City of Portland
Annex B - Communications

PORTLAND BUREAU OF EMERGENCY MANAGEMENT

Jo Ann Hardesty, Commissioner • Courtney Patterson, Interim Director

9911 SE Bush Street, Portland, OR 97266 • (503) 823-4375 • Fax (503) 823-3903 • TTY (503) 823-6868

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- Mike Nichols
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Portland Police Bureau (PPB)

- Josh Goldschmidt
- Troy King
- Anthony Zanetti

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INTRODUCTION AND BACKGROUND

PURPOSE

This Annex describes the technologies, policies, and procedures that City bureaus use to communicate between bureaus, with other regional government partners, and with outside agencies. It outlines the systems available to the City during routine and emergency operations and establishes a Concept of Operations for how the City will use technology and communications services during an incident or disaster. The Annex also outlines the roles and responsibilities for bureaus, local and regional government partners, and for private industry partners during an incident or disaster.

This Annex also serves as a high-level index to the various types of communications hardware available to City of Portland users. It is designed so that in a crisis, bureau emergency response personnel can quickly learn what assets are available across the City and, more importantly, whom to contact for more information about those assets. It describes the City's communications infrastructure as it currently exists (at the time of publication). This Annex also discusses the threats and hazards to and resiliency of the City of Portland's communications systems, and addresses system recovery prioritization and future technology needs.

The presence of a communications system or process in this Annex does not guarantee that a specific system will be used or prioritized during a given emergency. The actual communications methods used by first responders, City employees, and other partners will depend on the needs of the incident, what resources are available, and any incident-specific requirements for system interoperability. Each of the communications systems described in this document are relied upon even more heavily during emergency situations and disasters. A loss of one or more systems increases the load on the remaining systems and can hinder the management, response to, and recovery from an incident or disaster.

SCOPE

Annex B: Communications details the technology systems used by City of Portland bureaus during day-to-day operations, and by bureaus and some municipal partners during planned and unplanned events, incidents, and disasters. It does not cover public alert and warning technologies, which are detailed in a separate document (Annex C: Alert and Warning). This annex supports the City of Portland's Basic Emergency Operations Plan (BEOP), and applies to all City bureaus, staff, and elected officials.

OBJECTIVES

Annex B: Communications supports five primary emergency response objectives for the City of Portland:

1. Present the suite of communications technologies available at the City of Portland and discuss how they work together during emergency situations.
2. Act as a high-level communications technology index with an emphasis on which bureaus are responsible for technologies or services and whom to contact.
3. Present and summarize the threats facing the City's communications systems, the resiliency of these systems, and the limitations of these systems as currently implemented.
4. Manage expectations and summarize priorities for restoration of services after a disaster.
5. Assess potential future technologies available to the City to support emergency and technology planning efforts.

SITUATION AND ASSUMPTIONS

SITUATION

- Communication is information transfer and involves the technology associated with the representation, movement, interpretation, and processing of data among persons, places, and machines. It includes transmission, emission, or reception of signs, signals, writing, images, and sounds or intelligence of any nature by wire, radio, optical, or other electromagnetic systems.
- The City of Portland uses a combination of conventional landline telephony, internet-based voice-over-internet Protocol (VoIP) telephony, cellular voice and data services, satellite telephony, internet Protocol (IP)-networking or internet services (paging, video surveillance, crisis management via WebEOC, virtual private network (VPN) access, and Software as a Service [SAAS] products), ultra-high frequency (UHF) and very-high frequency (VHF) radios and microwave relay during daily operations.
- Public safety agencies within the City of Portland use a mix of cellular telephony, cellular data, a trunked digital land-mobile radio system (LMR), conventional paging and VHF radio for day-to-day operations and most emergency situations.

- Outside communications support will likely be required after a disaster, both due to damage to infrastructure and a significantly increased demand for services.
- The Bureau of Technology Services (BTS) is responsible for supporting nearly all the City of Portland's communications systems. In a disaster situation, restoration of specific City communications and technology systems follows a prioritization list included as Annex C in the BTS continuity of operations (COOP) plan[1].
- A large-scale emergency is likely to affect the ability of the City of Portland to communicate through damage, disruption, or degradation of hardware and software. Positive outcomes in emergency situations are generally predicated on the availability of communications channels; accurate and timely information is critical to guide decision-making and response actions.
- The City of Portland faces many different natural and human-caused threats and hazards which are discussed in detail in several locations:
  - Hazard-Specific Annexes (HSA) to the BEOP,
  - Mitigation Action Plan, and
  - Threat and Hazard Identification and Risk Assessment (THIRA) process.
- This Annex is focused on two specific hazards that pose the largest threat to communications systems: a large earthquake on the Cascadia subduction zone or the Portland Hills Fault earthquake and a cybersecurity incident.
- A large Cascadia subduction zone earthquake is expected to impact most of the City's communications network. While physical locations such as antenna towers, server racks or switching centers can be made highly resilient through reinforcement and base isolation, their connection to regional networks often occurs through copper or fiber lines which can be broken by differential settlement or earthquake-induced liquefaction. Many telephone and data lines cross rivers on or underneath seismically vulnerable bridges. Microwave antennas can be thrown out of alignment by strong ground motions, requiring manual realignment to restore full capacity.
- Cybersecurity incidents vary in nature, complexity, and impact and include computer viruses and malware, ransomware, theft and corruption of data, network penetrations, and denial of service (DOS) attacks. The nature of systems and technology subject to such incidents is increasingly complex and vast, including City-controlled computers and networks as well as mobile phones, networked devices, sensors, and third-party services. Many bureaus rely on Application Solution Provider (ASP) software systems that require internet connectivity to work. Examples of these systems at the City of Portland include NavMan GPS for vehicle tracking, SmartSheets for task tracking, and ArcGIS Online for mapping and GIS services. It is also possible that a terrorist attack, such as a Chemical, Biological, Radioactive, Nuclear, and Explosive (CBRNE) event could be coupled with a cybersecurity incident, adversely affecting the City's information technology systems, assets, operations, and/or infrastructure when it is the most necessary.

ASSUMPTIONS

- The communications systems and technologies listed in this Annex are adequate for normal operations, planned events, and most emergency scenarios.
- During any major disaster in the Portland region, normal communications systems such as the public-switched telephone network (PSTN) and cellular voice/data networks will be overloaded due to damage to public and private infrastructure combined with an increase in the demand for communication services. It is likely these networks will only have a fraction of the capacity they normally do, with bandwidth going to those users and services pre-identified for priority and pre-emption on the network.
- If a situation arises where one or more communications systems are overloaded, damaged or destroyed, some alternative systems and methods may be available on short notice. Note that these alternative systems may not be able to completely replicate the capacity or capability of the disabled systems. Currently there are few to no short-term options if damage disrupts internet connectivity on a large scale.
- The City of Portland's trunked digital radio system has been built with significant resiliency and redundancy, such that it is expected to be the primary mode of public safety communication during or after most disasters. However, continued radio system operation depends on the microwave relay and wired IP networks (backhaul) that connect the repeaters together remaining operational and the availability of sufficient fuel to drive on-site generators.
- Following a large cybersecurity incident or natural disaster, most communications systems will be at least partially operational at reduced capacity.

[1] Continuity of Operations Plan (COOP) OMF – Bureau of Technology Services (BTS), last updated 06/28/2017

- The volume and urgency of incoming (other local agencies, regional government and the public), internal (bureau to bureau) and outgoing messaging will be directly proportional to the scope, scale and severity of the emergency.
- Emergency managers will require accurate and timely information to support decision-making, resource allocation and response activities. As such, maintaining operational communication systems will be the highest priority during the incident or emergency.
- Physical damage to telecommunications and broadband internet networks is expected after a major earthquake. Voice and data networks will likely be heavily damaged, with highly limited network capacity for days to weeks. Some services could potentially be degraded for months.
- The availability of suitable emergency power (generators and backup batteries) will be limited during an emergency, and will constrain what communications assets are available and for how long.
- Access to skilled communications technicians, electronics technicians, mechanical specialists, electricians, and fuel handlers will be limited during a crisis due to a combination of high demand and limited availability. City employees familiar with City systems may be unavailable due to family commitments, may be unable to reach duty locations due to public infrastructure damage, or may be filling other critical roles. This may result in repair and maintenance tasks being assigned to contractors not specifically familiar with the City's systems.
- Should a major disaster such as a large earthquake occur, additional resources from regional, state, and federal partners will take days to weeks to arrive and ramp up. City bureaus will need to rely on local communications alternatives during that time.

CONCEPT OF OPERATIONS

INCIDENT RESPONSE

The City of Portland's response to large-scale emergencies and disasters follows federal guidelines as expressed through the National Incident Management System (NIMS) and the Incident Command System (ICS). The types and availability of various communication systems used during these events are a function of the size and complexity of the incident, the physical condition of the communications infrastructure, the volume of traffic needed to support incident response, and the availability of additional resources to meet the needs of the incident.

When the need for resources or coordination between bureaus exceeds normal operations, the City's emergency response function is engaged and the Emergency Coordination Center (ECC) is activated. City ECC activation levels reflect the City-wide response level, which are described in the next section (Readiness and Coordination Thresholds). Any City Incident Commander may request an ECC activation. The lead bureau's director, the PBEM Director, the PBEM Operations Manager, or the Mayor may also activate the ECC for an anticipated event or a major emergency. The ECC is a highly resilient facility, with redundant power, significant backup communications capability, large meeting areas and plenty of emergency food and water. The ECC is also adjacent to the BTS Radio Shop and a significant cluster of BTS information systems professionals, making it a nexus for communications support services to the City of Portland.

For small or localized incidents that do not require an ECC activation, most city bureaus will open their own Incident Command Post (BICP), from which response activities will be coordinated. Bureaus will use their existing communications systems to manage incidents, with assistance from BTS, other bureaus, and community partners as necessary to prevent outages and address any shortcomings in communication system coverage.

READINESS AND COORDINATION THRESHOLDS

The response of the City of Portland to unanticipated events, emergencies and disasters is organized into operational levels, with associated triggers that define when a given incident transitions from one level to another. Responses to incidents generally occurs at the lowest operational necessary to meet the needs of the incident.

Routine Operations

Routine operations are daily activities that are routine in nature and managed by individual bureaus without the need for higher levels of coordination. Routine operations also include situations that may result in a higher demand for communications services, such as multiple-alarm fires or large police responses. At this operational level, centralized communications infrastructure such as radio dispatch and the 9-1-1 call center are intact and are functioning within their designed operational capabilities.

For public safety bureaus such as BOEC, PF&R, and PPB, normal communications protocols during routine operations include:

- Dispatch and tactical communications over the City of Portland's trunked digital radio system.
- Firefighter and EMS tap-out (dispatch) operations using IP network notification linked to the 9-1-1 dispatch system, with voice dispatch through the City trunked digital radio system.
- Side-channel communications using cellular and conventional telephones.
- Voice, SMS, and email paging alerts.
- Mapping and data services to officers in the field delivered to Mobile Data Consoles (MDC) over an encrypted VPN using cellular internet service provided by Verizon Wireless.

For all City bureaus, normal communications protocols include:

- Email, file-sharing, voice, and video meeting traffic over the City's wired and wireless IP networks using Microsoft's Office 365 and Office 2013 (PPB) software suites.
- Voice, fax, and messaging over the City's VoIP and conventional telephony system.
- Access to file, print, and application servers via the City's TCP/IP network and/or VPN services.
- Semi-automated data communications systems including but not limited to microwave relay, security camera, electronic security systems (locks), traffic cameras and sensors, and automated industrial control systems.

Enhanced Operations

Bureaus move to Enhanced Operations when a planned or predicted event has the potential to escalate, an unplanned incident occurs that has the potential to escalate, and/or a situation requires a coordinated response from two or more bureaus. Examples of events that can trigger a move to Enhanced Operations include fires greater than three alarms, hazardous air conditions, excessive heat warnings, and the threat of winter weather conditions. During Enhanced Operations, city bureaus use normal communications channels (phone, email, radio) to communicate situation status updates to PBEM, which then disseminates the information throughout the City and to regional partners.

During enhanced operations, all communications systems in use during Routine Operations are functional and in use. There is a low but non-zero probability of network congestion and capacity issues. Portable or mobile assets such as tactical radio repeaters or communications trucks can be used to increase network capacity at the incident scene if necessary. Private communication service providers may be contacted in the event of a large public notification event to ensure sufficient network capacity.

Partial Activation

The City of Portland moves to a Partial Activation when multiple bureaus, agencies, or partners engaged in a response to a planned or unplanned event or incident are operating near, at, or just beyond the limits of their usual capacity (i.e. Normal or Enhanced Operations). The Emergency Coordination Center (ECC) is typically activated when incident operations are moved to the Partial Activation status. Triggers that may cause an ECC activation are included in both the BEOP itself and Annex A (Coordination, Direction and Control). When activated the ECC is staffed with personnel from responding bureaus and supported by PBEM, BTS, City personnel credentialed as ECC Responders, and community volunteers. The ECC starts to become a nexus for multi-agency coordination, resource ordering, decision-making and communications support.

During a partial activation, some of the communications in use during Routine or Enhanced Operations may not be fully functional due to system damage. A situation may also require the use of portable or mobile communications assets or the expansion of radio networks into additional frequency bands. Alternatively, communications may need to shift to a different format, such as moving from email over conventional networks to text messaging and voice communications over cellular networks (as in the event of a cyberattack on the City of Portland's IP networks).

Information sharing, including presenting a common operating picture and facilitating direct communications between decision makers, becomes critical. Crisis information systems such as WebEOC, OpsCenter, RAPTOR and ArcGIS Online[2] help maintain situational awareness, and should be the first source of incident response information for first responders, managers, and City leaders. Interoperable communication is an essential function during a partial activation when agencies and resources from outside the City of Portland are requested. A key function of the ECC Communications Unit is ensuring that all responders can talk to each other by sharing radios from caches, using radio gateways, or by using designated interoperability radio talkgroups.

[2] See City of Portland Communications Systems, subsection Crisis Information Systems for more information

Full Activation

The City of Portland moves to a Full Activation when significant events, emergency situations, or disasters involve extraordinary property damage or loss of life that will likely exhaust the capacity of responding bureaus or partners. These events may invoke (but do not require) a declaration of a city-wide State of Emergency[3] by the Mayor. Incident response is centrally managed at the ECC, which allows bureaus a single point of contact for coordination, resource requests, and messaging. The requirement for information sharing and a common operating picture becomes even more critical during a Full Activation.

During a Full Activation, many of the communications systems relied upon during Routine or Enhanced Operations may be non-functional, either due to system damage, lack of adequate emergency power, or a lack of capacity to meet very high public and first responder demand. Backup systems, such as satellite telephones, satellite internet connections, national interoperability radio frequencies, portable communications systems such as portable repeaters or communications vans, and amateur radio may become the primary communications networks available to incident responders. The bandwidth limitations of these services will require a significant amount of communications discipline; messages should be short, to the point, narrowly targeted, and prioritized. Responders and city personnel should anticipate that messages may take significantly longer to be created, sent, received, acknowledged, and replied to during a full activation.

CITY OF PORTLAND COMMUNICATION SYSTEMS

IP Networking and Internet Connectivity

IP networks and the internet are a critical facet of everyday life in modern America; it is arguably one of the most important infrastructure services today, outranked only by water, sanitation, and electrical power. The City of Portland relies on IP networks for:

- Voice and data communications, including email, telephony, paging, and conference calling.
- Providing access to City services via the internet, including building permitting, utility billing, access to hazard maps and community information, paying taxes, employee recruitment, reporting neighborhood issues, and coordinating access to recreational facilities. These are all important city services.
- Connecting desktop and laptop computers to file, database, scan/print, and application servers to allow City employees to perform essential functions.
- Connecting to alert and warning systems that notify and engage with residents during incidents and emergencies
- Providing the infrastructure for other City technology systems, including traffic cameras, wastewater treatment plant monitoring, Global Positioning System (GPS) tracking of City utility vehicles, information archiving services, and electronic security systems.

