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# Communication Using Gigabit at High Altitude Platform To Serve Specialist Users

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*Abstract— This paper shows the idea of utilizing gigabit remote correspondence joins from HAPs utilizing the 28GHz band. Observable pathway connections can be conveyed anyplace under a scope of about 150km range, making them perfect to serve various authority clients, for example, TV supporters who are expanding taking a gander at HDTV conveyance from occasions. The paper shows that it is workable for at any rate 22 spot bars to be conveyed from a solitary HAP sharing a typical recurrence band. A technique for picking the ideal pointing point for such spot pillars is determined, with the end goal that the most extreme got control is coordinated towards every expert client area. CINR results are additionally displayed.*

***Keywords*—Antenna beams, high-altitude-platforms (HAPs), peak CINR point, peak-received power**

## I. INTRODUCTION

The traditional wired technology was not able to meet the the requirements for applications like multi media therefore in order to fulfil this requirement High Altitude or Elevation Platforms are developed . HAPs are either aircraft or aircraft flying at approximately 17- 22 km altitude. Using this technology the range can be increased to a greater extent which can even cover those areas, which could not be covered by simple communicating systems. By sharing the frequency spectrum, they can also provide broadband and increased spectral efficiency. This paper basically explores the advantages and disadvantages of sharing a common radio spectrum with highly directional spot beams from an HAP. The ITU issued a framework to implement 3 G networks at 2GHz [1, 2 ]. Because high altitude platforms are works in the stratosphere, it offers less cost over a satellite and increased range compared to earth systems.

Using cognitive radio techniques, it should be possible for HAPs to also share with terrestrial systems in same frequency band, which is not currently permitted by ITU-R regulations. This means that HAPs could serve specialist users requiring high data rates, e.g. uncompressed HDTV. Cognitive radios are expected to be powerful tools to mitigate and resolve issues of general and selective ac cess to the spectrum (e.g. finding and effectively using an open frequency band).It gives an advantage of improving current spectrum utilization (Unused spectrum can be used in a local area, and occupied spectrum avoided) and increases the efficiency of wireless network due to higher user output reliability [3]. Cognitive radio has not been properly defined yet, but here we assume it to relate to dynamic assignment of spectral resource based on ‘learning’ about the current environment.

HDTV is in demand in among customers, requiring a 10-30Mbps speed for transmitting 1080icompressed signal[4 ]The pre broadcast services are given by uncompressed HDTV signal because compression brings excessive latency, and if it is lossful, the signal may be gradually degraded. The uncompressed video stream will be transmitted with a rate up to 3Gbps as opposed to the typical 20Mbps that is delivered on the traditional compressed-video method [5]. Using gigabit connections from HAPs can resolve transmission/reception issues, basically for HDTV's less resolution formats.

There are five sections in this paper and one of the section consists of the system scenario; system performance with multiple antenna beams are specified in section three; we also describe the further work and finally we will draw the conclusions.

## II. SYSTEM SCENARIO

The system scenario consists of a single HAP station with a service area of 300km diameter. The HAP is located at a distance of 10km from the middle of service area. The scenario is represented in Fig.1. We have used various directional antennas at HAP station, towards various random locations inside service area. For the ground test users, we assume that they use a directional antenna pointing at the HAP station.

In the case of a HAP, the spot beam is intended to serve a specialist user, but for the purpose of investigating the interference from multiple antenna beams, we decide to randomize the locations of users. These users could be for example remote broadcast units using HDTV, such as those deployed at events. We choose to point the spot beam towards each user or more specifically we try to ensure the peak-received power is directed towards the user.

