Wireless Technologies in Power System Operations

1. IEEE P1777: Questionnaire on Actual or Potential Uses of Wireless Technolog...

The IEEE PES Power System Communications (PSCC) and Substations Committees are establishing a joint Working Group and PAR (P1777) to assess how and where wireless data communications could be used in power system operations, covering T&D substations equipment, distribution field equipment, protection, maintenance, large power plants, distributed power plants, customer metering, and any other equipment used in power system operations.

We would greatly appreciate power system engineers and other operations people filling out the following brief set of questions on existing or new applications for which wireless communications might be beneficial, covering:

- Brief contact information
- Identification of the wireless application you are describing (you may fill out the questionnaire multiple times, once for each wireless application)
- Brief description of the wireless application, including whether it has been implemented, planned, or hypothetical
- Characteristics of the wireless application
- Possible benefits which could be gained from wireless communications
- Possible concerns about using wireless communications, including time-sensitivity, performance, configuration, mobility, time between servicing, security, and other quality of service requirements

2. Scope and Focus of IEEE PES P1777 Wireless Working Group

PAR Title: P1777: Recommended Practices for Using Wireless Data Communications in Power System Operations These Recommended Practices describe and make recommendations on the functional, performance, security, and on-site testing issues related to using wireless data communication technologies in different aspects of power system operations, including within electric power substations, in underground vaults, along transmission and distribution circuits, within generation and distributed generation plants, for customer electrical and metering equipment, and other electric power environments. We recognize that "Wireless Technologies" cover both the existing wireless media, such as microwave, MAS radio, spread-spectrum radio, VSAT satellite systems, and proprietary radio-based systems, as well as the newer IEEE 802.x and cellphone wireless data communication technologies. Therefore, we welcome responses to the Wireless Questionnaire on these existing technologies as well as the newer technologies such as: 1. WiFi: WiFi, the most popular wireless standard for networking computer systems, has the following basic characteristics: – Multi-user configuration – IEEE 802.11b data rate is 11Mbps – IEEE 802.11g data rate is 54Mbps – Frequency band is the 2.4Ghz band – Range of 100-150 feet – Equipment and WiFi systems/access points are usually privately owned 2. Bluetooth is used in cellphones, Personal Digital Assistants (PDAs), and other mobile wireless devices, primarily for communicating with computers, Intelligent Electronic Devices (IEDs), headsets, hands-free systems, and other gadgets. – Point-to-point links – Very short range of only 33 feet (approx 10m) – Frequency band is the 2.4Ghz band. – Relatively low data rate of 1.5Mbps – Equipment and Bluetooth systems are privately owned 3. Zigbee, based on IEEE 802.15.4, defines low-rate, very low duty cycle, wireless personal area networks often termed “meshed networks” as opposed to point-to-point. ZigBee builds upon this 802.15.4 standard to define application profiles that can be shared among different manufacturers to provide system-to-system interoperability. This effort is still a work in progress, although of great interest to industries (such as the power industry) that have extensive sensor networks. – Multi-user configuration – Range between devices is 30-300 feet. – Low data rate of <250 kbps – High availability due to meshed network configuration – Equipment and Zigbee systems are usually privately owned 4. WiMax (IEEE 802.16) wireless technologies has a primary focus of enabling a wireless alternative for cable, DSL, and T1 communication channels for consumer last-mile access to the Internet, including high-speed data, Voice over IP (VoIP), Video on Demand (VoD), and backhaul for IEEE 802.11 LANs. WiMax addresses the "first-mile/last-mile" connection for longer distances and faster rates. – Multi-user configuration – Range of 5 to 30 miles (5 more likely) – Data rates of (45-75 Mbps – Not clear if WiMax systems would be publicly or privately owned 5. Cellphone data standards, GPRS, is part of GSM effort to create a common European mobile telephone standard for a pan-European mobile cellular radio system (and now worldwide). The resulting mobile telephone standard allows cellphone users to “roam” across many cellphone systems and between most countries world-wide. New generations of cellphone technologies, termed 2.5G, 3G, and 4G are deployed in certain countries or are still under development. – Multi-user configuration – GPRS commonly used for data, with 30-80 kbps typical. – EDGE (enhancement to GPRS) provides 160-236 kbps – The range is wherever cellphone coverage is available! – Cellphone systems are owned by telecommunication providers

3. Background information

Names, companies, and contact information will remain private when we publish the results of the surveys, but we would appreciate either an email address or a phone number so that we may clarify answers or explore ideas.

