.5 Virus eradication systems
   10.1.6 Diagnostic programs
   10.1.7 Utility programs
   10.1.8 Laptop/Tablet with Com port, null modem, terminal software
   10.1.9 RS232 and USB interfacing
   10.1.10 Codeplug, Firmware, Flashcode

11.0 INTERFACING
11.1 List expected signal levels into or out of interconnected products used in radio work
11.2 Define impedance matching and explain impedance mismatch
11.3 Describe the various numbering systems used in two-way radio technology

12.0 TRANSMISSION LINES, CABBING AND CONNECTORS
12.1 Describe coaxial cable characteristics
12.2 Explain proper installation of coaxial connectors, jacks, plugs, describing crimping and prepping
12.3 Explain cable routing, bend ratios, pulling tension and building cabling regulations
12.4 Explain the purpose & theory of transmission line testing
12.5 Describe the functions of test equipment used in transmission line testing
12.6 Compare proper and improper impedance matching principles
12.7 Define ground loop and name common causes and effects
12.8 Define balanced/unbalanced pairs
12.9 Explain line loss for different types of cabling
12.10 Explain the importance of proper cable termination
12.11 Explain the principles used in Frequency Domain Reflectometry (FDR)
12.12 Compare Time Domain Reflectometry with FDR
12.13 Identify type-N, UHF, Mini UHF, BNC, TNC, SMA, and 7/16 DIN connectors

13.0 ANTENNAS AND TOWERS
13.1 Explain wave propagation and its relative speed in air or cabling
13.2 Describe reception theory and mobile antennas
13.3 Identify polar patterns for different types of antennas
13.4 Describe cross polarization
13.5 Define antenna gain and explain why it is important
13.6 Describe hand-held transceiver antennas
13.7 Explain the circuits for antenna combining networks
13.8 Explain how diplexers and duplexers are used
13.9 Define cavities, circulators and isolators and show where they are used
13.10 Explain the purpose and methods of grounding communications products
13.11 Explain lightning protection devices
13.12 Explain Beam tilt
13.13 Describe base station antennas  
13.14 Define receiver multi-coupling  
13.15 List radio tower components and installation practices  
13.16 Explain proper documentation in transmission sites  
13.17 Explain tower top amplifiers, their usage, testing for functionality, benefits and disadvantages  
13.18 Describe when and why attenuators are used

### 14.0 GROUNDING – LIGHTNING PROTECTION

14.1 Describe antenna grounding conventions  
14.2 Describe grounding standards for a communications facility  
14.3 Describe the concept of a common grounding electrode system and identify National Electrical Code (NEC®) requirements as related to a communications facility  
14.4 Name NEC lightning protection rules articles  
14.5 List proper bonding and grounding practices  
14.6 Define grounding blocks and explain how rods and proper wire sizes are used  
14.7 Explain how equipment protection is enhanced with the use of: Transient Voltage Surge Suppressors, (MOV’s [metal oxide varistors] and SADs[Silicon Avalanche Diodes]), also known as Surge Protection Devices (SPD)  
14.8 Identify exothermic welding methods

### 15.0 RADIO MATHEMATICS AND FORMULAS

15.1 Convert dB (decibel) readings to dBmV and microvolt levels  
15.2 Explain and compare dBi, dBm, dBW, dBd terminology  
15.3 Describe proper uses for scientific calculators  
15.4 List numbering systems commonly used in technician work (powers of 10, binary addition and subtraction, octal, hexadecimal)  
15.5 Convert frequency to wavelength and vice-versa  
15.6 Calculate the Effective Radiated Power (ERP) of a system given input and component losses or gains  
15.7 Calculate Effective Isotropic Radiated Power (EIRP)  
15.8 Calculate the free-space path loss of a given RF signal for a given distance

