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Infrastructure Obstructions to Radio Propagation

Wireless communications systems for public safety, first responders, and emergency personnel are complex, requiring a great deal of planning and configuration to operate effectively and efficiently. Obstructions—or interferences—to radio frequency (RF) resources are no stranger to public safety communications systems; such interferences can include active (e.g., competing radio signals interfering with radio propagation) and passive (e.g., building, topography) sources. In 2020, SAFECOM and the National Council of Statewide Interoperable Coordinators (NCSWIC) published the ***RF Interference Best Practices Guidebook*** to address many common active (and some passive) interference sources.

To complement the *Guidebook*, this document addresses passive and non-traditional obstructions to radio signals, focusing on additions, modifications, or improvements to infrastructure – including the introduction of uncommon elements (e.g., energy efficient windows) – that might cause signal weakness or loss. By highlighting these obstructions and providing examples of prevention and mitigation approaches, this document aims to equip communications system planners and administrators with knowledge to better prepare for changes to existing infrastructure.

Sources of Obstructions

Figure 1 below highlights several infrastructure and other non-traditional sources (mostly passive) of obstructions to radio propagation, demonstrating how these sources may be fixed or temporary (non-fixed) objects or structures. The examples provided should not be considered comprehensive. These sources might include anything built, constructed, or otherwise formed that gets in the way of a radio transmission or microwave link – including anything that might obstruct the link from passing through, into, or out of a structure.

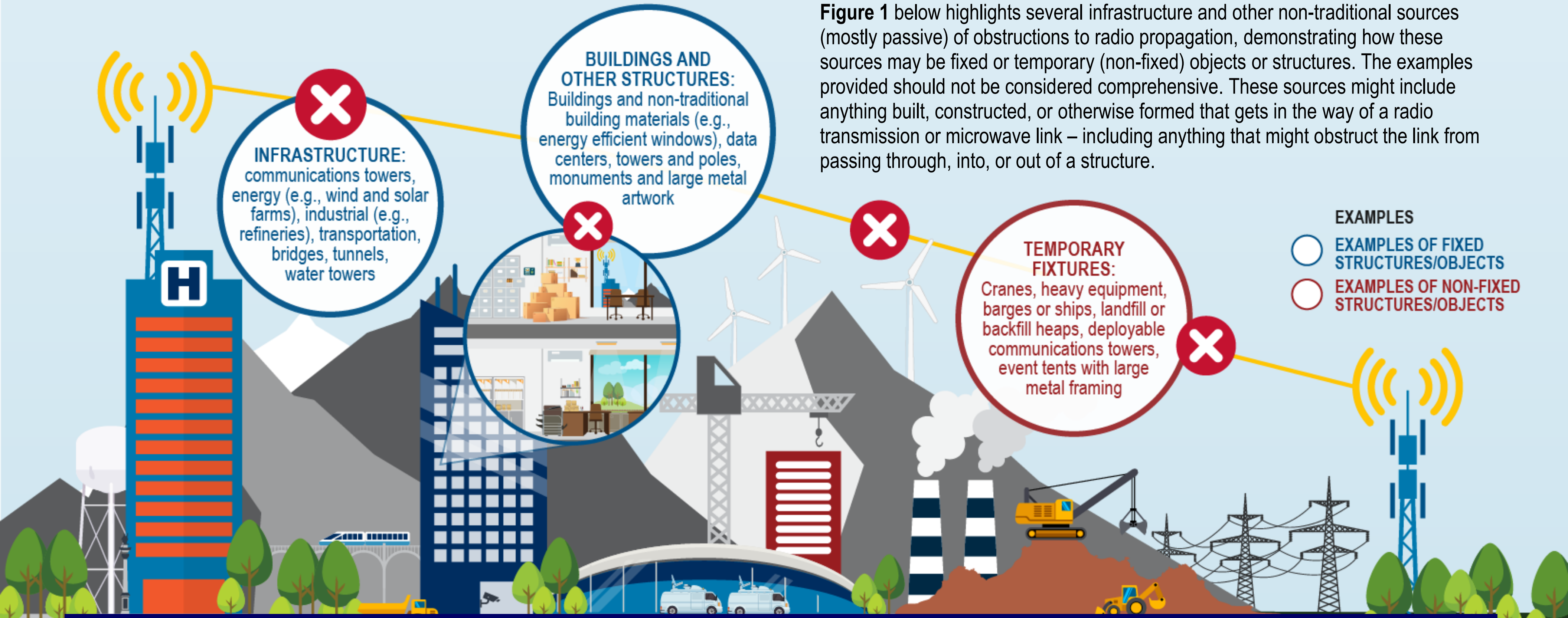

FIGURE 1: INFRASTRUCTURE AND NON-TRADITIONAL SOURCES OF SIGNAL INTERFERENCE

Preventing and Mitigating Obstruction

Agencies across the United States have used system planning, implementation techniques, administrative policy, and state, city, or municipal code to counteract the impacts of infrastructure obstructions to radio propagation.

Tables 1 and 2 provide several examples (not all inclusive) of approaches agencies have taken to prevent or mitigate obstructions. As Figure 1 suggests, obstructions, for purposes of this document, include:

Structural and human-made obstructions. This includes any structure that might weaken or interfere with radio signals. These structures may be fixed (e.g., bridges) or non-fixed (e.g., cranes), or may have moving or alternating components (e.g., wind turbines). Also, non-structural but human-made impediments such as high-piling backfill or landfill heaps could potentially attenuate signal, depending on circumstance.

