Full Coverage System Using High Altitude Platforms for East Coast Of Libya

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Abstract

In this paper, a High Altitude Platform system (HAPS) will be designed in order to provide full coverage area using five HAPS at east of Libya. Such system has the potential capability to serve a large number of users, either in dense urban areas or over a wide geographical area. They can be brought in temporarily for disaster relief or temporary coverage of entertainment events.The purpose of this study is to achieve the following objectives:

i. Determining the location of the aircraft.

ii. Computing the link budget for the uplink and downlink of the backhaul earth stations located at the edge of service and at10 Km far from the SPP of footprint**.**

iii. Proposing one alternative backhaul earth terminal to improve the availability of the link. Computing the availability improvement to be achieved.

Keywords— overview of HAPS, availability, typical link budget of HAPS, aircraft, rain attenuation, site diversity.

I. INTRODUCTIO

WHETHER TREATED AS A VERY LOW SATELLITE OR A VERY TALL MAST, A VEHICLE HOLDING A FIXED STATION IN THE STRATOSPHERE MAY OFFER AN IDEAL PLATFORM FROM WHICH TO SUPPORT A HOST OF WIRELESS SERVICES. HAPS CAN EXPLOIT THE BEST FEATURES OF BOTH TERRESTRIAL AND SATELLITE SCHEMES. THESE PLATFORMS WILL OPERATE AT ALTITUDES TYPICALLY BETWEEN 17 AND 25 KM AND WILL MENTION IF WE USE THE ALTITUDE OF 50 KM ABOVE THE GROUND IN STRATOSPHERETO PROVIDE A COMMUNICATION SERVICES. THERE IS A MINIMUM WIND SPEED AT THESE ALTITUDES [1]. THE ITU HAS LICENSED FREQUENCIES BASED ON REGION (AT AROUND 28 GHZ DOWNLINK AND AROUND 31 GHZ UPLINK FOR USE IN AFRICA).

This research is based on some considerations that should be taken into account to ensure that the best-offered service is delivered to the customers within the converge area. The assumptions are as follows:

- The system is not sensitive to transmission delay.
- Line of sight model between the ground station and the platform is assumed, where the received power is proportional to the squared distance.
- Also we ignore the earth curveting and assumed that we are providing coverage for a flat area.
- The ground station requires minimum C\No equal to -15 dB in order to function.

Five space platforms will be used to ensure 100% of coverage for the whole areafrom AL Magroun in the West to Lathron in the East and at the same time ensures that the minimum acceptable elevation angle at the edge of the coverage is 20 degree. Here, this research provides the coverage to East Libya and tried to minimize the interference between cells in this region and the cells in neighboring states. There will be some interference in order to provide hand off for users when they travel from city to another.

II. DESIGN PARAMETERS

East coast of Libya is so long distance. It covers an area of 73,750 Km^2. It is a long distance in the East coast it is Long path around 670km, Therefore it is not possible to cover the whole area by two space aircraft; however, by using two aircraft the elevation angle will be less than 20 degree and that will interfere the existing terrestrial infrastructure. That means there will be five coverage areas; in one pathfrom AL Magroun city to AL Bordi city. The coverage areas will have same radius and the five aircrafts will fly at same altitudes which is 25 Km.

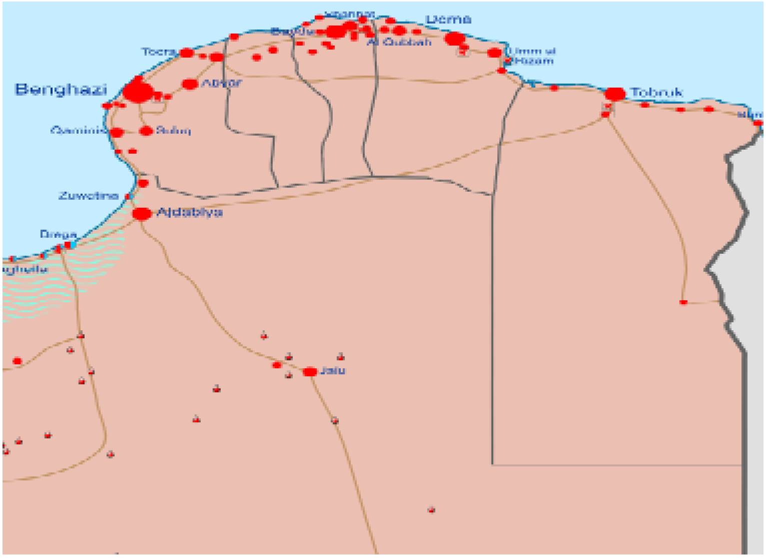


Figure 1 shows the map of East of Libya

Having five HAPSs, will cost the country but we have to make them five HAPSs for some reasons. For four HAPS, we notice that it will not some areas between cities at the edge of coverage because if we make the HAPS higher then it will make more interference between these two states but this area the neighbors will cover it because they are in the same country. For HAPS1 at border near to Egypt will be some area without coverage because if we go closerthen the coverage will interfere the infrastructure in Egypt, therefore, the edge was be designed to be at the boundary between Libya and Egypt.

