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A PRACTICAL GUIDE TO SITE SELECTION FOR COMMUNICATION ANTENNAS AND THEIR SUPPORT STRUCTURES IN NIGERIA

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ABSTRACT

Radio broadcasting and telecommunication transmitter stations should have their antennas properly positioned to make them capable of providing the required services. Suitable location of antenna structure will enhance signal clarity, wider coverage area and satisfactory reception of radiated signal. In most cases, engineering considerations in the determination of a station's performance are treated analytically. However, it is important to know that the ability to serve large audience effectively and at the same time achieve wider signal coverage are greatly affected by the excellence of the transmitter location and its selection must be governed or influenced by experience with intangibles not subject to mathematical calculations. Field survey method was adopted by which information from the major radio and wireless Operators in the country was obtained. The paper therefore focuses on the various factors guiding the selection of suitable transmitter sites. It also presents a step-by-step guide and some important considerations to be taken into account from the planning to the site-aquisition stages. It recommends co-location of infrastructures which is an option not yet attractive to Sevrice Providers in Nigeria.

Key words: antenna, site, guyed structure, self-supporting structure,tower.

INTRODUCTION

Radio communication involves information processing, transmission and reception of radio frequency energy that has travelled through space for which the antenna structure is an important component. Of importance also is the range to be covered by the transmitted signal (see table 1.0), which is a function of the operating frequency, antenna height, antenna properties, transmitter power and the nature of the surrounding terrain. Of these factors, frequency used, transmitter power and antenna height are important determinants of the range for a given radio communication service as can be seen from the expression (Kennedy, 1999)

$$\mathcal{E} = \frac{120\pi h_t I}{\lambda d} \qquad (1.0)$$

Here, $\boldsymbol{\varepsilon}$ is the field strength in volt/meter at a distance from the transmitting antenna with height h_t, I the antenna current, λ the wavelength of the operating frequency and 120π is the characteristic impedance of free space.

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

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

where c is the speed of light. Then 1.0 becomes

$$\mathcal{E} = \frac{120\pi h_t I f}{cd} \quad (1.2)$$

Or

$$d = \frac{120\pi h_t I f}{c\mathcal{E}}$$

Thus the distance or range covered by the propagated signal is directly proportional to the height of the antenna and the frequency of operation. Frequency matters are handled solely by government agencies empowered constitutionally to plan, monitor, and license and police the use of radio frequencies nationally. In the Federal Republic of Nigeria, such assignments are carried out by the National Broadcasting Corperation (NBC) and the Nigerian Communication Commission (NCC) for broadcasting and telecommunication services respectively. Table 1.0 shows frequency spectrum for both broadcasting and telecommunications.

Table 1.0 Frequency Spectrum

Frequency type	*Frequency band*	*Wavelength*	*Range and application*
VLF	3kHz-30kHz	10km	Long range,marine and radio-navigation
LF	30kHz-0.3MHz	1km	same as above
MF	0.3MHz-3MHz	100km	160-400km.AM radio, short wave radio
HF	3MHz-30MHz	10m	From 320km , shortwave radio,Amateur and Citizen Band
VHF	30MHz-300MHZ	1m	16-80km,VHF-TV,FM radio, Aeronautical, Amateur
UHF	300MHz-3GHz	10cm	upto 80km, UHF TV,Telecommunications,cellular radio
SHF	3GHz-30GHz	1cm	upto 80km, satellite comm., terrestrial microwave
EHF	30GHz-300GHz	1mm	almost unlimited in space,satellite, radar, radio astronomy

Courtesy: Townsend (1987).

For effective area coverage, the antenna system, location, height and type of support structure have to be given serious considerations. The task of this paper is to highlight solutions to the problems of acquisition of site for radio communication transmitting antennas. It covers both broadcasting and telecommunication systems.

The selection of sites for broadcast transmitting station require not only being able to identify large areas that will accommodate the necessary high antenna structures but also the ability to handle the public opposition and other various technical aspects of site acquisition. In the case of radio and television transmitting antennas, three basic problems exist: correct location, obtaining planning permission and negotiating terms of acquisition – which are more difficult as compared to problems associated with site acquisition for base transceiver station (BTS) used for mobile Communications. Thus, much effort and even more time are usually required for investigating and acquiring a site for either radio or TV transmitters. In practice, the activities of site acquisition for both radio and television stations overlap considerably and all that is required is a constant interflow of information until the site is finally acquired and construction commenced.

