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Reviewing and Classifying the Effective Factors in Selection Telecommunication Antenna Towers Sites.

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ABSTRACT

Telecommunications companies around the world attempted to cover most demand area in better services and low costs where the best distribution of antenna towers are represent one of the main factors to attempt the goal. In most cases, telecommunication experts analytically studied every case lonely. In this paper, we review and classify the most effecting factors for select telecommunication tower sites. These factors are classified into one of four categories: Governmental regulation rules, laws and internal policies; Transmission technology and tower properties; Geographical and demographical factors; and finally Company experience.

KEYWORDS

Telecommunication, Wireless towers, Technology factors, Geographic factors, Regulation and Policy factors.

1 INTRODUCTION

The rapid growth of telecommunication systems around the world is obliged to live in dynamic system [1]. Therefore, telecommunication industry services as one of the main parts of such system will be affected by dynamicity. Building efficient network represents the main challenge in telecommunication industry plans [2]. Selecting the optimal wireless telecommunication towers sites is one of the complex decisions in telecommunication industry [3]. The prime goals of such decision are: coverage the most demand area in highest signal quality with low cost [4],[5],[6], moreover, compression decision time is one of the internal targets. For that, when a company come up to the higher level of the goals by using better plan then highly competitive advantage will be achieved. Selecting the right site for placing wireless telecommunication towers is one of the challengeable telecommunication services for companies around the world [7]. Selecting an accurate site might found in changeable environment such as: cost [5] [6], technology, rules and spatial data. On the other hand, the wrong decision may cause financial problems, environmental damage [8] and [9], [10], Weak signal receiving may cause some accidents [11], health problems [12], and [4] and [13] ,[5]. The decision of selecting the site of the tower is mainly based on spatial data, environmental regulations [6] and some other internal and external factors. The purpose of this research is to review and classify the affecting factors on decision of selecting the better site of telecommunication towers with maximum cover of demand area. In next sections, we reviewed some research factors that affect the decision depending on regulations, demography and geography, technology, as well as experience factors.

2 BAKGROUND

2.1 An Overview of Selection Tower Site

Nowadays, telecommunication systems represent a core of communication among persons and organizations [1]. For that, telecommunication companies compete to offer the better efficient services through covering most demand area for their services [1]. The prime goals of selection tower site decision is to coverage the most demand area in highest signal quality with low cost[4],[5],[6], demographical [14], geographical regulations [5], [15] and policies barriers may face such decision. For that, the companies must find the better balance point between reduce the

expenses and provide better services under some constraints [3]. Therefore, it must be studied in early time for long term and short term of its planning [16]. A demand areas could be covered by one or more of communication technology such as: fiber optics, twisted pair, microwave signals [16]. Currently, telecommunication companies prefer to provide most services through wireless communication that required building a tower in each sub area; where telecommunication tower represents a bridge between two-way communication systems: users and the communication center point using radio frequency propagation that charged by data between the two points [17]. The coverage area with better signal is depend on the signal strength and the range of covered antenna [5] and [18]. Some barrier may cause bad signal such as: geographical terrain [5], weather, and other broadcasting signals. Building towers represents one of the budget challenges for the building cost [19], [5] and [6]. The budget of building towers is to find the balance point between cost and revenue [14], [5]. The cost is affected by many factors such as: technology, construction, maintenance and operations costs [20]. Moreover, the rented or bought area with construction equipment's are represented the budget challenges [14], [5]. On the other hand, the revenue is affected by number of users [4], [21],[22] and internal competitive policy with some government regulations [5],[15]. The construction cost of towers is depended on technology cost for tower type [19] and antenna system wind speed load [23], while the coverage area is determined by antenna system and tower height with signal frequency [5].

2.2 Technology Factors

Signal strength was studied by [24] and the range covered antenna without any barrier founded [5] and [18] where these factors depend on the technology, the type and height of tower [21]:

$$\varepsilon = \frac{120\pi h_\tau I}{\lambda d} \qquad (1.0)$$

here, ε is the field strength in volt/meter at a distance of transmitting antenna with height h_τ, I is the antenna current, λ is the wavelength of the operating frequency, and 120π is the characteristic impedance of free space.

Frequency (f) and wavelength (λ) are related as

$$f\lambda = c \qquad (1.1)$$

where c is the speed of light,

The range for covered area can be expressed from equations (1.0 and 1.1) as

$$d = \frac{120\pi h_\tau If}{\varepsilon c} \qquad (1.2)$$

Antenna technology give some factors that affect a signal efficiency such as: antenna load [16], transmission electricity [25], reliability and security [26], safety [27], frequency range [5], transmitter's output power, antenna type, gains, plane beam width, front-to-back ratio, polarization, nominal impedance, receiver sensitivity, cable loss [28].signal-to-noise ratio, bandwidth, frequency-dispersive wireless channel, multipath system , multiple antenna, and frequency index [29], space selective, frequency dispersive, and time varying, antenna system type, another frequency channel models [22]. easy to install, frequency range, bandwidth [30], ability to penetrate most surfaces [14], sight distance and angle [27], number of users [4], [22]. The following proprieties must be taken in account to accommodate antenna towers with better signals: tower weight [19], Tower footprint, Height of tower [16], Tower structure [5], wind loading [23], the distance between existing towers, elevation, and the real visibility [31]. Site-level safety management, operator charter and proficiency, superintendent character, maintenance management , crane and accessories, wind, employment source operator, type of load, antenna height, tower location, distance from server station [28].

