DEFINITIVE FACTORS

FOR SELECTING AND VALUING MOUNTAINTOP TELECOMMUNICATION SITES

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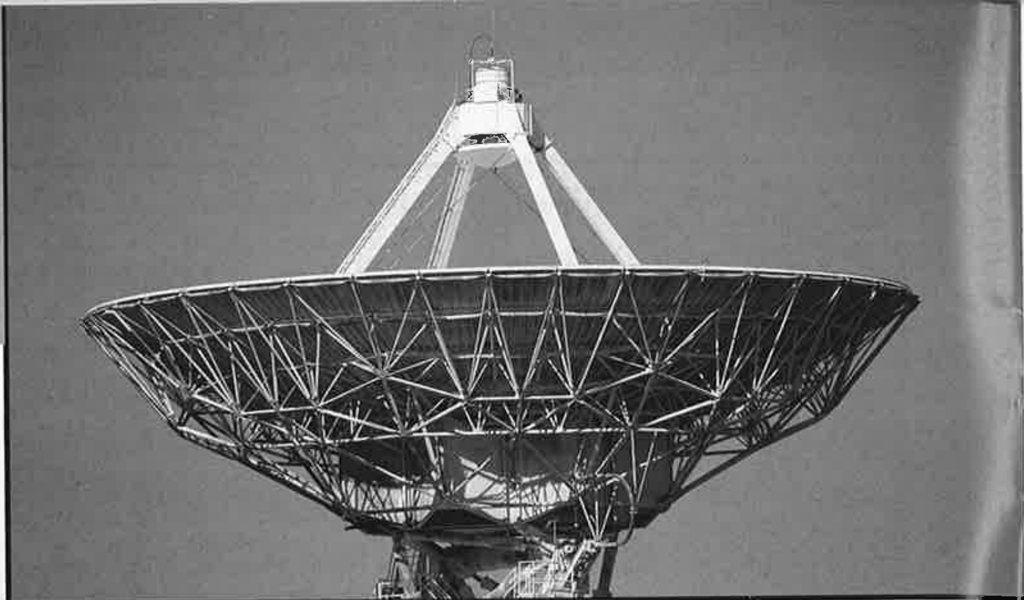

What makes mountaintops more or less suitable and valuable for telecommunications uses? The answer to this question cannot be easily answered by conventional real estate location analysis or appraisal methods. Frequently, real estate appraisers working for public agencies are faced with a problem of trying to decipher the scrambled signals of radio frequency engineering data, to no avail. Likewise, antenna site rental or sale data may often appear random or based on business or use values rather than market values rather than attributes of the real estate itself.

Based on this authors interviews with both public and private telecommunications sites users and antenna site developers, the following notable factors were found to affect the selection of communications sites in the following rough order of their importance.

Ownership Status.

The most important factor by far in the selection of telecommunications sites is whether the site is under private or public ownership. This factor is so critical, especially under the current build-out of wireless infrastructure, that most antenna site developers or users reported that it made all the other factors relatively unimportant. There are several factors that make privately owned sites more attractive to the commercial telecommunications business. First, a lessee can sign a long-term lease for a privately held site, but a U.S. Forest Service Use Permit, for instance, provides for only a 10-year maximum term, which is terminable upon notice. The less permanent the duration of a lease the more risk to the lessee. As a general rule, the more risk there is to a lessee translates into less rental return for the property owner. This isn't to deny that many public agencies often realize full market rents for antenna sites regardless of the terms and conditions in the lease. Nonetheless, such rents usually reflect non-market consideration because the rent along with the terms and conditions of the lease are imposed by one-side to the transaction in a "take-it-or-leave it" manner. It goes without saying this does not meet the legal criteria of "fair market value" as reflected by willing and knowledgeable parties, neither taking advantage of the other.