1. Names, companies, and contact information will remain private when we publish the results of the surveys, but we would appreciate either an email address or a phone number so that we may clarify answers or explore ideas.

Your name

Your company

Your job description or department

Your email address (optional)

Your phone number (optional)

3. What is the focus of your company or work, with respect to wireless technologies?

- Utility, looking to use wireless technologies
- Vendor, directly providing wireless technologies
- Vendor, using wireless technologies as possible communications for products
- Consultant, addressing possible uses of wireless technologies
- Other (please specify)

4. Types of Applications

Below are a list of possible types of applications that could benefit from wireless technologies. For each application, select the type that most closely fits (or select “Other” for a more general set of questions). You will be able to come back here to this page for each wireless application you would like to describe.

1. What is the status of the wireless application you are describing?

- Complete implementation or mature product
- Partial or on-going implementation or immature product
- Pilot implementation or prototype product
- Planned for near-term implementation or development
- Planned for future implementation or development
- Theoretical implementation or product
- Other (please specify)

2. Select the type of application with which you might use wireless technologies (the asterisk means you must answer this question)

- Condition monitoring within substations, generating plants, and other electrical sites
- SCADA monitoring and control within substations, generating plants, and other electric sites
- Condition monitoring along transmission and feeder circuits
- Local communications between feeder equipment such as automated switching
- SCADA monitoring and control along feeder circuits
- Maintenance monitoring and assessment of primary and secondary equipment in substations, plants, along T&D circuits, in vaults, and at customer sites
- Engineering interactions to determine status, update settings, acquire archival information
- Mobile data communications for data acquisition and control from outside substation or vault sites

- [ ] Temporary installations for construction, calibration, repairing power systems, testing systems, or upgrading primary or secondary equipment
- [ ] Emergency applications to restore failed or inadequate communications
- [ ] Metering, outage detection, connect/disconnect at customer sites
- [ ] Generic application (if no other choice fits)
- [ ] Other (please specify)

5. Condition monitoring with substations, generating plants, and other power e...

1. Briefly describe the application, e.g. "Monitoring temperature, pressure, and vibration of HV transformers" or "Acoustic monitoring of arcs inside gas-insulated busbars", or "Vibration monitoring of turbines"

2. Where is the location of the wireless system?

- [ ] HV substation yard
- [ ] HV substation control house
- [ ] Distribution substation
- [ ] Distribution vault
- [ ] Generating plant
- [ ] Customer site
- [ ] Other (please specify)

3. For condition monitoring, what types and how many sensors are involved?

	<10	<30	<100	<300	<1000	>1000	N/A
Temperature sensors							
Pressure sensors							
SF6 leakage sensors							
Acoustic sensors							
Vibration sensors							
Wind speed sensors							
Humidity sensors							
Ice or snow weight/pressure sensors							
Voltage sensors							
Current sensors							
Frequency sensors							
Harmonics sensors							
Other (please specify)							

4. If "other sensor", please describe it

6. SCADA monitoring and control from substations, generating plants, etc to c...

SCADA systems collect power system data from equipment in substations, generating plants, and other sites, as well as issue control commands to equipment at these sites. The primary use is for power system operations, but other data can be collected as well.

1. Briefly describe the purpose of the SCADA application, e.g. SCADA for transmission operations, SCADA for distribution operations, etc.

2. What types of SCADA data is to be monitored?

- Power system data (voltage, current, breaker status, etc.)
- Generator non-power data (turbine speed, heat rate, etc.)
- Condition monitoring data (temperature, pressure, vibration, etc.)
- Harmonics data (fault voltage, current, etc.)
- Facilities data (security data, secondary equipment status, etc.)
- Other (please specify)

3. What types of SCADA data is to be controlled?

- Power system control (breakers, capacitor switches, LTCs, etc.)
- Generator control (raise/lower of governor, generation settings, etc.)

- Facilities control (doors, gates, secondary equipment control, etc.)
- Other (please specify)

7. Condition monitoring along transmission and feeder circuits

Condition monitoring can also be needed along transmission and/or feeder circuits. Given the lack of an enclosed area, and the often long distances, the requirements for wireless communications could be very different than for condition monitoring within enclosed areas.