III. Calculations and discussion:

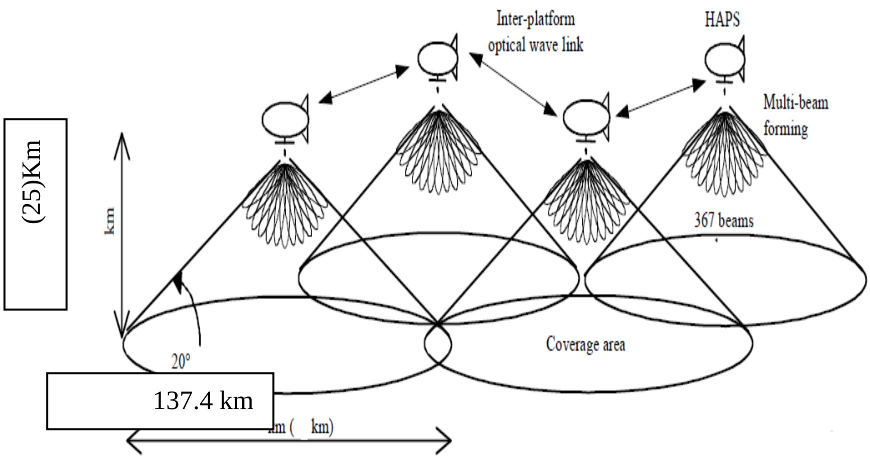
HAPS1, HAPS2, HAPS3 and HAPS4 and HAPS5 will be denoted as A, B, C, D and E respectively. Since the five HAPSs have same parameters (coverage radius and latitude) and the same Elevation angle the calculations will be performed of these five HAPS's.

If it is assumed that the user terminal at the edge of coverage receives the downlink signal with 20 (deg) elevation angles, then the slant path will be calculated from equation 1. For a radius coverage of 68.7Km and 25 Km altitude, the slant path will be 73.1Km for five HAPS's. The calculations and equations are based on ITU Recommendations [2, 3, and 4].

	Latitude (deg)	Longitude (deg)	Space segment latitude(Km)	Coverage radius (Km)	Elevation angle (deg)
HAPS 1	31^{0}52'26.72" N	24^{0}23'09.18" E	25	68.7	20
HAPS 2	32^{0}10'25.19" N	22^{0}56'49.78" E	25	68.7	20
HAPS 3	32^{0}32'10.54" N	22^{0}00'08.06" E	25	68.7	20
HAPS 4	32^{0}18'29.04" N	20^{0}54'48.21" E	25	68.7	20
HAPS 5	31^{0}40'06.92" N	20^{0}30'34.03" E	25	68.7	20

If we assume that, the GS is located 10 Km away from the sub platform point (SPP), the elevation angle can be obtained using equation 3.1. In this case the elevation angle for the HAPS are 68.2(deg) and the slant path is 26.93 Kmfor five HAPS's.

Figure 2 :Communication System Using HAPS



The uplink and downlink budget for this GS will be obtained for two scenarios: first with clear sky and the second for rainy condition. The results will be illustrated in Index for the five HAPSs including the two scenarios respectively. At the same time each scenario will be divided into two sub scenarios in which the calculations will be performed when the GS is located at the edge of the coverage area and when the GS is located 10Km from the SPP.

It is noticed from the two elevation angles, for that angle of 20 deg, the signal will travel longer distance and rain path than that one resulted with all HAPSs. The elevation angle is very critical parameter in this respect, and it must be calculated carefully to assess how much exactly attenuation that may affect the received signal in case of a rainy – channel condition is found.

It is worth mentioned that, by using simple mathematical calculations, it can be realized that the east coast can be covered only by using four HAPS's and 35% footprint with radius of 68.7Km. However, due to the irregular shape of the east coast and since we assumed our coverage has circular shape, there will be some angles has no coverage. For that reason, the necessarily of using five HAPSs cannot be avoided, even if we look to the HAPS1 and boundary of Libya we'll see there are a gap between the edge of coverage and Egypt boundary and we cannot cover it because the radiation pattern will cover some of Egypt.

IV. IMPROVEMENT OF SYSTEM AVAILABILITY

It can be seen from the results obtained in the previous section that, the link margin in the rain condition scenario is much less that in the clear sky scenario. This will degrade the overall system performance and in order to avoid this drawback there are some techniques that can be used such as: increasing the transmission power as far as we are not exceeding the limited allowable power, we also can use high gain receiving antennas in order to increase the link margin.

The availability of the service can be also improved by applying one common technique such as site diversity. In this regard, a redundant earth-space link will be established at a particular distance from the main one. This effort is to make the redundant link avoid the rain cell area. It is experimented that the availability will increase as the separation distance between two links (stations) increase. Since the diversity gain will increase, the rain attenuation effect on the HAPS-based downlink signal will be decreased.

Since we use five platforms, we can deploy Platform diversity so that the ground stations which are near to the edge of the cell can select the platform which offer a better channel condition amongst two platforms .

V. CONCLUSION

In this article, the use of high-altitude platforms has been proposed to provide a full coverage for East cost of LIBYA. Results obtained in the system design have shown that they are suitable to implement the coverage of large radius. They support services with better performance with respect to terrestrial stations which make HAPS a promising infrastructure for a future system which will require the co-sitting of navigation and communication stations for the provision of integrated services.

In brief, link budget can be well-calculated by referring to the ITU recommendations regarding this area of engineering. That kind of recommendations shows the how to set the related parameters properly to achieve a good system performance; moreover common HAPS system specifications are also presented

In order to design a HAPS-based system with acceptable QoS, the design must be based on some considerations. For instance, to cover a wide area, the platform needs to be located in the highest latitude. So that, user terminals in the coverage edge will also receive the signal with acceptable level of strength especially during rain events

One of the most common and efficient method to increase the system performance when rain event takes place is the site diversity. Many studies have been published about side diversity and it has been reported that the diversity gain and the optimal performance can be achieved by furthering the separation distance as long as possible.

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