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OBJECTIVES OF THE STUDY

The study is:

i) To ensure that new communication towers or masts are located in an area compatible with the neigbourhood or with the surrounding community to the extent possible.

ii) To promote and encourage co-location of communication facilities in particular antenna support structures as the primary option for mobile/wireless communication services instead of the construction of additional single-provider towers.

iii) To encourage the location of communication towers in non-residential areas, otherwise in areas where the adverse impact on the community is minimal.

SIGNIFICANCE OF THE STUDY

The deployment of communication infrastructure in Nigeria in recent times have been massive. This is as a result of the ever increasing demand for wireless mobile services. There is also a noticeable increase in the establishment of radio and television stations since this sector was deregulated. It is believed that information provided in this text will be helpful to prospective Site Engineers who may be employed by these firms.

The paper is divided into the following sections: section I covers the Introduction; section II the Literature review; Section III the methodology; Section IV discusses some vital issues on site selection, steps for proper investigation of selected sites and site acquisition for eventual deployment of infrastructure; while conclusion is in section V.

LITERATURE REVIEW

Acquisition of sites for antenna and their supporting structures are taken seriously in certain countries and has been an issue of discuss recently in many literatures. (Grant, 2003), examined the health risk communication towers and masts could pose when located within residential areas. Ronald (2001), discussed the recommendations endorsed by the Canadian Board of Health and the planning protocol for the siting of base antennas. His paper outlined the rational behind this recommendations.

There are also statutory matters that must be complied with before the final erection of approved structures. Townsend (1987) analyzed the constitutional jurisdiction in relation to radio communication, regulation of radio antennas and their support structures in Canada. The project outlined detailed guidelines which would be of assistance to municipalities desirous of drafting by-laws which relate to the siting and operation of radio antennas. Safety and environmental concerns were presented in Baller et al. (2003) and the local government perspective in the U.S.A. on the siting of wireless facilities. It also summarizes the leading decisions on tower siting that the courts have issued since the enactment of the Federal Telecommunications Act of 1996.

Apart from the above areas that have been given prominence by different authors, technical and economic issues are also of vital importance that should be given the required attention. It is the purpose of this study to undertake this task in which a step-by-step guide in selection of sites for antenna and their supporting structures is presented.

METHODOLOGY

The strategy adopted in this study was to tap from the experiences of Field Engineers who over the years have engaged in activities that are practically related with the subject matter. To achieve this, a number of Broadcasting and Mobile Communication outfits were visited. Their Site Engineers were interviewed and useful information were gathered based on their field experiences. In addition some technical manuals and Field Reports on previous jobs on antenna siting were studied.

Table 2: Service providers visited

S/N	*Service Provider*	*Service type*	*Remarks*
1	MTN wirless	GSM	Site photographs
2	GLO mobiles	GSM	Read reports/interview
3	Etisalat	GSM	Read reports/interview
4	Airtel	GSM	Read reports/interview
5	Starcomm	CDMA	Staff interview
6	Nigerian Telecommunications Ltd	Land-line	Technical manual/photograph

Table 3: Radio and Television Broadcasting stations

S/N	*Station*	*Service type*	*Remarks*
1	Radio Nigeria Owerri	FM Radio	Technical manual/photograph
2	Radio Nigeria PortHarcourt	FM Radio	Technical manual
3	Ray Power	FM Radio	Staff interview
4	NTA	UHF TV	Staff interview
5	AIT	UHF TV	Staff interview

Tables 1 and 2 summarizes activities involved in the collation of information necessary for the report which cut across broadcasting and telecommunication services.

DISCUSSION

Site Selection and Consideration

The initial planning, up to the stage where a technically preferred site can be pinpointed on a map is done. The work of site finding commences with the production of a site brief which specifies the preferred location with acceptable tolerances and states the predicted antenna height above ground level (AGL), the area to be served and the estimated population coverage.

Assume the design of an ideal U.H.F TV relay site, the basic specification would probably contain clauses similar to the following – the site should be:

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(i) Virtually in line-of-sight at the proposed antenna height, with the desired service area.

(ii) In line-of-sight with the main or relay station from which the signal feed is to be taken and have a sufficiently wide path between obstructions to avoid ghosting.

(iii) So located as to be free from co-channel interference (CCI) and other radio interferences.

(iv) Currently in the ownership of a party willing to sell or lease at an acceptable price.

(v) Acceptable to Government Authorities.

(vi) In such a position that the antenna structure will not be hazardous to human health and to aircrafts.

The above six requirements are essential. In addition however, the ideal site should preferably:

(i) Be free from geological problems like erosion and the soil should be such that it has the capacity for supporting the antenna structure without need for sophisticated foundations. The soil should not be rocky but good enough to allow for the grounding of the radio antenna which is very necessary for the protection of the radio equipment against damage from lightening stroke. For an AM broadcasting antenna, ground screen is a requirement and is made up of several cables that are buried below the soil surface.

