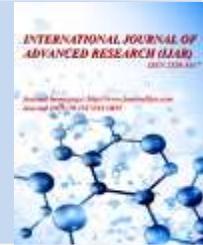




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### RESEARCH ARTICLE

#### STRATELLITE UNMANNED AERIAL VEHICLE AS A INTER-SAT PLATFORM IN STRATOSPHERE.

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#### Manuscript Info

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 GEO, LEO, HALO.

#### Abstract

This paper is about the new project designed by the Sanswire Corporation pronounced as stratellite which are being designed to provide better data services around the world. This is completely obsessed with the concept of satellite technologies and the stratospheric layer that is above 10 km from the earth's surface. It is true that the data services are playing a prominent role in fast hi-technology and in discerning that idea it is necessary to provide very low signal latency and no data losses. The idea of making this airship is to replace 1000's of the tower on the earth, which are necessary for wireless data transmission and reception from above 400-22, 400 miles above and it may incur data losses due to long transmission path back and forth coming. This is like a blimp, but 25 times stronger in every aspect than those and this does not require any unsustainable energy for its processing. This is having solar panels designed on top of it for energy generation in order to move the airship or to store it in the nacelle fuel storage. This is having great applications in navigational aids, border surveillance system, telecommunication and many more. It is an intermediate platform designed for effective data transmission on the GEO, LEO satellite with low signal latency. The HAP technology is designed for HALO network and that is a WMAN which is having a range of 10-100 Gbps data rate and satellites are also based on the same concept for data transmission and reception. Due to long distances the data could be loss and to suppress that affect the satellite hub station is designed and it is going to be the best technology as in providing low signal latency and with the coverage area of 3,20,000 square miles. This is a steady static platform with 24 hour connectivity with ground station due to its height and this is a hub with great payloads for radar and navigation purposes.

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#### Introduction:-

There are several reasons for searching other possibilities how to exploit effectively the existing limited radio spectrum as well as to use the advantages of both terrestrial and satellite propagations and to avoid their disadvantages. Broadband communications by means of high altitude platforms (HAPs) allows such possibility. HAPs, in US military development projects named Unmanned Air Vehicles (UAVs), are unmanned airplanes, airships, and balloons (like in fig. 1), with radio communications payload, operating in the stratosphere and

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providing wireless communications between terrestrial places. They can serve also as an intermediary between satellites and terrestrial surface.

HAP technology has been seriously developed in 1997 with the idea of effective data communication at long distances above earth surfaces.

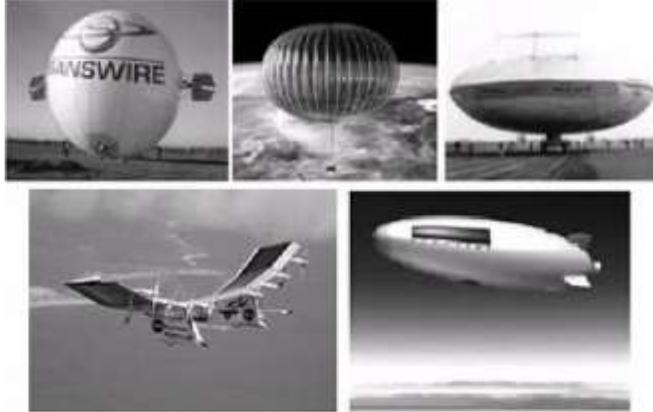


Fig.1: - HAP vehicle shapes.

There are several current worldwide projects on HAPs, including programs in the US, Europe, Japan and Korea. Several successful trials have been already realized; some HAPs nowadays operate in Japan and America, and the other new ones are commercially tendered. Their main advantages are small delay, like in terrestrial telecommunications, and feasibility of line-of-sight coverage for all terrestrial places under considering, like in satellite communications.

The other interesting advantages in comparison with terrestrial and satellite communication will be described in the third part of the following text. In the next parts of this article are listed the main technical propositions of HAPs, there are also briefly described physical layer, expected utilization, some world HAPs projects and related successful trials. This single blimp is highly capable of data communication at large cellular coverage area.

