Improving In-building Radio Communications for First Responders

Larry Thomas, Tony Van Wouw, Jason Cairney, Mark Griffioen, Len Garis

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CENTRE FOR PUBLIC SAFETY & CRIMINAL JUSTICE RESEARCH

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Preface

This paper is aimed at builders, developers and civic staff engaged in the construction of structures that will have areas inside of the building where emergency communications for first responders (Fire/Rescue, Ambulance, and Police) may be impaired. Wherever possible plain language is used; technical details are readily available elsewhere and in the referenced documents of this report. The goal is to eliminate costly surprises late into the planning or construction phases of a building project, which may be radio signal opaque inside.

This paper does not supersede the building code or any other statues, bylaws, ordinances etc.

The authors of this paper look at the problem of in-building communications from a first responder perspective, specifically where communications inside residential and commercial properties is done via a digital radio system to the APCO P25 standard, operating in the 700 MHz band. This frequency band is part of the new public safety radio frequency spectrum adopted throughout North America with infrastructure that resembles a private cellular system.

Many urbanized centres, such as the lower mainland of BC have moved to the new public safety spectrum. It should be noted, the 700 MHz infrastructure is not yet universally deployed in all first responder environments, some VHF and UHF radio infrastructure continues to be deployed in many communities and used by first responders. South-West BC will be used as reference for this paper.

The term BDA/DAS used in this paper refers to a bi-directional amplifier (BDA) with a distributed antenna system (DAS) that takes signals from outside the building and distributes them to internal areas of the building and vice-versa. For simplicity the term is further shortened to BDA in the paper.

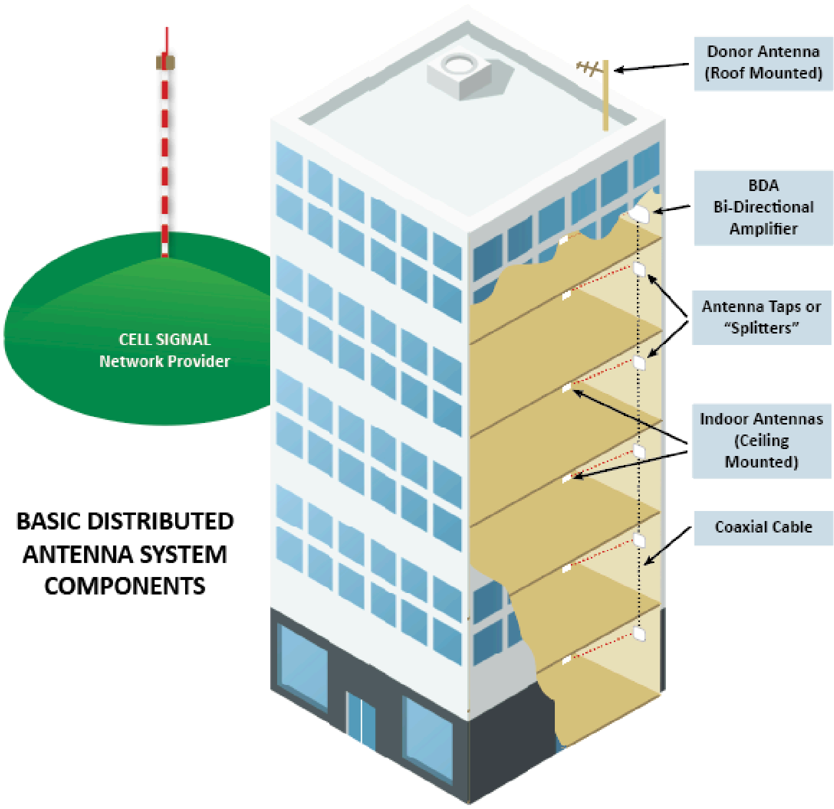
Executive Summary

The Canadian government and the department of Innovation, Science and Economic Development (formerly known as Industry Canada) have adopted policy for Public Safety agencies and their use of wireless communication systems in the 700 MHz frequency band[1].

New building construction is all about energy efficiency—keeping heat out in summer and holding on to it in winter. Unfortunately, this also means that modern buildings keep radio signals out[2]. The accelerating use of modern, high tech materials for exterior cladding is exacerbating radio coverage challenges.

The emergency radio communications systems used by public safety first responders in southwest BC, are key to the successful resolution of emergency incidents. Modern practices require that constant connectivity with support teams is available to ensure a successful outcome of an incident, as well as the safety of the first responders.

Achieving satisfactory in-building emergency radio communications in modern or large dense buildings is readily attainable by utilizing technologies designed by radio frequency engineers. Mobile vehicle repeaters which arrive to an incident on the responding agency apparatus or Bi-Directional Amplifiers (BDAs) with Distributed Antenna Systems (DAS) pre-built/installed in buildings are popular solutions for in-building radio coverage.



Provided that builders, developers and civic staff engaged in the construction of new or renovated/change of use structural projects work together early in the conceptual and design phases; these basic principles and regulations such as bylaws can be preplanned to ensure a satisfactory and economical outcome for all.

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[1] RP-006 — Policy for the Use of 700 MHz Systems for Public Safety Applications and Other Limited Use of Broadcasting Spectrum http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf09133.html

[2] The Dangers of Modern Buildings By Bill Tracey, TMS's Advisor newsletter 2016

A number of BC Municipalities have drafted bylaws that mandate the consideration and inclusion of radio infrastructure into buildings for providing essentially complete radio coverage throughout the internal areas of the buildings. This equipment is designed to overcome the natural shielding that results in areas of no radio coverage such as subterranean garages and internal areas of buildings constructed with cladding, doors and windows designed to conserve energy.

The motivation behind this paper is to reduce risk in both financial and time costs for all parties. By engaging proponents and municipal staff early in the development process, proponents are made aware of the need for emergency communications in the community and can plan to equip their designs with the necessary cable raceways and conduit to allow for the installation of BDAs if required. A process flow diagram included in this paper is proposed to facilitate the flow of information between the various municipal planning departments and proponents of new construction in the community.

In practice, a BDA system consists of a small “donor” antenna that is pointed at the nearest radio site connected to a BDA which in turn feeds a DAS or distributed antenna system. The process of designing a BDA system and even determining the need for one is well established and a plurality of companies in BC and throughout North America are conversant in the design of such systems. Commercial software like iBwave and others allow modelling with a high degree of confidence which reduces the financial risk. The antennas of the DAS are typically small half-spheres or cones about the size of a surveillance camera.

Once constructed and tested, the operation and maintenance of the BDS systems remains with the building owners and forms part of the core infrastructure like elevators, ventilation and lighting that is maintained for public safety.

The wide usage of BDA systems in parts of the southwest region of British Columbia and throughout the USA has largely demystified the design, application and cost of these systems and created a pool of companies and individuals capable of working with and for building proponents and municipal staff to ensure that universal emergency radio communications is provided to the emergency services of the municipalities.

Discussion

POLICY FOR THE USE OF 700 MHZ SPECTRUM FOR PUBLIC SAFETY APPLICATIONS

The Department of Innovation, Science and Economic Development reiterates the importance of this limited radio spectrum being released to significantly advance public safety communications in Canada. A suitable level of interoperability among public safety organizations is critical. This will ensure that the spectrum is used efficiently and is deployed in an orderly manner.