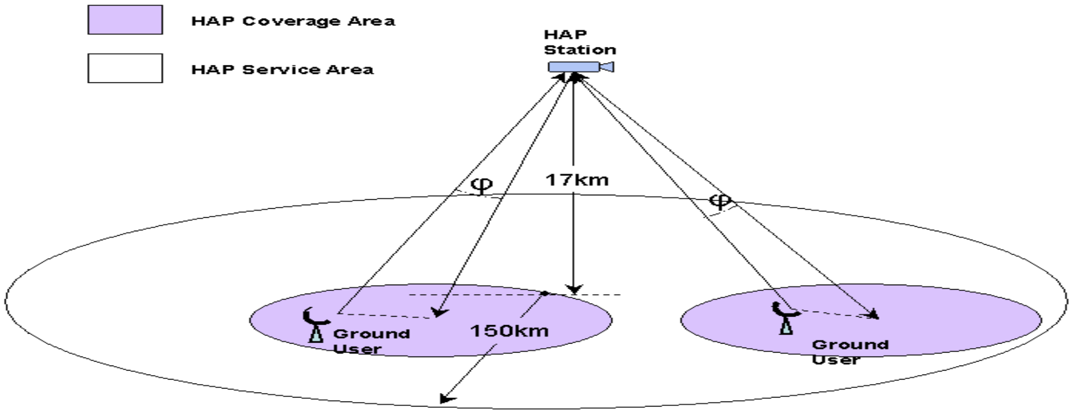

Fig.1 The HAP station with various directional antenna and terrestrial station scenario

An extremely restricted beamwidth is required to convey the connection spending plan to help gigabit per sec transmission rates. Besides, the tight beam width can be utilized to diminish values of impedance at different HAPs masterminded at a point far from the bore sight of client reception apparatus which has been received by same specialists [1], yet that is past the extent of this paper. In our situation, we accept that the HAP is kept semi stationary and the recieving wire payload is completely balanced out.

We first need to calculate the Carrier to Noise Ratio (CNR) and the Carrier to Interference plus Noise Ratio (CINR) to determine system working. It could be achieved by assessing the quality of the CNR and the CINR from HAP and terrestrial test users in frequent positions across the service area. Second, to determine the relationship between interference and the noise floor, we should calculate the Interference to Noise Ratio (INR). Regulators use the INR to directly measure the interference impact of one system on another.. An INR level of -10dB is often used. It is very conservative and often much higher levels of interference can be tolerated, by other systems [1].

The CINR of multiple beams from single HAP could be found as [3, 6, 7]:

$$CINR = \frac{C}{N_F + I} = \frac{P_{Hm} A_{Hm}(\phi_m) A_U(\theta_m)\left(\frac{\lambda}{4\pi d_m}\right)^2}{N_F + \sum_{j=1}^{N} P_{Hi-j} A_{Hi-j}(\phi_j) A_U(\theta_j)\left(\frac{\lambda}{4\pi d_m}\right)^2} \tag{1}$$

The INR of multiple beams from single HAP and ground users can be calculated as in [3, 6, 7]:

$$INR = \frac{I}{N_F} = \frac{\sum_{j=1}^{N} P_{Hi-j} A_{Hi-j}(\phi_j) A_U(\theta_j)\left(\frac{\lambda}{4\pi d_m}\right)^2}{N_F} \tag{2}$$

Where thermal noise floor is represented by $N_F$ and transmit power and gain from any 1 beam of antenna of HAP are represented by $P_{Hm}$, $A_{Hm}(\phi_m)$. $P_{Hi}$ and $A_{Hi}(\phi_i)$ represents $j^{th}$ interfering beam of HAP antenna and gain at angles $\phi_m$ and $\phi_i$ far from bore sight respectively. The user transreceiver is pointed towards HAP and gets power from its bore sight, so $\theta_m$ comes to be zero as well as $\theta_i$. $\left(\frac{\lambda}{4\pi d_m}\right)^2$ is the FSPL from the main beam of the transreceiver and the $j^{th}$ interfering beam of the transreceiver.