The City of Portland's wide-area network (WAN) consists of fiber-optic cables that connect all the different city local-area networks (LANs) together through a topology (geographic arrangement) known as a ring network. The city's network is bi-directional, which means that traffic to or from a node (physical location or local network gateway) can go one of two directions. This adds some resiliency in that a single break in the ring such as a cut fiber line or a broken gateway does not prevent the rest of the network from communicating. Figure 1 summarizes the topology (geographic arrangement) of the City's WAN.

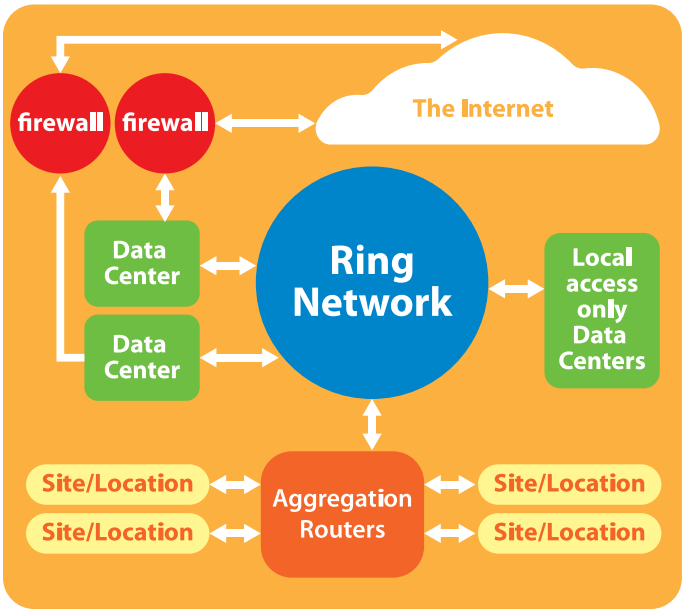

Figure 1: Simplified schematic of the City of Portland WAN

[3] Portland City Code Chapter 15.04.040

High-speed links also connect the City WAN to an off-site data center, which now hosts most essential City services and file servers. The data center is a purpose-built facility powered by electricity from two different substations, such that a disruption at one substation does not necessarily cause a service outage. The facility is built to modern seismic safety standards and includes significant battery resources with backup on-site generators for power outages. BTS is currently working on a second data center located outside the state of Oregon to provide additional resiliency for essential services.

As built, the current City WAN is reasonably resilient. The ring topology protects against some disruptions, and connections to the internet are maintained by having multiple ISPs. Facilities whose primary network connection is through circuits leased from third parties, such as CenturyLink or Comcast, are only as resilient as the third-party network. There are also risks to service outages due to intentional or accidental disruption of key internet / IP networking elements such as domain-name servers (DNS), which function as a combination address book and network map for computers, or dynamic host control protocol (DHCP) servers, which assign computers their physical address on the internet.

Conventional Telephony and Paging

Wired telephones, group calling, voicemail messaging and call-center services at the City of Portland use a VoIP system provided by Avaya. VoIP systems use the same wired Ethernet networks as data traffic, which saves on construction costs. Many paid value-added services offered by traditional telephone companies such as voicemail, call waiting, and call forwarding come free with VoIP implementations. One disadvantage of VoIP systems is that, unlike conventional plain-old telephone system (POTS) lines which receive power directly from the phone network, is that the phones will not work without power to both the desktop handset and the communications servers which transmit and manage the calls.

The City of Portland maintains two telephone switches to connect its VoIP system to the public switched telephone network (PSTN); one is a dedicated system managed directly by CenturyLink for BOEC to host 9-1-1 calls, while the second is an Alcatel-Lucent switch managed by BTS. Local dial tone service is provided by CenturyLink with long distance and some conference call services provided by AT&T. In addition, several City offices and facilities are still served by commercial telecommunications provider directly (CenturyLink) rather than through City-owned switches. As of late 2018, BTS is working to migrate the City's telephone connection to the PSTN from the Alcatel-Lucent switch to Session Initiation Protocol (SIP) trunks, which will allow for both voice and multimedia data and for more advanced management of that voice and data traffic. SIP trunks bring more traffic capacity and even higher reliability to the City's connection to the PSTN. SIP trunking services will eventually replace the non-911 City telephone switch.

Copper-wire (POTS) service is provided in several locations to facilitate facsimile (fax) machines, computer modems, and to support desktop phones for the National Alert and Warning System (NAWAS). NAWAS is an 'always on' telephone line coordinated by the Oregon Office of Emergency Management (OEM) through which attack or severe weather warnings are relayed. It is the modern-day equivalent of a party telephone line. These systems (fax, modems and NAWAS) are dependent on both the City's PSTN switch and on the resiliency of the host telecommunications provider (CenturyLink).

Paging services are provided by BTS using a software system called PageMaster. The PageMaster system integrates with the City's messaging infrastructure and virtual computer-aided dispatch (vCAD) systems and provides text message services to both pager devices and wireless phones. Pagemaster communicates with telecommunication providers via the use of code modules known as "devices" that represent a gateway to telecommunications providers such as Verizon or CenturyLink. The software is run on-premises and not through a SAAS contract. PageMaster is dependent on WAN connectivity to function but has two different failover modes:

- If the paging server is non-functional or internet connectivity to the data center is down, pages can be sent from computer workstations on the operations floor at the 9-1-1 dispatch center.
- A secondary backup for the Pagemaster system uses dial-up modems over traditional twisted copper-pair telephone lines (POTS). Not all Pagemaster devices support sending pages using dial-up modems.

Many essential City employees, ECC responders and elected officials are subscribed to the Government Emergency Telecommunications Service (GETS) system, which provides priority access to the PSTN when the network is highly congested. Users get put at the head of queues when circuits are busy and receive priority routing when calls do connect. According to the Department of Homeland Security (DHS), approximately 85% of local telephone lines in the US can use the GETS system. GETS calls can also be made from and to cellular telephones via the WPS service, described in the next section. PBEM administers and controls access to the GETS

program for bureau emergency managers at the City of Portland; the emergency managers are then expected to maintain the program accounting for their bureau.

Both the City's connection to the PSTN and the separate 9-1-1 dispatch switch are eligible for priority restoration and reconstruction after a disaster under DHS's Telecommunications Service Priority (TSP) program. This program is designed to ensure that mission-critical communications links (circuits with the National Security / Emergency Preparedness (NS/EP) attribute) go to the front of the line when recovering from large-scale outages.

The City's VoIP system is reasonably resilient; the desk sets are commercial-off-the-shelf (COTS) hardware and easily replaced, while the software back-ends exist on virtual servers which can be re-provisioned quickly. The connection between the City VoIP system and the PSTN are slightly less-resilient; it currently relies on a single telephone switch that is no longer in active production. This risk should be partially addressed by the previously mentioned SIP trunking initiative. The 9-1-1 switch does not suffer from this limitation. Finally, the paging system is dependent on the City's IP network and on the PSTN connection.

Wireless Telephony and Data

The City of Portland is a heavy user of cellular voice and data services. While the VoIP telephone system and its connection to the PSTN are the primary communications channel during incident response for personnel in BICPs and the ECC, cellular phones have become essential for first responders in the field. City use of cellular wireless voice and data includes:

- Select City personnel are issued cellular telephones to facilitate their job duties; all first responders and most bureau managers have them. All traffic on City cellular phones is monitored, with participation in a text messaging archiving system named SMARSH mandatory.
- Communication between BOEC and PPB officers in the field, using a cellular modem and a mobile data console (MDC) and a virtual-private network (VPN) connection over the internet. This allows officers access to law enforcement databases, vCAD dispatch status screens, electronic maps, email and other collaboration tools.
- Communication between BOEC and PF&R operations personnel in the field, using the same cellular data system and equipment as PPB. This gives PF&R first responders mapping capabilities, access to the Fire Information System, vCAD dispatch status screens and other collaboration tools.
- Several bureaus, including PWB, BES, and Parks & Recreation, use cellular modems for wireless connections to data acquisition and monitoring systems (SCADA).

To facilitate communications during an incident, City-issued cellular phones can be subscribed to Wireless Priority Service (WPS). WPS is like GETS in that it provides priority access when networks are congested, but instead works over cellular networks rather than the PSTN. WPS is not automatically activated with a GETS subscription; it must be added separately. Only city-issued cellular phones on a city-administered wireless service provider are eligible for WPS. PBEM administers and controls access to the WPS program for bureau emergency managers at the City of Portland; the emergency managers are then expected to maintain the program accounting for their bureau.

The City of Portland maintains several different wireless local-area networks (WLANs) to provide network and internet connectivity to mobile devices, conference rooms, workshops and open spaces without the need for installing Ethernet cables. One of these networks (CityGuest) is an open hot spot available at most City buildings and is completely isolated from the rest of the City's IP networks for security reasons.

While Verizon Wireless is the primary wireless data service provider for the City of Portland, several bureaus maintain cellular phones, air cards (a device designed to connect computers to a cellular data network), or cellular WiFi hot spots on competing providers, including AT&T, Sprint, and T-Mobile. The intent is for these services to function as a backup in the event the Verizon Wireless network is down.

The City of Portland also makes use of microwave data networks to transfer data from remote locations or places where it would be prohibitively expensive to put in fiber-optic lines. A microwave communication network offers very high speed and high bandwidth communications between multiple points, limited only by the need for all linked locations to be able to see each other (line of sight). Microwave links are often used to provide high-bandwidth paths between other types of communications systems (radio towers, satellite dishes and cell phone towers); these paths are collectively referred to as "backhaul". Most of the City's trunked digital radio network is interconnected using microwave relay dishes. PWB uses microwave links as one part of their Bull Run Watershed network, while PPB uses a microwave system to relay live video and data from airplanes during surveillance operations. BES uses microwave relay for some portions of their SCADA system supporting wastewater treatment and stormwater operations.

Overall, the resiliency of the city's wireless data systems is good. Wi-Fi networks rely on wired IP networks for backhaul and their connection to the internet; if the City of Portland WAN or its connections to the internet are down, Wi-Fi networks are also likely to be down. Verizon Wireless can actively engage in network management to keep cellular towers running for as long as possible during a crisis; the primary limitation on their network are the availability of fuel and backup generators. Most Verizon cell sites only have two to four hours of battery backup, depending on whether the site has a backup generator, and only about a day's worth of fuel is stored at generator sites. The Verizon central switch is highly resilient, constructed inside a building built to modern earthquake standards, with multiple days of battery backup and generator fuel.

Semi-Autonomous Data Networks

Most other commercial wireless voice and data providers have similar resilient network hubs and also face similar disaster power challenges at tower sites. These services typically use City-owned fiber lines, VPNs over the public internet, microwave relay data systems or a mix of all three network types. Operations, maintenance and repair of these systems are typically the responsibility of the owning Bureau, with connectivity to City networks supported by BTS. Specific details about these networks is beyond the scope of this Annex, but a partial list of known systems includes:

- PBOT traffic cameras
- PBOT traffic signaling network
- BES SCADA systems supporting wastewater treatment
- PWB SCADA systems supporting drinking water treatment and delivery
- Remote video surveillance
- Building security systems

Crisis Information Management Systems

A crisis information system (CIMS) is a mix of computer hardware and software used to help emergency management professionals deal with a wide range of incidents. They are designed to quickly share information among multiple stakeholders, collect information from multiple sources according to pre-defined schema, and then aggregate and present that data as a single shared view of the incident (common operating picture) so that all responders are acting on the same information. As most events and incidents are geographically-based, mapping is an integral component of most crisis-information systems. Interoperability is a key characteristic of a good CIMS; many allow for sharing of information between servers over the internet.

At the City of Portland, the following systems are in use:

- **ArcGIS Online (AGOL):** A software package from ESRI Inc., a pioneer in the geographic information systems (GIS) field, AGOL moves GIS from desktop software to web browsers and the cloud. AGOL is used to provide real-time mapping solutions during planned and unplanned events, consuming data from a wide variety of static dataset and online data feeds. New functionality, including post-earthquake damage assessment dashboards, are being developed all the time. BTS's Corporate GIS (CGIS) department maintains Portland's AGOL system and provides analysts and cartographers skilled in its use for ECC activations.
- **CASM NextGen**: A web-based information sharing system sponsored by the Department of Homeland Security's Emergency Communications Division (DHS ECD). CASM NextGen serves as a repository of information of all things communications-related, including trained & certified communications unit personnel (COML, COMT, COMC, etc.), portable communications assets, radio caches, and information on state and local communications networks.
- **Everbridge**: A cloud-based emergency notification and communication management system. It is used to contact both City employees and residents with emergency messages via telephone, email and text message (SMS). It can precisely target messages to individual geographic areas and to determine when or if a message was received and acknowledged. Everbridge is run as a hosted software service by a company of the same name.
- **OpsCenter**: A web-based information sharing system very similar to WebEOC supported by the State of Oregon's Office of Emergency Management (Oregon OEM) through Homeland Security grants. The system is fundamentally a database customized for emergency management; users interact with the database via a Web portal, via RAPTOR, or using a dedicated database management client (SQL Server Management Studio). All requests for State resources must be submitted through OpsCenter; as such, nearly every county EOC in Oregon uses OpsCenter. The system is hosted locally by OEM in Salem and is provided (along with RAPTOR) free of charge to Oregon municipalities. Some counties have chosen to host their own local instances of OpsCenter. The disadvantage of this approach is that

there is no automatic connectivity between the State instance and the local instance; any information that needs to be shared with the State must be done so manually.

- **Real-Time Assessment and Planning Tool (RAPTOR):** A web mapping software package built and maintained by Oregon OEM to give OpsCenter mapping capabilities and as graphical map-based method of displaying a common operating picture. RAPTOR is built from the same JavaScript API that ESRI uses for ArcGIS Online, with the OpsCenter database and internet data feeds the primary information storage mechanisms. Information can be shared between the City of Portland's ArcGIS Online portal and RAPTOR.
- **Versaterm vCAD:** A software system used to organize, prioritize and communicate information recorded by 9-1-1 call takers to dispatchers, who then use the information alongside built-in mapping capabilities to send police, fire and EMS responders to incidents. The vCAD system consists of a wide variety of different applications, including remote desktop client terminals and a web-based (BBSS; Browser-based Status Screen) viewer for viewing the status of police and fire units. First responders can connect remotely to the vCAD system using NetMotion software on their MDCs. The vCAD system is run by dedicated BTS administrators using on-premises application servers in virtual machines at multiple data centers.
- **WebEOC:** The most widely used CIMS across the USA today. WebEOC consists of a webserver connected to a database and is used to allow input of data through tables and maps in a web browser. Users interface with WebEOC via "boards", which are task-specific web pages built in a mix of JavaScript, HTML5 and proprietary WebEOC codes. Access to information is highly regulated, with users assigned to positions in the ICS structure and combined into groups with different permissions to different types of information. WebEOC is run as hosted software-as-a-service (SAAS) over the internet by an ASP named Juvare; their servers exist in the Microsoft Azure cloud network. Data is interchanged with different WebEOC instances in other counties (Clark, Clackamas) using a Fusion server, which is hosted by Washington State for the entire region.