2.3 Geographic Factors

In reality, the broadcasting not spread around flat and clear area which is preferred [5], [16], [21], but there are some geographical barriers that prevent or weaken the access of the signal. The following paragraph will summarize these impairment factors into: electrical power interference that effect on signal and tower [5], environmental pollution [9], lightning and

electromagnetic radiations [32],[33],[34], plane root, birds and foliage movements [24]. In the other fact some terrains factors should be studied for the candidate points such as: Soil type [19], quality of the land must have ability to build the tower in different environment cases such as wind speed and load [23], earthquake, ice load, seismic loading [5], coastal area, and water ways [35]. In addition, some topography factors may cause poor signals intensity such as: height of the buildings, ray intersection with three and two-dimensional surfaces, electric parameters, large posts, traffic, and indoor furniture in, metal-framed windows, cells intersection [22], wooded and flat areas [5], tree highs, clad areas, and agricultural lands [21]. Moreover, the candidate points preferring to be found in highest point for economic reason and better signal [36], therefore some geographic factors must be studied such as: slope [21], steep area [31], elevation, drainage, networking , meteorological observation [18], higher area and soil erosion [6] [5], [14], mountainous, slopes, hilly, forestry, trees, vegetation, wind, raining, soil moisture, climate characteristic [28], location accessibility for maintenance issues [6] and [5],availability of electricity [37],[30], [5].

On the other hand, population density in demand area [4],[18],[5], probability increasing of users [6], average household income, age, transit ridership [4], type of users [18] should be studied with ability of antenna load and other network requirements.

2.4 Regulation and Policy Factors

The telecommunication towers and antenna signal are subject to conflict with some of the polity ingredients, for that, most of governments around the world developed the regulation for managing and organizing the telecommunication industry. The selection points may have some government restrictions [5],[15],[6], i.e. some areas are protected by laws and regulations such as: military zones, wild life areas, residential area, flooded area [6], archeological area, environmental area, health services area, and airplanes routes [5],[10],[38]. In addition, its restricted by monitoring safety where government strategic plan gives legislative authority to use the land, broadcast ranges licenses to coordinate between all parties [15]. Here are some examples on different times to develop standard criteria to cover towers properties. In 1996, Telecommunications Industry Association (TIA) through engineering committee TR-14 developed the first edition of minimum standard criteria for telecommunication tower properties (ANSI/TIA222-F-1996 and ANSI/EIA/TIA-222). Developed criteria covered: steel standards, wind loading by mile or second, paint type, bolt tightening, foundations, climbing and maintenance, safety facilities, loading considerations for earthquakes, and existing structures analysis. Another example, in 2004 Canadian telecommunication industry and the University of New Brunswick cooperate to publish a reviewing report for national antenna tower policy factors; it was used to select the tower site. At this report, they developed a framework depend on six questions that answered by public consultation. That report was used to make an authority decision processes for supporting radio communication antennas structures. This paper sum up the main points that stated in the report as: government responsibility to develop and monitor the rules for land usage and tower building, granting the broadcasting ranges license, participation in risk management and safety improvements. According to the previous factors, Dubai government requirement meets: aviation authority, town planning and environment, as well as reserved area used for some special purpose by institutes such as: army and heritage institution must sign agreement to share their towers with other companies whenever they need arises to reduce the number of towers [20]. The tower should be built faraway from health facilities, educational institutions and electrical stations. [14] said that company's developed their internal policy where budget and availability of resources represent the effective factors. The decision policies could be divided into: Techno-economic [3] taken in account: institute strategic plan, management pressure, prices, services and the budget factors [5].[6],[14]. In addition, mostly they take in account agreements cost and new technology prediction, resources availability factor and expert availability. Disaster management, maintenance cost, transmission system,

transmission time, data security was studied by [36].

2.4 Data and Experience Factors

According to [14], geographic, demographic and technology data must be available in company databases, otherwise cost will be raised. A company historical data of success–fail cases and availability of other institutions data will be a data driven decision making. Most companies have access to scientific resources which give them the opportunities to improve their decision; in this case a knowledge based system is used to provide them with needed experiences.

3 Conclusions

This study is attempted to review and classify the most important and effected factors on telecommunication tower sites selection, where the critical ones was taken in account. These factors could be classified into four categories: the technology factors table 1, the geographical and demographical factors table 2, the regulation and policy factors table 3, data and experiences factors table 4.

Table 1. Technology Factors

Category	Cat. Type	Factor	Factor Type
Technology			Signal strength,
			Signal range ratio
			Signal traffic
			Band width
			Congestion ratio
			Capacity of services
			Communication System Type (output)

Table 2. Geographical and Demographical Factors

Category	Cat. Type	Factor	Factor Type
Geographical and Demographical	Service area		Soil erosion
			Ability to access site
			Electricity availability
	Terrain		Flat area
			Steep terrain
			Barriers (building, tree)
			Slope
			Visibility
			Higher area
			Area availability
	Users		Population users' number
			Type of users
			Density of use network

Table 3. Regulation and Policy Factors

Category	Cat. Type	Factor	Factor Type
Regulation and Policy	External	Protected Area	Military zone
	Internal		Archeological area
			Environmental area
			Health services area
			Airplanes routes
			Interact with other signal
			Interact with electrical power
			Public area
			Gov. Strategic plan
		Policy	Institute Strategic plan
			Management pressure
			Lower prices
			Better services
		Budget	Land price,
			Maintenance cost
			Construction cost
			Agreements cost
			Reward cost
			reproduction cost new
			Income prediction
		Resources	HR Experience
			Vehicles
			Cranes
			Electronic power motor

Table. Data and Experiences Factors

Category	Cat. Type	Factor	Factor Type
Experience			Company historical data
			Other institutes historical data
			Scholar resources

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