The problem of delay is another reason that many telecommunications operators shun public or government owned sites. In order for new communications businesses to be competitive in the current environment of the build-out of the national wireless infrastructure, they often must act quickly in locating and securing telecommunications sites. For example, the permit processing time on U.S. Forest Service land is reported to range from two months to two years with an average of one year. Other levels of government often have permit processes that are similarly complicated and time-consuming. Because of this, site developers and users will often shun more desirable sites for sites which are more readily developable or usable even in extra costs are sustained to engineer the antenna system. The rule for siting telecommunications sites is not the conventional "location, location, location," but "timing, timing, timing."

Competition.

For commercial telecommunications sites located on hilltop or mountaintop locations, the presence or absence of nearby competitive antenna tower facilities may be critical to its suitability and economic feasibility. Conversely, competition is usually not a factor in proprietary public safety or two-way radio systems. If the rack space on an antenna tower is already filled-up, however, then there may be sufficient demand to make a competitive site feasible for development into a new communications site. Another invisible factor is that there may be no additional antenna rack space available on a tower at the required elevation or separation needed to make the site suitable to a new user. A market analysis must often be conducted to determine proximity to competitive telecommunications facilities for commercial applications.

Because of the usual availability of sites, small land area required for antenna facilities, and the capability of engineering different properties into suitable telecommunications sites, the market for telecommunications sites is mainly a "buyer's market." It is rare to find a site that is technically irreplaceable, not considering avoided costs.

Area Coverage.

The amount of area that a telecommunications site offers for transmitter coverage is all-critical to many users. Elevation is a necessary, but not sufficient, precondition for radio frequency signal propagation. The base transmitter height per se is not always the most important variable in a given service area in affecting signal coverage unless the gain in elevation leads to less interference or avoidance of signal blockage.

Paradoxically, some sites with radio wave "shadows" (i.e., uncovered areas) may actually be desirable in

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those infrequent situations where sending a non-interfering signal is sought. Non-peak mountain tops or ridgelines with extensive signal blockage in one direction are usually avoided for location of commercial telecommunications sites. An exception is where the user requires signal blockage in one direction to avoid interference with other systems or where only uni-directional signal transmission is sought, such as in the case in many radar systems. In general, however, remote mountain peak sites have a good radio, television, and microwave transmission and reception potential because of their high elevation, few interfering natural barriers, and often low surrounding foliage.

Interference/Co-Location.

Even the highest mountain peak, tallest building, or tower on which to put a telecommunications antenna may not be optimum due to strong interfering signals from miles away or its own signals bounced-back in what is called multi-path signals or "ghosting" problems. Radio waves at similar frequencies, or higher energy output radio waves such as from radar, can present a significant interference to other telecommunications systems. Radar waves for example can present interference to other telecommunications facilities within a 600 feet radius. Interference can seriously degrade the operation of nearby communications systems. There are several measures that can be taken to mitigate or eliminate interference:

(i) eliminate one of the interfering systems,
(ii) use a unidirectional antenna,
(iii) alter the height of the interfering base station's antenna,
(iv) installing a tone squelch system,
(v) move the frequency away from the interfering signal, also called "frequency frogging,"
(vi) install a filter on the antenna, (vii) separate telecommunications systems by a minimum of 600 feet, and
(vii) Select a site that blocks the interfering signal from one direction.

Changing the frequency is cited as the most important measure to avoid interference. Frequency coordination is part of the licensing process regulated by the Federal Communications Commission (civilian), the Spectrum Analysis Center (military), the Associated Public Safety Communications Officers (local government), the Utilities Telecommunications Council (UTC), and the Federal Communications Commission

(FCC). Telecommunications sites are often selected which provide adequate shielding from interference even though they may result in a somewhat longer transmission path.