The Department considers it would be advantageous for public safety agencies, large or small, to use this spectrum with a degree of flexibility. A flexible policy would enable interoperability as required, and take into account shared public safety needs in a given geographic area.

Radio interoperability is considered an essential feature for public safety applications. Together with this radio systems policy, the Department is also undertaking a consultation to establish the entire range of possible radio interoperability levels that could be required for any spectrum designated for public safety applications.

For the above reasons, the Department is establishing this policy to oversee the development of public safety radio systems and will assess applications based on the criteria outlined in Section 5.1.

5.1 Policy Criteria

In general, to promote the orderly and efficient development of public safety radio systems in the bands 764–770 MHz and 794–800 MHz, a public safety agency or its service provider seeking authorization to establish a mobile communication system for the protection of life and property, will have to:

- justify the spectrum requirement in terms of radio traffic and forecasted use;
- report on the discussions with other public safety agencies on the potential for developing and sharing a common radio system to meet their communications needs;
- report on discussions with other public safety agencies regarding the potential for some interoperability among their safety services;
- commit to having radio equipment with standards and frequency selectivity, in order to be able to use the mutual aid channels in accordance with Standard Radio System Plan 511 (SRSP-511), during regular operation and in times of emergency; and
- be capable of meeting a minimum level of radio interoperability by using mutual aid channels with a shared standard for the band.

CHALLENGES WITH EMERGENCY RADIO SIGNAL COVERAGE INSIDE NEW OR LARGE DENSE BUILDINGS

Emergency radio communications inside buildings has become increasingly difficult as builders modernize their construction techniques to increase energy efficiency. The metallic content of the cladding, doors and high efficiency windows used in new construction increases the loss to the radio signals used for communication – and effectively mimic a Faraday cage[3], impairing communications within the building. When multi-residential or commercial projects are combined with off-street subterranean parking, the number of areas where communications is compromised increases dramatically.

Wireless users expect and rely on communications wherever they go, including inside large structures, high rise buildings, underground parking, malls, basements, subways, etc. When wireless radio frequency (RF) signals pass through any material they lose strength and when the RF signal levels fell below a given amount, communications becomes unreliable or completely stops. Whenever the area needing radio coverage is below grade (underground) it is almost certain a RF distribution system will be needed.[4]

It is well known that most mobile wireless communications in urban environments terminate in an indoor environment. Because of this, it is not only desirable but, more and more, legally mandated that upgraded and new public safety networks guarantee a level of in-building coverage for first responders. Until relatively recently, wireless public safety networks have been deployed with the goal that in-building coverage will be provided to whatever extent possible by the outdoor network of high sites.

It is now widely recognized that this approach leaves many crucial highly populated areas in high-rise office buildings, shopping malls, hospitals, government buildings and tunnels with severely limited coverage for emergency services. To fill in this coverage with additional, very expensive high sites is economically impractical.[5]

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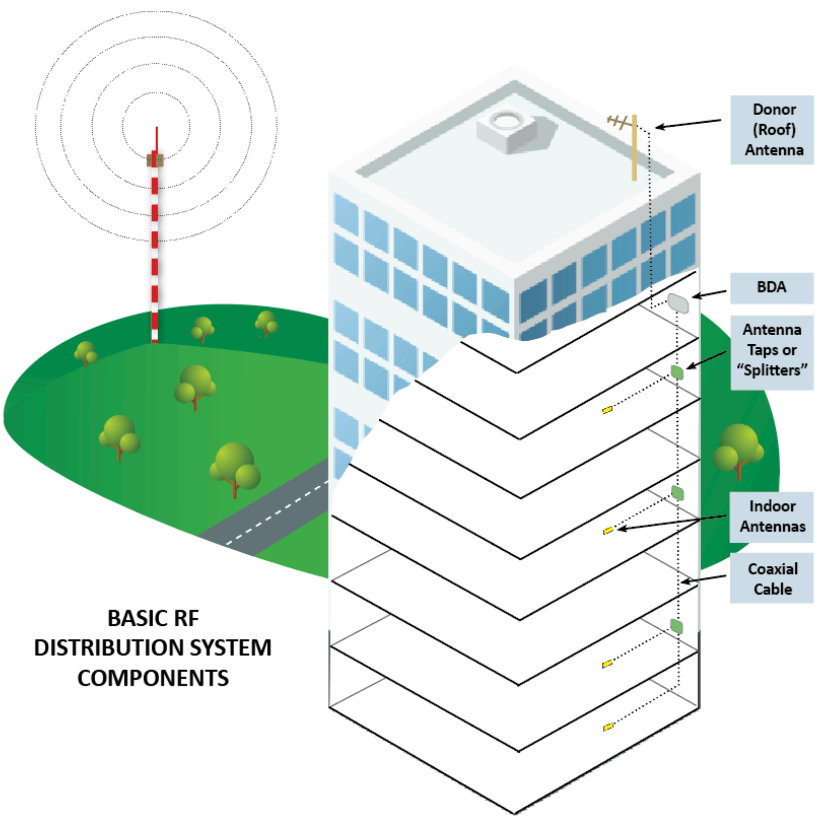
[3] https://en.wikipedia.org/wiki/Faraday_cage

[4] National Public Safety Telecommunications Council (NPSTC)- Best Practices for In-Building Communications. In-Building Working Group, Stu Overby, Chair. Stu.overby@motorola.com - November 12, 2007 page 3 used with permission from © 2005, 2007 Jack Daniel Company

Cellular companies have devised costly methods to address this issue by adding additional cell sites or signal boosters in areas where their clients live, move and work. This is required to satisfy the needs of the end-users and is ultimately reflected in the cost of the cellular service.

Fire and other emergency services use multiple fixed radio towers similar to cell towers to provide coverage to first responders but providing 100% coverage in all areas of all structures is not feasible. Further, there is no fee for service model available to enhance the radio coverage similar to the model used for cellular network users. Achieving universal coverage for first responders requires additional infrastructure such as BDAs or as an alternative, high power portable vehicle repeaters which are typically fitted to selected emergency vehicles or apparatus to enhance the coverage on the scene of an emergency incident. These two technologies are designed to provide the same results and are mutually exclusive as they can interfere with each other and impair the greater emergency radio system.



ACHIEVING ACCEPTABLE RADIO COVERAGE INSIDE BUILDINGS

The BDA/DAS system is essentially a strategic installation that is available full time to all first responder agencies, as opposed to the vehicle repeaters, which are pre-programmed to be operated by a single agency, such as fire service.

Mobile repeaters can be installed in agency specific vehicles and be programmed to interact and

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[5] Providing Robust In-Building Coverage in Public Safety Wireless Networks - By Gary Grimes, Dekolink Americas

"boost" radio signals from the vehicle to users with portable radios inside a building. The very nature of vehicle repeaters means they are transient with unpredictable coverage patterns dependent on the user location. The use of vehicle repeaters also place the cost of providing improved in-building coverage on the municipality and have some other drawbacks as described in Table 1.