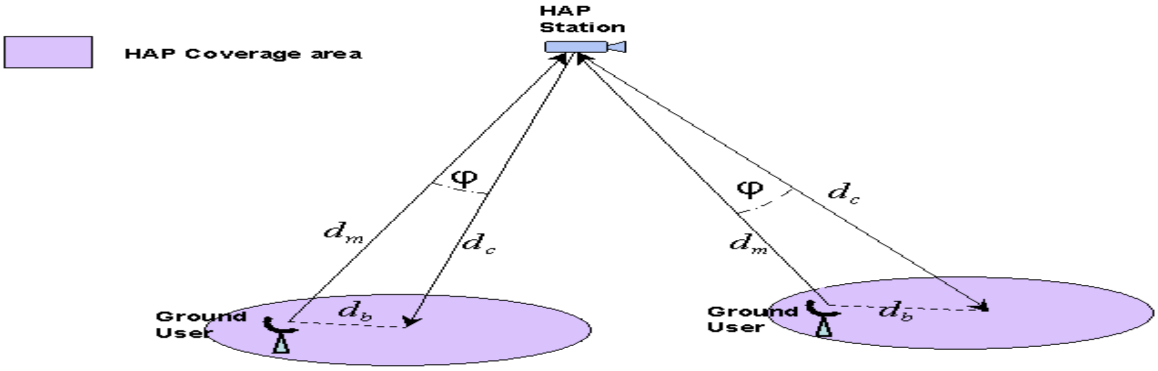

Fig. 2 HAP and Ground user geometry

As shown in Fig. 2, $d_m$ represents the length of the link from HAP to the user. The length from the ground user to the aiming point can be expressed as $d_b$ and a distance from the HAP to the aiming point is named $d_c$. The angle between the bore sight of the transreceiver of the user and the bore sight of transreceiver of the HAP can be expressed as:

$$\phi = \arccos\left(\frac{{d_m}^2 + {d_c}^2 - {d_b}^2}{2 d_m d_c}\right) \tag{3}$$

### A. *Mathematical model for antenna beam*

A cosine function that uses a power *n* can efficiently approximate the main lobe pattern for aperture antennas of medium and high directivity specified as [8].

$$D = D\max(\cos\theta)^n \tag{4}$$

here $D$ represents aperture antenna directivity, is the angle to antenna bore sight is given by $\theta$, $n$ gives rate of roll-off of the pattern. When sidelobe levels are very low, peak directivity is often approximated by [8]

$$D\max = \frac{32\log 2}{\theta^2{}_{3dB} + \phi^2{}_{3dB}} \qquad (5)$$

$\theta_{3dB}$ and $\phi_{3dB}$ represents 3 dB beam widths of the antenna in 2 orthogonal planes. We could rewrite this by making these values equal if we can assume a circularly symmetric beam antenna [8]:

$$D = (\cos\theta)^n \frac{32\log 2}{2\theta^2{}_{3dB}} \qquad (6)$$

$n$ also gives 3 dB beam width as a function, and is defined as the point when the directivity reduces to 50 percent of its highest value, thus [8]

$$\left(\cos\frac{\theta_{3dB}}{2}\right)^n = 0.5 \qquad (7)$$

and so

$$\theta_{3dB} = 2\arccos\left(\sqrt[n]{\frac{1}{2}}\right) \qquad (8)$$

As shown in the equation above, we can calculate $n$ once the 3-dB beamwidth is decided.

### *B. Antenna gain factor*

HAP and user beams of the antenna could be modelled by using the approximation in the previous section, but now introducing a side lobe floor of the antenna. This produces the equations respectively [6, 8, 9, 10]:

$$A_H(\phi) = G_T\left(\max\left[\cos^{n_H}(\phi), s_f\right]\right) \qquad (9)$$

$$A_U(\theta) = G_R\left(\max\left[\cos^{n_U}(\theta), s_f\right]\right) \qquad (10)$$

where $G_T$ and $G_R$ represents bore sight gain of the HAP transmit and user antenna respectively, $s_f$ represents side lobe floor. $G = \eta \cdot D$, where $\eta$ is the reception antenna productivity. Furthermore $n_H$ and $n_U$ control the pace main beam power control move off of the HAP receiving wire and client radio wire individually. We receive a circularly symmetric pillar so as to disentangle the estimation, and accept that it can point toward any path to serve clients in the administration territory.

### *C. Pinnacle receptor power calculation position.*

The connection between the pinnacle receptor power area and the target of HAP reception apparatus has been shown in Fig. 3. As it is known that these profoundly directional receiving transreceivers on the HAP are not prone to point towards sub-stage point; the receptor power area veers off from the pointing point. This deviation is a significant factor that worries us, since authority clients will require great got control execution. The more the bore sight of the radio antenna veers off from the opposite line, the further the pinnacle got control point veers off from the pointing point. Given this common association of the pinnacle power control point and the pointing purpose of receptor antenna, we can ascertain the ideal pointing purpose of directional reception apparatus from HAP by determining the pinnacle receptor power first.