In terms of resiliency, the principal point of failure for CIMS are connectivity to the internet. RAPTOR, WebEOC, and OpsCenter are not available without an active internet connection. In the post-CSZ earthquake environment, the City ECC and portable communication vehicles with satellite connectivity may be the only location these services are available. While AGOL will not work without an internet connection, most of its functionality is still available through desktop GIS software maintained on City computers. Versaterm vCAD runs locally, and so should still be available for use at the 9-1-1 public-safety answering point (PSAP); however, elements of vCAD that rely on network access such as BBSS or the MDT clients may not be usable if wired and wireless internet networks are down. In addition, the current vCAD implementation uses a third-party plugin authored by CenturyLink to do geolocation and geocoding of incoming 9-1-1 service calls; this system depends on access to the PSTN via CenturyLink.

Satellite Communications

Satellite voice and data communications are often the resource of last resort in a disaster; they are one of the few systems after amateur radio that offer connectivity outside the affected area. The City of Portland has several satellite-based communications systems that can provide a limited amount of connectivity through almost any disaster. These include:

- Portable satellite telephones operating on the Iridium network of low-Earth-orbiting satellites are issued to a select number of City employees, including key officials in public safety and city infrastructure bureaus as well as to elected leadership positions. These devices allow for managers and elected officials to remain in communication when other systems are down or until they can reach their bureau EOCs or the City ECC. Satellite phones are billed per-minute, and extensive use can quickly become costly. Reception quality is typically poor and only available when the user is outside and has a clear line of sight to the satellite free from trees and buildings. Portable satellite telephones can send and receive text messages; often texting is the best mode for communicating when other options are unavailable.
- The City ECC maintains a Ku-band very small aperture terminal (VSAT) providing 30 VoIP telephone lines (20 at the Portland ECC and 10 at the Water Bureau EOC)) to the nationall PSTN as well as an uplink/downlink for data and internet traffic. This satellite terminal is designed to keep the ECC in touch with the outside world should existing wired and wireless IP networks fail. The Portland Water Bureau EOC is also served by this VSAT. The connection is flat-rate and billed by the bandwidth used, with a monthly limit and a cache of pre-paid data for emergencies.
- The Portland Water Bureau maintains a Ku-band VSAT system at its Interstate maintenance facility for voice and data service during large-scale communications outages. This system provides for 10 VoIP telephone lines and a data uplink/downlink like the ECC's terminal.

- Several portable communications vehicles, including PF&R's MC9 unit and PWB's Emergency Communications trailer, also host VSAT dishes capable of voice and data service. Bandwidth and data allowances vary depending on the service plan and satellite network, but most systems can be ramped up to provide broadband internet-level speed if necessary. These systems are covered in greater detail in the Mobile / Portable Communications Assets section.
- Many City of Portland vehicles are equipped with two-way GPS tracking devices that provide continuous position data, allowing emergency managers to track or route resources more efficiently. While the tracking devices communicate via satellite, the tracking display system runs as hosted SAAS and requires internet access to function correctly.

Radio Systems

The primary radio system used by the City of Portland is based around a Motorola SmartZone Project-25 trunked digital repeater network operating in the 700 and 800 MHz public safety bands. The network features two simulcast rings with almost 95% coverage of the Portland metro area, supplemented by several fill-in repeater sites. The repeaters are linked together using a high-speed microwave communications system. The system uses 20 frequency pairs in a trunking mode to provide several hundred discrete talkgroups ("channels").

The trunked digital radio system is highly resilient, with two separate master sites, each of which feature two different zone controllers which can operate the radio network by itself. In the event of a failure of both master sites, each individual repeater can continue to operate on pre-defined talkgroups in a failsoft mode. Nearly all repeater sites have eight hours of battery backup power, supplemented by propane generators providing an additional five to seven days of power to the tower site. Several of the radio repeater tower sites also host backup linked analog repeaters operating in the National Public Safety Planning Advisory Committee (NPSPAC) frequencies, with frequencies pre-programmed into nearly all radios issued to Portland employees by BTS.

There are many agencies outside of the City of Portland that can communicate over the trunked digital radio system. Some use the system full-time, while others like hospitals and public health districts maintain small radio caches in case of emergencies. A partial list of regional users includes:

- Cities: Corbett, Fairview, Gresham, and Troutdale.
- Volunteer fire operations on Sauvie Island and in Corbett Fire District #14.
- Multnomah County Sheriff
- Transportation: Port of Portland, Multnomah County Roads and Bridges, TriMet, Portland Streetcar
- Public Works: Multnomah County Drainage District (MCDD), PGE, Metro,
- Federal: USCG, DEA, FBI, NOAA, BATFE, US Marshalls, Bonneville Power, USFS and Federal Protective Services
- State: ODOT, PSU Police, Oregon ANG, OSP, OLCC and Mountain Wave SAR
- Hospital networks: OHSU, Providence (Milwaukie, Portland), Legacy (Emanuel, Good Samaritan), the Hospital Emergency Administrative Radio (HEAR) networks and others.

The trunked digital radio system is the most resilient communications network in the City of Portland and is the primary conduit for first responder communications during an extended incident or disaster. If the trunked radio system is taken down, all City radios can operate in simplex mode on one of the frequencies normally assigned to the repeater network. When this happens, radio frequency assignments will come to responders via BOEC, with regional communications mainly occurring over Federal interoperability channels; this is discussed in more detail in the Communication System Resiliency and Interoperability section.

In addition to trunked digital radios, all PF&R vehicles and stations maintain land-mobile conventional VHF radios able to operate on State and local channels. All PF&R fire stations host a dual-band amateur radio Go-Kit, complete with radio, batteries, coaxial cable, and a magnetic mount antenna. These Go-Kits are designed to be deployed and operated by AUXCOMM personnel (next section). Each fire station also hosts either a VHF-only or dual-band UHF/VHF base station antenna on the roof for use with Go-Kits; these antennas are accessed via a lock panel outside the station, such that access to the interior of the station is not necessary to connect a radio to the antenna. PBEM, PWB and PPB maintain a limited stock of VHF mobile and handheld radios able to communicate on conventional VHF frequencies. These radios are also useful for communicating with the HEAR network, which connects hospitals, ambulances and fire agencies together over VHF channels.

Auxiliary Communications (AUXCOMM)

AUXCOMM is a blanket term introduced by the Department of Homeland Security's Emergency Communications Division Communications (DHS ECD) to cover all the different amateur radio volunteer organizations. ECD's goal is standardization of training and operation to make it easier to incorporate amateur volunteers into operations using ICS. Amateur radio is often considered the "method of last resort", since it is a highly reliable distributed network that has experience operating independent of commercial or government support.

AUXCOMM organizations associated with the City of Portland include:

- **Multnomah County Amateur Radio Emergency Services (MCARES):** ARES is a volunteer organization of licensed amateur radio operators associated with the American Radio Relay League (ARRL) that specializes in emergency communications. ARES members are trained in ICS and EOC operations and are experienced in handling large volumes of radio traffic. Many ARES members are skilled electronics and radio technicians and can be relied upon to help repair broken City communications systems or provision ad-hoc emergency work-arounds. The primary duty station for ARES members is at the ECC in the Communications Unit, managed by the COML. However, ARES is a county asset, such that all requests for service should be coordinated with Multnomah County. MCARES maintains a significant mobile and portable communications capability including:
    - A 14-foot long emergency communications trailer supporting voice and data communications on amateur radio frequencies in the HF, VHF and UHF bands. The trailer can operate using shore power or propane generators and is air-conditioned.
    - Amateur radio digital go-kits capable of voice and data communications over VHF and UHF amateur radio frequencies. The kits are built around hard-sided waterproof Pelican-style cases, and powered by a mix of batteries, propane generators and solar panels.
    - A portable UHF repeater with a 45-foot push-up mast capable of transmitting both on amateur radio frequencies and on a national UHF interoperability frequency.
- **Neighborhood Emergency Teams (NETs)**: Many NET volunteers are amateur radio operators, and the NET program maintains close ties to MCARES. During an emergency event, NET members will canvas their neighborhoods and NET amateur radio operators will provide preliminary damage reports and information on community impacts to the ECC. As necessary, the City ECC may use amateur radio to communicate information and request resources, including disaster declarations, to first responders and other city employees through the ECC.
- **Basic Earthquake Emergency Communications Network (BEECN)**: A BEECN is a location that residents and volunteers can go after a major earthquake to ask for emergency assistance or to report severe damage or injuries. There are 50 BEECN sites. Currently 42 of the sites have BEECN caches deployed within a five-block radius. If there is a need for a cache after a major earthquake at a site without a cache, PBEM will work to deliver a cache as soon as possible. Each cache has equipment including a hand-crank AM/FM radio receiver and a UHF handheld transceiver radio. The UHF radio connects the BEECN cache to the nearest City fire station for information updates and situation status reporting. The BEECN project maintains 6 business band UHF frequencies for simplex operations, as well as a single repeater pair. BEECN also has access to a portable UHF repeater with a 30-foot push-up mast; this is designed to enhance coverage of the BEECN system in SW Portland neighborhoods. BEECN sites may be used as a method of last resort for City staff to check in with supervisors after a disaster.

PBEM maintains a small cache of 2-meter band handheld amateur radio transceivers that can be checked out by NET or BEECN volunteers. Several other city bureaus, including BOEC, PWB, PF&R and PPB maintain caches of amateur radio equipment of varying types and ages, though most bureaus do not have their use included in their emergency operations plans. Many of the mobile and portable communications assets listed in the next section also include some ability to utilize the amateur radio bands. PBEM maintains radio equipment capable of supporting amateur radio communications at the ECC, including:

- 2 m and 70 cm transceivers programmed with local and regional ARES radio templates.
- 2 m and 70 cm transceivers equipped with radio modems to allow for digital communications (including email) over VHF and UHF radio frequencies.
- A high-frequency (6 m to 80 m) transceiver equipped for SSB, AM and CW modes on the amateur frequencies as well as the federal SHARES frequencies (see Communications System Resiliency and Interoperability section).

Every PF&R station maintains an amateur radio go-kit, consisting of a power supply, coaxial cable, a 2 m or dual-band 2 m/70 cm transceiver radio, and all the equipment necessary to connect the radio to an antenna inside a weatherproof hard-shell case. The go-kits are not designed to be taken away from their assigned fire station. Many (but not all) also contain a UHF handheld capable of communicating with BEECN nodes. Most PF&R stations also have an external gain antenna for amateur radio mounted somewhere on the building, with an access port near ground level for operators to connect their go-kits to.

Mobile / Portable Communications Assets

PPB maintains several mobile communications systems, including:

- A mobile command and communications truck to support the Special Emergency Reaction Team (SERT) and Crisis Negotiation Team (CNT) operations. The CNT van includes radios operating on VHF (low-band and public safety), UHF and on the City's trunked digital radio system, a sophisticated audio/video recording system, data modems accessing all four cellular wireless providers in the Portland metro area, and a small cache of Motorola handheld radios that work on the trunked digital radio system.
- Two radio interoperability bridges (gateways). One is capable of cross-connecting five different radio frequencies/channels with a cellular and a landline telephone line, while another can bridge together two radio networks.
- Two mobile precinct units capable of communicating over the city's trunked digital radio system, public safety VHF radio frequencies, and cellular wireless networks. The mobile precincts also maintain a capability to establish temporary wired connections to the PSTN.
- Two analog (non-trunked) 800 MHz portable radio repeaters for tactical operations.

PF&R maintains several mobile communications assets, including:

- A mobile command and communication engine (MC9) at Fire Station #9. MC9 offers nearly every possible communications device available at an EOC, including:
  - A dedicated telephone switch with five cellular-based line and one satellite line.
  - A VSAT system for voice and data.
  - A wireless network (WLAN) serviced by both cellular modems and the VSAT system.
  - A suite of radios including amateur UHF and VHF, marine VHF, land-mobile VHF and the City's trunked digital radio system
  - A small cache of Motorola handheld radios able to operate on the City's trunked digital radio system
  - Communications repair equipment including conventional telephone wire, CAT-5e Ethernet and the tools necessary to build or repair cables.
- PF&R also maintains two tactical 800 MHz conventional (non-trunked) repeaters. These units are designed to support incident scene communications where the City of Portland trunked digital radio systems is unavailable due to failure. All City-issued radios that are programmed with the PF&R template have these frequencies pre-assigned as talkgroups.

BOEC maintains an off-site backup dispatch center inside a trailer that can be used by dispatchers and call-takers if the primary 9-1-1 call center is non-functional. The trailer uses a separate telephone circuit from the one used by the 9-1-1 dispatch center. Some dispatch functionality, including fire and EMS tap-out and integration with law enforcement and fire networked data systems, is unavailable at the secondary site. The primary focus of the secondary site is emergency call-taking and radio dispatch. The backup site does not have space or telephone line capacity to fully replicate the entire 9-1-1 call center; the ability to handle large call volumes is hampered when operations move to the backup site.

PBEM maintains a small cache of Motorola handheld radios for use during ECC field operations. PBEM has access to an ACU-1000 communications gateway, which allows for multiple disparate communications systems (radio, cellular telephone, PSTN, satellite) to be bridged together to allow different organizations to talk to each other. Currently, the ACU-1000 is set up to crossband repeat land-mobile and amateur radio UHF and VHF radio systems. PBEM also maintains two portable radio go-kits:

- The HF Go-Kit is focused on high-frequency radio, with the ability to transmit data and email over long distances. This system is designed to provide regional communications to OEM in Salem, FEMA Region X in Bothell (Washington), and to logistics centers in the eastern part of Oregon (Pendleton, Bend).

- The VHF-UHF Go-Kit is focused on providing crisis communications at a remote location with little to no communications infrastructure in place. This system provides voice and limited data communications over conventional land-mobile VHF radio, amateur UHF and VHF band radio, and the City of Portland's trunked digital radio system. This Go-Kit can, with enough notice to purchase a SIM card, provide satellite internet access and telephony via the Inmarsat BGAN service.

PWB maintains a portable command trailer equipped with VSAT voice and data connectivity, amateur UHF/VHF radios, and a City trunked digital radio, all powered by a high-capacity onboard generator. The trailer is cached on Portland's west side to facilitate emergency communications with Water Bureau repair operations.