TABLE 1: COMPARISON OF BDA AND VEHICLE REPEATERS

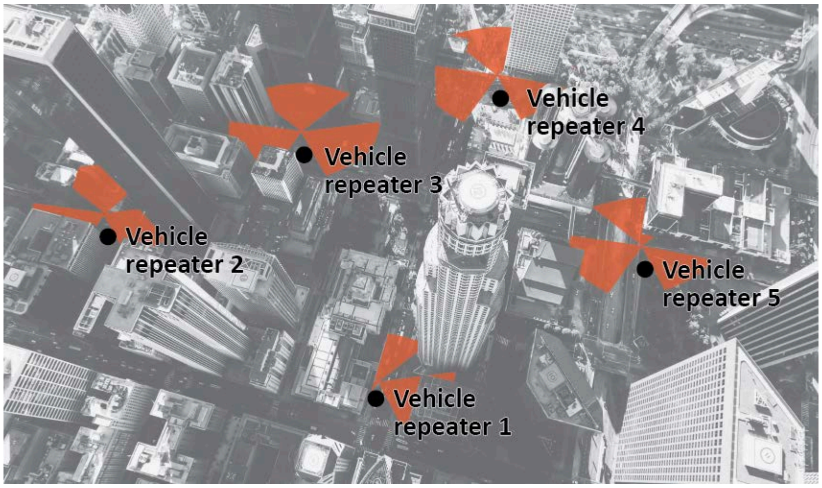
BDA/DAS System	Vehicle Mounted Repeater
Permanently in place and operational. Coverage is essentially universal for all first responder agencies to meet applicable bylaw.	Requires set up and coverage is dependent on placement of the vehicle. Coverage is not predictable unless site is previously tested. Attenuation of the signals by the building will likely result in areas of poor or no coverage, especially in underground garages.
Coverage has been tested and is known to the emergency services.	Coverage is best effort and dependant on vehicle location. Requires trained staff for proper deployment and set-up.
Runs on AC with battery back-up. Power is monitored and alarm is presented to fire panel.	Runs from vehicle power.
Works for all agencies that use Public Safety radio system	Agency specific – deployed by the first-on-scene agency. Arrival and deployment of repeaters by other agencies may cause unintended results and possibly system outages.
May cause interference to vehicle repeaters if the latter is deployed without regard to the existence of a BDA in the building.	May cause interference to an installed BDA and the Public Safety radio system if deployed without regard to existing BDA in the building.
Cost for purchase and maintenance is borne by the building owner as part of the building infrastructure.	Cost is borne by the municipality
Operation may be impaired or interrupted by poor maintenance by the owners.	Maintenance by emergency services staff likely to be more rigorous resulting in higher equipment reliability.
Depending on local bylaws, often does not cover pre-bylaw constructed buildings.	Covers existing buildings that were constructed before bylaw requirements.

Both of the foregoing solutions may provide the necessary communications reliability but reflect entirely different strategies to solving the problem.

The choice of solutions to in-building radio communications has to date been dependant on the working relationship between developers and municipal governments. Developers naturally focus on the cost (time and dollars) of a project, while municipal governments, who control the issuance of building and occupancy permits, are concerned about public safety and costs borne by the municipality for communications hardware and solutions. As a result, different municipalities have responded with different strategies.

ADDITIONAL COMMENTS REGARDING BDA VS VEHICLE REPEATERS

For in-vehicle repeaters to be effective, considerable training is required to provide the necessary communications coverage. Note that the apparatus that supports the in-vehicle repeater may have to move during an emergency incident resulting in a radical change of radio signal coverage that is unpredictable. The operators and supervisors at the scene would require significant training and discipline to provide effective radio coverage **and** optimal apparatus deployment. The result is generally a compromise and likely will not satisfy both needs simultaneously. Unless a building is tested thoroughly beforehand, it is unlikely that all areas can be covered sufficiently for safe and reliable communications. Software modelling can be used (see iBwave comments below) but only actual testing can confirm the coverage for all anticipated apparatus locations at each site.



If the BDA requirement is made known early in the planning process it can represent a small incremental cost to the project. If identified late in the process it can be costly. Coring through existing concrete and installing BDA systems after a building is completed is costly and disruptive.

Through efforts such as this paper, builders and municipalities can readily identify which proposed developments need a BDA system before the design phase is completed in order to place sufficient cable ducts, external access for the donor antenna and room for the BDA itself. If this is executed correctly, the cost is expected to be in the $50K to $120K depending on the size and complexity. The final results of a BDA system cannot be fully established until the building is completed as doors, windows and external cladding increase the effective blocking of the radio signals.

Commercial software is available to reduce the risk; iBwave is one such product that has been in use for system designers. Several radio engineers firms in south west BC specialize in the design, installation and maintenance of these systems. The software is used to simulate the radio path loss from the nearest known tower signal site, utilizing the proposed structure location, design and intended use. This in turn allows a radio frequency engineer to assess the likelihood of whether the building will have sufficient user in-building radio coverage or not.

For both solutions, as dwelling and commercial density increases, and as buildings are re-furbished, changes in coverage will occur over time. Commercial buildings for instance may start out with open office plans and evolve into storage areas. The former has little effect on radio signal propagation; the latter has the potential to block radio signals. This slow erosion of radio coverage requires careful vigilance by public safety authorities; generally fire safety officers engaged in safety inspections are the first to notice these changes.

EXISTING BYLAWS: CASE STUDY, HISTORY AND PURPOSE

Approximately a decade ago, the City of Surrey instituted a bylaw that states the conditions that must be met in multi-residential and commercial buildings/developments for coverage, maintenance and alarming. The key typical criteria to determine if a BDA system is required is as follows:

1. distance to radio system network tower sites and signal strength; or
2. buildings or structures:
    a. using construction methods other than wood frame; or
    b. with metal cladding or Low E reflective glass; or
    c. with greater than 5000 square meters in gross floor area; or
    d. over 12 meters in height; or
    e. with floor levels that are partially or wholly underground.

The purpose of the bylaw is to set the minimum requirements for successful communications coverage for first responders but is mute on the methods required to achieve the necessary conditions. It places the cost of providing the required signal coverage on the proponent/developer/owner.

Note that the technical "how to" was never an issue as there are numerous commercial undertakings making, designing and installing these systems. The fundamental missing piece is making the interaction between the proponent/builder/developer and the municipal government predictable and cost effective.

Other cities in Metro Vancouver – including the City of Port Coquitlam, Township of Langley and City of Burnaby – have adapted, and have either implemented similar bylaws or were in the process of doing so at the time of report publication.