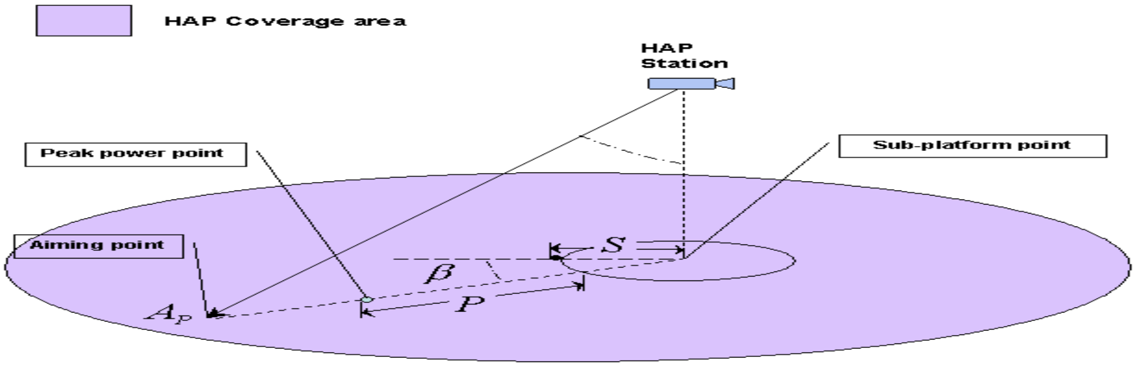

Fig. 3 Pinnacle receptor point and Aiming point from various directional receiving antennas of one HAP

In our situation, the HAP isn't in the focal point of the administration zone, so it implies the HAP dividing span isn't zero any more. We accept the HAP separating sweep equivalent to 9 km, which is the level good ways from the focal point of the administration region. The peak receptor power area will be on a similar line with the pointing point, so we can utilize a similar facilitate proportion (for example expecting a lot of x facilitates then X1/ X2 = X3/ X4 to ascertain obscure parameters.

With the change in beam width of the HAP radio antenna, it can cause the area of the pinnacle receptor power point likewise to move, as can an adjustment in the separating range. It is conceivable to infer the area of the pinnacle receptor power from HAP considering radius spacing, radio antenna rolloff and aiming offset. We expect that the focal point of the administration territory and receptor antenna point are on x axis, so area of variable pinnacle receptor power value moves along the xaxis. To ascertain the area of pinnacle receptor power as an element of HAP area and HAP reception apparatus pointing area, it could separate the Carrier part of condition (1) as for client area X and can make it zero. The equation (1) is given as [6]:

$$\frac{d(Carrier)}{dx}=\frac{d\left[P_{H\,m}A_{H\,m}(\phi_m)A_U(\theta_m)\left(\frac{\lambda}{4\pi d_m}\right)^2\right]}{dx}=0 \quad (11)$$

From equation (4), (5) and (13), only $\cos^{n_H}(\phi)$ in equation (4) and $d^2{}_m$ are related to the user position X, hence [6] could be written as:

$$\frac{d(Carrier)}{dx}=\frac{d\left[\cos^{n_H}(\phi)\left(\frac{1}{d_m}\right)^2\right]}{dx}=0 \qquad (12)$$

where [6]

$$\cos(\phi)=\frac{\left[(S-X)^2+H^2\right]+\left[(S-P)^2+H^2\right]-(X-P)^2}{2\sqrt{(S-X)^2+H^2}\cdot\sqrt{(S-P)^2+H^2}} \qquad (13)$$

$$d_m=\sqrt{(S-X)^2+H^2} \qquad (14)$$

where $P$ represents HAP transreceiver pointing position along Xaxis. Spacing radius is represented by S. Height of HAP is represented by H. Therefore at last the equation is derived as [6]:

$$\begin{aligned}&2(P-S)X^2+\left[4S(S-P)+H^2(n_H+2)\right]X\\&-2S\left(S^2+H^2-S\cdot P\right)-n_H\cdot H^2\cdot P=0\end{aligned} \qquad (15)$$

This equation (1) could be solved to find the location of the peak received power as follows [6]:

$$X=\frac{-B\pm\sqrt{B^2-4AC}}{2A} \qquad (16)$$

where

$$A=2(P-S) \qquad (17)$$

$$B=4S(S-P)+H^2(n_H+2) \qquad (18)$$

$$C=-2S\left(S^2+H^2-S\cdot P\right)-n_H\cdot H^2\cdot P \qquad (19)$$

. To find or to derive the position of aiming point of Transreceiver by using a given pinnacle receptor power point:

$$A_P=\pm(P-S) \qquad (20)$$

Here aiming point position is represented by $A_P$, assuming the pinnacle receptor power and aiming points lie on the x-axis. However, we can generalize the result for an arbitrary derived peak received power point ($P_X, P_Y$) anywhere on the service area. Here [6] it is shown that the pinnacle receptor power is lies on line which falls in between transreceiver aiming point and HAP sub-platform point.