1. Briefly describe the purpose of the application, e.g. "Monitoring ice buildup on transmission circuits" or "Temperature monitoring of feeder equipment"

2. Where is the location of the wireless system?

- Along transmission circuits
- Along overhead distribution feeders
- Along underground distribution feeders
- In a substation, but used for circuit monitoring
- In a vault, but used for underground circuit monitoring
- Other (please specify)

3. What types and how many sensors are involved per installation?

	<10	<30	<100	<300	<1000	>1000	N/A
Temperature sensors							
Pressure sensors							
Acoustic sensors							
Vibration sensors							
Wind speed sensors							
Humidity sensors							
Ice or snow weight/pressure sensors							
Voltage sensors							
Current sensors							
Frequency sensors							
Harmonics sensors							
Other (please specify)							

4. If "other sensor", please describe it

8. Local communications between feeder equipment such as automated switching

Communications between equipment on feeders can be used to support local automation.

1. Briefly describe the purpose of the application, e.g. "Local automated switching", or “Fault indication devices”

2. What types of equipment are involved?

- Automated switches
- Fault indicators
- Reclosers
- Capacitor bank switches
- Voltage regulators
- Power quality monitors
- Other (please specify)

3. What types of data are communicated between equipment?

- Status
- Power system data (voltage, vars, current, etc.)
- Settings information
- Protection information

- Power quality data
- Condition monitoring data
- Control commands (open/close, raise/lower, etc.)
- Other (please specify)

9. SCADA monitoring and control of equipment on distribution feeder circuits

SCADA systems collect power system data from equipment on distribution feeder circuits as well as issue control commands to equipment, including distributed generation (DG). The primary use may be for power system operations, but other data can be collected as well, for power quality assessment, maintenance, planning, etc.

1. What types of data is to be monitored?

- Power system data (voltage, current, breaker status, etc.)
- Condition monitoring data (temperature, pressure, vibration, etc.)
- Harmonics data (fault voltage, current, etc.)
- DG operational data (operating mode, status, kW/MW output, etc.)
- DG non-power data (fuel data, emissions, turbine speed, heat rate, etc.)
- Facilities data (security data, secondary equipment status, etc.)
- Other (please specify)

2. What types of data is to be controlled?

- Power system control (breakers, capacitor switches, LTCs, etc.)
- DG control (raise/lower of governor, generation settings, etc.)
- Facilities control (doors, gates, secondary equipment control, etc.)
- Other (please specify)

10. Maintenance monitoring and assessment of primary and secondary equipment in...

Maintenance monitoring and assessment of primary and secondary equipment in substations, power plants, along T&D circuits, in vaults, distributed generators, and at customer sites.

1. Briefly describe the purpose of the application, e.g. "Life-cycle assessment of circuit breakers", or “Transformer preventative maintenance”

2. Where would the maintenance monitoring be located?

- Generating plants
- Transmission substations
- Distribution substations
- Vaults
- Transmission lines
- Distribution circuits
- Distributed generation (DG) sites
- Customer sites
- Other (please specify)

3. What types of equipment are involved?

- Virtually all types (you can't define them all now)
- Generation prime mover equipment
- Generators
- Circuit breakers
- Transformers
- Load tap changers
- Switches
- Fault indicators
- Reclosers
- Capacitor bank switches
- Voltage regulators
- Power quality monitors
- Communications equipment
- Other (please specify)

4. What types of maintenance data is monitored?

- Virtually all types (you can't define them all now)
- Equipment status
- Power system data (voltage, vars, current, etc.)
- Historical data
- Settings information
- Power quality data
- Condition monitoring data
- Other (please specify)

5. What types of maintenance actions could be taken?

- Execute diagnostic routines
- Set maintenance parameters
- Other (please specify)

11. Engineering interactions to determine status, update settings, acquire arch...

Engineering interactions to monitor, assess, and update settings of equipment in substations, power plants, along T&D circuits, in vaults, distributed generators, and at customer sites.