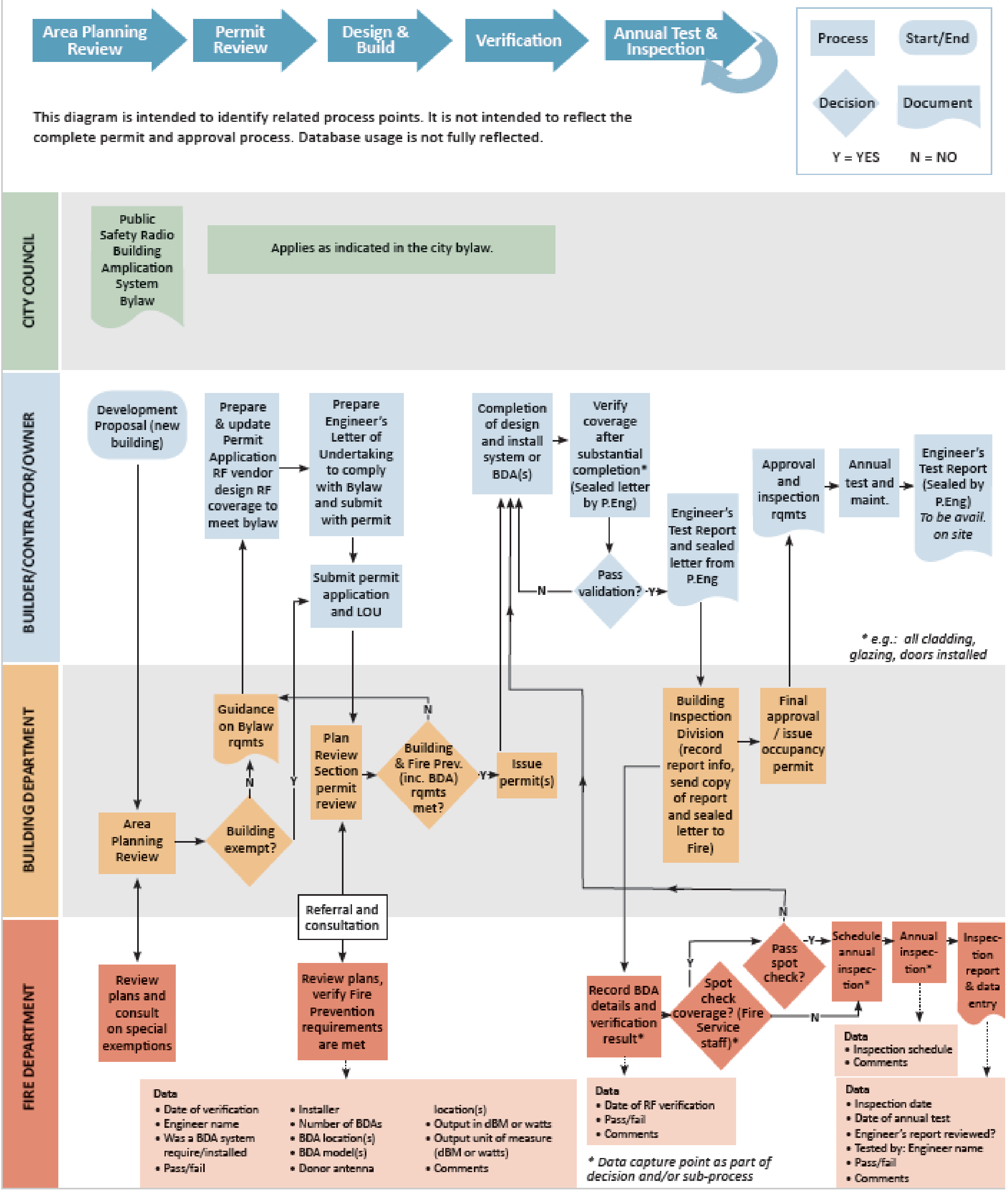
On June 2016 Ministerial Order (Issued by the Government of British Columbia, Canada) M209 added "(h) radio repeater systems for emergency communications" to the local authority jurisdiction of British Columbia municipalities. This action removed any possible issues with the legality of the original City's bylaw allowing communities to enforce the need for BDAs.

See Appendix A for a sample bylaw.

WORK FLOW FOR MUNICIPALITIES TO FACILITATE BDA INSTALLATION

An example of a flow process diagram that describes graphically how a proponent (e.g., building developer) for a new development or a significant change in an existing facility may be handled. The goal of this flow process diagram is to clearly mark the touch-points between the building developer and a municipal planning department that are needed to obtain municipal approval for building and occupancy permits.

Bi-directional Amplification (BDA) Process – Generic



The flow process diagram underscores the responsibilities for the proponents and clearly indicates that there will be multiple touch points with Municipal staff while also illustrating where professional certification is required in reporting and testing the compliance of the BDA system with any applicable bylaw. The key issue is starting the conversation early so that proponents and staff are aware of the process and can educate themselves on the requirements of the municipality and if enacted, the applicable bylaw.

Any structure that meets the criteria of the applicable bylaw will be identified during the initial contact with the municipality's area planning review group. From this point forward the proponent has a clear indication if a BDA system is required. At this point the proponent is strongly advised to engage appropriate technical expertise to assess and design the BDA system and to include in the planning and construction, electrical conduit for the coaxial cable to connect the parts of the system. There are many similarities between the pre-wiring of a CATV/Phone systems and BDAs except that the latter needs more infrastructure in parking garages and sometimes stairwells. Proponents planning for the installation of WiFi systems are also generally well equipped to handle the placement of addition conduit for BDA systems. The flow diagram specifically highlights where professional design and testing input is required to ensure a successful outcome.

The graphic above is provided to highlight a process and the required steps. An actual process may have to be modified to reflect individual municipality processes/practices.

GENERAL PHYSICAL REQUIREMENTS FOR A BDA SYSTEM

While the interaction between proponents and municipal staff are clearly shown in the flow process diagram, it is up to the proponents to plan for the installation of the BDA system. Although every system is unique, they will always require the following items:

1. A bi-directional amplifier (BDA). These are commercially available and cost $4K to $25K. Note that for the P25 radio system in use in southwest BC, one key specification is that the signal delay should be less than 10 micro-seconds. The signal delay becomes an issue with the current standard P25 Phase II when a first responder is transitioning from coverage from the radio tower to coverage by the BDA system. When the radio sees both the main signal and the BDA signal, a larger difference in timing can result in signal impairment. Note that BDAs that have low delay numbers are actually simpler and cheaper than more complex channelized units. The fact that the P25 system is operating in protected spectrum also allows for simpler BDAs.

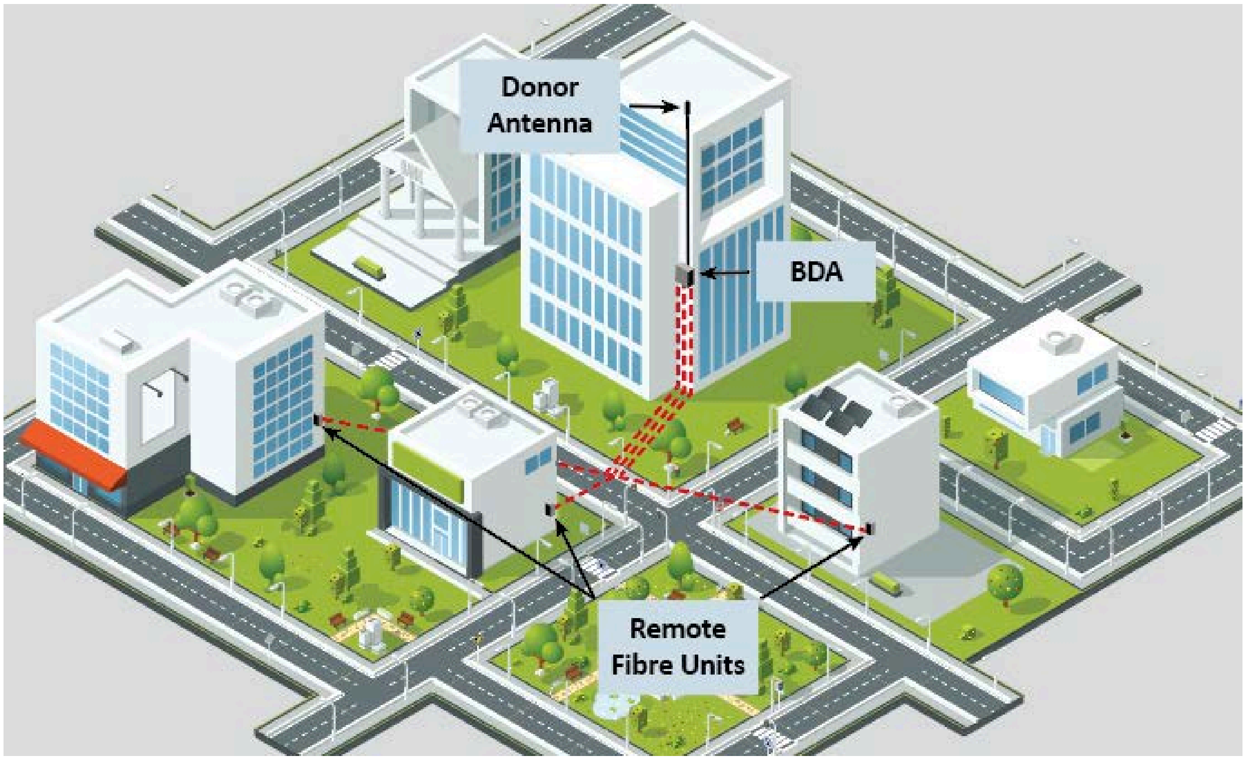
2. A donor antenna. This is simply a small high gain antenna pointed at the nearest radio tower site. The antenna is typically no more than 90cm long and 30cm wide and weighs less than 1kg. Commercial undertakings involved in the installation of these systems can also install the antennas and the necessary coaxial cable in a manner that meets building and electrical codes; specifically as they pertain to grounding. The antenna does not need to be on the highest point of the building provided that radio line of sight is maintained with the radio tower.