### 16.0 MODULATIONS SCHEMES

16.1 Describe AM (Amplitude Modulation) methods and limits  
16.2 Describe FM (Frequency Modulation) methods and deviation limits  
16.3 Describe companding  
16.4 Describe pre-emphasis/de-emphasis and what purpose it serves  
16.5 Explain the principles and advantages of SSB (Single Side Band)  
16.6 Define TDMA (Time Division Multiple Access) and describe the concept  
16.7 Compare CDMA (Code Division Multiple Access) with TDMA and FDMA modulation schemes  
16.8 Define and describe QPSK (Quadrature Phase Shift Keying) and OQPSK (Offset Quadrature Phase Shift Keying)  
16.9 Describe Digital Modulation techniques including the APCO (Association of Public Safety and Communications Officials) Project 25 standard  
16.10 Describe the common types of encryption and algorithms used in two-way communications  
16.11 Explain keyloading  
16.12 Define GSM (Global System for Mobile Communications)

### 17.0 CONTROL SYSTEMS

17.1 Describe how DC remote control systems operate  
17.2 Explain the functions of a remote and a remote adapter  
17.3 List typical frequencies, currents and voltages used in a DC system to key a transmitter, change frequencies, and engage the monitor functions  
17.4 Describe how tone remote control systems operate  
17.5 Explain the differences between High Level Guard Tone and Low Level Guard Tone  
17.6 Explain the advantages of a tone control system over a DC control system  
17.7 Define DTMF (Dual Tone Multi Frequency) and name an application where it is used  
17.8 Define SCADA (Supervisory Control and Data Acquisition) and explain where it is used  
17.9 Describe the use of IP remote control
18.0 RF INTERFERENCE
18.1 Define receiver de-sensitization (de-sense) and explain the causes
18.2 List reasons for spurious emissions and receiver response
18.3 Explain site compatibility and reasons for site incompatibility
18.4 Describe co and adjacent-channel interference
18.5 Explain Image Frequency
18.6 Explain transmitter noise
18.7 Define Noise Floor
18.8 Explain Harmonics and Sub-Harmonics
18.9 Define BPL (Broadband over Power Line) interference
18.10 Describe natural noises that can affect radio communication
18.11 Explain wind generated static electricity
18.12 List interference detection methods
18.13 Define inter-modulation and list causes
18.14 Describe minimum filtering and techniques that should be applied at a communications site to help minimize interference
18.15 Describe Passive Intermodulation (PIM)

19.0 RF COVERAGE ANALYSIS, TESTING AND DIAGNOSIS
19.1 Describe RF coverage modeling as defined in the Telecommunications Industry Association (TIA) technical service bulletin 88 (TSB 88)
19.2 Describe service area
19.3 Describe Reliability
19.4 Describe how different portable configurations impact system coverage (i.e., type of antenna, use of speaker-microphone)
19.5 Describe a balanced coverage design
19.6 Describe RF coverage modeling verification as defined in the TIA TSB 88
19.7 Describe the distortion pattern of a radio signal caused in a side mounted antenna
19.8 Identify common obstructions

20.0 TEST EQUIPMENT AND MEASUREMENTS
20.1 Explain the functions of a Communications Service Analyzer
20.2 Describe how the TDR (Time Domain Reflectometer), OTDR (Optical Time Domain Reflectometer) and FDR (Frequency Domain Reflectometer) are used
20.3 Define SWR (Standing Wave Ratio) and show how SWR and watt meters are used
20.4 Define return loss and insertion or cable loss and explain the difference
20.5 Compare S/N and C/N
20.6 Describe how dummy loads, DMMs (Digital Multimeters), logic probes, pulsers, and signal generators are used
20.7 Explain SINAD/AC voltmeter/distortion analyzers and audio generators usage
20.8 Describe how spectrum analyzers are used
20.9 Identify common RF test cables and converters used in 2-way communications
20.10 Describe how variable power supplies are used in service technician work
20.11 Explain how to perform power measurements
20.12 Describe how to use frequency and modulation measurement equipment