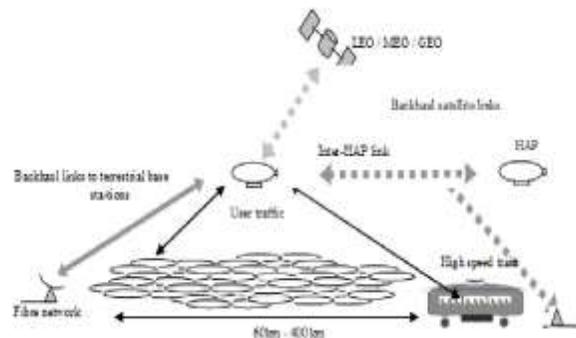


Fig.2: - Cellular frequency reuse concept of communication.

### Stratellite:-

Stratellite airships are lightweight, leak proof for helium gas tank, resistance to radiance at altitude of 13 miles. Each stratellite is having a clear line of sight communication.

The engines should be strong to handle 55 m/Sec wind velocities. For long endurance, only a part of the irradiance is available for direct propulsion and other needs to be processed after getting charge and store the energy from solar panels on top of the stratellites. This is required in order to work for communication and propulsion equipment.

The satellite is designed to carry payloads for radar and navigation purposes and they are aiming to create an intermediate platform or a stable hub station in stratosphere and it is being at the mercy of stratospheric weather conditions.

This airship is having a nacelle at the bottom, which is having fuel cell storage tank and that is connected to the solar panel on top of the stratellites via a ring like path. They had their own power to move i.e. The power is stored in the fuel cell tank and the propellers start with that stored energy and then the 3 axis geometrical orientation could be achieved after that. The possible launch capabilities require 24 hours to set-up and it can be easily ascent and descent at the defined location.

They do not require launch vehicles and they can be refurbished or redeployed easily. There is no need of proper constellation platform and at that altitude the frequency reuse concept can be achieved with higher capacity data services of satellite systems.

#### **Working of Stratellite:-**

The stratellites usually undergoes two processes due to its steady location in the stratosphere. It is for the first time that the hub is not moving and located just above the earth's surface at 13 miles constantly. It evolves two processes:

When the stratellite moves upward it has to be light in weight for boosting it into the stratospheric layer. The helium tank will exert the helium outwards and the layer of air on the inner surface of the body made up of polyester named as Mylar is made to move outward from the propellers.

When the stratellite is at 13 miles altitude above the earth's surface, it will be going to remain at constant location. For stationary location the propellers are working altogether with GPS technology to achieve 3-axis geometrical orientation in the stratosphere.

For this the body will pressurize the helium back inside the helium tank and the air will be an outermost layer inside the body. It will make it heaves and stationary too, which will be best for communication and other purposes.

#### **Specification of stratellite:-**

Firstly, the general characteristics involves the size of the airships and that is 245\*145\*87 ft and the volume is 1.3 million ft<sup>3</sup>.

Secondly, the airship's physical characteristic involves:

1. Service ceiling at 70,000ft/ 21,000 m.
2. Dual envelopes made up of the dynamo (also called as spectra).
3. For navigation there are 6 onboard GPS system are being installed and connected to the engines.
4. The payload capacity is 3000 lbs and these equipments are for radar and navigation.
5. The cruising altitude is at 20,000 m.
6. Lifting gas for airship is Helium gas that is inert and not inflammable in nature and it never reacts with other elements in order to make new compounds.
7. The LOS is 4, 80,000 km<sup>2</sup> approximately equals to the area of France.
8. The maximum aloft time is 18 months, but it has the capability of undergoing redeployment again. It comes back on earth and again launch with ease while satellites can't do so.

Thirdly the material includes in stratellite are:

1. The spectra are the outer layer of satellite and that is an optical fiber stronger than the steel and more effective than those. That fiber is used for designing bullet proof vests.
2. There is a regenerative fuel cell at the bottom, which is pronounced as nacelle and that is having storage of energy for running the motors if needed. The cell is chare with the energy from solar panel on top of the ceiling.

#### **Technologies of Stratellite:-**

This is a UAV and based on HAAPS technology. High altitude airship platform station technology is based on HALO networks. High altitude, long operation network is used for broadband multimedia network. The network is having WMAN star topology which is a wireless metropolitan area network. They are having two networks first at terrestrial to look up angles and another into space with very high look up angles.

They are more advantages because of low signal latency and highly economical in nature. Apart from that they are having a very large coverage area and large bandwidth for data communication.