3. Distributed antenna system. This part of the overall system consists of low gain antennas that tap the signal from the coaxial cable connected to the client side of the BDA and distribute it throughout the areas where signal transmission from the radio tower is impaired. The coaxial cable is typically less than 15mm in diameter and the antennas vary in shape but are generally about 30X30X20 cm or less.

4. Equipment shelter. BDAs vary in size as a function of the total area that they have to cover but are generally less than 60X80X50 cm. Typically the municipality's bylaw and best practices specifically, indicate that an uninterruptible power supply be included, and that an alarm connection to the fire panel be included. As a result, the proponent is advised to construct a communications closet or "head end" at a central location with conduit available for the antenna cables and alarm cable to the fire panel. Total power for the BDA is typically less than 150 watts.

The foregoing are only general requirements, the specifics unique to the development proposed will be identified by the proponent during the design phase of the building. Very large and complex structures may require multiple BDAs, or distributed units using a fibre optic interconnect. As stated earlier, multiple and competent design/build companies reside in the southwest BC area to aid in getting the development design right in order to avoid later re-work of the electrical conduits.

A description of components is provided in Appendix B.



INSTALLATION, TESTING AND FINAL PERMITTING

Provided that the building has enough conduit to reach all of the previously identified areas where additional signal coverage is required, installation is generally straight-forward. However, testing cannot be completed until the building is essentially complete and all of the doors and windows are in place. This means that the final occupancy permit and final testing will occur very close together and proponents are urged to work especially closely with their RF engineering provider to receive sealed sign off to ensure that unnecessary delays are avoided.

The overall process is simple common sense – identify if a BDA is required early in the planning process and add enough conduit during construction to facilitate the installation of the cables, antennas and equipment. Generous additional spare communications conduits will allow developers/owners/builders to effectively "future proof" their structures for future wireless systems that have not yet been invented.

Testing of the system must be done by the builder's communications contractor and certified by a licensed professional engineer. The results of the testing are then presented to municipal staff and spot checks in the development are then conducted by users of the P25 radio system. Upon meeting these requirements, municipal staff may issue the building permit.

The bylaw also identifies that the BDA system will have to be licensed with Industry Canada. Although this is specialized permitting work, most of the firms engaged in the design and building of these systems have staff who are competent and capable of doing this. Completion of the licensing process is generally straightforward and requires the cooperation of the emergency radio network provider to complete. The costs of the licensing and the annual renewal are the responsibility of the owners of the development.

Conclusion

This paper is designed to help bring a focus to the need to improve in-building radio coverage for first responders, while providing education on the technology options and systems available for local governments to consider.

Reliable in-building radio coverage is increasingly important for public safety communications, both to enable a rapid and effective response, and to protect the safety of both the public and first responders. The communications needs of first responders do not stop when they enter a building. Whether it is a fire fighter calling mayday for help, a lone police officer requiring backup, or a paramedic team overwhelmed with a challenging patient, they all rely on their radio communication device to reach assistance outside the building.

In most communities, a patchwork of radio coverage is common. However, there is a range of in-building coverage solutions available that can economically extend the coverage of the outdoor network to the indoor environment.

In particular, bi-directional antennas (BDAs) can ensure that crucial in-building radio coverage is provided in a cost-effective way for public safety networks. The cost of deploying these units is significantly less if infrastructure is installed during the development stage.

Portable vehicular repeaters can also provide enhanced radio coverage without having to retrofit existing buildings. However, the optimum location of vehicle repeaters to provide in-building radio coverage must be determined through rigorous testing and replicated each time an incident occurs at that specific location. This has a negative effect on both response time and reliability.

However, both of these solutions can provide enhanced coverage, if the solution is engineered properly. Systems that are deployed without good planning or no engineering can cause network performance problems and a lack of real in-building coverage for first responders. Every site is different and requires a planned design by qualified Radio Frequency engineers.

Finally, having a clearly defined bylaw, and a planning process which engages developers/builders with the planning & development department as early in the development process as possible, is essential to achieving effective in-building radio coverage in the most efficient manner possible.

Author Biographical Information

Larry Thomas is a Deputy Fire Chief for the City of Surrey, BC, and is a Chartered Manager, C. Mgr with 29 years' experience. He is currently responsible for Human Resources, Labour Relations, Information Technology and the Communications division. He has a background in Science from Simon Fraser University and Economics from Douglas College. Contact him at LSThomas@surrey.ca

Anton (Tony) van Wouw, P.Eng. has over 40 years' experience in telecommunications system design and construction. He graduated from the Royal Military College of Canada in 1973 and initially spent five years as a Combat Systems Engineer in the Canadian Navy. He has worked around the globe and has been a consulting engineer for many of Canada's largest telecommunications firms, resource extraction companies, public safety organizations, power generation companies as well as First Nations communities. For many clients he has acted as the lead for projects in lifeline critical projects valued at millions of dollars and covering large geographic areas. As the principal of Exotek Systems, he can be reached at tony@exotek.ca

Jason Cairney is an Assistant Chief for the City of Surrey. He joined the Surrey Fire Service in 2002 as a firefighter and is currently responsible for Fire Prevention. He has a background in Business Administration from Centennial College, as well as hazardous materials response and training. Contact him at JWCairney@surrey.ca

Mark Griffioen is Deputy Chief of Community Services: Fire Prevention, Emergency Preparedness and Community Engagement. He started his career in Surrey as a Paid-on-Call fire fighter in 1994. He became interested in fire service administration through his work in pre-incident planning. You can reach him at MEGriffioen@surrey.ca

Len Garis is the Fire Chief for the City of Surrey, British Columbia, an Adjunct Professor in the School of Criminology and Criminal Justice & Associate to the Centre for Social Research at the University of the Fraser Valley (UFV), a member of the Affiliated Research Faculty at John Jay College of Criminal Justice in New York, and a faculty member of the Institute of Canadian Urban Research Studies at Simon Fraser University. Contact him at LWGaris@surrey.ca

APPENDIX A – Sample Bylaw

This sample bylaw is provided for reference only (placeholders for customized details have been highlighted). A bylaw should only be considered after consultation with a registered Radio Frequency Engineer and City Legislative and Legal services.