1. Briefly describe the purpose of the application, e.g. "Update protective relay settings", or “Set DG operational actions for the next 24 hours”

2. Where would the equipment being monitored by engineering be located?

- Generating plants
- Transmission substations
- Distribution substations
- Vaults
- Transmission lines
- Distribution circuits
- Distributed generation (DG) sites

- Customer sites
- Other (please specify)

3. What types of equipment are involved?

- Virtually all types (you can’t define them all now)
- Generation prime mover equipment
- Generators
- Circuit breakers
- Transformers
- Load tap changers
- Switches
- Fault indicators
- Reclosers
- Capacitor bank switches
- Voltage regulators
- Power quality monitors
- Communications equipment
- Other (please specify)

4. What types of engineering data is monitored?

- Virtually all types (you can’t define them all now)
- Equipment status
- Power system data (voltage, vars, current, etc.)
- Historical data
- Settings information

- Power quality data
- Condition monitoring data
- Other (please specify)

5. What types of engineering data is controlled/set?

- Virtually all types (you can't define them all now)
- Protection settings
- Operational settings, such as voltage levels for LTC actions
- Communication data reporting settings, such as data sets, deadbands, alarm limits, etc.
- Loss-of-communications settings, to act as defaults if communications are lost
- Other (please specify)

12. Mobile data communications for data acquisition and control outside substat...

Mobile data communications can be used by field crews to access data and issue controls from outside substations, vaults, and/or DG installations.

1. Briefly describe the purpose of the application, e.g. "Monitor safety status in vaults", or “Perform maintenance activities from outside substation”, or “Retrieve power quality data from a DG site”.

2. Where would the equipment be located?

- Transmission substations
- Distribution substations
- Vaults
- Distributed generation (DG) sites
- Other (please specify)

3. What types of equipment are involved?

- Virtually all types (you can’t define them all now)
- Generation prime mover equipment
- Generators
- DG equipment
- Circuit breakers

- Transformers
- Load tap changers
- Switches
- Fault indicators
- Reclosers
- Capacitor bank switches
- Voltage regulators
- Power quality monitors
- Communications equipment
- Other (please specify)

4. What types of data are monitored?

- Virtually all types (you can't define them all now)
- Equipment status
- Power system data (voltage, vars, current, etc.)
- Historical data
- Settings information
- Power quality data
- Condition monitoring data
- Other (please specify)

5. What types of data are controlled/set?

- Virtually all types (you can't define them all now)
- Protection settings
- Operational settings, such as voltage levels for LTC actions

- Communication data reporting settings, such as data sets, deadbands, alarm limits, etc.
- Loss-of-communications settings, to act as defaults if communications are lost
- Other (please specify)

13. Temporary installations for construction, calibration, repairing power syst...

Temporary installations for construction, calibration, repairing power systems, testing systems, or upgrading primary or secondary equipment.

1. Briefly describe the purpose of the application, e.g. "Monitoring data during construction", or “Temporary siting of DG”.

2. Where would the equipment be located?

- Transmission substations
- Distribution substations
- Vaults
- Distributed generation (DG) sites
- Transmission lines
- Distribution circuits
- Customer sites
- Other (please specify)

3. What types of equipment are involved?

- Virtually any types (you can't define them all now)
- Generation prime mover equipment
- Generators
- DG equipment
- Circuit breakers
- Transformers
- Load tap changers
- Switches
- Fault indicators
- Reclosers
- Capacitor bank switches
- Voltage regulators
- Power quality monitors
- Communications equipment
- Other (please specify)

4. What types of data are monitored?

- Virtually any types (you can't define them all now)
- Equipment status
- Power system data (voltage, vars, current, etc.)
- Historical data
- Settings information
- Power quality data
- Condition monitoring data
- Other (please specify)

5. What types of data are controlled/set?

- Virtually any types (you can't define them all now)
- Protection settings
- Operational settings, such as voltage levels for LTC actions
- Communication data reporting settings, such as data sets, deadbands, alarm limits, etc.
- Loss-of-communications settings, to act as defaults if communications are lost
- Other (please specify)

14. Emergency applications to restore failed or inadequate communications

Emergency applications often require communications to be moved quickly to a site where the existing communications have failed.

1. Briefly describe the purpose of the application, e.g. "Emergency communications for a substation ", or "Emergency communications as backup during storm".