HALO is a central hub network designed for carrying certain payloads and having long lifetime. It is multi-platform station with multiple launches in the stratosphere.

#### **HALO Network:-**

Today's era is all about fast life with high technologies and high data rates. So, to have fast access is desired and this technology is replacing 1000's of towers on the earth's surface and that is highly desired for low signal latency and to suppress the effect of data losses due to long distance communication. It's like GEO satellites are placed at 22,400 miles above the earth's surface and the data needs to travel for 44,800 miles in total and that could cause data losses due to long distance communication. This issue is overcome with the idea of an intermediate platform station i.e. stratosphere.

HALO network is having low power use terminals, short delays, scalability of capacity and great cellular communication. They are having 4G communication and WMAN is working on the LMDS spectrum that is the system with gateway beams of 28-30 GHz and they are having 15 to 150 Gbps throughput capacity.

They are having 4 network elements and it includes:

1. Customer premise equipments
2. Business premise equipments
3. HALO gateway
4. Network control stations

Apart from that it is having three types of interfacing for Signaling purposes, such as:

1. UNI (user network interfacing)
2. NNI (node network interfacing)
3. B-ICI

The 4G for HALO networks is intended to provide high speed; capacity, low cost per bit and IP based services at 20 Mbps data speed. They are 25 times bigger than blimps. Blimps are just like a tethered balloon, but very small in size as compared to stratosphere.

The disadvantages of this are prototype stage and due to non-commercialized in nature.

#### **HAAPS:-**

Specification of HAPS

In the following we can introduce some interesting specifications of HAP systems:

1. "Floating" or quasi-stationed position in the stratosphere at about 20 km altitude, well above both civil air routes and wind flowing (there is 5% of air density of the atmosphere at sea-level). The aero-planes and aircrafts can circle or move slowly in air space with radius of several kilometers.
2. Solar power.
3. Remote controlling from the earth stations on the ground.
4. In the case of airships - long endurance of station, e.g. Several months or more. The ship can be brought down for retrofitting and maintenance, and can be returned back to its position.
5. Line-of-sight up to 800 000 square kilometer area, according to operational altitude.
6. Payload capacity allows uphold a lot of antennas for different services.
7. Cellular is covered by wireless signal, without dead places on the earth's surface with broken relief (fig. 2).
8. Providing communications also for users with high speed moving terrestrial vehicles.
9. Wi-Fi technology and Wi-Max application for communications in bands 2 – 66 GHz. The work group ITU-R 9B has proposed more ITU-R re-recommendations for HAPS systems.

#### **Utilization of HAPS:-**

The scope of utilization of HAP is great and very promising. They are intended many of civil and military HAPS benefits, which can be divided in three groups:

1. Broadband telecommunications services (cellular, a lot of new generation multimedia broadcasting and both-directions communications like as video-on-demand, video conferencing, Internet browsing, files downloading, interactive games, e-commerce, etc.). They will be allowed not only for static receivers, but also for slow walking users or for users travelling in high speed moving vehicles.
2. Environment monitoring (security and other commercial and military purposes).

### 3. Vehicles localization.

These possibilities will be provided for much more users in a high density urban environment and also for sparsely populated rural regions. HAPs will be able to supplement the insufficient capacity of stationary terrestrial and satellite basic stations and can be fast allowed in the case of extraordinary or acute mass happenings, like as great sport matches and competitions, culture actions and catastrophes as well.

#### **Comparison of HAPS with both terrestrial and satellite communication:-**

As it is described in the introduction, HAP communications are fast as the terrestrial ones. Moreover, the signal attenuation and distortion on the score of rain and meteorological perturbations are less, because of less distance of their activity. The signal covering of terrain can be perfect, due to undistorted line-of-sight between transmitter and receiver antennas, which is not always possible in the case of terrestrial broadcasting. The HAP vehicles can be placed on the quasi-stationary position faster and less difficult than it is in the case of the placement of the radio communication masts. The change of HAP placement is possible and fast, as well, unlike of terrestrial base station.

The main advantageous aspects of HAP exploitation in comparison with satellite communication are about a tenth of the cost, less demanding start and maintenance, the possibility of start repetition, and, at last but not at least, the larger capacity and smaller signal delay.