In addition to preventing and mitigating obstruction to primary RF sources, system administrators and planners should be aware of potential consequences for microwave backhaul and other wireless technologies when new structures are being planned or constructed.

In-building obstructions. Although radio signals may not be interrupted by the mere presence of a structure within the communications ecosystem, signal propagating into or out of that structure may experience signal weakness or loss, nonetheless. This may be the result of specific building components or dense materials (e.g., energy efficient windows, metallic cladding) or concentrated objects or storage (e.g., rows of server racks) inside the building. In these instances, techniques to accomplish improved in-building coverage might be useful.

Table 1 outlines several common practices system planners and implementers might apply during system development or incident coordination to prevent or mitigate signal obstruction. This list is not intended to be comprehensive.

TABLE 1. EXAMPLES OF SYSTEM PLANNING AND IMPLEMENTATION PRACTICES

General System Planning and Implementation Techniques
Strategic site selection (e.g., improving line of sight, avoiding overcrowded RF sites)
Requirements for design modeling and coverage testing included in procurement documents
Geographic Information Systems (GIS)-based coverage modeling tools for planning and forecasting
Thorough testing for RF emissions or interference, including at-site testing (site “walk throughs”) and drive testing
Deployment of transportable cellular sites (mobile broadband vehicles), such as Cellular on Wheels (COWs) or Cellular on Light Trucks (COLTs), during special events or unique incidents requiring improved coverage
Coordination and communication with vendors or builders during planning and construction of infrastructure (in some cases, coordination may be required for legal or licensing purposes; when this is not the case, opening communication channels with vendors or builders is generally encouraged nonetheless)
Adjustments to system components (e.g., antennas, filtering) to accommodate changes to the environment and avoid non-line of sight
Signal testing of point-to-point microwave relay links
Best practices for RF interference mitigation, such as avoiding sharing frequency with non-licensed users, are employed (see ***RF Interference Best Practices Guidebook*** for additional information)
Techniques Specific to RF Coverage Inside or Throughout Buildings
Strategically positioned vehicle repeaters during incident response
In-building installation of public safety/emergency response systems such as radiating cable systems (“leaky cable”); Distributed antenna systems (DAS), including signal booster systems or bi-directional amplifiers (BDAs); or Wi-Fi routers
Codified fire code addressing emergency responder radio coverage (see Table 3)

In addition to the best practices in Table 1, some municipalities have chosen to pursue more formal guidance to prevent and mitigate signal obstruction. Table 2 summarizes some of the policies or rules instituted by the identified states, territories, and cities.

These examples are presented not as recommendations, per se, but as examples of current practices, and are not a comprehensive listing of rules and codes. Table 3 describes common building, fire codes or standards that might apply to public safety communications. In most cases, state and local jurisdictions codify language expressly, reference code or policy, or adopt modified versions of the applicable codes or standards (in whole or in part) included in Table 3.

TABLE 2. EXAMPLES OF STATE, TERRITORIAL, OR CITY RULES AND CODES

Jurisdiction	Rule or Code
City of Mesa, Arizona	New buildings meeting certain criteria must meet approved existing radio coverage – as defined by city code – within the structure. Height, area, and structure material are taken into consideration (city code includes language from 2018 International Fire Code; see Table 3 for additional information)
City of Omaha, Nebraska	For cable television systems construction, RF leakage shall be checked at emergency radio services reception locations to “prove no interference signal combinations are possible”
City of West Hartford, Connecticut	Buildings or structures that cannot support the required level of radio coverage shall be equipped with an internal multiple antenna system with Federal Communications Commission (FCC)-type accepted BDAs; testing procedures must ensure two-way coverage at a minimum of 95 percent; annual testing is the responsibility of the building owner
New York City, New York	For required high-rise buildings, a Fire Department Auxiliary Radio Communication System must be installed within the building according to specification
State of California	Certain existing buildings that do not have approved in-building emergency radio coverage shall be equipped with such coverage according to technical specifications

TABLE 3. COMMON STRUCTURAL CODES AND STANDARDS ADDRESSING EMERGENCY RESPONSE RADIO COVERAGE

Standard or Code	Description
International Fire Code (IFC)	The IFC provides minimum regulation for fire prevention and protection. **2018 IFC Section 510** addresses emergency responder radio coverage in new and existing buildings, including technical and installation requirements, maintenance, and testing of coverage
National Fire Protection Association (NFPA)	The NFPA provides global standards for fire prevention and protection, including several standards related to emergency services and public safety **communications systems**, equipment, **alerts and warnings**, and **personnel**

About SAFECOM

SAFECOM is managed by CISA. Through collaboration with emergency responders and elected officials across all levels of government, SAFECOM works to improve emergency response providers’ inter-jurisdictional and interdisciplinary emergency communications interoperability across local, regional, tribal, state, territorial, international borders, and with federal government entities.

About NCSWIC

Established by CISA in July 2010, **NCSWIC** supports statewide interoperability coordinators (SWICs) from the 56 states and territories by developing products and services to assist them with leveraging their relationships, professional knowledge, and experience with public safety partners involved in interoperable communications at all levels of government.