2. Where would the equipment be located?

- Any location
- Transmission substations
- Distribution substations

- Vaults
- Distributed generation (DG) sites
- Transmission lines
- Distribution circuits
- Customer sites
- Other (please specify)

3. What types of equipment are involved?

- Virtually any types (you can’t define them all now)
- Generation prime mover equipment
- Generators
- DG equipment
- Circuit breakers
- Transformers
- Load tap changers
- Switches
- Fault indicators
- Reclosers
- Capacitor bank switches
- Voltage regulators
- Power quality monitors
- Communications equipment
- Other (please specify)

4. What types of data are monitored?

- Virtually any types (you can't define them all now)
- Equipment status
- Power system data (voltage, vars, current, etc.)
- Historical data
- Settings information
- Power quality data
- Condition monitoring data
- Other (please specify)

5. What types of data are controlled/set?

- Virtually any types (you can't define them all now)
- Protection settings
- Operational settings, such as voltage levels for LTC actions
- Communication data reporting settings, such as data sets, deadbands, alarm limits, etc.
- Loss-of-communications settings, to act as defaults if communications are lost
- Other (please specify)

15. AMI – metering, outage detection, connect/disconnect at customer sites

Automatic Metering Infrastructures (AMI) could include wireless communications to or at the customer sites, to access metering data, outage detection, tamper detection, connect/disconnect, energy usage, billing information, thermostat monitoring and control, access to building management system, access to customer distributed generation, demand response, and many other functions.

1. Briefly describe the purpose of the application, e.g. "Communications between Broadband Power Line (BPL) and the customer meter", or “Communications for electric, water, and gas meters”.

2. Where would the equipment be located?

- Industrial customer site
- Commercial customer site
- Residential customer site
- Distributed generation (DG) sites
- Other (please specify)

3. What types of equipment are involved?

- Virtually any types (you can’t define them all now)
- Electric meters
- Gas meters
- Water meters
- “Customer gateway”

- Thermostat
- Building management system
- Distributed generation system
- Demand response system
- Other (please specify)

4. What types of data are monitored?

- Virtually any types (you can't define them all now)
- Metering data
- Equipment status
- Power system data (voltage, vars, current, etc.)
- Thermostat settings information
- Distributed generation data
- Demand response status (price, level, time, etc.)
- Power quality data
- Other (please specify)

5. What types of data are controlled/set?

- Virtually any types (you can't define them all now)
- Thermostat settings
- Distributed generation settings
- Demand response settings (price, level, time, etc.)
- Other (please specify)

16. Generic or other applications not covered elsewhere

If none of the categories fit your application, please answer the following generic questions.

1. Briefly describe the purpose of the application.

2. Where would the equipment be located?

- Power plants
- Transmission substations
- Distribution substations
- Vaults
- Distributed generation (DG) sites
- Transmission lines
- Distribution circuits
- Customer sites
- Field location
- Control center location
- Other (please specify)

3. What types of equipment are involved?

- Virtually any types (you can’t define them all now)

- Generation prime mover equipment
- Generators
- DG equipment
- Circuit breakers
- Transformers
- Load tap changers
- Switches
- Fault indicators
- Reclosers
- Capacitor bank switches
- Voltage regulators
- Power quality monitors
- Communications equipment
- Other (please specify)

4. What types of data are monitored?

- Virtually any types (you can't define them all now)
- Equipment status
- Power system data (voltage, vars, current, etc.)
- Historical data
- Settings information
- Power quality data
- Condition monitoring data
- Other (please specify)

5. What types of data are controlled/set?

- Virtually any types (you can't define them all now)
- Protection settings
- Operational settings, such as voltage levels for LTC actions
- Communication data reporting settings, such as data sets, deadbands, alarm limits, etc.
- Loss-of-communications settings, to act as defaults if communications are lost
- Other (please specify)

17. Wireless communications configuration

For the application you are describing, please describe the wireless communications configuration that you might expect to use (or are using).

1. What wireless technology (one or more) might you, or did you, use?

- WiFi (multi-user, 100-150 foot range, 54 Mbps) (IEEE 802.11x)
- Bluetooth (point-to-point, 30+ foot range, 1.5 Mbps) (IEEE 802.15.1-based)
- Zigbee (meshed network, 30-300 foot range, <250 kbps) (IEEE 802.15.4-based)
- WiMax (multi-user, 5-30 mile range, 45-75 Mbps) (IEEE 802.16-based)
- Cellular phone systems (dial-up, world-wide, 30-236 kbps) (GPRS or CDMA)
- Microwave system
- Multiple Address Radio System (MAS)
- Non IEEE 802.x-based spread spectrum radio
- Satellite-based VSAT or other
- Proprietary radio
- Do not know
- Other (please specify)

2. (Do not answer this question - being kept for historical reasons)

- WiFi (multi-user, 100-150 foot range, 54 Mbps)
- Bluetooth (point-to-point, 30+ foot range, 1.5 Mbps)
- Zigbee (meshed network, 30-300 foot range, <250 kbps)
- WiMax (multi-user, 5-30 mile range, 45-75 Mbps)
- Cellular phone systems (GPRS) (dial-up, world-wide, 30-236 kbps)
- Do not know
- Other (please specify)