SAMPLE BYLAW

Public Safety Radio Building Amplification System Bylaw

....

(a) WHEREAS there is a need for certain buildings and structures to have radio support and amplification systems to ensure the City's fire service, law enforcement and other emergency services radio communications networks provide public safety grade reliability essential to public safety and emergency response;

(b) AND WHEREAS certain buildings and structures constructed of steel, reinforced concrete or reflective glass can cause radio signal penetration losses thereby degrading the quality of communications provided by emergency services radio communications networks;

(c) AND WHEREAS radio support and amplification systems within buildings or structures can overcome the degradation of emergency communications and are vital to public safety, policing and emergency services.

Under its statutory powers, including subsections 8(3), 8(7), 8(8), 63, 64 and 66(1) of the Community Charter, S.B.C. 2003, c. 26, the Council of the City of *(insert City name here)* enacts the following provisions:

INTENT OF BYLAW

(a) to require new or renovated buildings and structures, unless specifically exempt, to install and maintain Amplification Systems that provide highly reliable in-building communications for users of the public safety communications service provider radio system within the City;

(b) to provide highly reliable public safety and emergency response in-building radio communications ensuring the health, safety and protection of persons through the requirements of this Bylaw, and

(c) the activities undertaken by or on behalf of the City pursuant to this Bylaw are not contemplated nor intended to, nor does the purpose of this Bylaw, extend to the protection of persons from economic loss, the assumption by the City of any responsibility of ensuring compliance by a person with this Bylaw, or providing a warranty with respect to any building for which a Permit or Occupancy Permit is issued.

CONTENTS

Part 1

INTRODUCTORY PROVISIONS

Title

1. This Bylaw may be cited as the "Public Safety Radio Building Amplification System Bylaw, *(Date, Bylaw No.)* ".

Definitions

2. In this Bylaw,

"**Amplification System**" means the in-building radio communications support and amplification systems described in Section 4 of this Bylaw;

"**Building Official**" means the person appointed by the City as the General Manager of Planning and Development or such person's authorized delegate;

"**City**" means the City of *(insert city name here)*

For the City of *(insert city name here)* the designated public safety communications service provider is XXX and its services encompass all the features and functions of its radio communications systems, including microwave radio systems, provided to fire services, law enforcement, Emergency Health Services (EHS) and other emergency services;

"**Fire Chief**" means the person appointed by the City to be the head of its fire services or such person's authorized delegate;

"**Occupancy Permit**" means the permission or authorization in writing by the Building Official to occupy a building or structure;

"**Permit**" means authorization in writing by the Building Official to perform construction regulated by a Building Bylaw; and

"**Shadowed Area**" means an area that suffers attenuation or obstruction of radio signals to or from the area as a result of the interposition of all or any part of the building or structure in the radio signal path between the area and the transmitting/receiving site of the public safety communications service provider.

Part 2

REQUIREMENTS TO PROVIDE A RADIO COMMUNICATIONS SUPPORT SYSTEM

General

3. Except as otherwise provided, no person shall erect, construct, change the use of, or renovate any building or structure or any part thereof, or cause the same to be done, which degrade the radio coverage provided by the City's public safety communications service provider as experienced by its users, including but not limited to fire services and law enforcement personnel. For the purposes of this section, adequate radio coverage shall include all of the following:

   (a) System access and "Delivered Audio Quality" (DAQ) of 3.4 or better (speech understandable with repetition only rarely, some noise or distortion may be present) for communication between a portable (handheld) radio with simple flexible whip antenna ("rubber ducky") and the public safety communications service provider radio communication sites:

(i) within the building, for a minimum of 90% of the area of each floor of the building, including underground areas such as for parking; and

(ii) within the building, for 100% of fire command centres, stairwells, protect-in-place areas, lobby refuge areas, equipment rooms and high-hazard areas; and

(iii) in areas that are in the Shadow Area of the building, in 90% of all areas where DAQ 3.4 could be achieved before the erection, construction or modification of the building or structure.

(b) As an aid to system design, DAQ 3.4 has been measured by NTIA (U.S. Department of Commerce, National Telecommunications and Information Administration) to be approximately equivalent to 22 dBs (22 dB SINAD) for analogue signals modulated with a 1 kHz tone at 1.5 kHz deviation, and to 2% BER (Bit Error Rate) for P25 digital signals. It may also be approximately equivalent to a received signal level of -95 dBm, in the absence of other signals that may affect the receiver. Good design should provide a margin of not less than 10 dB to allow for uncontrolled variables. Based on the foregoing, the design target for indoor coverage should be -85 dBm.

(c) The radio frequency range to be supported shall be any frequencies used by the public safety communications service provider's network. If signal amplifiers are used, they shall include filters that will protect the amplifiers from overload and the system from interference by out-of-band signals.

(d) In the event that active amplification is required to meet the foregoing communication quality requirements in the building including Shadowed Area of the building, coordination with the public safety communications service provider is required to ensure that its outdoor radio communication performance is not degraded. If there is a trade-off to be made between maintaining the public safety communications service provider's outdoor radio communication performance and restoration of signal strength in the building and Shadowed Area, the trade-off decision shall be made by the public safety communications service provider and communicated to the Fire Chief by the building owner.

Amplification Systems Allowed

4. Where a building or structure requires an Amplification System to achieve adequate radio communication coverage, such system shall include any of the following that are sufficient to achieve the required coverage:

(a) passive antenna systems or radiating cable systems;

(b) distributed antenna systems with uni-directional or bi-directional amplifiers as needed;

(c) voting receiver systems; or

(d) any other system acceptable to the Fire Chief, as signified in writing on a case by case basis.

If any part of the installed Amplification System contains an electrically powered component, the system shall be equipped to operate on an independent "Uninterruptible Power Supply" (UPS), using a battery and/or generator system, for a period of at least four hours without external power or maintenance. All amplifiers and electronics required by the system shall be protected by NEMA type 4 or higher enclosures. The UPS shall automatically charge the batteries in the presence of external power. The UPS shall provide a monitored alarm signal to indicate failure of primary power, failure of the UPS system power output, and/or discharge of the batteries. Silencing of this alarm shall be the responsibility of the person maintaining the equipment. The Fire Service shall be notified of any failure, either immediately that the failure is detected, but not later than (2) hours after the initial failure occurred.

Critical alarms detected by the equipment regarding battery condition and amplifier performance shall be reported immediately.

A system summary alarm, consisting of a relay contact closure or equivalent, shall be provided to the building fire panel via a hard wired connection.

All active systems shall be licensed by the federal regulator, Innovation, Science & Economic Development Canada (ISED), and shall comply with the applicable Standard Radio Systems Plan (SRSP). Any license required shall be renewed annually by the building owner and the cost of the licensing borne solely by the building owner.