Assets Available through Mutual Assistance

Communications demands during large incidents or disasters such as a CSZ earthquake are likely to outstrip the capacity of the City of Portland's existing communications systems, especially if backhaul or internet access is compromised by infrastructure damage. Additional resources may be available from a mix of County, State, Federal and private industry partners. If the ECC is activated, the Communications Unit Leader (COML) will be responsible for coordinating or requesting additional communications assets when requested. A partial index of these assets includes:

- All the major **wireless telecommunications companies** (Verizon, AT&T, and T-Mobile/Sprint) maintain a mix of trailer-mounted Cellular (tower) on Wheels (COW) and Cellular (tower) on Light Truck (COLT) available for use in emergencies or to locally augment existing cellular infrastructure when demand is high. Most portable cellular towers will require on-site backhaul, either through a satellite internet connection or via a microwave relay, to connect cellular service to the rest of the PSTN and the internet. They will also require power via a portable generator, sometimes referred to by service providers as a GOAT (Generator on a Trailer). Note that each provider operates a different type of cellular network based on different technologies; AT&T subscribers may not be able to use a mobile cellular tower provided by Verizon. This implies that mobile cellular assets from multiple companies will likely be needed after a disaster to restore some level of service to public and private subscribers. While terminology varies by provider, the most common terminology for these devices are:
  - Cellular on Wheels (COW): Often consists of a portable mast, antennas and an equipment box mounted on a trailer. These units may or may not have on-board power and require a support vehicle for transport.
  - Cellular on Light Truck (COLT): Usually consists of a portable mast, antennas, electronic equipment, an on-board generator and places for communications technicians to work. Often these units also contain built-in microwave or satellite dishes to provide for backhaul.
  - Cellular Repeater on Wheels (CROW): Used primarily by Verizon to refer to their version of a COW.
- **Verizon Wireless** maintains a **Crisis Response Team (V-CRT)** to support first responders and government agencies during emergencies. Portable cellular tower equipment is requested through a nationwide hotline staffed around the clock (see Attachment 1). Response time is dependent on availability of personnel and physical resources which, for a multi-state incident or during fire season, may be deployed or in use elsewhere. Verizon responders are also able to provide phones, wireless hot spots, and emergency communication go-kits designed to provide an ICP or EOC with wired and wireless telephony, equipment charging stations, and internet access. V-CRT support is requested through an 800 number that rings the regional Verizon Network Operations Center. Once the request is vetted, local Verizon account and technical representatives will be notified.
- **CenturyLink Telecommunications**: As the primary carrier for connection of the City of Portland's telephone system to the PSTN, local CenturyLink engineers are the first point of contact for any service outages. They may be able to provide network engineers to assist with circuit restoration. CenturyLink and the BOEC 9-1-1 dispatch center participate in the Telecommunications Service Priority (TSP) program through the Department of Homeland Security; this allows CenturyLink to make telephone and data circuits available for priority use by first responders and City bureaus upon request. During a disaster, services are available by contacting the CenturyLink Business Continuity Management Office; in all other scenarios requests are funneled through the local Service Delivery Coordinator.
- **Cisco Tactical Operations**: Cisco Systems provides a wide range of hardware, software and services to the information technology industry. the Tactical Operations division is focused on providing emergency communications support and system recovery assistance in support of humanitarian

operations. Resource requests should be directed to Cisco Tactical Operations via email. Cisco has the following assets potentially available for deployment:

- **Network Emergency Response Vehicle (NERV)**: This is a NIMS Type II Mobile Communications Center. Its functionality is roughly identical to that of PPB's CNT truck or PF&R's MC9.
- **Emergency Communications Unit:** This is a NIMS type III Mobile Communications Center mounted in a trailer. Its functionality is very similar to that of the MC ARES or Portland Water Bureau trailers, though it does require external power. Cisco's ECU has an on-board VSAT dish to provide voice and data service when other sources of backhaul are unavailable.
- **Emergency Communications Kits:** This kit is designed to provide an ad-hoc command post or local EOC with voice, data and internet connectivity. It includes a network switch, a VoIP gateway, a communications bridge, and the ability to connect to the internet via POTS lines, satellite links or using a cellular data network.
- **Rapid Response Kits:** This kit is designed to support a network engineer working on remote network management, service restoration, traffic management and security. BTS has similar go-kits already provisioned.
- **Mesh Response Kit:** This kit is designed to implement a full-featured cloud-managed wireless local area network (WLAN), including traffic shaping and firewalling. It can operate with or without connection to the internet.
- **Phone Kit:** Eight (8) Cisco VoIP phones with a Meraki network switch managed through the Cloud for turn-key operation. Requires an internet connection for backhaul and a connection to the PSTN.

Communications assets may be available through a mutual aid request to other counties within the Urban Area Security Initiative (UASI) region, provided those assets are not already in use. A partial list of known UASI-region assets includes:

- **Columbia County**: Columbia County Emergency Management maintains a portable communications trailer initially funded by UASI grants. This trailer has an on-board generator, two radio operation workstations with access to amateur and public safety UHF and VHF radios, a HF radio capable of digital operations, and a small cache of VHF handheld radios. Columbia County also maintains several PodRunner emergency communications carts, which have similar functionality to the trailer but in a smaller and more portable form.
- **Washington County**: The Washington County Consolidated Communications Agency (WCCCA), which is responsible for 9-1-1 dispatch and much of the land-mobile radio systems used by Washington County agencies, maintains a mobile communications trailer. In addition, Washington County maintains several caches of 54 VHF radios for use in emergency situations that may be available by request. Washington County/WCCCA is connected to the Portland trunked digital radio system via an ISSI interconnect.
- **Clackamas County**: Disaster Management maintains a small (6 units) cache of dual band VHF and 700/800 MHz Motorola APX handheld radios; these units are intended for use by the Regional Mass Fatality Team but may be available by request. Clackamas County Communications (CCOM) maintains a cache of approximately 90 radios and the City of Lake Oswego a smaller cache of approximately 25 radios. The Clackamas 800 Radio Group (C800) is in the process of revamping the County radio system as a P25 Phase 2 compliant trunked digital radio system. Clackamas County 9-1-1 (CCOM) and WCCCA partner to maintain both the Washington and Clackamas county radio systems.
- **Multnomah County**: Multnomah County Emergency Management (MCEM) maintains caches of handheld and mobile VHF radios that may be requested in an emergency if not already in use by County responders. MCEM also has several portable terminals (Inmarsat BGAN) for satellite voice and data communications. Most Multnomah County public works operations use a mix of land-mobile VHF and 800 MHz handheld radios; while unassigned radios do exist, they are generally kept as operational spares rather than as cached radios. The full Multnomah County radio inventory is kept in WebEOC. Requests for assets should go through either the Multnomah County EM duty officer or via WebEOC.
- **National Incident Radio Support Cache (NIRSC)**: The NIRSC is a national resource composed of multi-channel radio systems, frequencies, and kits that are available for supporting complex incident communications. It may be the largest cache of portable radio equipment in the world, including (as of 2014) 8,000 handheld radios, 200 portable repeaters and 15 portable satellite voice and data systems. The Cache is intended primarily to support wildland firefighting efforts and is maintained by the National Interagency Fire Center in Boise, Idaho. However, equipment from the caches can be requested for use on any federally-

supported incident or disaster. Resources from the NIRSC are ordered through the Oregon Office of Emergency Management (OEM) via a resource request from Multnomah County. Oregon Department of Forestry (ODF) is responsible for coordinating the logistics of NIRSC deployments, though the resource request runs through OEM.

- **State of Oregon Strategic Technology Reserves (STR)**: STR assets are deployable, pre-positioned equipment that is capable of re-establishing communications when communications infrastructure is damaged or destroyed. These assets may be available by request to the state Office of Emergency Management via Multnomah County. The closest trailer to Portland is in the city of Milwaukie. The trailers are equipped with:
  - An amateur radio go kit containing Icom VHF/UHF and HF radios, a PACTOR data modem, and appropriate wire antennas.
  - A public-safety portable radio box containing 12 Harris XG-100 700/800 MHz P25-capable handheld transceivers. These are dual-band (VHF and 700/800 MHz) radios.
  - A portable satellite telephone and data terminal utilizing the Inmarsat BGAN service.
  - Two portable radio antenna masts; one for amateur radio and one for land-mobile radio in the public safety bands.
  - Battery backup systems.
  - A portable gasoline-powered generator.
  - A host of necessary equipment for portable radio operations including tools, coaxial cable, battery chargers, guy lines, sandbags and anchors.
- **Oregon National Guard (ONG) Weapons of Mass Destruction Civil Support Team (WMD-CST)**, usually abbreviated to CST. Oregon's 102nd CST is one of ten teams in the United States established to support state and local authorities in the event of any incident involving weapons of mass destruction. Each CST is made up of 22 active-duty Army and Air National Guard soldiers. While the primary focus of these teams in around response to a Chemical, Biological, Nuclear, Radiological and high-energy Explosive (CBRNE) event, CSTs also have significant mobile communications capabilities. These units typically have a communications van capable of satellite voice and data, connection to the PSTN and cellular data networks, and radio communications over amateur, public-safety and military frequencies in the UHF and VHF bands. Resources from the 102nd CST may be available via a resource request to Oregon OEM through Multnomah County.
- **Civil Air Patrol**: Civil Air Patrol is a Federal asset and maintains the largest nationwide HF network and regional VHF repeaters. CAP can provide airborne platforms for direct radio relay and carrying a customer's portable repeater which can provide over a 50-mile radius of coverage. CAP communications staff can provide radio operator augmentation and manual relay teams. CAP aircraft and vehicles are equipped with full VHF interoperability capability to include both the Non-Federal interoperability channels and local mutual aid and interoperability channels including the Oregon SAR channels, Oregon FireNet and Washington OSCCR. Oregon CAP maintains a fleet of four-wheel drive communications vehicles equipped with multiple VHF radios and a high frequency radio with automatic link establishment (ALE) capability for long range communications. Two of those vehicles are assigned to the Portland Metro area. Oregon CAP has three mountain top repeaters in the greater Portland Metro area along with two tactical repeaters operating on USAF assigned frequencies. CAP assets may be requested from Oregon OEM through Multnomah County or by contacting the CAP National Operations Center.
- **United States Air National Guard (ANG) Mobile Emergency Operations Center (MEOC)**: Oregon ANG's MEOC is designed to provide a communications and planning nexus in the field for complex or multi-agency incident response. The trailer features satellite voice and data service, an ACU-2000 gateway capable of patching multiple disparate radio systems together, radios across all the common military and civilian bands (VHF, UHF and 700/800 MHz), a mast-mounted long-range surveillance camera hooked to digital video recorders, and a coffee machine. The trailer also features a VoIP telephone system capable of using satellite, cellular networks or a landline (Ethernet) connection to the internet. A combination of batteries and an on-board generator allow for three to five days of operations without access to external power. This unit may be available via a resource request to Oregon OEM through Multnomah County

Note that this section is not an exhaustive list of assets available in a crisis; it is focused on assets that are readily available locally or can be requested from Multnomah County or the State of Oregon. Additional equipment, such as COWs/COLTs, generators, and repair crews, may be available from adjacent states or FEMA. Any request for communications assets should also include the consumables and personnel to repair and maintain the systems. For example, COWs and

COLTs will require generators and fuel, which will in turn require both electricians and refueling resources.

COMMUNICATIONS SYSTEMS OUTAGE REPORTING

The overall responsibility for restoration of communications services rests with BTS, with system prioritization pre-emptively set in the Citywide COOP plan approved by the DPC. The ECC will be an information broker and coordinator for system status updates and resource requests. Information regarding alternative communications paths will be coordinated and sent by BOEC to first responders and routed to other City bureaus via PBEM Duty Officers during routine and enhanced operations or the ECC if it is activated. If any sort of cyber threat such as hacking, malware infection or denial-of-service attack is noted or suspected to be the cause of a communications system outage, BTS Information Security should be immediately notified.

In the event of an ECC activation or disaster that adversely affects communications hardware or software, outage and error reports should be recorded and reported promptly. During a full activation after a regional disaster such as a CSZ earthquake or terrorist attack, the communications unit leader (COML) or a deputy will be the first point of contact when reporting an outage. During normal and enhanced operations and during most partial activations, errors and outages should be reported as follows:

- **City trunked digital radio system**: BTS Public Safety Technology Division via the BTS Help Desk.
- **VoIP telephones**: BTS Communications via the BTS Help Desk.
- **IP networking and internet services**: BTS Communications via the BTS Help Desk, and, if the ECC is activated, the COML.
- **Database, Data Center or Windows servers and messaging**: BTS Production Services via the BTS Help Desk, and, if the ECC is activated, the COML.
- **Paging**: BTS Production Services, notified through the BTS Help Desk, and, if the ECC is activated, the COML.
- **9-1-1 telephone system, vCAD and radio dispatch systems**: BOEC Emergency Coordinator and/or Operations Floor Supervisor, both of which can reach out to public-safety centric BTS support.
- **WebEOC**: PBEM Duty Officer or WebEOC Technical Specialist, if the ECC is activated.
- **Amateur Radio**: PBEM Duty Officer.
- **Portable Communications Assets**: Responsible party for the host bureau (PF&R, PPB, PWB).
- **Satellite Telephones**: BTS Communications via the BTS Help Desk.

In addition to the BTS contacts, Annex C (Alert and Warning) specifies several conditions where the PBEM Duty Officer should also be notified of a communications system error or outage. These include:

- Any interruptions in 9-1-1 service or BOEC operations.
- The activation of a bureau or citywide COOP plan due to a communications outage.
- Any communications system outage that affects more than 20% of the City's workforce.

All outage and error reports must contain:

1. Reporting party's name, telephone number, email address, and their city bureau.
2. Date, time, and location at which the outage or error was noted.
3. Is the outage or error causing an immediate threat to life or property?
4. The time and date of the last known successful use of the system.
5. The service type (voice or data; wired or wireless networking, radio or microwave) and details, including type and model of devices used to access the system.
6. Number of people are affected by the outage? What is their role in the response to the incident?
7. A description of the actions and activities that were underway before the error or outage.
8. Any additional information that might help technicians diagnose problems.

MAXIMIZING RESOURCES DURING A CRISIS

The City's existing communications networks are capable of handling system loads during normal and enhanced operations with few if any changes to hardware, software or procedures. Most partial activations will also not significantly stress communications networks. Additional resources, such as more 9-1-1 call takers at BOEC or the presence of a mobile

communications van at an incident scene, may be required to deal with a surge in system usage during a crisis, but the networks themselves are likely to be fully functional.

During a disaster or full ECC activation, it is likely that some portions of the City's communications infrastructure could be unavailable, damaged, or destroyed. Given that the need for timely communications is heightened during a crisis, the demand for communications channels may outstrip supply. There may be competing demands and priorities, especially for interoperable communications assets. In the event of communications outages or shortages, resources may be reallocated or prioritized by the following authorities:

1. Priorities written in Bureau emergency action plans.
2. The general resource prioritization scheme described in the next sub-section of this annex.
3. If an Incident Command has not yet been established, representatives from the responding Bureau(s) will have the authority to designate and prioritize the usage of communications assets. For incidents involving radio communications BOEC will also likely play a role in frequency and talk group assignments.
4. The ECC Communications Unit Leader (COML), or, if the incident is large enough to involve multiple jurisdictions, a Communications Unit Coordinator (COMC). Both the COML and COMC will be focused on tactical operations such as incident response and scene stabilization. Note that there are currently no certified COMCs within the State of Oregon.
5. City leadership through the Disaster Policy Council (DPC). The focus of the DPC is on strategic rather than tactical priorities and may address general policy in terms of acceptable usage and service restoration priority.

General Resource Prioritization

If the available communications resources are not sufficient to support City and partner operations during a full activation or disaster, the assignment of resources (bandwidth, frequencies, hardware) should follow the three priority levels set by the National Incident Management System (NIMS):

- First priority is life safety, both of response personnel and the general public. This priority includes:
  - Alert and warning communications, in accordance with Annex C
  - Tactical command and control of life-safety operations
- Second priority is incident stabilization, which covers actions designed to prevent the scope, duration or intensity of an incident from escalating. This priority includes:
  - Emergency coordination and support (i.e. EOC to EOC, ICP to ECC)
  - Tactical command and control of non-life-safety operations
- Third priority is the preservation of property, both private and public.

The implication of this priority list is that administrative traffic and other users of the City's communication network can be restricted or prohibited to sustain higher-priority communications traffic. On heavily congested radio networks, traffic can be managed using a net control operator. Net control functions like a PSTN telephone operator: the net controller chooses who can speak to whom, when they can speak, and for how long. This allows a significant number of users to be managed on a single talkgroup.

Network policing and traffic shaping, also known as ensuring quality-of-service (QoS), can be employed on both wired and wireless IP networks to assign higher priority to certain types of information or to completely shut down non-essential traffic. Network policing is used to limit traffic to a certain speed; it can either be done for an entire connection (i.e. limit each network device such as a laptop or cell phone) or by protocol (limit internet traffic while maintaining full-speed LAN traffic). Network policing is designed to protect the network from disruption due to large bursts of demand, such as large file transfers or streaming video. Traffic shaping performs a similar function, but instead of cutting off traffic over a certain rate the priority of some types of traffic can be delayed so that it is transmitted when the network is not as busy. A good example of traffic shaping would be de-prioritizing streaming video in favor of real-time VoIP calls. On-call BTS network engineers can adjust these parameters across most of the City's WAN in real time.