3. What communication configuration (one or more) might you, or did you, use?

- Point-to-point
- Meshed communications network
- LAN
- WAN
- Using/piggybacking over existing communications network
- Local mobile
- Wide area mobile
- Other (please specify)

4. Identify any specific wireless configuration issues of concern?

- Electrically noisy environment
- Potential interference from other known radio sources
- Potential interference from other unknown radio sources
- Need for multiple wireless networks

- Long distance between end point and wireless node
- Long distances for wireless transmissions
- Outdoor temperature extremes
- Outdoor weather conditions
- Other (please specify)

5. (Optional) Describe any additional wireless configuration characteristics or issues

18. Power supply requirements

Power supplies for wireless systems may be direct access to main power or a station battery, or may consist of specific batteries for the wireless devices.

1. What are the power supply requirements for the wireless devices? If battery power is preferred or required, indicate how long between battery replacements would be desired.

- Mains power is available
- Station battery power is available
- Battery power only, available without recharging or replacement for a few weeks
- Battery power only, available without recharging or replacement for 1 year
- Battery power only, available without recharging or replacement for 5 years
- Battery power only, available without recharging or replacement for 10+ years
- Alternative power source possible: e.g. solar cells, power “harvesting”
- Other (please specify)

2. (Optional) Are there special issues related to power supplies for this wireless application, such as reliability of PTs for access to mains power, inaccessibility of location for replacing batteries, or significant expense for replacing batteries?

19. Data characteristics

Data volume, response times, time sensitivity, and other factors can drive the type of wireless communications that are feasible and beneficial.

1. What is the typical periodicity of data transmitted?

- Periodically, between 100 milliseconds and 1 second
- Periodically, between 1 and 10 seconds
- Periodically, between 10 and 60 seconds
- Periodically, every few minutes up to once an hour
- Periodically, every few hours
- Periodically, longer than a few hours
- Other (please specify)

2. Is data (also) transmitted upon event?

- Not transmitted upon event
- Upon event (alarm condition) only
- Upon event (alarm condition) as well as periodically
- Other (please specify)

3. What is the time sensitivity (maximum latency) of the data being transmitted?

- Must be received within a few milliseconds of occurrence
- Must be received within a few seconds of occurrence
- Must be received within a few minutes of occurrence
- Time sensitivity/latency is not an issue

- Some transmissions may be “lost” without impact on the application
- Other (please specify)

4. What amount of data traffic is transmitted per end node (e.g. per sensor)?

	< 100 bps	< 1kbps	< 500 kbps	< 1 Mbps	> 1 Mbps	Varies/Don’t Know
Average bits per second	é	é	é	é	é	é
Peak bits per second	é	é	é	é	é	é

5. What are the availability requirements?

- Availability > 99.999% (less than 5 minutes outage per year)
- Availability > 99.99% (less than 1 hour outage per year)
- Availability > 99.9% (less than 9 hours outage per year)
- Availability > 99% (less than 4 days outage per year)
- Availability not an issue
- Other (please specify)

6. What are the security requirements?

- No security is needed
- Physical security (against theft or damage) is needed
- Authentication of users (human and software) is required
- Confidentiality (e.g. encryption) is required
- Integrity of data (against tampering, errors, or failures) is required
- Other (please specify)

7. What data protocol (one or more) is (will be) used over the wireless portion of the system?

- Don’t care: will convert any protocol to desired protocol with a protocol converter
- Don’t care, so long as it runs over IP
- DNP3
- Modbus
- Fieldbus
- IEC 61850 GOOSE/GSE/SMV
- IEC 61850 ACSI
- Web services
- Don’t know
- Other (please specify)

20. Assessment of wireless technologies versus alternative communication techno...

Wireless technologies are one of many communication technologies. If you have assessed them against other possibilities, how have they fared?

1. Are (Have) you assessed wireless technologies against alternative communications technologies for your application? If so, which and with what results? (Only answer for those you assessed.)