Radio equipment shall only be selected from the ISED Radio Equipment List as described at: https://www.ic.gc.ca/eic/site/ceb-bhst.nsf/eng/h_tt00020.html

Procedures to Verify and Maintain Compliance

5. Tests and measurements to verify and maintain compliance shall be made at the sole expense of the building owner. The procedures used shall be developed by the owner, subject to acceptance by the Fire Chief, and in compliance with the following guidelines:

(a) Acceptance Test Procedure

Acceptance tests and measurements shall be performed after completion of installation of the Amplification System. Tests shall be performed using radio frequencies assigned by the public safety communications service provider, after proper coordination with an authorized representative of that system and with the Fire Chief and the OIC of Police for the City of *(insert city name here).* If queuing occurs on the radio system while testing is underway, testing shall be terminated immediately and resumed only when traffic levels on the system drop to the level where queuing will no longer occur.

(i) Where the Shadowed Area, or the floor plate area of a building, is greater than 4,500 m2 the area shall be divided into a uniform grid of not more than 15 m on a side, or if the floor area is smaller than 4,500 m2 it shall be divided into a uniform grid of approximately 20 equal areas, to a minimum of 9 m2, and measurements shall be taken in each grid area. The size of the grids shall also be reduced, or the number of grids increased, upon recommendation of the Fire Chief or inspector in areas where special construction or other obstruction may significantly affect communications. Tests shall also be performed in fire command centres, stairwells, protect-in-place areas, lobby refuge areas, equipment rooms, and high-hazard areas.

(ii) Tests shall first be made using a portable (handheld) radio of the type used by emergency service personnel, carried at hip level (with external speaker/mic) and using a simple "rubber ducky" antenna, and shall be deemed satisfactory if DAQ 3.4 or better (speech understandable with repetition only rarely, some noise or distortion may be present) can be achieved for a five-second test transmission in each direction. If system access is not reliable, or if DAQ 3.4 for five seconds cannot be achieved at any location, the test operator may move a maximum of 1.5 m in any direction inside of the grid and repeat the test. If system access continues to be unreliable, or if DAQ 3.4 still cannot be achieved, or if there is any doubt about whether it can be achieved, a failure shall be recorded for that location.

(iii) For all tests, a pre-defined “Harvard” sentence should be used, such that the listeners are not aware of the sentence in advance on each test. A different recorded sentence should be used at each location.

(iv) A maximum of two (2) non-adjacent grid areas on a floor or in a shadow will be allowed to fail the test. In the event that three (3) or more areas on a floor or in a shadow fail the test, the floor or Shadowed Area may be divided into 40 approximately equal areas to a minimum of 4 m2, and the tests repeated. In such event, a maximum of four (4) non-adjacent grid areas will be allowed to fail the test. If the Amplification System fails the 40-area test, the building owner shall have the system altered to meet the 90% coverage requirement; otherwise the Amplification System will not be accepted.

(v) If the Amplification System fails to provide acceptable communication in any of the fire command centre, any portion of a stairwell, protect-in-place areas, lobby refuge areas, equipment rooms, or high-hazard areas, the building owner shall have the system altered to meet the 100% coverage requirement for these areas, otherwise the Amplification System will not be accepted.

(vi) Backup batteries and power supplies shall be tested under full load by generating communication traffic automatically for a duration of at least one hour. If within the one-hour period, the battery shows no symptom of failure or impending failure, the test shall be continued for additional one-hour periods to determine the integrity of the battery. The battery shall not fail within a four-hour continuous test period.

The gain values of all amplifiers shall be measured, using a service monitor that has been calibrated by a certified laboratory within the past 12 months, and the results shall be kept on file by the building owner for future verification and monitoring of performance. The gain records file must have multiple back-ups and be stored in more than one location.

(b) Annual Tests

At least annually, the building owner shall test all active components of the Amplification System, including but not limited to all amplifiers, power supplies and back-up batteries, and shall keep a record of such tests as part of the Fire Safety Plan for inspection by the Fire Chief or other inspector designated by the City. Amplifier gain shall be adjusted if necessary to re-establish the gain recorded upon acceptance testing, and batteries and power supplies shall be tested under load for a period of at least one (1) hour to verify that they will function properly during a power outage.

Additional tests or inspection of records may be conducted from time to time by the Fire Service at the discretion of the Fire Chief, after giving reasonable notice to the building owner. If communications within the building or within the Shadowed Area appear to have degraded, or if the tests show unacceptable communications performance, the owner of the building or structure is required to remedy the problem and restore the

Amplification System in a manner consistent with the original acceptance criteria, unless the owner can demonstrate conclusively that the degradation is solely the result of external changes not under his or her control.

(c) Qualifications of Testing Personnel and Test (Measurement) Equipment

Tests shall be performed by or under the direct supervision of a professional engineer registered in the Province of British Columbia and qualified in radio communications. Test reports shall bear the seal of the engineer.

Portable radios used shall be of a size and type as designated as acceptable by the Fire agency, or such replacement radio as may be in use by the Fire agency at the time, accepted by the public safety communications service provider and programmed to operate on a P25 radio tuned to a P25 test channel. SINAD, BER, and signal strength measurements shall be made using appropriate instrumentation acceptable to the Fire Chief. Radios and measurement equipment shall have been tested for conformance to design specifications within twelve months prior to the conduct of Amplification System acceptance tests or re-tests.

Exemptions

6. This Bylaw shall not apply to:

(a) any single-family detached or semi-detached residence;

(b) any building or structure that complies with all of the following:

i) is constructed entirely of wood frame;
ii) does not have any metal cladding;
iii) does not have any Low-E reflective glass;
iv) does not have any portion of the building or structure with a floor level that is partially or wholly underground, including basements, cellars and crawlspaces;
v) the area of all the floors of the building or structure is less than 5000 square metres, as measured to the lesser of the outside edge of the exterior walls or sheathing; and
vi) is less than 12 metres in height, as measured from the lowest ground elevation of the building or structure to the highest point of the building or structure; or

(c) any building or structure that is approved for an exemption to this Bylaw by the Fire Chief or Building Official in writing.

Permit and Occupancy Conditions

7. No Permit or Occupancy Permit shall be issued for any building or structure until the requirements of this Bylaw have been met to the satisfaction of the Building Official and the Fire Chief.

Right of Entry

8. Every owner or occupant of a building shall, at all reasonable times, permit the Building Official or the Fire Chief to enter into and inspect any building or structure to ascertain whether the regulations and provisions of this Bylaw are being obeyed and any person who refuses entry shall be in violation of this Bylaw and shall be liable to the penalties hereby imposed.

Deemed Nuisance

9. The construction or erection of a building or structure which interferes with the City's fire services, law enforcement and other emergency related telecommunications networks shall constitute a nuisance because it threatens the health, safety and welfare of the residents and visitors to the City. In addition to any other remedies or enforcement procedures provided herein, the City may seek an injunction to restrain such a nuisance.

Part 3

OFFENCES AND PENALTIES

Offences

10. Every person who violates any of the provisions of this Bylaw or who suffers or permits any act or thing to be done in contravention of this Bylaw or who neglects to do or refrains from doing any act or thing which violates any of the provisions of this Bylaw shall be liable to the penalties hereby imposed and each day that such violation is permitted to exist shall constitute a separate offence.