#### **The main tasks of HAP development as airships:-**

The aeronautic constructors in the area of HAP stations (HAPS) have a lot of interesting work. It deals with a research and development of suitable shapes of vehicles, coverage and construction materials, propulsion and movement of HAPs, power supply and exploitation of solar energy.

There is also a job for developers in the area of remote navigation, controlling and of operation without human operator on board.

In radio communications, the examination of well known communications modes, modulations, coding and net protocols will be pursued by searching of the new concepts in digital signal processing and communications. The communications feasibility of inter-platform links are investigated, likewise the backhaul links between HAPS and satellites. The new hardware including smart-patch antennas are developed for mm-waves and microwave applications. Budget system design will be elaborated for all mentioned link types. Existing microwave ITU frequency bands utilization and searching of new bands must be reconsidered, investigated, discussed and negotiated.

#### **The Signal Technics Problem and Radio Regulation for Stratellite:-**

Telecommunication services at a range of modulation/coding schemes are specified. The several linear and non-linear modulation schemes (including QPSK - Quadrature Phase-shift Keying, QAM - Quadrature Amplitude Modulation, M-APSK - Mary Amplitude and Phase Shift Keying or StarQAM on the one hand and CPM - Continuous Phase Modulation, GMSK - Gaussian Minimum-Shift Keying and MA-MSK - Multi-Amplitude Minimum Shift Keying on the other one are the objective of evaluating process. Probably FEC coding will be required, especially when channel conditions are poor to maintain link integrity. Appropriate codes will be selected for each service type, having regard to the BER requirement (Bit Error Ratio), delay limitations, and computational load (especially for higher data rates). Codes considered will include (but not be limited to) convolution codes, turbo-codes, product codes and RS (Reed-Solomon) codes.

The interference and synchronization problems must also be investigated and solved.

Regarding to equalization it is expected that the platform - terminal link will be relatively benign in terms of dispersion, and hence that equalization will not be required. However, there may be circumstances where use of equalization would allow access to a platform at low elevation angles, where ground reflection might occur.

Multiple Access methods are taken into account and may be based on a combination of Frequency / Time /Code Division Multiple Access. As well, TCP/IP, Wireless ATM, Wireless, IP and HiPer Access protocols are investigated in context of HAP.

ITU-R Study Groups have extensively discussed the operational and technical characteristics of HAPs for the use of hops was agreed at WRC 97 (World Radio communication Conference in October-November 1997). There had been produced total 14 recommendations for HAPS in 47/48 GHz bands, 28/31 GHz bands and others for a period of 2000-2005. It was a temporary solution, because the mentioned bands are reserved for Fixed Services and IMT-2000. In some works there are investigated the utilization of IEEE 802.16a referred to Wi-Max and intended for terrestrial non-line of sight systems operating in the 2-11 GHz bands [4], [5].

As it was mentioned, there is a cellular concept of covering considered. Recommendation ITU-R F.1500 indicates that a typical HAPS based network (HAPN) may offer up to 2100 cells, with a 7-times frequency reuse factor, within a service diameter of 468 km. In addition, there may be up to 40 gateway stations within a diameter of 181 km. Depending on the bandwidth assigned to an individual HAPN, there may be up to 330 000 simultaneous user terminals in operation from a subscriber base of more than 5 million. Each of these user terminals will have an antenna directed towards the HAPS. The 2 100 beams from the HAPS will extend across the whole of the coverage area, with frequency reuse.

#### HAP channel model problems:-

For the perfect theoretical handling of many HAP communications problems it is necessary to have an appropriate model of HAP channel.

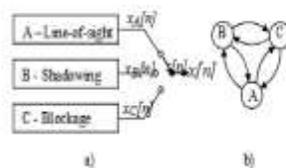


Fig. 3 Switching process  $s[n]$  in generation of the observed sequence  $x[n]$  (a), and semi-Markov state model of HAP communication channel (b) [6].

User link between HAP station and moving receiver in high speed train is critical in this sense, and hence it is an objective of intensive research and tests. The scenario of this channel can be modeled by analogy to statistical models for mixed propagation conditions described in ITU-recommendation [6], which was primarily intended for satellite links. This model exploits hidden Markov state chain approach. The chain comprises three types of states (A, B, C), i.e. Three types of receive quality, and transitions between them, as it can be depicted by a simple scheme in fig. 3.