	Feasibility	Reliability	Commercial availability	Purchase cost	Installation ease	Maintenance ease
Fiber optic cables						
Copper wires						
Leased telephone circuits						
Microwave systems						

Multiple Address Radio (MAS)						
Power line carrier (PLC)						
Broadband power line (BPL)						
Spread spectrum radio						
VSAT satellite systems						
Paging systems						
Other						

2. If you used the "other" category in the previous question, what technology were you describing?

21. Possible benefits from using wireless technologies

Wireless technologies can provide many benefits, but these vary in importance from application to application, as well as from one specific circumstance to another. Please assess the importance of each benefit in a business case for your application.

(For simplicity, these benefits compare the “wireless technologies” against “wired cabling”, although it is recognized that other types of comparisons are possible).

1. Cost comparisons between “wireless technologies” and “wired cabling” for this application (only answer those that are applicable)

	Minimal benefit	Low benefit	Medium benefit	Large benefit	Very large benefit
Lower cost for wireless media compared to cost of purchasing cables					
Lower cost for installing wireless devices since no trenching or running of cables is needed					
Lower installation effort and disruption caused by trenching, rights-of-way issues, and cable installation					
Low cost of wireless technologies makes application cost-effective, while using cables prevents the implementation of the application					
The now-feasible, cost-beneficial application provides additional benefits to other applications, such as more data for condition monitoring also may provide data for future equipment specifications					

2. Comparison between “wireless characteristics” and “wired characteristics” for this application (only answer those that are applicable)

	Minimal benefit	Low benefit	Medium benefit	Large benefit	Very large benefit
Characteristics of wireless technologies make the application technically feasible					
Avoid ground potential rise problems					
“Air-gap” electrical isolation is automatically provided between wireless devices connected to power equipment and other devices					

3. Installation and maintenance comparison between “wireless technologies” and “wired cabling” for this application (only answer those that are applicable)

	Minimal benefit	Low benefit	Medium benefit	Large benefit	Very large benefit
Faster and easier installation of wireless technologies since licensing requirements are avoided (e.g. microwave path licensing)	☐	☐	☐	☐	☐
Power system technicians are not needed, so faster, easier, and less expensive installation of wireless technologies	☐	☐	☐	☐	☐
Easier maintenance since only need to test the end devices, not a cable	☐	☐	☐	☐	☐
Improved safety for users since they do not need to be close to power equipment: outside vault	☐	☐	☐	☐	☐
Improved environmental conditions for users, since they may be outside the substation in their warm/cool van	☐	☐	☐	☐	☐

4. Mobility benefits of wireless technologies for this application (only answer those that are applicable)

	Minimal benefit	Low benefit	Medium benefit	Large benefit	Very large benefit
Mobility of wireless devices so that they can be used while in motion	☐	☐	☐	☐	☐
Ease of moving wireless systems to new locations, particularly during emergency situations or during temporary construction activities	☐	☐	☐	☐	☐

5. Are there other types of benefits that were not listed?

22. Potential concerns for using wireless technologies

There are many potential concerns for using wireless technologies. Some may impact specific applications more than others. Some are being addressed by the wireless industry and may not be as problematic as they were in the past. Some may require additional effort by the power system industry to address.

For the one or more types of wireless technologies you might or are using for this application, please select the appropriate level of concern.

1. WiFi, the most popular wireless standard for networking computer systems, has the following basic characteristics:

– IEEE 802.11b data rate is 11Mbps
– IEEE 802.11g data rate is 54Mbps
– Frequency band is the 2.4Ghz band
– Range of 100-150 feet

	Minimal concern	Minor concern	Some concern	Large concern	Very great concern	Don't know
Wireless equipment may not work well in an electrically noisy substation						
Wireless equipment may not survive in a harsh outdoor environment						
Internet hackers may be able to eavesdrop on information						
Unauthorized users may be able to eavesdrop on information						
Unauthorized users may be able to disrupt wireless communications						
Unauthorized users may be able to issue unauthorized control commands						
Limited range of transmission						
Low data rates						
Availability less than needed due to potential interference						
Vendor products do not provide adequate industrial-level reliability						
Standards are not yet solidified						

2. Bluetooth is used in cellphones, Personal Digital Assistants (PDAs), and other mobile wireless devices, primarily for communicating with computers, Intelligent Electronic Devices (IEDs), headsets, hands-free systems, and other gadgets.