Best Practices to Mitigate Communications Limitations

This section is adapted from the Washington County Emergency Operations Plan Functional Annex D, with some minor modifications. It summarizes industry-wide common-sense measures to help limit the load on communications systems. These best practices include:

- Use face-to-face communications wherever possible. For example, the co-location of all Command and General Staff at an Incident Command Post (ICP) provides the best direct communication and reduces the demand on communication system resources.
- Enforce radio, telephone and network discipline and good operational practices. During emergency operations, keep communications short and minimize non-emergency traffic. Ensure that the receipt of important information is acknowledged, especially information sent via electronic mail.
- During emergencies all users should strive to use plain language in all communications. Avoid agency-specific abbreviations, technical jargon and unnecessary wording.
- When geographically possible and operational security allows for it, use shared tactical radio talkgroups that work in simplex mode. Simplex channels do not use repeaters and may even work better than repeated talkgroups for on-scene communications. In a situation where the City trunked digital radio system is non-functional or working at a reduced capacity this best practice is an operational requirement.
- If responding agencies do not share common radio or data systems, use a gateway to establish interoperable communications. There are several portable gateways available at the City of Portland that can bridge different radio (and satellite or PTSN telephone systems) together into a seamless network. For IP networks, ensure that guest access and authentication is available for outsider responder use.
- Avoid data-intensive network activities, especially if IP networks are damaged or operating over a backup satellite or wireless connection. Schedule large file transfers to occur at night or in the early morning when demand for network resources is likely to be less. Most satellite data connections charge by the quantity of data transmitted or received at expensive rates compared to cellular wireless companies; consider finding other methods besides satellites to download large amounts of data.
- Where interoperable communications cannot otherwise be established between response agencies, exchange or use cache radios and/or cellular phones to establish interoperable communications for responders. Caching cellular telephones is not currently a common practice at the City of Portland, but all the public safety bureaus and some of the public works bureaus maintain small caches of radios usable on the Portland trunked digital radio system.
- Judicious use should be made of wireline and wireless telecommunications priority services. As mentioned in the previous section on the City's communication systems, both the Government Emergency Telephone System (GETS) for PSTN telephone circuits and Wireless Priority Service (WPS) for cellular networks are available to City bureaus and employees. Both services provide a way for voice calls to take priority over other users and/or to preempt other users to complete calls through heavily loaded circuits. Note that at this time the prioritization services apply only to voice calls; wireless data prioritization and preemption are features promised by the major wireless carriers that have not yet been implemented at the City of Portland.
- Liaising with private industry partners such as CenturyLink, Verizon, Comcast, AT&T and Flexential should be a key task of BTS staff and communications unit personnel in the ECC. Engineers with these agencies may be able to assist with service restoration or rerouting.

HAZARD SCENARIOS

A complete discussion of the hazards and disasters the City of Portland BEOP is designed to address is presented in both a series of hazard-specific annexes and in the Mitigation Action Plan (MAP). This section of Annex B is narrowly focused on two specific scenarios for which substantial damage and/or service interruption of the City's communications systems is anticipated:

1. Earthquakes: This scenario includes not just the expected Cascadia subduction zone (CSZ) mega-quake but also moderate (energy magnitude 6 – 7.5) earthquakes on faults in the greater Portland metropolitan area.
2. Cyber threats An intentional attack on the on the City of Portland's technology and communications systems can pose a significant risk to life and property. Communications system outages due to virus or denial-of-service attacks can hinder the response to the physical terrorist incident.

Damage to the City's communications infrastructure during an earthquake can take a wide variety of forms, including:

- Disruption of fiber optic lines hosting the City's WAN due to earthquake damage. Fiber lines carried underground in conduits can be compromised when the soils surrounding the conduit liquefy and settle, or when large-scale land movements such as surface ruptures or landslides bend, break or shear through conduits. Fiber optic lines carried above-ground on poles can be broken by falling trees, buildings, and other man-made objects or cut when one or more utility poles are downed by liquefaction or other earthquake-related soil failures.

- Disruption of electrical power generation or transmission systems. All City communications systems are dependent on electrical power to function. Earthquake damage to electrical substations, transformers, transmission lines, and local distribution lines may render communications systems inoperable until power is restored. Many of the City's systems, including the data centers, radio repeater towers, and PSTN switches feature both battery and generator back-up to provide some resiliency to power failures.
- Microwave relay networks rely on a precise alignment between the transmitting and receiving antennas to allow for high-speed large-bandwidth connections. Earthquakes can disrupt this alignment by moving the antennas on the towers or by moving the towers themselves through land displacement, settlement or landslides.
- Both IP and conventional (PSTN) telephone networks are dependent on switching facilities to manage traffic and provide gateways between networks. Not all the buildings hosting these types of facilities for the City of Portland (either City-owned or third party) are built to modern seismic standards and may be at risk of damage or partial collapse during a large earthquake.
- Cellular voice and data services are provided by a mix of tower sites and so-called "small-cell' units mounted to buildings and city infrastructure. Tower sites suffer the same risk as microwave relay sites discussed above and are also vulnerable to disruptions in electrical service.
- Backup generators for communications systems rely on a mixture of hydrocarbon fuels (liquid propane and diesel) to recharge battery backups and to supply power when the local grid is unavailable. Portland's critical energy infrastructure hub (CEI) is highly vulnerable to earthquake damage, and there is only one pipeline from Washington State that provides liquid fuels to the region. The COML will work with the logistics chief to prioritize and acquire fuel for communications infrastructure.
- Many city utilities including both voice and data service cross the Willamette and Columbia rivers on bridges that are vulnerable to damage or collapse in a moderate or severe earthquake. Because of the geography of Portland, there are few paths to the internet backbone that do not cross at least one river.
- Fire can be a significant factor in infrastructure damage during an earthquake. The shaking can compromise both electrical power and natural gas service lines, which can lead to fires and explosions.

Cyber-attacks on public infrastructure and government facilities are on the rise and can cause significant disruption to communications services. Almost all the City's communications systems are connected via the WAN and require safe network or internet access to function correctly. Disruptions to the WAN, to the switch that connects the PSTN to either the City's telephone network or the 9-1-1 telephone switch, or to the City's ability to connect to the internet can significantly hamper the ability to respond to incidents and disasters.

A partial list of the types of cyber threats the City faces from Cisco Systems[4] includes:

- Malware: A blanket term describing a wide variety of hazardous software, including worms, spyware, ransomware, viruses and keyloggers. Malware breaks through known vulnerabilities in the network (worms and viruses) or infects a device when users install questionable or risky software. The most common infection vector continues to be corrupted attachments contained in emails.
- Phishing: Fraudulent communications designed to trick recipients into revealing sensitive data, including account passwords and credit card information. Primarily uses email as the attack vector; when it happens in person it is often referred to as social engineering.
- Man-in-the-middle (MitM): Also known as eavesdropping, MitM attacks occur when an attacker inserts themselves in secret into a transaction between two parties. Once the attack is successful, information can be corrupted or stolen. Two common attack vectors are from additional malicious software installed on a computer previously infected with malware, or from hijacking traffic on insecure public wireless networking connections.
- Denial of Service (DOS): DOS attacks flood a network or server with enormous amounts of information requests, with the goal of exhausting all available resources and forcing the target network offline. Because of the massive amount of traffic, a DOS'd network is unable to service legitimate user requests. These attacks typically use hundreds to thousands of computers that have been previously compromised by an attacker via other means to launch the attack from multiple locations simultaneously.
- SQL Injection: Most modern websites use a database server behind the scenes to store information. These databases use a formal syntax called Structured Query Language to allow applications to search and request data. A SQL injection

[4] Cisco Systems, "Common Cyberattacks", last accessed 10/29/2018: https://www.cisco.com/c/en/us/products/security/common-cyberattacks.html

occurs when malicious data is submitted to the database, usually through a poorly-validated website, which forces the server to reveal information that would normally not be accessible.

- Zero-day Exploits: These represent flaws or vulnerabilities in a hardware or software product in use by the City of Portland for which the vendor does not have a solution, patch, or work-around. Once a zero-day exploit is published, cyber criminals generally have tools designed to exploit the vulnerability in a matter of hours to days.

Cybersecurity threats by themselves pose a significant danger to City operations; email servers already process enormous amounts of spam email, much of which may be infected with malware or is a phishing threat. Divisions such as the Water Bureau and Development services maintain significant amounts of personally identifiable information which, if compromised, could lead to identity theft, credit card fraud or other serious crimes. A cyberattack could limit the City's ability to generate revenue (taxes, parking fees, building permits), deliver essential services (traffic lights, water, sewage), and communicate with the public (website, information lines).

ROLES AND RESPONSIBILITIES

This section outlines the roles and responsibilities for each City of Portland bureau related to communications systems. The organization's Roles are the expected actions and behaviors associated with a position or bureau, while Responsibilities are the duties to act on elements under the position's or bureau's span of control. Note that this Annex does not exempt bureaus or partners from the responsibility of agency-specific emergency operations and continuity of (business) operations planning.

For the purposes of discussing the roles and responsibilities of different bureaus and agencies in supporting the Communications function, this Annex divides participants into three classes:

- **Primary Bureau**: The primary bureau is responsible for acquiring, provisioning, supporting and maintaining a communications system, and is the first point of contact for any questions or issues about that system. Primary bureaus are likely to be the heaviest users of the City's communications systems and the most affected by system down-time. Primary agencies may require assets and personnel from supporting bureaus to maximize responsiveness and minimize system outages.
- **Supporting Bureau**: A supporting bureau contributes to the mission(s) of other bureaus but is not solely responsible for the maintenance and provisioning of communications systems. These bureaus will likely require timely communications to perform at their peak.
- **Partners and Adjunct Agencies**: Partners and adjunct agencies include a mix of public and private agencies and organizations, including County, State and Federal agencies, non-governmental organizations, volunteer auxiliaries and industry partners. These organizations have roles in communications at the City of Portland, be it as vendors, system providers or mutual-aid support.

Responsibilities of All City Offices and Bureaus

- All bureaus must maintain a current COOP plan. Bureau technology experts should consult their bureau's COOP planner to ensure that there is a plan for which describes:
  - Office/bureau operations, including telephony, paging, printing, file storage & sharing, and email, without internet or Portland wide-area-network (WAN) access.
- During an emergency, communicate communications needs and requirements to the City of Portland ECC for inclusion in an incident communications plan. These requests should encompass any needs for equipment, new service, additional capacity for existing services, and any needs for communicators and/or engineers to maintain and service equipment.
- Maintain and support GETS and WPS subscriptions for key personnel to support emergency communications.

Primary Bureaus

The **Bureau of Technology Services (BTS)** has the role of provisioning and maintaining nearly all the City of Portland's communications, networking and computer hardware infrastructure. BTS has the primary responsibility for restoring communications services after an incident or disaster. Service restoration is based on prioritized essential functions detailed in the City-wide COOP plan. The BTS bureau-specific COOP plan translates this list of prioritized essential functions into a service restoration matrix describing in what order technology products will be restored. Given its critical role in both emergency operations and the return to routine operations after a disaster, there will be a significant demand on BTS for services and personnel. BTS is responsible for the following communications-related functions:

- Provision, maintain, repair, and provide end-user technical support for:
  - Wired and wireless LAN/WAN networks
  - The City's trunked digital radio system
  - Desktop and computer hardware & software
  - Voice-over-IP and conventional telephony
  - Paging services and wireless telephony
  - Microwave backhaul systems for voice and data communications
  - Internet connectivity
- Maintain contracts with commercial vendors for cellular telephone service, cellular data service, and satellite communications service.
- Provide technology support for the trunked digital radio system to regional partners including the cities of Gresham and Troutdale, Multnomah County Sheriff and local ambulance services.
- Coordinate the repair / replacement of damaged or destroyed BTS critical communication equipment and/or resources.
- Reestablish and/or maintain radio communication connectivity between 9-1-1 dispatchers and first responders by ensuring that radios & radio controllers are functioning properly.
- Provide incident responders to the Portland ECC including communications technicians (COMTs) and ICS Communications Unit Leaders (COMLs).
- Provide information technology support to Bureau EOCs and the City's ECC through a mix of a centralized Help Desk function, roving IT specialists and contracts with consultants and external agencies.
- Take a lead role (BTS Information Security) in any emergency response to a cybersecurity incident.

Bureau of Emergency Communications (BOEC): BOEC's role is as the Primary Public Safety Answering Point (PSAP) for the City of Portland and Multnomah County. Service requests are received via a switched telephone network and are relayed to emergency service providers using a Computer-Aided Dispatch (CAD) system via the trunked digital radio system, to mobile display consoles (MDC) through cellular modems, and through both conventional and wireless telephones to individual public safety professionals. BOEC's communications responsibilities are:

- Staff and run the 9-1-1 dispatch center. BOEC's highest priority essential function is to answer and process incoming 9-1-1 and emergency calls.
- Maintain an off-site alternate dispatch center capable of controlling and assigning resources if the primary site is damaged or disabled.
- Coordinate communications and operational dispatch of public safety personnel at all operational levels.
- Assign and coordinate radio frequency assignments on interoperability channels and if the trunked digital radio system goes into failover mode.

The **City of Portland Emergency Coordination Center (ECC)** is a highly resilient building with multiple redundant communications systems including a large backup generator, solar power, satellite internet access, satellite telephony, and both public safety and amateur radio operations facilities. The ECC is designed to support large multi-agency emergency responses and facilitate cooperation and interoperability among city, county, state and federal resources in a crisis. The ECC's responsibilities during an emergency are:

- Support city communications where possible using the trunked digital radio system, air-band and land-mobile VHF and UHF radios, satellite voice/data, and regional voice and data communications using amateur radios.
- Enhance communications and cooperation between multiple stakeholders responding to an incident or disaster by supplying a reliable and resilient common work space.
- Support public information functions using a switched telephone Message Center, Joint Information Center (JIC) and VHF radio connections to fire stations and BEECN nodes.
- Assign communications methods and/or channels according to ECC objectives and prioritized city essential functions in conjunction with or in support of BOEC.

The **Portland Bureau of Emergency Management (PBEM)** is assigned the role of promoting readiness, coordinating emergency and disaster response, and building resilience for the City of Portland. PBEM is the primary maintainer of the City BEOP, hazard-specific annexes and functional annexes. PBEM's responsibilities with respect to communications are:

- Maintain the City ECC and providing staff to activate and support Bureau incident operations.
- Provision and maintain WebEOC, an online crisis information management software used by the City of Portland and

most neighboring counties to exchange information and maintain situational awareness.

- Work with Multnomah County to support auxiliary communications (AUXCOMM) through the Amateur Radio Emergency Services (ARES), the BEECN program, and through Portland Neighborhood Emergency Team (NET) amateur radio operations.
- Maintain the City's amateur radio station, W7ECC, which provides local UHF, VHF and VHF air band radio resources as well as statewide communications using HF voice and digital radio services.
- Maintain a small cache of Motorola handheld radios for use by ECC responders during a crisis.

Portland Fire and Rescue (PF&R) is the primary fire and medical customer for the City's trunked digital radio system and is also a major user of MDCs and cellular data for mapping, dispatch and all-hazard technical response documents. PF&R communications responsibilities include:

- Maintain portable UHF-VHF amateur radio go-boxes at each fire station for communications after a failure of the trunked digital radio system. PF&R frequently collaborates and/or cost-shares with PBEM to maintain these systems.
- Maintain a fixed mobile VHF radio and external gain antenna at each fire station for communication with PF&R personnel during a failure of the trunked digital radio system.
- Maintain an external antenna and ground-level coaxial cable plug in to support amateur radio operations during a disaster. The primary use is to act as a human bridge for transmissions from BEECN radios to other city bureaus and supporting agencies.
- Provide a comprehensive suite of mobile communications technologies, including satellite voice & data, multiple cellular provider voice & data, amateur UHF / VHF / HF radio, marine VHF radio and other land-mobile radio systems, aboard Mobile Command Unit Nine (MC9).