(ii) Have existing vehicular access, or be positioned such that access can be provided at reasonable cost.

(iii) Be surrounded by open land to facilitate the erection of mast or tower.

(iv) Be within reasonable distance of an adequate and reliable means of electricity supply.

(v) Be clear of existing and proposed overhead high tension (HT) cables.

(vi) Be free from legal encumbrances.

The above items are important points that must be born in mind during site investigation activities. In practice the ideal site is rarely found, and the final choice is usually a matter of compromise.

Antenna and Support Structures

An antenna is fundamentally a device that translates guided wave energy into radiating energy (Schantz, 2005). Radio frequency (RF) is propagated into space in the form of electromagnetic waves.The size of the antenna operating at a particular frequency depends on some fraction of the wavelength. The lower the frequency, the longer the wave length (see table 1.0) and the bulkier the antenna.

Consequently radiating elements used for MF and HF broadcasting are bulkier than those used for VHF and UHF broadcasting. Such radiating elements require very good and solid structures to hold them in position. For AM broadcasting, the radio towers that serve as the structures are in theselves the radiating antenna.

Types of Support Structures

Support structures for antennas are used to achieve antenna height and support. Two main types of antenna support structures are in use, the self-supporting and guyed types.

Self-supporting structures are the towers and have square or triangular shapes and tapper as the height increases making them structures with large base areas as illustrated in Fig 1 (a) and (b). Their construction can be of tabular steel lattices with reinforced concrete base.

Guyed structures have their base dimensions the same as the top of the structure and are held in position by many guy wires attached at various segments and then properly fixed to positions specially prepaid on the ground. Fig. 2 illustrates a guyed structure with the antenna at the top of the mast. This type of structure, unlike the self-supporting types require large area of land to secure the structure because of the guy lines. The higher the mast, the longer the guy lines and the larger the land area.

Economic and Technical Considerations

Choice for support structures are governed by two important factors:

(i) Economic factor: The cost of construction of a guyed or self supporting structure should be considered. Self-supporting towers are more expensive than the guyed structures. The extra reinforced concrete at the base, the several steel materials used throughout the column of the structure and their paintings give credence to the high cost of this type of structure. However one advantage of this type of structure is the smaller site size it requires compared to the guyed variety. This makes it suitable to be sited in urban areas due to the high cost of land. A guyed structure requires large acres of land for the guyed wires. This makes it very unreasonable and uneconomical to site such structures where there is lack of land space and where available, very expensive.

(a)

(b)

Fig.1 (a) Square-base self-supporting antenna tower (courtesy:Nigerian Telecommunication Ltd). (b)Triangular-base self-supporting antenna tower (courtesy:MTN wireless Nigeria Ltd).

Fig 2: Guyed type antenna structure (courtesy:Radio Nigeria-Heartland FM, Owerri)

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(ii) Technical factors: The choice of structure to be constructed may depend upon the type of service to be rendered. AM radio broadcasting uses the mast as its radiating element. A high directional AM radio antenna may require up to 12 independent antenna towers, each requiring many guy lines (Townsend, 1987). This will necessary require a very large area of land. Antenna weight and other loads to be carried by the antenna should also be considered (see Fig 1). For this reason, self-supporting structure is preferred to the guyed type.

Investigation

The first step in investigating a site for its suitability involves thorough examination at the recommended site and any nearby alternatives which might be considered suitable. Alternative sites are necessary should the preferred site prove unavailable or unsuitable for any reason. The land owner or his representative should be contacted in advance. However, it frequently happens that an owner is one who prefers acting through an agent. In such a case, several weeks might elapse before any definite answer can be received. It is also important to approach the Local Government Council at the same period the initial approach to the land owner was made. This is to seek the informed views of the Planning department of the Local Government Council. Sometimes no reaction at all can be obtained without the submission of an outline planning application.

Approval should also be sought from appropriate Authorities like the Ministry of Transport, Aviation, Lands and Survey.The public Power Supply Authority should be consulted regarding any plans they might have for the future. Although in most cases existing over-head power cables are readily visible, there is always the possibility that new ones may be erected in the vicinity of the site. In the absence of power supply in the site the Authority should be requested to give an estimate of the cost of bringing in electricity supply to the proposed site.

Means of site access is investigated at this stage and in cases where no satisfactory road exist, estimates for providing suitable access are prepared. For economic reasons, sites should be acquired where possible as close as possible to existing public roads. This will avoid the cost associated with the construction and maintenance of new roads.