where

$$P=\frac{2SN^2-4S^2N-H^2(n_H+2)\cdot N+2S^3-2SH^2}{2N^2-4SN-2S^2-n_H\cdot H^2} \qquad (21)$$

which is derived from the equation (13), (15), (16) and

$$N=\frac{P_X-S}{\cos\beta}-S \qquad (22)$$

The ground distance among pinnacle receptor power point and HAP is represented by $N$. Where:

$$\beta=\arctan\left(\frac{P_Y}{P_X-S}\right) \qquad (23)$$

With the help of this relationship the analysis could be found out at any instantaneous point and the position of pinnacle receptor power at that point could also be found out.

## III. SYSTEM PERFORMANCE WITH MULTIPLE ANTENNA BEAMS

In this section, 22 directional antennas from a single HAP are included in this scenario. The aiming points of the directional antennas are decided by the locations of the peak received power points that we discussed in the previous section. We specify the locations of the 22 peak received power points at random inside the service area. Once the positions of the peak received power points are confirmed, we can calculate the aiming points of the antennas, in order to ensure peak received power reach the ground users.

The default parameter values used in the simulation are listed in TABLE. 1.

| Parameter | Default Value |
|---|---|
| Frequency | 28 GHz |
| Coverage area radius | 150 km |
| Platform height | 16 km |
| HAP spacing redius | 9 km |
| Number of antenna beams | 22 |
| Sidelobe floor | -30 dB relative to peak |
| Noise floor | -204.8 dBW |
| Antenna efficiency | 94% |
| HAP Antenna roll-off factor | 728 |
| User Antenna roll-off factor | 18204 |
| Hap antenna beam width | 5 degrees |
| Ground user antenna beamwidth | 1 degrees |

TABLE. 1 Default parameter value used in simulation performance

### A. CINR Performance

The CINR performance is shown in Fig.4. Now we also take into account the effect that interference has on the overall CINR values for the random user locations. In each case the impact of interference is different.

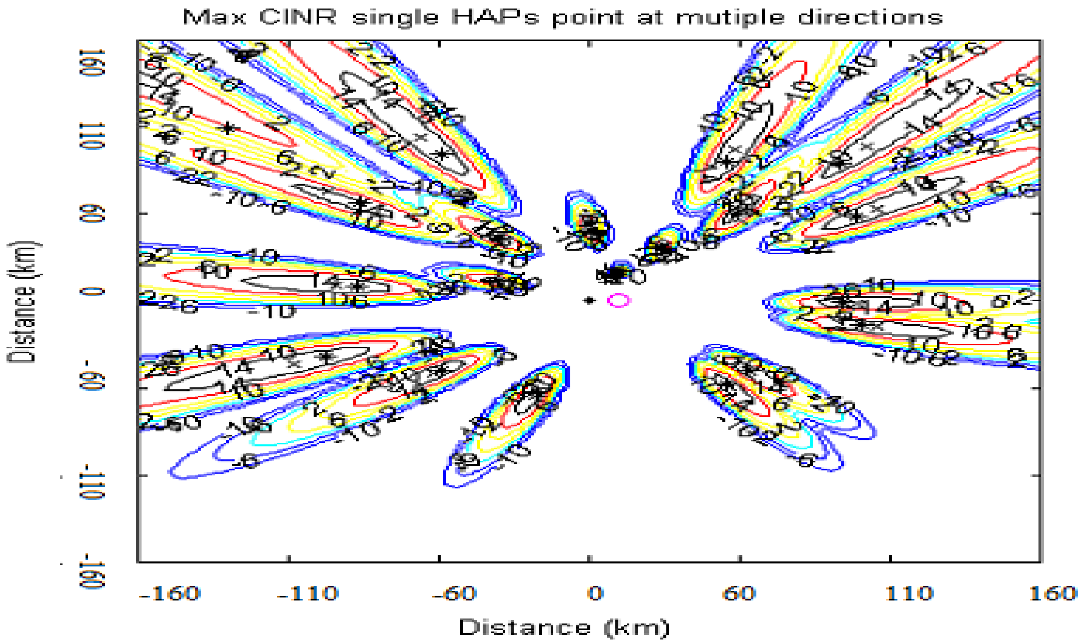

Fig. 4 CINR contour plot for multiple beams on the same channel from one HAP station.