The **Portland Police Bureau (PPB)** is the primary law enforcement customer for the trunked digital radio system and wireless data services via cellular modem. PPB is supported by a dedicated team of BTS technicians. PPB's responsibilities for emergency communications include:

- In conjunction with BTS maintain portable field-deployable communications assets capable of communicating via radio and cellular networking technology, including:
  - Aviation assets with microwave relay capability
  - Portable analog repeaters for 800 MHz radio operations
  - Mobile precincts for shelter and operational support
  - Radio and telecommunications gateways to patch disparate systems into a single network
- Confirm communications links with Bureau EOCs, the City ECC and partner agencies, including participation in drafting incident communications plans.
- Provide security for City communication systems if necessary and if resources are available.
- Coordinate the use of backup radio frequencies with BOEC and the Communications Unit Leader in the City ECC or Bureau EOC.

Supporting Bureaus

The **Portland Bureau of Transportation (PBOT)** uses a mix of the trunked digital radio system, conventional telephony, wireless telephony and internet data to dispatch and coordinate road construction and maintenance activities. In addition, PBOT installs, maintains and controls fiber optic communications lines that connect traffic signals and road cameras with the City of Portland's intranet. Communications responsibilities for PBOT include:

- Assisting BTS with access to remote communications facilities such as repeater sites during snow & ice events or after a disaster.
- Supporting reconstruction of fiber-optic voice and data lines disrupted during a disaster.

The **Portland Water Bureau (PWB)** is responsible for providing water to the City of Portland and maintaining water quality to national standards. PWB also maintains all fire hydrants within City limits. Communications between the water treatment and storage facilities and the Bull Run reservoir are over fiber-optic land-lines, cellular data networks, desktop & mobile satellite telephones and the City trunked digital radio system. Given the importance of adequate water to disaster sanitation, firefighting and public health, restoration of communications services is of high importance in the post-disaster environment. PWB communications responsibilities include:

- Maintain a mobile trailer able to provide local communications support with cellular voice & data, both land-mobile and amateur radio systems, and mobile voice & data via a satellite link.

- Support PWB rangers, Dispatch and PWB maintenance personnel throughout the City with both mobile and man-portable trunked digital radios and satellite telephones for communication in the watershed and throughout the City.
- Support public notification efforts via a call center in the event of hazardous water conditions such as a boil-water notice.
- Maintain GETS/WPS priority calling access for key PWB personnel and maintenance staff.
- Maintain and scheduling service for the radio tower located in the Bull Run watershed.

The **Office of Management and Finance (OMF)** supports all City bureaus by providing accounting, contracting, procurement, facilities management, risk management, strategic planning and human resources services. OMF's role with respect to communications systems includes:

- Own and maintain City property by the Facilities Services division, including the generators and fuel tanks at radio repeater sites. At some sites, the City also owns the land and the radio towers.
- Procure, install and maintain a GPS position tracking system for City of Portland vehicles. City Fleet is the agency inside OMF responsible for these systems.
- Maintain City owned gas stations and disperse fuel to all bureaus except PF&R. City Fleet is the agency inside OMF responsible for these systems.

Key External Partners

- **Multnomah County**: All support requests for mutual aid, including communications support and ARES activation, must go through Multnomah County. Multnomah County has critical emergency response roles such as public health, therefore maintaining reliable and redundant communications systems between the County and the City is essential.
- **State of Oregon**: Maintains several caches of portable radio equipment and telecommunications equipment useful in restoring voice and data service. Maintains state-wide radio systems for interoperable communications. Able to provide communications technicians and foster situational awareness and interoperability through the online RAPTOR web tool. Relevant state agencies involved in communications support include:
  - Office of the State Fire Marshal (OSFM)
  - Oregon State Police (OSP)
  - Oregon Department of Transportation (ODOT)
  - Office of Emergency Management (OEM)
  - Oregon National Guard (ONG)
  - State Interoperable Executive Council (SIEC)
- **Federal Emergency Management Agency (FEMA)** can coordinate and provide communications resources ranging from portable cellular towers to satellite internet and voice connectivity.
- **Amateur Radio Service** organizations include:
  - **Multnomah County ARES** provides auxiliary communications support to the City ECC, to the Portland NET program, and to other organizations such as search-and-rescue or local hospitals. Their role is to provide communications when all else fails.
  - **Portland Amateur Radio Club (PARC)** provides several radio repeaters that Portland NET and Multnomah County ARES rely on. They also provide significant experience in repeater operations, ad-hoc antenna design and radio repair.
  - **Amateur Radio Repeater Group (ARRG)** provides the largest state-wide network of linked amateur radio repeaters and supports many different county ARES teams. They also provide significant experience in repeater operations, ad-hoc antenna design and radio repair.
  - **Western Oregon Radio Club (WORC)** provides several radio repeaters that Portland NET and Multnomah County ARES are secondary users on. They also provide significant experience in repeater operations, ad-hoc antenna design and radio repair.
- **CenturyLink**: Primary ISP for the City of Portland and service provider for the BOEC/911 telephone system. Also supports more than 50 copper-wire (T1) data connections to remote City offices and community centers.
- Nearly all City of Portland issued satellite telephones use a low-earth orbiting satellite network provided by **Iridium Communications**. Satellite telephones are likely to be the first line of communications for city officials immediately following a disaster.
- **KnightSky Communications** provides backup satellite internet and telephone services to the City of Portland's ECC and the PWB Interstate facility.

- **Verizon Wireless**: Mobile broadband voice and data service provider utilizing cellular 4G / LTE wireless networks. All PPB and PF&R MDCs communicate with the City via a private network hosted by Verizon running over the public internet. Prioritizes and pre-empts other traffic for first responders and public safety.
- **Flexential** (formerly ViaWest) hosts the City of Portland data center where most of the city's application and file servers live. In addition, Flexential provides for high-speed data links between the City of Portland's hosted data center in Hillsboro and the City of Portland WAN.
- **Comcast Communications** provides fiber IP networking connections between several city sites; this service is anticipated to be replaced in 2021. Comcast also provides cable television services to many City offices.
- **Pittock Internet Exchange (PIE)**, which is run out of the historic Pittock Building in Downtown Portland, is a key point in the City's IP network infrastructure. It hosts the **Northwest Access Exchange (NWAX),** which provides connectivity and traffic routing to the City of Portland network and is an important regional internet exchange (the place where content providers (CDNs) and service providers (ISPs) exchange traffic).

The responsibilities of all commercial data and communication service providers are contractually specified by service-level agreements (SLA) maintained by BTS. However, in the post-disaster response environment these providers may also be constrained by their dependence on other companies. Many telecommunications companies do not own all their own fiber cables and instead lease some capacity from other parties. Post-disaster restoration of services in these cases will rely both on the City provider and the third party. Contact information for emergency response and management staff for several of the service providers are contained in Attachment 1.

COMMUNICATIONS SYSTEM RESILIENCY AND INTEROPERABILITY

According to the National Research Council (NRC), resilience is "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events"[5]. Investing time, money, and effort into resilience can reduce the financial impacts and long recovery times common after a disaster.

In communications, resiliency can be thought of in terms of two components: the ability of a single communications system to survive disruptions and the availability of fallback methods to keep communications flowing.

Interoperability is the ability of public safety agencies to talk across disciplines and jurisdictions via various communications systems, which in the past has typically been over shared radio channels. Interoperable communications networks must allow users to exchange voice and/or data with one another on demand, in real time, when needed, and as authorized (i.e. access controls). Common challenges to interoperability in communications include proprietary hardware and software, competition for limited bandwidth or radio frequency spectrum, encryption, politics and money.

VOICE COMMUNICATIONS RESILIENCY AND SYSTEM FAIL-OVER

Trunked Digital Radio System

The resiliency of the City's trunked digital radio system is **very good**. The system features two different master sites from which the entire network can be controlled. Each master site features backups for all hardware necessary to run the radio network (zone controllers, site controllers, and simulcast system infrastructure), and both master sites have battery and generator backup.

The primary threats to the resiliency of the radio systems are:

1. Physical destruction or disabling of the towers, generators, batteries and hardware due to earth movements during a large earthquake.
2. Physical destruction of network infrastructure due to human activities such as vandalism.
3. Availability of power from the electrical grid.
4. Availability of fuel for radio tower and data center backup generators in a crisis.

The Portland trunked digital radio system failover path contains several steps at each primary site, with reduced functionality included at each step:

- Fail-over to secondary zone controllers. There should be no impact on network operations.

[5] National Research Council. 2012. Disaster Resilience: A National Imperative. Washington, DC: The National Academies Press. https://doi.org/10.17226/13457.

- If all zone controllers fail, the radio system will no longer be in wide-area trunking and will instead be in **site-trunking**. During site-trunking the various repeater sites become islands and all talkgroups remain operational. Radio system users will only communicate with other users on the repeater site they are affiliated with. Site-trunking usually occurs if a site loses communications with the zone controllers due to a hardware link (microwave or fiber-optic cable relay) failure. The principal impact on users if site-trunking is triggered is that the dispatch consoles at the 9-1-1 center will no longer be able to talk directly to the radio network. Dispatchers will have to switch to backup radios. Radio users could be isolated from other users if they connect to a repeater that is not the primary site being utilized; this could happen in some of the outlying areas in outer east and northwest Portland where fill-in repeaters are used to improve the radio network coverage.
- If site-trunking fails, the radio network goes into a **simulcast failsoft** mode, where the repeaters are connected via microwave but are unable to communicate with a zone and/or site controller. All talkgroups will still be usable, but each talkgroup is assigned one of the twenty frequency pairs used by the City's trunked digital radio system. Because there are more talkgroups than frequencies, multiple talkgroups will be assigned to the same frequencies, resulting in longer-than-usual wait times for users when they push-to-talk on their radios.
- If simulcast failsoft fails due to network infrastructure damage, the radio system enters a **stand-alone failsoft** mode, where each repeater site becomes a stand-alone conventional repeater that is not linked to any other repeater on the network. Talkgroup operations remain the same as during simulcast failsoft operations, but with degraded geographical coverage as fewer sites will be used to cover the Portland metro area.
- In the case of a complete and total failure of the City's trunked digital radio system, conventional 800 MHz repeaters using NPSPAC interoperability frequencies are available on several of the City's repeater towers.

VoIP Telephony

The resiliency of the City's VoIP system is **good** and is anticipated to **improve to very good** in the future with the provisioning of SIP trunks via AT&T. The City's VoIP system is a mix of Avaya CM6 and CM7 running on virtual servers in the City of Portland data center. A failure of a virtual VoIP server can be remediated within four to eight hours. Failure of a physical server may require several days to replace and restore.

The desktop phones are the primary physical hardware resource for the City's VoIP system. The devices themselves are in production and readily available from national vendors. As such, BTS keeps only a limited number (20 – 30) of desk telephones in stock for service replacements; larger numbers of desk sets (for relocations or new facility build-outs) are ordered as needed. The desktop phones are not a common point of failure for the system.

The primary threats to the City's VoIP system are:

- Reduced or eliminated network connectivity due to damage or destruction of the City's fiber ring WAN.
- Reduced or eliminated network connectivity due to damage to fiber or copper access lines connecting City facilities to the WAN.
- Hardware or software failure due to malware, Distributed Denial of Service (DDoS) attacks, or other cybersecurity threats.

Fail-over for the City's VoIP system consists of additional telephony application servers spun up across the City's data center redundant server stacks. A limited number of desktop handsets are kept in stock, with softphone apps for City laptops and desktops a possible fall-back option until replacement handsets can be ordered.

Public Switched Telephone Network (PSTN) Connectivity

The resiliency of the City of Portland's connection to the PSTN is **adequate**. Local dial tone is provided by CenturyLink with long-distance service provided by AT&T. Service-level agreements (SLAs) are in place with both providers which detail contract-mandated up-time and repair priorities. TSP is available to support restoration of the 9-1-1 switch.

The primary threats to the City's connection to the PSTN are:

- Damage or destruction of the Alcatel-Lucent switch due to earthquake, fire, building collapse or cyber-attack. Spare components will be difficult to find, as the switch itself is long out of production. Replacement may be the only option. However, the recent move to SIP trunking for the VoIP system will help mitigate a switch outage once it is finished. The Alcatel-Lucent switch is slated for retirement.
- Damage or destruction of CenturyLink's PSTN network due to earthquake, fire, flood, or cyberattack. Repair of this network is largely out of the City's direct control.

There is currently no fail-over for the non-9-1-1 PSTN switch. CenturyLink can re-route traffic to alternate local switches to route around damage to their network. This vulnerability will be mostly mitigated by the switch to SIP trunking for voice telephony in 2019.

Satellite Telephony and Data

The resiliency of the City of Portland's fixed satellite connections at the ECC and the Water Bureau Interstate building are **very good**. Both facilities are expected to survive large earthquakes and have redundant power and network connections. The satellite voice and data networks can operate independently from the City WAN if necessary. The ECC is the most seismically resilient building the City currently owns. VSAT devices deployed on City of Portland vehicles (MC9, Water Bureau EM trailer) have a similar level of resiliency. The resiliency of the City's mobile satellite telephones is **adequate to good**. The handsets are off-the-shelf devices and can be replaced quickly from several vendors, but no replacement phones are kept in stock. It can be difficult to get a satellite phone signal through in areas with tall buildings (such as downtown Portland) or in thick forest cover (Washington and Forest Parks).

The primary threats to connectivity through satellite systems at the City of Portland are:

- Destruction of the physical infrastructure (local servers, routers, VSAT terminals, and satellite dishes) necessary to support satellite data and voice uplink and downlink. Even if the satellite dish and terminal are undamaged by an earthquake, the shaking may push the dish out of alignment with the satellite. This will require human intervention to fix.
- Insufficient satellite bandwidth due to increased demand. Slow network speeds and incomplete calls have been noted during hurricane and wildfire responses in the past when large numbers of users are on the system at the same time.
- Compromise of the VSAT terminal, portable phone handsets, the teleport (satellite downlink facility) or of the satellites themselves through a physical (solar flare / CME) or cyber-attack. The City's provider (KnightSky) uses the Intelsat network of satellites for fixed satellite terminals and the Iridium network for mobile satellite phones.

Should handheld satellite telephones cease to function, operations will shift to either the trunked digital radio network or to conventional (PSTN) and cellular telephones when such services are available. There is no ready fail-over for the fixed VSAT terminals should they be damaged or destroyed; no spares are kept in stock and ordering new hardware could take days to week. Mobile or deployable assets, either from the City itself or provided via mutual assistance, may be necessary to restore satellite communications.

DATA COMMUNICATIONS RESILIENCY AND SYSTEM FAIL-OVER

IP Networks

The resiliency of the various City IP networks ranges from **good to very good**. The ring network that forms the backbone of the WAN creates two redundant paths between any two locations on the network, such that any one break in the network still allows traffic to flow across the entire network. Most major City of Portland facilities are connected to the WAN by at least two different circuits; the loss of a single circuit will not cripple internet or local-area network connectivity. The City also uses two different internet access providers (CenturyLink and Flexential) for redundancy. However, a few City offices and facilities are connected via older technologies (copper T1 lines and SONET) that are not as resilient as the rest of the network. BTS plans to eventually migrate these sites to new technologies to increase resilience.