The future development of the surroundings should be considered especially if the site is meant for A.M broadcasting. The site should be in an undeveloped area void of buildings and large amounts of metal which will distort A.M signal patterns. Such undeveloped area will also provide the space required for the stays of the antenna structure.

Reports on this initial investigation should be made and studied to determine if the site appears favourable, need future technical appraisals or otherwise, state reasons as to why the site is unsuitable.

Site Acquisition

While an application made to the Authority is being considered, the site may be tested for its suitability for radio wave propagation. This is to ensure that there are no unexpected propagation difficulties within the proposed service area. At the same time negotiations are on for acquiring the site, it is also necessary to negotiate for a right of access.

This aspect demands considerable diplomacy and skill. The site may be acquired based on either freehold or leased terms. Freehold purchase entails only agreeing on a price, while leasing involves agreement on a price and duration of lease e.g. a 21 year lease with an option to renew for a similar period. However, besides the purchase of the land itself there are other matters such as fencing, shared rights of access, maintenance of road, tenant compensation, routes of electricity supply, all of which need to be negotiated and included in the documentation by a solicitor.

The following is a list of the various matters that must be agreed between the firm (intending buyer) and the land owner before solicitors can proceed with the documentation:

(i) Whether the site is to be leased or purchase freehold.

(ii) If leased, the duration of the lease.

(iii) Period and amount of rent reviews.

(iv) Cost of purchase or basic rental.

(v) Precise route of access and what other parties, if any will be allowed to use the access road or track.

(vi) The overall width of rights of access and nature of finished surface of the track.

(vii) Details of boundary and any other fences or walls required or requested.

(viii) Route of electricity cables to the site.

(ix) Where appropriate which trees to be cut.

(x) If site can be sub-let or leased to other users and in so doing if the landlord will require an additional rental for such sub-tenant.

Sites for AM and FM Radio Transmitters

Guidelines' for the selection and acquisition of sites for antenna structures are basically general. The investigation and acquisition of base station transceivers (BTS) sites for mobile wireless communication also follow the same general pattern but may not include several steps mentioned above. However, sites for AM transmitters present special challenges in that several antenna structures are sometimes specified. Such a site requires many acres of level ground for accommodating the mast-stay blocks and the earth mat.

Possibly, the greatest problem in sitting a comparatively low powered AM station is the need to find a location closes enough to the service area yet sufficiently remote from residential development and any installation which could adversely affect the AM transmission. That is why such stations are seen within the Green Belt areas which surround most large towns.

It is also common to find FM stations located in similar areas. In Nigeria, there are several FM stations located far away from the center of the cities they are meant to provide service to. In Imo State, Radio Nigeria Heart-Land FM 100.5 is sited at Azaraegbelu, Owerri. Radio Nigeria Treasure FM 98.5 and Ray Power FM 106.5 are both located at Choba, PortHarcourt in Rivers State. There are other FM stations in PortHarcourt that are also located away from the city center.

In practice AM stations may require larger sites than those of FM stations broadcasting at VHF band. Fig 3.0 ssummarizes the essential procedures for investigating the suitability and availability of proposed sites for a transmitting station.