The CINR curves in Fig. 4, which have no serious interference nearby, maintain an elliptical shape, since the directional antenna has a large angle away from the vertical. The antenna beams overlap with each other in the figure shrink heavily under the interference from the same antenna beamwidth from the HAP, since the signal from HAP reaches major lobe of ground user's antenna and no shadowing effect is considered, therefore increased interference is observed. After adding 22 antenna beams within the service area, most of the ground users can receive a CINR greater than 9dB.

### B. Orientation of Aiming Point and Comparison of Peak received Power and Peak CINR

The peak-received power point is the location where people can receive the most powerful signal; the peak CINR point is the place where signal to noise plus interference ratio appears to be the strongest. We show these points in Fig. 5 with peak received power point marked as '*', the peak CINR point marked as filled 'o' and the aiming point marked as 'x'.

Fig. 5 depicts the difference among the pinnacle receptor power point and the peak CINR point. It could be clearly seen that the peak-received power point does not coincide with the peak CINR point in 4 spot beam coverage areas. The degree of distortion will depend on the location of interferers nearby. The degree of distortion is shown to be greatest in the upmost beam. In all other cases the peak CINR point is furthest most point of the three away from the sub-platform point. This is because the interference (including from the sidelobes) tends to push the peaks outwards.

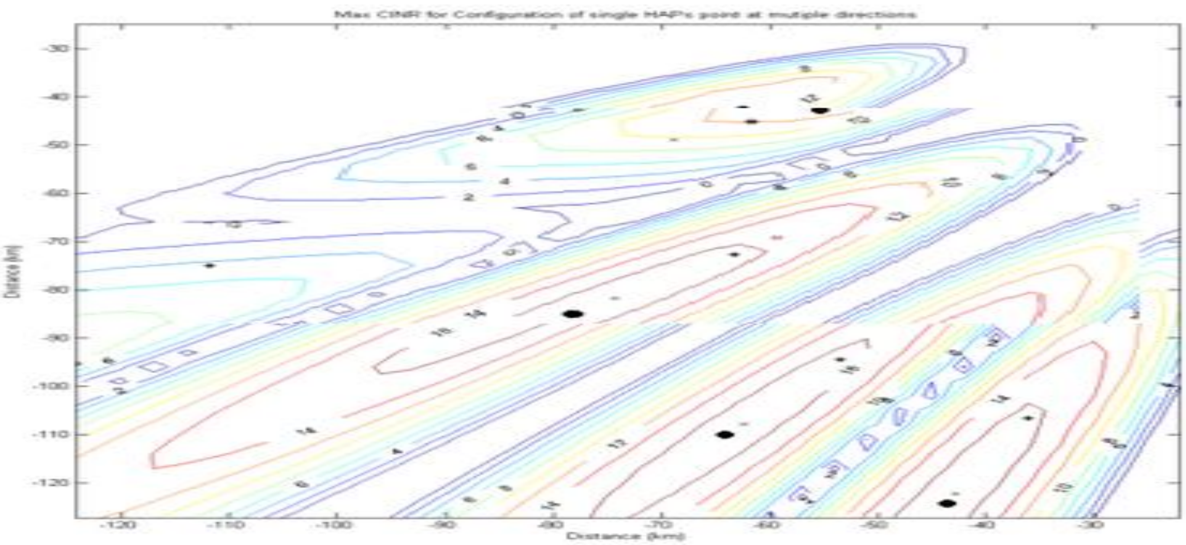

Fig. 5 CINR contour plot derived from Fig. 4 with aiming point, peak CINR location and peak received power

## IV. FURTHER WORK

As it is known to all of us that electromagnetic spectrum is over populated and mainly radio waves, thus it has to be ensured that new HAP systems should not create much interference and should not waste the bandwidth as it is required by other terrestrial communication networks.

One point to be considered is how cognitive radio could be implemented to intelligently direct beams in the presence of interferers so that the locations of peak CINR (rather than received power) coincide with specialist user locations.

## V. CONCLUSION

It could be noticed that it is possible to use a single HAP to provide multiple spectrum gigabit link communications over an extended service area of 150 km radius while using multiple antenna beams. After adding 22 antenna beams put within the service area, most of the ground users can receive a CINR greater than 9dB. It is also possible to decide where to point the antenna by specifying the peak received power location that is an important design parameter from a user perspective. Overall these results indicate a single HAP with a multiple antenna beams system can provide an alternative way to terrestrial systems to provide high-speed communications.

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