Penalties

11. Any person who violates any of the provisions of this Bylaw shall upon summary conviction, be liable to a penalty of not less than $200 and not more than $5,000 plus the cost of the prosecution, or a term of imprisonment not exceeding thirty (30) days, or both.

Part 4

GENERAL PROVISIONS

Commencement

12. This Bylaw shall come into force on the date of final adoption hereof.

PASSED FIRST READING on the __________ day of ____________________, 2017.

PASSED SECOND READING on the __________ day of __________________, 2017.

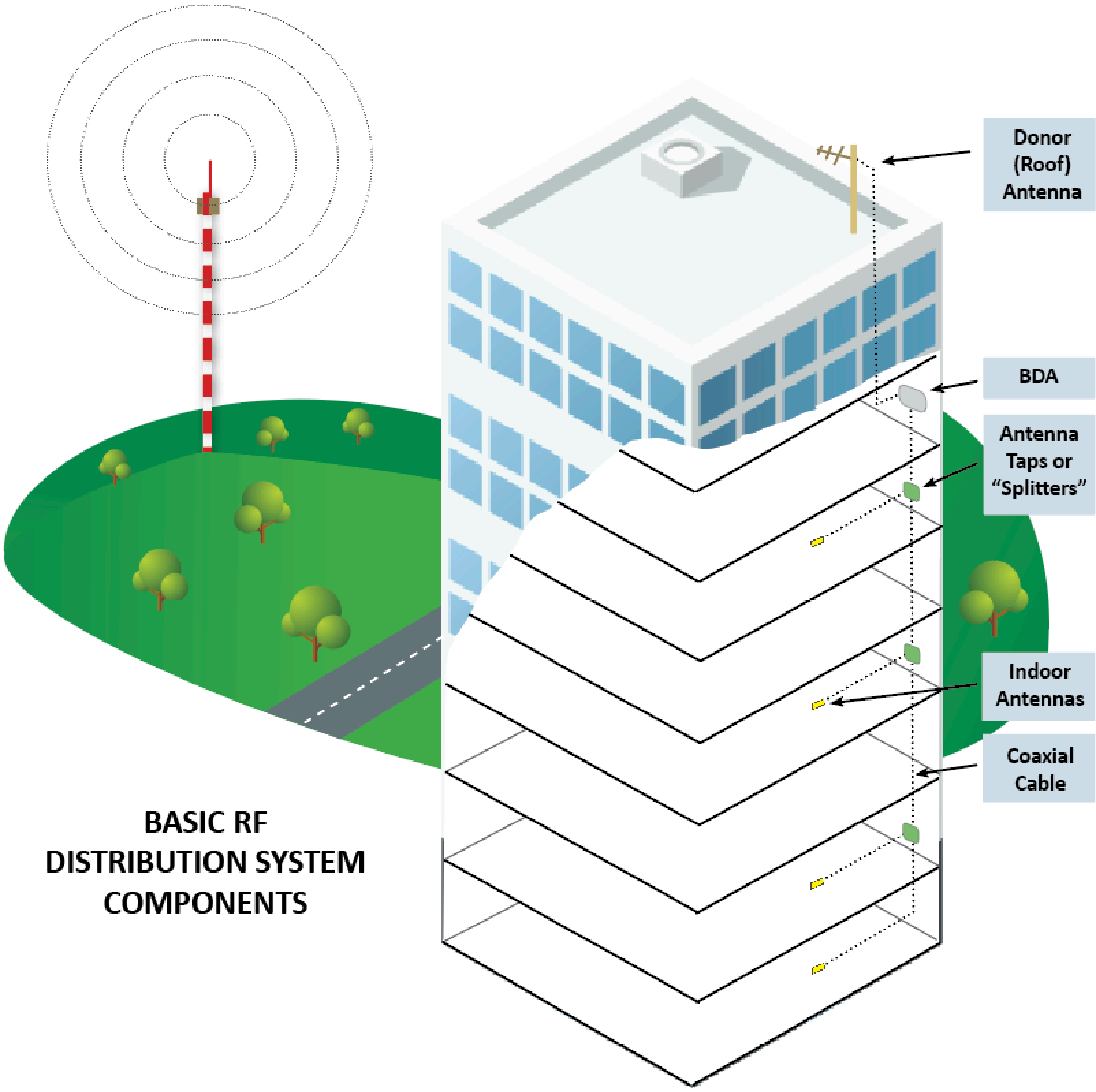
PASSED THIRD READING on the __________ day of ____________________, 2017.

RECONSIDERED AND FINALLY ADOPTED, signed by the Mayor and Clerk, and sealed with the Corporate Seal on the ____ day of ________________.

_________________________________ MAYOR

__________________________________ CLERK

APPENDIX B – Description of BDA/DAS Components



1. **Donor (roof) antenna**. This is called the "DONOR" antenna. It is usually mounted on the roof, or

a side of the structure, where a clear line-of-sight path exists to the distant radio tower. The distant site is also known as the "Donor". This is a two way interface;

- the DOWNLINK" is the RF signal direction going INTO the structure.
- the "UPLINK" is the RF signal being sent back OUT of the structure.

2. **BDA (Bi-Directional RF Amplifier)**. A very specialized RF amplifier which selects what frequencies are to be amplified in the downlink and uplink paths (they are different) and increases the RF signal strength in both directions. The FCC calls these amplifiers 'signal boosters' and there are very specific federal rules on their operation that should be followed by the system designer.

3. **The RF distribution network**. The most common method is to use coaxial cables. The coaxial cables fall into two classes; standard (non-radiating) and radiating.

- Standard (Non-radiating) coaxial cables route RF signals to multiple indoor antennas placed in areas where radio operation is needed. Special devices that take a portion of the RF signal out of the main coax cable to feed multiple antennas may be used. There are several types of these devices and they may be called "taps", "splitters" or "de-couplers", all serving the same purpose.
- "Radiating" coaxial cables (sometimes called 'leaky coax') intentionally allows low level RF signals to 'leak' in and out along the path of the cable. The ideal location for radiating cables is in passageways, tunnels etc.

The RF signal loses strength going through coaxial cable. These losses increase with length and RF frequency. In most cases, the maximum usable length of a coaxial cable is less than 1000 feet. Coaxial cables used for RF distribution must be 50 ohm (not 75 ohm) type.

Indoor antennas can be placed at the end of a coaxial cable or 'tapped' into a coaxial cable to allow multiple antennas along the coaxial cable route. This method is called Distributed Antenna System or "DAS". 700 MHz antennas are typically small and unobtrusive, some looking similar to smoke detectors.

Ideally, the indoor antennas will be located where they are optically visible from every location you wish to communicate, however RF signals can travel through 2 - 4 wood or drywall walls but the signal will be weakened. In parking garages, low profile (2" thick, 6 " diameter) antennas are sometimes glued to the lower side of overhead structural beams with construction adhesive. Locations of antennas sometimes follow the layout for video surveillance cameras, with both often serving the same area.

"RF-Over-Fiber" uses Fiber Optic cables. When a long coaxial cable would be required to connect antennas inside a larger structure, a long tunnels or adjacent buildings, it may be more practical to use 'RF-over-fiber' technology. Instead of using coaxial cables, the signals are converted to light and transported over fiber optic cables. On longer distances, fiber often offers less cost and easier installation.

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