The principal threats to the City's IP network infrastructure are:

- Disruption or degradation of service due to damage or destruction of the copper (T1) or fiber (DS1) lines leased from commercial providers to provide service to smaller and remote offices. These are legacy connections and are dependent on the service provider's ability to respond to network outages.
- Disruption or degradation of service due to damage or destruction to the fiber optic lines that connect bureaus and offices to the WAN.
- Disruption or degradation of service due to extended electrical grid outages. While the City's hosted data center and on-premises Emergency Communications data center feature battery backup power and emergency generators, not all city offices or facilities have access to redundant power.

Cellular Data Networks

The resiliency of Portland metro area cellular voice and data providers is **good**. The metro area features excellent 4G LTE coverage from four competing networks (AT&T Wireless, Verizon Communications, Sprint, and T-Mobile). The tower and small-cellular antenna network is reasonably dense giving good coverage across most of the City, with some sparse spots in the West Hills and Forest Park. The main Verizon Wireless

switch in Hillsboro is a purpose-built facility hardened to current seismic safety standard with connections to two separate electrical substations, battery backups for multiple hours and a minimum of a week's worth of fuel for backup generators. Other providers have similar facilities.

The principal threats to private cellular voice and data networks the City uses are:

- Physical damage or destruction of cellular networking towers and repeaters due to fire, ground movement, wind, flooding, or vandalism. While most cellular networks have some level of redundancy in their coverage, removal of a single major tower in an urban area can have a significant impact on the ability to handle traffic.
- Service outages due to local or regional network issues on a provider's backhaul network. This threat can be partially reduced by having cache wireless phones or SIM cards for different wireless providers. In addition, as carriers move off 3G standards to 4G (LTE) and 5G networks, proprietary voice and data protocols are giving way to open standards, allowing for opportunities to roam on multiple carriers not previously available.
- Sufficient fuel to continue cellular repeater operations during a protracted electrical power grid outage. While central offices and switches generally have battery capacity and generator backup sufficient to last a week or more, most cellular repeater sites have 2 – 4 hours of battery backup and a day's worth of generator fuel.

The trunked digital radio system is the primary fail-over mode for cellular voice call outages, with the utilization of secondary providers on different networks (AT&T, T-Mobile/Sprint) a possibility for only some users. The only fail-over mode available for most City users of cellular data, especially those utilizing vehicle data modems, is the City's wireless LAN where and if it is available.

Verizon reserves the right to manage network traffic to balance loads and keep their radio access network running. This may include limiting or prohibiting data to some or all subscribers. As of late 2018, discussions are underway with Verizon to add priority access and pre-emption capability for City of Portland first responders.

Microwave Data Networks

The City of Portland uses point-to-point microwave systems to connect the trunked digital radio system into a simulcast network and to provide voice, data, and industrial control to remote sites such as the Bull Run reservoir. The resiliency of this system is **good**; as a key part of the City's radio system its maintenance and support are essential functions. Microwave technology is mature and extremely common; obtaining spare or replacement parts is not difficult. However, the City does not maintain a stockpile of hardware on hand for repairs, meaning that any failure may take hours to days to repair.

The principal threats to microwave data systems are:

- Misalignment of microwave dishes due to wind, earth movements, vandalism, or tower collapse. A misalignment between two dishes can reduce the network speed and capacity of the microwave link or break the network entirely. Re-alignment is an intensive procedure that can take several hours to complete.
- Sufficient fuel to continue microwave relay operations during a protracted electrical power grid outage. Microwave systems associated with the City of Portland's trunked digital radio system share the same battery and generator backup systems, and so can be expected to perform in a similar fashion in terms of availability and reliability.

There are no inexpensive or immediately available work-arounds for a microwave system outage. Microwave relay is used in situations where fiber optic cable interconnects are infeasible or too expensive, so replacing functionality with these technologies would be counterproductive.

COMMUNICATION SYSTEMS RECOVERY PRIORITIES

Restoration of the technologies underpinning critical communications networks is the highest priority in the list of the City's Continuity of Operations (COOP) essential functions list. Recovery and/or maintenance of the trunked digital radio system is the second highest priority. BTS is the lead bureau for both essential functions. The BTS COOP plan breaks these top priorities into discrete mission-essential functions and prioritizes them in terms of the anticipated recovery times:

1. Immediate to 12 hours
   - Trunked digital radio system maintenance and restoration, including alternate power, microwave relay restoration and communications controller/server restoration.
   - Services related to operations using the trunked digital radio system including radio provision, installation and repair.

- Telephone services, including voicemail, long-distance calling, Automated Call Distribution (ACD), and both POTS and VoIP lines.
- Coordinate and support cellular telephone voice and data services. While it is recognized that restoration of the actual cellular network is an industry responsibility, BTS will aid where possible.
- Paging services, including text messages to cellular providers and one- or two-way alphanumeric pages.
- City of Portland Data Center operations.
- 9-1-1 network operations including connection to the PSTN.
- Police information technology operations, including application and file servers, networks, and mobile apps (NetMotion).

2. 12 – 72 hours
   - CAD/vCAD.
   - SCADA and industrial control network infrastructure.
   - Pager support for bureaus.
   - Email and calendar service on the Portland WAN via Microsoft Exchange Server / Outlook.
3. 3 – 10 days
   - Skype for Business text and voice IP messaging.
   - Secure and anonymous network file transfer services (Secure FTP / Anonymous FTP).
   - Video conferencing and desktop sharing.
   - Calendar and email synching with cellular and wireless devices.
   - Audio/Video services.

During ECC operations, tactical resource restoration prioritization will focus on optimizing emergency response communication operability and interoperability. Once the ICS command structure is in place, the Communications Unit Leader, in conjunction with the Public Safety Branch, Public Works Branch, BTS representatives, and the Operations team, will schedule, task and allocate resources to repair or restore communications systems necessary for tactical operations. It is expected that tactical restoration priorities will focus on the restoration and/or additional provisioning of radio circuits and cellular voice / data networks.

The Disaster Policy Council (DPC) will guide strategic, rather than tactical, communications restoration priorities. Strategic prioritization focuses on restoration of broader routine communications capabilities to the community as quickly as possible. This may include prioritizing internet restoration since the public relies on this platform for daily life.

INTEROPERABLE COMMUNICATIONS

During a regional emergency, the ability to communicate with regional and State partners will be key to a successful incident response and recovery. For first responders, the focus for interoperability efforts is land-mobile radio systems, with a goal of ensuring enough common frequencies that users of different systems can communicate with each other. Interoperability can also include the sharing of information regionally via a crisis information management system, a cache of cell phones available for use by out-of-area responders, or shared logins for EOC and ECC computer systems.

At the Federal level, communications interoperability is promoted and managed by several agencies and quasi-governmental organizations, including the Federal Communications Commission (FCC), the National Telecommunications and Information Administration (NTIA), the National Public Safety Telecommunications Council (NPTSC), and the Department of Homeland Security's Emergency Communications Division (DHS ECD). Of these agencies, DHS ECD is generally the most active with respect to wireless communications interoperability. Important Federal resources that support interoperable communications include:

- **National Interoperability Field Operations Guide (NIFOG):** A technical reference for emergency communications planning and for radio technicians. A digital version is available for iOS and Android smart phones and tablets.
- **Auxiliary Communications Field Operations Guide (AUXFOG)**: A version of the NIFOG that is specifically targeted towards auxiliary communicators such as ARES, RACES and CERT. A digital version is available for iOS and Android smart phones and tablets.

Interoperable communications in Oregon is coordinated by the State Interoperability Executive Council (SIEC), a function of the Office of the State Chief Information Officer (OSCIO) under the Department of Administrative Services

(DAS). The SIEC is composed of representatives from public safety organizations, state and local public works bureaus, Oregon tribes, and state & local government. The mission of the SIEC is to facilitate state-wide wireless communications interoperability through:

- developing recommendations for policy and operational guidelines,
- identifying new technologies and standards, and
- coordinating local, tribal, and state communications resources.

The primary documents driving interoperability in Oregon are:

- **Oregon Statewide Communications Interoperability Plan (SCIP)**: The SCIP is the guidance document for all state and local interoperability efforts; it is a national standard produced by DHS customized by states and local authorities for local needs. The SCIP serves as both a reference, indicating what functionality already exists across the state for interoperability, and as a roadmap illustrating where and when improvements can be made.
- **Oregon Regional Tactical Interoperable Communications Field Operations Guide (TICFOG)**: The current version of the Oregon TICFOG is only available electronically, either as a PDF download or as a mobile device application for Android and iOS devices (Oregon eFOG). The TICFOG is very similar to the federal NIFOG but focused solely on local and state communications networks.

PF&R, PPB, and PBEM have radio gateways that can be used to bridge together disparate radio networks when needed. Regional interoperability with Washington, Clackamas and Clark counties' radio systems is provided using Inter-RF Subsystem Interfaces (ISSI), which allow for shared talkgroups. The Portland system is also connected to the State Radio Project (SRP) via an ISSI interlink with Washington County. On the Portland trunked digital system, interoperable talkgroups include:

- **Metro A, B, and C**. Most City of Portland bureau radio templates include these, but it is not guaranteed that other counties or agencies have these programmed in all their radios.
- County-level interoperable talkgroups (**MULT A** through **MULT D**, **CLACK A** through **CLACK D**, **WASH A** through **WASH D**, and **CLARK A** through **CLARK C**).
- **ECC Metro**.
- **Red, Blue, Green and Yellow** (Portland-centric only, not regional). These talkgroups are programmed into every City of Portland trunked digital radio but may not be used by all regional partners.
- State of Oregon 700 and 800 MHz interoperability channels (**OROPS**). These talkgroups are programmed into every City of Portland trunked digital radio but may not be used by all regional partners.

If the trunked repeater networks are down, backup radio communications occur on state and federal frequencies. Guidance as to which frequencies are to be used comes from the NIFOG and/or the Oregon TICFOG through either the ECC Communications Unit Leader or BOEC dispatchers.

The City of Portland's IP networks are simultaneously both interoperable and non-interoperable. City networks are based on TCP/IP, which is the dominant modern networking stack and the system that underpins the internet. However, access to most of the City's computing resources is regulated through user accounts and strict access controls. First responders from other jurisdictions may have difficulty accessing City systems without the use of either shared logins for EOC/ECC activities or the provisioning of temporary user accounts in the City domain controllers. Alternatively, sharing services can be provisioned inside a demilitarized zone (DMZ), which is a section of the Portland WAN that is accessible from both the outside and the inside, but does not let traffic pass into the rest of the network from outside.

FUTURE COMMUNICATION SYSTEM NEEDS AND PROJECTS

FIRSTNET

The Middle Class Tax Relief and Job Creation Act of 2012 created the First Responder Network Authority (FirstNet) with the singular goal of establishing, operating and maintaining an interoperable public-safety broadband network. The U.S. Congress set aside $7 billion to pay for establishing the network as well as 20 MHz (LTE Band 14) of radio-frequency spectrum specifically allocated to first responders. The rationale for FirstNet stems from lessons learned after the terrorist attacks of September 11, 2001. Fire, police and EMS personnel were hampered in their response to the World Trade Center disaster by a lack of interoperable communications between multiple agencies on-scene and a lack of available radio-frequency channels to support multiple agencies.

In 2017, AT&T was chosen as the sole-source provider to build and maintain the FirstNet broadband network. They are the only organization with access to LTE Band 14, which they will use for both public-safety communications and for commercial wireless services. All money collected from public safety users is redirected to maintain and upgrade the FirstNet network; AT&T revenue will come from commercial users licensed to co-exist in LTE Band 14. The FirstNet network build-out consists of the following components[6]:

- **Long-Term Evolution (LTE)**: A standard for high-speed wireless communication developed by a multiple stakeholder partnership (3GPP) and a registered trademark of the European Telecommunications Standards Institute (ESTI). LTE specifies a packet switching network like TCP/IP; previous wireless telecommunications standards such as GSM or CDMA used circuit-switched networks. FirstNet has dedicated bandwidth across the entire United States with a 20 MHz frequency allocation (LTE Band 14) in the UHF frequencies; this is adjacent to existing land-mobile radio services currently in use by the City of Portland's trunked digital radio system.
- **FirstNet Core**: The backbone of the FirstNet network, the Core consists of a nationwide packet-switched IP data network consisting of both national and local data centers that provide a gateway between the radio access network and the public internet or PSTN.
- **Radio Access Network (RAN)**: The cellular site equipment, antennas and backhaul connections that allow mobile and handheld devices to connect to the network.
- **Public Safety Devices and Accessories**: In-vehicle routers, smartphones, tablets, radio modems and other hardware devices that will allow connection to the RAN and/or the FirstNet core.
- **Public Safety Applications**: Apps for computers, smart phones and tablets, available solely through a FirstNet-controlled app store. Arguably the most important component, Mission-Critical Push-to-Talk (MCPTT), has not been implemented by AT&T/FirstNet as of late 2018.

As of late 2018, BTS in conjunction with other City bureaus such as BOEC, PF&R and PPB, have established a pilot project to evaluate FirstNet capable devices in the field. The City of Portland's public safety bureaus are currently heavily invested in Verizon Wireless mobile devices, and the cost to replace these devices with new ones from AT&T would be significant. A kick-off for this project is anticipated for Q3 or Q4 2019 and is dependent on how quickly AT&T finishes the new tower and antenna hardware construction to support LTE Band 14 in the greater Portland metro area. AT&T has already made priority and pre-emption available to FirstNet subscribers on other LTE bands within their existing 4G LTE cellular network.

A Congressional Research article[7] discusses several potential issues with FirstNet, including:

- Interoperability: As of 2018, AT&T's policy is that only AT&T-based RANs will be able to access the FirstNet Core. Only devices sold and/or officially supported by an AT&T partner will be allowed on the FirstNet core. Verizon Wireless has expressed an interest in interoperating with the FirstNet Core, but has so far been rebuffed. In response to this, Verizon began work on their own public-safety centric core network and is planning on marketing wireless devices that support both their public-safety offerings and FirstNet.
- Band 14 LTE Build-out: As of 2018, AT&T's policy was that they were only building new cellular sites for Band 14 in rural locations where the network was already under-served or in areas needing additional capacity. According to the CRS article, it is unclear if AT&T intends to build out Band 14 nationwide or rely on their existing 4G LTE infrastructure where possible.
- Mission-Critical Push-To-Talk (MCPTT): This is the essential function of the City's trunked digital radio system. AT&T currently does not support MCPTT on FirstNet and are not anticipated to roll it out until at least March 2019.
- FirstNet Sustainability: By law, FirstNet must be self-sustaining. AT&T/FirstNet must enroll enough subscribers to keep the lights on, and to do that they must offer better coverage, services and features than existing users currently have. As of late 2018, there is little that FirstNet offers not already available to Verizon subscribers, though that is likely to change in the future.

SMALL UNMANNED AERIAL SYSTEMS

Small unmanned aerial vehicles / systems (sUAV/sUAS) or, as they are more commonly known, drones, have become exceedingly popular in recent years, both for recreational and commercial operations. The demand for and use of UAS is

[6] https://firstnet.gov/network/network-elements

[7] The First Responder Network (FirstNet) and Next-Generation Communications for Public Safety: Issues for Congress, Congressional Research Service, 2018. Last accessed 10/30/2018. https://fas.org/sgp/crs/homesec/R45179.pdf

expected to continue to grow rapidly. Even if UAS operations are not embraced directly by the City of Portland, first responders and emergency communicators can expect to see them on-scene more frequently. In the aftermath of 2018's Hurricane Michael in Florida, AT&T utilized a new unmanned aerial vehicle known as a Cell-on-Wings or "Flying COW" capable of providing local LTE data and voice service for up to 6500 users[8]. On a less positive note, aerial wildfire-fighting operations were hampered or halted several times during the 2017 and 2018 fire seasons due to unauthorized UAS entering restricted airspace.