21.0 TROUBLESHOOTING
21.1 Describe techniques for localizing circuitry defects in communications equipment
21.2 Explain how to use block diagrams and test points
21.3 Explain how to use heat or cold to locate intermittent circuitry problems
21.4 Compare PC board and surface mount component replacement techniques
21.5 Define signal overdrive and explain its causes and effects

22.0 WORKPLACE SAFETY FOR RADIO ENVIRONMENT
22.1 List the general topics contained in CFR 47 Part 15 (Code of Federal Regulations) pertaining to two-way communications
22.2 Explain basic FCC (Federal Communications Commission) rules pertaining to two-way communications
22.3 List licenses required for radio stations and technicians
22.4 List FAA (Federal Aviation Administration) rules pertaining to communications systems
22.5 List OSHA rules for contractors working on antennas/towers, heights, ladders, including fall safety and portable Ladder Safety according to ANSI 14
22.6 List NEC® provisions applicable to radio, antenna, and cabling workers
22.7 Explain work environment concerns for technicians
22.8 List fire potentials for electronics technicians in the work environment
22.9 Describe ground faults and devices used to preclude shock hazards
22.10 Define ESD (Electrostatic Discharge)
22.11 Describe safety precautions when handling fiber optic cabling
22.12 List electrical shock potential to electronics workers
22.13 Describe transmitter RF (Radio Frequency) exposure hazards
22.14 Explain RF monitoring and its purpose
22.15 List Beryllium hazards
22.16 Define First Aid and explain precautions uncertified workers should observe

End of Wireless Communications Competencies Listing
(with 22 major Categories)

Notes: Certain of the above items will appear redundant, having been addressed in more than one CATEGORY. Also, some of the Competencies above may well have been included in the BASIC or Associate level training and certification skills standards and examination. In most cases these redundant items may need only slight revisiting of the topic, a different view of the topic. However, they are included more than once so that there is assurance that their application in each category is addressed.

This competencies listing is compiled to serve two purposes:
1. To provide educational institutions and Industry with the material they need to construct an outline for any course of instruction in wireless communications for students or employees.
2. To provide an outline for those studying to sit for the Wireless Communications or FCC GROL exams as a guide to the knowledge and skills they will need.

Suggested Additional Resource and Study Material:

WEBSITES:  eta-i.org; edmssa.org; glms.com; fcc.gov; nfpa.org; motorolasolutions.com; c-csc.org; enterprisewireless.org; urgentcomm.com; iweceexpo.com; missioncriticalmagazine.com; rcrwireless.com; and many others…

-Available through ETA at 800-288-3824 or online at http://www.eta-i.org/
General Communications Technician, Level 1, 2Ed.; Ira Wiesenfeld, P.E., CETsr, Rob Walker, LAS, PIM, Jay Thompson, CETsr, A.J. Wiesenfeld, BSEE, LAS; ISBN 978-0-9915913-5-0; Self Published; 2015; softcover. Contact ETA® International at 800-288-3824 or eta@eta-i.org
General Communications Technician, Level 2; Ira Wiesenfeld, P.E., CETsr, Rob Walker, LAS, PIM, Jay Thompson, CETsr, A.J. Wiesenfeld, BSEE, LAS; ISBN 978-0-9915913-3-6; Self Published; 2015; softcover. Contact ETA® International at 800-288-3824 or eta@eta-i.org
The Associate CET Study Guide, 6E; ISBN 1-891749-07-2; ETA International; 2012; —Available through ETA at 800-288-3824, $60
Wiring For Wireless Sites; Wiesenfeld; ISBN 978-1401810375; Prompt, 2002;
-Available through ETA at 800-288-3824 or online at http://www.eta-i.org/
Electronic Communications for Technicians, 2E; Wheeler; ISBN 978-0131130494; Prentice Hall, 2005
New HAM Radio License? Now What?; James Sanders, AG6IF; Kindle Edition; Amazon; 2014

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