The first state (A) represents clear line-of-sight (LOS) condition. This state can occur with probability  $P_A$  and the signal level in this state can be de-scribed by the Nakagami- Rice cumulative distribution. The Loo distribution can be exploited to express the signal level in the second type of state (state B with probability  $P_B$ ), which represents slightly shadowed condition (by trees and/or small obstacles). Third state (C with probability  $P_C$ ) is fully blocked receive (by large obstacles, such as mountains and buildings), and signal level has Rayleigh distribution.

The state transitions between states can be modeled by the switching process  $s[n]$  (fig. 3). The all state durations can be described by probability functions as follows: power-law distribution of state A duration, log-normal distribution for duration of states B and C. The mathematical expressions of mentioned distributions and the choice or setting of their parameters can be found in [6], [7].

#### HAAPS Projects:-

The research program of HeliNet Consortium (2000-2003) funded by European Union Framework 5 program developed the small solar powered airplanes and focused also on traffic monitoring, environmental surveillance and broadband telecommunications [8]. The project participants were Politecnico DI Torino, University of York, Josef Stefan Institute, Technical University of Budapest, CASA Technical University of Catalonia and Ecole Polytechnique Federale de Lausanne.

The European CAPANINA research consortium started its work in November 2003 and is led by the University of York. It involves 14 partners from Europe and Japan and was partially funded by the European Union – Framework 6 Programmed. The main objective of the project is to deliver low cost broadband communications services to small office and home users. There was realized CAPANINA high altitude trail in northern Sweden, in October 2005.

12,000 m<sup>3</sup> balloons, carried radio and optical communications equipment, flying at altitude of around 24 kilometers and provided communications in the mm - wave band (28/29 GHz) using Wi-Fi (IEEE 802.11) at distances ranging up to 60 km. There was also performed the first known optical 1.25 Gbit/s downlink from stratosphere to an optical receiver on the ground over a link at distances of up to 64 km [1].

Currently the European COST 297 – HAPCOS is realized with the participation of 16 countries. Its main objective is to increase knowledge and understanding of the use of High Altitude Platforms for delivery of communications and other services, by exploring, researching and developing new methods, analyses, techniques and strategies for developers, service providers, system integrators and regulators [9].

The USA already commercially offers Stratellite- HAP aircrafts, products of Sanswire Network, LLC Loaded with a lot of communications antennas for different purposes [2].

US also develop the military unmanned communications aircrafts equivalent to HAPs and named UAVs. (Unmanned Aerial Vehicle). They are remotely piloted or self-piloted and can carry cameras, sensors, communications equipment or other payloads. They have been used in a reconnaissance and intelligence-gathering role since the 1950s [10].

Japan and Republic of Korea have operated their own HAPs, and participate in international Asia Pacific Telecommunications HAP projects and in ITU-R Study Groups, Work Groups and Expert Groups in the area of HAP communications. They joined European HAP projects, as well.

#### **HAAPS ISSUES:-**

1. Placing a platform at an altitude of 13 miles reliably above the coverage area is cost efficient and being able to stand all the aspects that are being necessary for the airships. For long stretches of time if dirigible could stand and it could also nullify the effects of weather in stratospheric layer.
2. The altitude is above 65,000-70,000 ft from the earth's surface and the wind velocity at such a height is about 30-40 m/s which depends on the latitudes. The effect due to wind, dust will incur loss of data in communication.

#### **Conclusion:-**

The aim of this article is to offer the knowledge about developing new communications technology. High altitude platforms (HAPs) can fill the gap between the communications feasibilities of both terrestrial and satellite base stations. This technology is an objective of interest of many universities and civil research centers, as well as of military research groups. It is an interesting call for constructors in the area of aeronautic materials, vehicle shapes and propulsion. There are also the research tasks in the area of wireless communications technologies, as well as exploiting the existing Wi-Max and Wi-Fi technologies.

In this paper, the brief overview of the technical specifications of HAPs, the aspects of communications research and development tasks, the utilization feasibility of HAP technology and state of the art of this research problem in the world was described

#### **Acknowledgement:-**

This work has been done in the frame of generating low latency and no to data losses, while communicating at very far distance above the earth's surface that is High Altitude Platforms for Communications and Other Services. I am grateful to the ECE department of Poornima College of Engineering for their support.

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