Co-location is the siting of multiple antenna structures within the same local area. This may take several forms such as multiple antennas attached to a freestanding antenna structure (i.e., donor site, piggy-back site), a roof mounted antenna, a facade mount on the exterior of a building, contained within an office or residential unit, or within an "antenna farm" along a mountain ridge line. Co-location is problematic because it may create signal interference. Twenty feet is the ideal vertical platform separation for antennas. Tower structural design must not allow for additional weight and wind loads. Properly engineered concrete footings and slabs must be 6 to 8 feet deep. Beanstalking is the term used when the adding of multiple antennas may create a negative visual impact. And zoning codes may require aesthetic monopoles (i.e., fake trees) that are devoid of external handholds. This may require the whole structure to be lowered for servicing with a disruption in service to other co-users. For the above reasons as well as others, a co-location site may not be as desirable as a freestanding site.

Line of Sight.

Clear line of sight between two geographical points is critical to microwave and two-way radio communications systems, but not to cell sites, which are typically located at, lower elevations. Route design will take advantage of prominent elevated natural terrain, tall man-made structures or existing antenna platforms. Route layout and site selection is usually done on topographic maps.[1] Site selection decisions are often made on line of sight clearance of the radio beam together with proximity to drop and insert points. Economics often limits antenna heights to 300 feet maximum with corresponding maximum distances of 70 miles. Factors that interfere with line of sight communications are close in vegetation, the curvature of the earth, Fresnel (i.e., reflection) zones and interference. Depending on the technology, radio line of sight can extend farther than visual line of sight because it can reach over the optical horizon. Antenna sites that transmit radio waves beyond the optical horizon are called tropospheric scatter/diffraction sites.[2] Such over-the-horizon hop sites are typically for military uses and will require larger land area and greater site improve-ments such as potable water, sanitary systems, on-site living quarters, paved roads and the availability of more prime power. Real estate appraisers should avoid comparing ground rents and purchase prices on line-of-optical sight telecommunications sites with large over-the-horizon sites or cellular or personal communication system (PCS) sites.

Reflectivity.

Reflectivity can cause signal path loss. Contrary to what might be thought, heavily forested areas may offer less reflectivity and thus a better signal path, than smooth surfaces such as over water or desert. Telecommunications engineers use a terrain scale in evaluating reflectivity (top of page 15).

Environmental Constraints.

More than half of the candidate sites for telecommunications facilities are reported to be eliminated due to environmental sensitivity of some sort.[4] The measures required to mitigate any negative impacts to a sensitive site usually are prohibitive as to cost and time and force most telecommunication site locators to find an alternative site solution rather than move ahead with the permit and licensing process of a sensitive site.

Reflectivity Terrain Scale[3]

1. Heavily wooded forest land	Low (good)
2. Partially wooded (trees along roads)	
3. Sagebrush, high grassy areas	
4. Cotton with foliage, rough sea water, low grassy area	
5. Smooth sea water, salt flats, flat earth	High (poor)

Zoning.
Obviously, zoning is a critical site selection factor. In response to the more recent wave of telecommunications site permit applications, many municipalities have had public pressure to adopt ordinances that restrict or limit the selection of the sites, the height of towers, or design of the towers, especially along scenic highways or mountains. Telecommunications

Therefore, environmental sensitivity is an important site elimination factor rather than a site location factor because such sites are usually avoided.

Power Supply.
Unlike development of most other types of land, the development of telecommunications sites requires only the availability of electric power and not water or sewer utilities. Electrical power malfunctions in the form of a blackout or momentary dropout can raise havoc with computers used in connection with communications systems and can affect customer satisfaction and bottom line profitability. Thus, uninterruptible power supply (UPS) and a dual-backup generator system is critical to any commercial communication system. Remote mountain antenna or dish sites usually have a stand-by electrical power system in the form of a "kick-in" battery system which works until a diesel-driven or gas turbine generator can get started. Solar panels are currently used to charge a battery plant during the day.