Oversight for City of Portland sUAS programs is managed by a City sUAS work group. This work group has representatives from almost all city bureaus and is chaired by the Water Bureau with guidance and oversight by City Risk and the City Attorney's Office. Potential uses by City of Portland bureaus for UAS include:

- Utility inspection, including water, sewer, power, communications, bridges, roads, and dikes.
- Fatal accident crash scene reconstruction
- Improvised Explosive Device (IED) disposal and render-safe operations
- Law enforcement searches for armed suspects
- Search and rescue operations
- Aerial mapping for land-use and urban planning.
- Post-earthquake or flood damage assessment.
- Situational awareness during large events or in the post-disaster environment.

As of 2018, the State of Oregon has four laws[9] on the books relevant to UAV operations:

- HB3407: Makes weaponization of a UAS a class C felony, allows law enforcement to use UAS to reconstruct an accident scene, and prohibits the use of a UAS over private property "in a manner that intentionally, knowingly or recklessly harasses or annoys the owner or occupant of the property".
- HB4066: Regulates the use of drones by public agencies, including data retention policies and public notification procedures. Prohibits the use of drones near critical infrastructure elements, including correctional facilities. Prohibits weapons from being attached to UAS.
- HB5702: Specifies fees for public UAS registration.
- HB2710: Allows law enforcement agencies to operate UAS if they have a warrant or are exercising one of a list of enumerated exceptions. Requires UAS to be registered with the Oregon Department of Aviation. Allows legal action (in some circumstances) by a landowner against a UAS operator flying below 400 feet AGL over their property. Created new crimes and civil penalties for mounting weapons on drones or interfering with public UAS.

In addition, all UAS pilots operating commercially in Oregon must follow the FAA's Part 107 rules. These rules specify the maximum size, weight, speed and range of small UAS, as well as operational requirements including constant line-of-sight, daylight or civil twilight operations only, maximum operational altitude and restrictions on where drones can be flown. Part 107 also establishes the requirement for UAS operators to obtain a Remote Pilot Certificate from the FAA prior to public or commercial operations.

The use of UAS technology raises significant privacy issues. The FAA has largely left the task of addressing privacy issues to states and local municipalities. According to the Electronic Privacy Information Center[10], Oregon's law (HB2710) is one of the best in the United States in terms of protecting personal privacy from UAS operations by public agencies and law enforcement. The only shortcoming appears to be the lack of equivalent rules that apply to commercial drone operators.

SATELLITE INTERNET AND TELEPHONY – IRIDIUM NEXT

Nearly all the City of Portland's portable satellite telephones (i.e. those not hooked up through a VoIP switch to a VSAT terminal) use Iridium Communications' low-earth orbiting satellite network. The Iridium constellation consists of 66 active satellites in orbit that provide worldwide voice telephone calls and can provide a very limited (effectively 2400 bits per second, which is equivalent to a 1980s-era dial-up modem) data connection. The original Iridium satellites were launched between 1997 and 2002 and were designed for an 8-year operational life.

[8] https://youtu.be/IpLX3j-7Z2M Last accessed 10/30/2018

[9] https://uavcoach.com/drone-laws-oregon/ Last accessed 10/30/2018

[10] https://www.epic.org/state-policy/drones/ Last accessed 10/30/2018

Iridium Communications is currently replacing these satellites with new ones through the Iridium NEXT project. The new satellite's constellation, which will consist of 66 active satellites with nine in-orbit spares and six spares on the ground, was completed in January 2019. The new satellites, when turned on, will provide much higher data speeds (up to 128 kilobytes per second) to satellite telephone handsets and better call quality. The Iridium NEXT constellation is also expected to provide higher bandwidth connections to portable VSAT terminals and may be a viable competitor to Inmarsat's expensive BGAN satellite data service. While the details of Iridium's new commercial service (Certus) that uses the NEXT constellation have not been released yet, the higher speeds and better call quality are expected to require brand new handsets. A project to identify user requirements and potential vendors to replace existing City satellite phones will begin in early- to mid-2019 once full details on the new network are released from Iridium.

PLAN DEVELOPMENT AND MAINTENANCE

- The PBEM Operations section is assigned responsibility for the development and ongoing maintenance of this Annex. BTS is responsible for communicating any changes in their continuity of operations plans that may affect emergency communications to PBEM in a prompt fashion.
- All documents generated as part of a partial or full activation of the City's emergency response function or the Portland ECC shall be maintained in accordance with City and State record retention rules. If the Portland ECC is activated, record collection will be the responsibility of the Documentation Unit of the Planning Section, assisted by the Communications Unit Leader. Examples of types of communications-related documents that may be generated by an activation include:
  - ICS Forms, including ICS-205/205a, ICS-213, ICS-214, ICS-217/217a and ICS-309.
  - Communications resource requests.
  - Communications system procurement documentation.
  - Communication error and outage documentation.
- It will be reviewed and revised as necessary following each Full Activation of the ECC or at least every five (5) years. The Attachment 1 (Master Contact List) will be updated annually by the PBEM Operations section.
- Changes to this Annex may be reviewed by the Emergency Management Steering Committee (EMSC) and/or Disaster Policy Council (DPC) prior to adoption and implementation.

OPERATING STATUTORY AUTHORITY

This Annex, as well as all other sections of the City's BEOP, operate under statutory authority of the Oregon Revised Statues (ORS) chapter 401, "Emergency Management and Services", section 305, "Emergency management agency of city, county or tribal government". Emergency functions are implemented through Title 15, Emergency Code, of the City of Portland's Charter, Code and Policies.

GLOSSARY

Abbreviations for City Bureaus:

PF&R: Portland Fire & Rescue	**BOEC**: Bureau of Emergency Communications
PBEM: Portland Bureau of Emergency Management	**OMF**: Office of Management and Finance
PPB: Portland Police Bureau	**PWB**: Portland Water Bureau
BDS: Bureau of Development Services	**BES**: Bureau of Environmental Services
BTS: Bureau of Technology Services	**PBOT**: Portland Bureau of Transportation

Automatic Link Establishment (HF-ALE): A standard method to digitally initiate and sustain HF radio communications. It uses digital scanning to locate the best frequency (in terms of propagation) to make the highest-quality radio link possible.

Bandwidth: The amount of information (analog or digital) that can be carried by a communications system during a specific time period. Describes the size of the "tube" used to carry voice or data.

BICP: Bureau Incident Command Post

CAD: Computer-Aided Dispatch, a system for tracking incoming calls for service and assigning resources to respond.

COML: Communications Unit Leader; a NIMS ICS position in the Logistics Section, Support Branch. Qualifications for the COML position include attendance of a Type III or higher COML course and completion of a COML task book based on

standards set by the Office of Emergency Communications – Department of Homeland Security or the National Wildfire Coordinating Group (NWCG).

COMC: Communications Coordinator; an official in control of a radio spectrum within a defined geographical area. The COMC works with COMLs to coordinate use of licensed or granted radio spectrum among multiple user organizations.

COMT: Communications Unit Technician; a NIMS ICS position in the Logistics Section, Support Branch. Qualifications for the COMT position include attendance of a Type III or higher COMT course and completion of a COMT task book based on standards set by the Office of Emergency Communications – Department of Homeland Security or the National Wildfire Coordinating Group (NWCG).

COTS: Commercial Off The Shelf; refers to a product or pre-packaged solution that is readily available and not custom-made. COTS solutions are generally cheaper then custom-build solutions even when necessary local system integration is required.

COW / COLT: Cell(ular) on Wheels / Cell on Light Truck; portable mobile cellular networking access point used to provide wireless coverage in locations where coverage is minimal or compromised.

CSZ: Cascadia Subduction Zone. In this document used to refer to a very large earthquake that has the potential to affect regional communications across the Pacific Northwest.

Digital (Radio): Digital radios are different from analog radio in how signals are transmitted. Analog radio uses a variety of techniques, including amplitude (AM), frequency (FM) and single-sideband (SSB) modulation, to encode voice data atop a carrier wave. Digital radio uses the same carrier wave, but instead of encoding voice or music, it just encodes zeros and ones (digital data). The radio itself transforms audio to and from digital data. Digital radios are more efficient and allow for many more channels in the same frequency space but require computer hardware and software to function correctly.

Failsoft: A backup operational mode for radio repeaters in a trunked system. If communication with the master site fails, repeaters can be set to switch automatically to failsoft mode and function much like a conventional repeater. The only talkgroups available will be those pre-selected for failsoft use on the individual repeater.

Gateway (router): A computer that sends traffic and controls access between networks. Gateways are the devices that connect corporate networks to the internet.

HF: High Frequency; used to refer to radio waves with frequencies ranging from 3 to 30 MHz. HF radios are used to talk over distances of hundreds to thousands of miles; they are not limited to line-of-site communications like VHF and UHF radios. Radio waves at high frequencies travel through a method called 'skywave'; they bounce off layers of charged particles in the Earth's upper atmosphere (ionosphere).

Hz / Hertz: A unit of frequency defined as the number of cycles per second; in radio, it defines the number of complete sine waves cycles per second. Also see:

- **KHz**: Kilohertz; one thousand hertz.
- **MHz**: Megahertz; one million hertz
- **GHz**: Gigahertz; one billion hertz

Internet Protocol (IP): The principle communications protocol for relaying data across network boundaries on the internet. The protocol is responsible for delivering packets of data from one host to another based solely on the information (IP addresses) contained in the header of each packet.

IP Network: A communications network that uses internet Protocol to send and receive messages between one or more computers. One of the most common forms of computer networks today.

Linking (repeaters): The connection of two or more radio repeaters together such that they appear to be a single network. It does not matter which repeater your transmitted message is received by; it will be rebroadcast on all other linked repeaters.

Master Site: The central point for all radio traffic in a trunked radio system, and is responsible for routing, network access and frequency coordination.

MDT: Mobile Data Terminal, a ruggedized computer system designed for mapping and information sharing to vehicle operators. Used mainly by police officers and firefighters.

Modem: Modulator-Demodulator; a network device that encodes and decodes digital information for transmission over wired or wireless communication networks. In this document, modems (TNCs) are used for transmitting data wirelessly using amateur radio frequencies.

NPSPAC: National Public Safety Planning Advisory Committee. Used in communications documentation colloquially to refer to 6 MHz of radio frequency spectrum in the 800 MHz band reserved solely for public safety interoperable communications. Complements other such frequency assignments like the national VHF and UHF interoperability channels

P25: Project 25, an international standard coordinated by an industry group named APCO for public safety land mobile radio systems. While P25 is a standard, the implementation of that standard is left up to the radio vendor. The City of Portland uses radios with Motorola's P25 implementation, ASTRO 25.

POTS: Plain Old Telephone System. The classic centrally-switched telephone network carried over copper wires. Largely replaced in many contexts by VoIP.

PSAP: Public Safety Answering Point; a physical location where 9-1-1 requests for emergency service are taken, prioritized, assigned and routed.

PSTN: Public Switched Telephone Network; the aggregate of all circuit-switched telephone networks that are operated for public telecommunications. It began its life as analog fixed-line telephone systems (POTS) and is now almost entirely digital in its core network. In this document, PSTN does not include wireless telephone networks; while they are technically part of the PSTN they have unique properties that warrant consideration separate from fixed telephone lines.

Repeater: An electronic device that receives and re-transmits radio signals, often at higher power to cover large distances. Repeaters use two different frequencies (a 'repeater pair'); one to receive incoming transmissions and a different frequency for transmitting received signals over a wide area.

RF: Radio-frequency; used in this document in reference to wireless communications.

Ring (network): A network topology (arrangement of communication elements) where every node (server, router or gateway) connects to exactly two other nodes. Traffic in a ring network can be either unidirectional (traffic moves in one direction only) or bi-directional (either direction out of or into a node). A bi-directional ring network such as the City of Portland's WAN is resilient, as it can survive a break in the ring and still function.

Router: An electronic device that receives and forwards data packets on computer networks. They are the backbone of IP networks.

SCADA: Supervisory Control and Data Acquisition; a software system that gathers, collects, visualizes and archives from industrial devices. These systems are also used to monitor for hazardous or undesirable conditions and to remotely control attached devices. SCADA systems often communicate over a mix of private and internet networks.

Simplex (radio). Simple radio communication occurs when two radios talk directly to each other without the use of a repeater. The range of a radio in simplex mode is a function of height above the ground surface, the power of the transmitter, and whether a direct line-of-site exists between the sender and the receiver. In general, most handheld radios are limited to a few miles in simplex mode.

Simulcast (radio): Simultaneous broadcasting; the same signal is transmitted by multiple radios or repeaters on the same frequency. This makes it possible for a single frequency pair (transmit and receive) to cover a wide area. It relies on very precise timing correlated to GPS receivers.

SIP Trunk: A method where a phone system operates using an internet connection to send and receive calls rather than a direct connection to the PSTN. SIP trunks route voice communications and messages over the same cables as other data traffic. The internet Service Provider (ISP) maintains the connection to the PSTN rather than the telephone subscriber.

Tap-out: The process of notifying and dispatching firefighters at a station to an incident.

TCP/IP, also **IP**: Transmission Control Protocol/internet Protocol; a conceptual model and set of rules and technologies for connecting computers together into networks. While there are other networking protocols, TCP/IP-based networks dominate the landscape today.

Trunking (Radio): Trunking is a process through which many different users (talkgroups) can share a small number of discrete radio frequencies. It is analogous to a switched telephone system; a computer is used as the "operator" and connects talkgroups together using frequencies assigned in real time. Because not every frequency is in use every second, conversations can spread across multiple frequencies in time, making the most efficient use of the available radio spectrum.

This allows for many more simultaneous users and many more channels than conventional radio systems that do not use trunking.

UHF: Ultra-High frequency. Used to refer to radio waves with frequencies ranging from 300 MHz to 3 GHz. In public safety usage, "UHF" usually refers to the 300 and 400 MHz bands. Portland's trunked system operates in the 700 and 800 MHz bands, which is still considered UHF, but are not often called as such by those using the systems. UHF radios work well in urban areas, with their shorter wavelengths able to get better penetration into buildings and off urban structures. They have less range than VHF radios in open country and through vegetation.

VHF: Very-High Frequency; used to refer to radio waves with frequencies ranging from 30 to 300 MHz. Traditional FM broadcasters use VHF, as well as many land-mobile, public safety and marine users. Historically, VHF low-band was used by State Police or Highway Patrol to cover long stretches of rural areas. VHF radios work better with longer range than UHF radios in open countries, at sea and in wooded areas.

VoIP: Voice over internet Protocol; a group of technologies (hardware and software) to deliver voice communication over IP networks. A modern replacement for voice telephony.

VPN: Virtual Private Network; technology that allows a private network such as a corporate LAN to extend across a public network, allowing users to send and receive data as if they were physically connected to the LAN. VPNs are usually encrypted so that their traffic cannot be examined by non-authorized users.

VSAT: Very Small Aperture Terminal; a two-way satellite ground station with a dish antenna that is smaller than 3.8 meters (about 12.5 feet) in diameter. VSAT systems are portable, often being mounted on trailers, on building roofs or atop a communications van.

WAN: Wide-Area Network; a telecommunications or computer network that extends over large geographical distances, often linking together multiple LANs. The City of Portland IP network is a WAN.

WLAN: Wireless Local-Area Network; a LAN that runs over wireless RF communications protocols instead of a wired (Ethernet) network.

ATTACHMENTS

Attachment 1: Master Contacts List for Public and Private Communications Technology Services

Portland Bureau of Emergency Management

9911 SE Bush Street
Portland, OR 97266-2562
www.portlandoregon.gov/pbem

PBEM

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