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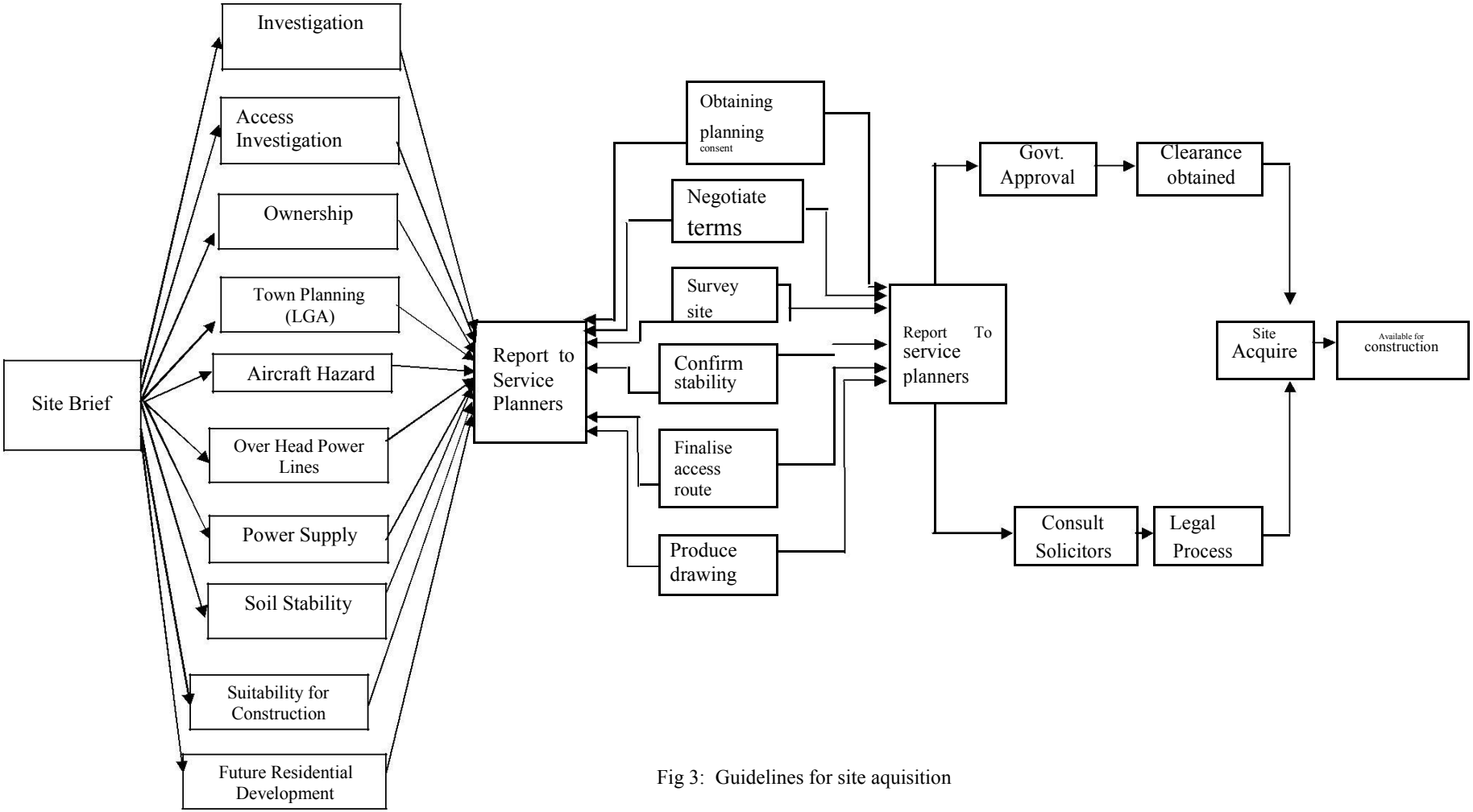

Fig 3: Guidelines for site aquisition

CONCLUSION

The experience In this paper, critical steps necessary to be undertaken for the acquisition of sites for antennas and their support structures for radio transmitters have been examined. This guidelines cover procedures for both broadcasting and telecommunication firms.These procedures are general and the actual process of site acquisition are similar for all types of transmitting stations.

It is important to maintain a flexible approach to the choice of sites within the technical limits imposed. The nature and location of the sites will determine the type of antenna structure. In some situations a stayed mast can be utilised in preference to a self-supporting tower or vice versa. Technical as well as economic considerations should be the driving force for the choice of structure. Co-location of antennas by service providers is an attractive option that should be encouraged.

Finally, if the landowner refuses to sell or lease a site, or the site proves unacceptable due to difficulties of access, construction, health and aircraft hazards, etc, a decision should be made to abandon that particular site and to investigate the possible alternative.

RECOMMENDATIONS

For directional antennas and particularly highly directional dishes,support structures should be rigid enough not to allow deflection caused by extreme windspeed. With microwave antenna any movement of a very limited margin will result in partial or total loss of signal.Therefore the structure to be specified should be governed by the location, height, headload, windload and the impact on the environment.

Aesthetic considerations are also important.Towers and mast should be designed to add to the beautification of the areas where they are located.

Attention must be given to structures' ability to withstand harsh atmosperic conditions. Towers and mast sited in cities like Lagos, PortHarcourt, within the coastal region of the country are exposed to salt laden and corrosive atmosphere. Such structures should be regularly monitored and maintained to maximise their mean-time between failure (MTBF).

Where there is scarcity of land and to avoid the proliferation of antenna towers and masts,their attending cost and health hazards, co-location of facilities is recommended.This is the placement of new telecommunication facilities on existing tower or mast owned and maintained by another service provider.This will entail entering into negotiation with the owner as to agree on terms that will be suitable for both parties.The agreement will likely include what portion of the tower to be used, section to locate outdoor RF equipment and power genarating plant as well as charges and rentals. This practice is not common in Nigeria.

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