Commercial communication systems and sites are constructed on the basis of a break-even point cost. The cost to extend electrical power to a remote mountainous site is weighed against a stand-alone power system, which typically does not cost more than $75,000 according to industry sources. Therefore, when the cost of extending electrical service substantially exceeds about $75,000 it is no longer cost effective compared to an on-site system.

facilities are usually allowed under a conditional use permit process. Many political jurisdictions prefer such facilities be aggregated into one tower or be unobtrusively designed as part of existing buildings. Mountaintop sites may have less visual blight problems than cell sites because of their remoteness.

Subdivision Ordinances.

One of the most scrambled pieces of misinformation about telecommunications sites is their size. Governmental or quasi-public utilities are immune from subdivision laws and can create a division of land to fit the specific needs of a telecommunications site. Also, ground leases are often permitted over a small portion of land where a similar parcelization for sale purposes would not be allowed. Private telecommunications site developers are not afforded this dispensation from subdivision laws. Therefore, the size of telecommunications sites may vary widely and present confusing signals to those who do not recognize this difference. Telecommunications sites are typically purchased or leased on a per site value not on the basis of a price per acre, per square foot, or per foot of elevation above mean sea level. Most tele-communications antenna facilities can be accommodated in a 5,000 square foot area, not considering access roads. But the actual amount of land acquired may have to be much larger in order to meet subdivision laws.

On-Site Topography.

A less critical factor in the selection of mountain top telecommunications sites is the actual topography of the site footprint. If a level site has to be created on the ridgeline of a mountain this adds cost to the system. The grading cost typically runs a magnitude of order of three times (3x) the conventional grading cost on level sites.

Road Access.

The availability and quality of roads to mountain peak telecommunication sites can also be critical in the site selection decision. If a communications site user has to grade a new road to a site the cost could be substantial. Sites with existing roads provide more of an assurance of access under different weather conditions. Electrical generators require weekly inspection and frequent maintenance as well as emergency repair. It is significantly less expensive to haul construction and communications equipment up a mountain dirt road than to air drop it on to the site. Dirt roads must often be widened and re-graded to accommodate the width of a semi trailer truck with a "low-boy" trailer that can carry a bulldozer or other equipment. The cost of cutting a new road to a telecommunications site can be prohibitive but, nonetheless, the cost is sometimes assumed because of the quality of the site.

Microclimate.
Rainfall and other atmospheric conditions such as fog, clouds, mist, haze, dust, smoke and salt particles in the air can cause attenuation of radio waves. In dense urban areas, many telecommunications dishes are hung on tall buildings where they can be sheltered from rain attenuation.

Available Land Area.
The minimum land area required for telecommunications sites depends on the type of tower mounting systems used: self-supporting towers, guyed towers, highest hill or ridge, tall buildings, piggy-back sites on TV towers, monopoles on level sites, etc. Guyed supported towers are preferred because of their lesser capital cost, but they may present a disadvantage where land values are high because they require a larger footprint. Local air navigation ordinances may limit or condition the location, height and marking of towers. Telecommunications engineers sometimes use pre-computed tables that indicate the minimum land area required for guyed towers. The typical monopole or lattice antenna tower footprint is only about 5,000 square feet of land area.

In summary, many less-than-optimum sites can be engineered for suitability as telecommunications sites. The greater the re-engineering and extra costs involved, the greater the likelihood the site will be avoided for communications usage. Avoided delay and avoided costs are critical in the selection and valuation of telecommunications sites. ■

1 For a discussion of topographic route methodology see: 1.) R.L. Freeman, Radio System Design For Telecommun-ications, John Wiley & Sons, 1987, p. 30; and 2) W.C.Y. Lee, Mobile Cellular Telecommunications, McGraw Hill, 1995, p. 143.
2 R.L. Freeman, Radio System Design For Telecommunications, John Wiley & Sons, 1987, p. 142-143.
3 R.L. Freeman, Radio System Design For Telecommunications, John Wiley & Sons, 1987, p. 37.
4 Jim Hodges, P.E., SRI International.

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