– Bluetooth is designed for low-traffic serial point-to-point links
– Very short range of only 33 feet (approx 10m)
– Frequency band is the 2.4Ghz band.
– Relatively low data rate of 1.5Mbps

	Minimal concern	Minor concern	Some concern	Large concern	Very great concern	Don't know
Wireless equipment may not work well in an electrically noisy substation						
Wireless equipment may not survive in a harsh outdoor environment						
Internet hackers may be able to eavesdrop on information						
Unauthorized users may be able to eavesdrop on information						
Unauthorized users may be able to disrupt wireless communications						
Unauthorized users may be able to issue unauthorized control commands						
Limited range of transmission						
Low data rates						
Availability less than needed due to potential interference						
Vendor products do not provide adequate industrial-level reliability						
Standards are not yet solidified						

3. Zigbee, based on IEEE 802.15.4, defines low-rate, very low duty cycle, wireless personal area networks often termed "meshed networks" as opposed to point-to-point. ZigBee builds upon this 802.15.4 standard to define application profiles that can be shared among different manufacturers to provide system-to-system interoperability. This effort is still a work in progress, although of great interest

to industries (such as the power industry) that have extensive sensor networks. – Multi-user configuration – Range between devices is 30-300 feet. – Low data rate of <250 kbps – High availability due to meshed network configuration

	Minimal concern	Minor concern	Some concern	Large concern	Very great concern	Don't know
Wireless equipment may not work well in an electrically noisy substation						
Wireless equipment may not survive in a harsh outdoor environment						
Internet hackers may be able to eavesdrop on information						
Unauthorized users may be able to eavesdrop on information						
Unauthorized users may be able to disrupt wireless communications						
Unauthorized users may be able to issue unauthorized control commands						
Limited range of transmission						
Low data rates						
Availability less than needed due to potential interference						
Vendor products do not provide adequate industrial-level reliability						
Standards are not yet solidified						

4. WiMax (IEEE 802.16) wireless technologies has a primary focus of enabling a wireless alternative for cable, DSL, and T1 communication channels for consumer last-mile access to the Internet, including high-speed data, Voice over IP (VoIP), Video on Demand (VoD), and backhaul for IEEE 802.11 LANs. WiMax addresses the "first-mile/last-mile" connection for longer distances and faster rates:

– Multi-user configuration
– Range of 5 to 30 miles (5 more likely)
– Data rates of (45-75 Mbps

	Minimal concern	Minor concern	Some concern	Large concern	Very great concern	Don't know

Wireless equipment may not work well in an electrically noisy substation						
Wireless equipment may not survive in a harsh outdoor environment						
Internet hackers may be able to eavesdrop on information						
Unauthorized users may be able to eavesdrop on information						
Unauthorized users may be able to disrupt wireless communications						
Unauthorized users may be able to issue unauthorized control commands						
Limited range of transmission						
Low data rates						
Availability less than needed due to potential interference						
Vendor products do not provide adequate industrial-level reliability						
Standards are not yet solidified						

5. Cellphone data standards, GPRS, is part of GSM effort to create a common European mobile telephone standard for a pan-European mobile cellular radio system (and now worldwide). The resulting mobile telephone standard allows cellphone users to “roam” across many cellphone systems and between most countries world-wide. New generations of cellphone technologies, termed 2.5G, 3G, and 4G are deployed in certain countries or are still under development.

– GPRS commonly used for data, with 30-80 kbps typical.
– EDGE (enhancement to GPRS) provides 160-236 kbps
– The range is wherever cellphone coverage is available!

	Minimal concern	Minor concern	Some concern	Large concern	Very great concern	Don’t know
Wireless equipment may not work well in an electrically noisy substation						
Wireless equipment may not survive in a harsh outdoor environment						
Internet hackers may be able to eavesdrop on information						

Unauthorized users may be able to eavesdrop on information						
Unauthorized users may be able to disrupt wireless communications						
Unauthorized users may be able to issue unauthorized control commands						
Limited range of transmission						
Low data rates						
Availability less than needed due to potential interference						
Vendor products do not provide adequate industrial-level reliability						
Standards are not yet solidified						

23. Another wireless application?

If you have another wireless application that you would like to describe, please select “next wireless application”. If you are done, please select “done”.

1. Do you have another application of wireless technologies that you would like to include in this survey?

- Next wireless survey
- Done

24. Thank-you

Thank-you very much for participating in this survey. The IEEE PES P1777 WG will be publishing a report summarizing and analyzing the result of these questions, and provide recommended practices based in part on your responses. If you have any further questions or comments, or would like to participate in the P1777 work, please either enter them below or contact fcleve@xanthus-consulting.com.

1. Please provide any comments on the questionnaire: