MOBILE COMMUNICATIONS VIA STRATOSPHERIC PLATFORMS

Gorazd Kandus[1]

ABSTRACT:
High Altitude Platforms (HAPs), physically positioned in the lower stratosphere at altitudes around 20 km, have recently been shown to have the potential to deliver a range of communications services. These include multimedia applications requiring broadband access to the network and make HAP based wireless access systems a potential supplement to terrestrial and satellite systems.

In this paper, HAP-based systems are analysed with respect to terrestrial and satellite broadband wireless access systems. The most interesting services and applications are briefly introduced. The main focus is on the alternative HAP system and network architectures, ranging from stand-alone platforms to multiple platform configurations which may include wireless and free space optical links. Operating scenario requirements and restrictions imposed by the type of the platform are also taken into account.

Key words: High Altitude Platform, Network Architecture, Network Requirements, Stratospheric communications

I. INTRODUCTION

Aerial platforms equipped with a payload for the provision of communication services are seen as a promising means to provide broadband access to some specific operating environments not best suited to terrestrial wireless or satellite communication systems. They are expected to fly in the lower stratosphere at altitudes between 17 and 22 km and are in the literature typically referred to as high altitude platforms (HAPs). Two distinct types of aerial platforms have been

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proposed for the provision of communication services from the stratosphere: – unmanned airships; and manned/unmanned aircrafts [1, 2].

HAPs combine some of the best characteristics of terrestrial wireless and satellite communication systems while avoiding many of their drawbacks. In comparison to terrestrial wireless technologies, HAPs require considerably less communications infrastructure, they can serve potentially large coverage areas from a single site, and the cell planning is more straightforward since they are able to provide line-of-sight links. When compared to satellite systems HAPs will provide a quasi-stationary coverage area, low propagation delays, broadband capability using small sized antennas and terrestrial terminal equipment, and easy maintenance and upgrading of the payload during the lifetime of the platform. All these characteristics make HAPs suitable also for the provision of broadcast and multicast services, while typical services from HAPs include basic voice, video and data communications, as well as advanced applications such as telemedicine, news gathering, localisation and navigation, news and emergency message broadcasting, videoconferencing, remote sensing, etc.

In addition to long-term provision of broadband access to fixed or mobile users HAPs are particularly well-suited for temporary provision of basic or additional capacity requirements. They can be rapidly deployed and their flight path can be controlled in compliance with changing communication demands, providing network flexibility and re-configurability. In this context typical applications of HAPs include short-term large-scale events and establishment of ad-hoc networks for disaster relief.

From the system architecture perspective HAPs will provide broadband wireless access for single-user or group terminals in the coverage area, serviced from fixed or mobile / portable ground stations operating as backhaul nodes. HAPs can operate as stand-alone platforms; alternatively, HAPs can be interconnected via the ground segment or by interplatform links (IPL) in the sky segment forming a network of platforms. Taking into account the location of switching equipment we can distinguish between platforms without on-board switching (transparent platform) and those with on-board switching (switching platform). The choice between switching on the ground and on board depends on QoS requirements and on limitations with respect to the weight and power consumption of the platform payload. While HAP system can be deployed as a stand-alone network it will typically be connected to external networks via gateways providing suitable internetworking functionality. User terminals communicate with platforms via user links in the mm-wavebands, while the hub ground stations, hosting gateways to external networks and different servers, are connected to platforms via backhaul links, together forming an up/down link segment.

II. HAP SYSTEM ARCHITECTURE

From the system architecture point of view HAPs can be used in different configurations. General most extensive architecture is depicted in Fig. 1.

The simplest configuration consists of **standalone platform** where system coverage is limited to a single HAP cellular coverage. Only communication between fixed, portable and mobile user terminals within this coverage is enabled.

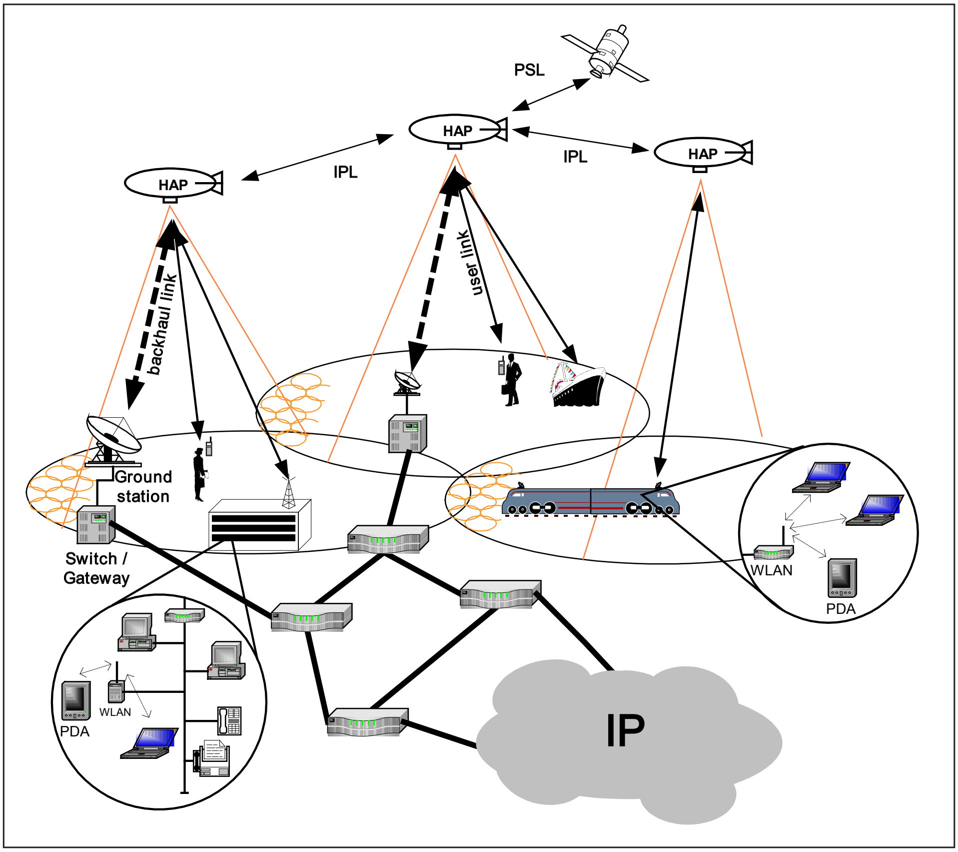

Fig. 1. HAP System Architecture

Additionally, connection to other public and/or private networks via Gateway Station (GS) is foreseen. This scenario can be further divided into two distinct topologies taking into account where the switching is taking place: (i) *Bent-pipe standalone platform* (scenario with on ground switching), where the path between two users encompasses uplink from user to platform, feeder downlink to GS, where the switching is performed, feeder uplink from GS to platform and downlink to target user. (ii) *Standalone platform with onboard switching*, where the path between two users takes only uplink from user to platform, where switching is performed; and finally downlink from platform to target user. Standalone platform scenario is first of all suitable for temporarily provision of basic or additional capacity required for the short time events with a large number of participants, in case of natural disasters, or in areas where the fixed infrastructure has suffered a major failure, the onboard switching would be advantageous in many cases, or a moveable ground station is needed.

In the case of **multi-platform** constellation HAPs can be interconnected via ground stations or by interplatform links (IPL) forming a network of platforms, thus arbitrarily extending the system coverage. If the *HAPS are Interconnected via ground stations* flexibility of system coverage is low due to platform operation dependence on ground infrastructure. HAP operation is enabled only above the area where the ground station is placed. Thus, the flexibility of system coverage can be increased only by utilisation of movable GSs and flexible Terrestrial Network Link (TNL) segment. *Interconnection of HAPs via interplatform links* enable communication between adjacent platforms without any ground network elements included. In this scenario GSs can be used only as gateways to other public and/or private networks, or also to provide a backup interconnection between platforms in the case of IPL failure. In this scenario only platforms with onboard switching payload are envisaged, in order to take advantage of IPL implementation. Thus, the path between users A and B within a single platform consists of uplink from user A to the platform, where switching is performed, and downlink to user B. The path between two users in distinct HAP coverage consists of user uplink from user A to the platform, where switching payload chooses the most suitable sequence of IPLs towards the platform, which is serving user B. The last part of the path between users represents user downlink to user B. The main advantages of using IPL in the HAP network are: system operation is independent of terrestrial network; reduced requirements for terrestrial and UDL segments; highly flexible system coverage and lower signal delays. While the main disadvantages are: IPL terminals represent additional weight and power consumption on board and potential difficulties in realisation of IPLs because of unpredictable weather conditions on HAP operational altitudes.

The most extensive scenario as depicted in Fig. 1 has also *Platform to Satellite Links (PSL)*, which are particular useful if HAPs are placed above the areas with deficient (rural and remote areas) or non-existent terrestrial infrastructure. Using PSL HAPs can be connected to other public or private networks. In addition, PSLs could also be used as a backup solution in the case when the connection with the rest of the network via IPLs or GS is disabled due to a failure or extreme rain fading on up/down link segment.

III. INTERWORKING REQUIREMENTS

Interworking with other networks is one of the main properties of each communication system as the appropriate interworking with other networks exploits the full capabilities of the system. In general there are two main fundamentally different ways of solving the interworking issues (i) loose interworking and (ii) tight interworking [5].

Loose interworking is defined as the utilization of HAP network as an access network complementary to current access networks. There are no common network elements with other networks (i. e. avoiding the common SGSN, GGSN nodes, etc.). In the case of loose interworking the HAP network is more independent and flexible. In order to provide IP compatibility at the level of HAP, security, mobility, and QoS need to be addressed using IETF schemes.

In the tight interworking HAP network is connected to some other network as the sub part. For example HAP network can be connected to the rest UMTS network (the core network) (HeliNET scenario) in the same manner as other UMTS radio access technologies (UTRAN, GERAN). In this way, especially the mechanisms for mobility, QoS and security of the UMTS core network can be reused. In addition the GGSN is the interface between the UMTS core network and the Internet.

In this paper we are focusing on loose interworking with a particular consideration of interworking with an IP networks. Different services demands different network architecture requirement. Thus we divide the candidate services in two main categories: (i) *Native IP based services:* High-rate unrestricted information Tx. service, FTP, High resolution image communication service, Mixed document communications service, Data retrieval service, Multimedia retrieval service; (ii) *Not native IP base:* Video telephony, ISDN videoconference, Video surveillance, Video/audio information transmission service (DVB), MPEG-2 or 4, Voice.

For the first group of services general network requirements apply, which are suited for the provision of IP based services and encompass the mobility and handover issues, described in the next paragraph.

The second group has higher QoS requirements and also in some cases (e. g. DVB, MPEG-2 or 4) the IP is not the most appropriate for providing such services, thus some adaptations and additional architecture requirements are necessary. As an example we are describing VoIP requirements.

The requirements for mobility and handover differ depending upon the type of the networks involved. Several different mobility options can be considered Mobility shall be supported between HAP networks belonging to different administrative domains. Handover shall be provided within a HAP network belonging to the same administrative domain. Different types of handover might be performed. It can be based on the MAC layer, or network handover procedure with the possible addition of higher layer mobility protocols. In All-IP concept the Mobile IP and all its flavours is recommended. In addition, handover should be supported within a HAP network belonging to different administrative domains. Terminals shall support mobility between different HAP and other networks.

IV. REQUIREMENTS FOR PROVISION OF VOIP SERVICES OVER HAP NETWORK

Although the voice over IP (VoIP) has been in existence for many years, nowadays it becomes more and more popular and a viable alternative to traditional public switched telephone networks (PSTN). In addition, VoIP promises to deliver many nice features such as advanced call routing, computer integration, unified messaging, integrated information services, long-distance toll bypass, and encryption [6]. Because of the common network infrastructure, it is also possible to integrate other real time and non-real time media services, which are particularly well suited for broadband access networks (e. g. HAPS). In order to identify the requirements for VoIP services in HAP networks we will first describe the VoIP features.

The basic VoIP functions are [6]:

– Signaling; Different signaling protocols are used in VoIP (e. g. SIP, H. 323)

– Database services; Database services are used to locate an endpoint and translate the addressing that two (usually heterogeneous) networks use. A call control database contains these mappings and translations. Another important feature is the generation of transaction reports for billing purposes.)

– Call connect and disconnect (bearer control); In a VoIP implementation, the connection is a multimedia stream (audio, video, or both) transported in real time. This connection is the bearer channel and represents the voice or video content being delivered. When a communication is complete, the IP sessions are released and optionally network resources are freed.

– CODEC operations Signaling; The process of converting analog waveforms to digital information is done with a coder-decoder. There are many ways an analog voice signal can be transformed, all of which are governed by various standards. Each encoding scheme has its particular bandwidth needs. The output from the CODECs is a data stream that is put into IP packets and transported across the network to an endpoint. These endpoints must use the standards, as well as a common set of CODEC parameters.

These functions must be able to perform the same functions as the PSTN network. The major components of a VoIP network, while different in approach, deliver very similar functionality to that of a PSTN and enable VoIP networks to perform all of the same tasks that the PSTN does. The one additional requirement is that VoIP networks must contain a gateway component that enables VoIP calls to be sent to a PSTN, and visa versa.

There are four major components of a VoIP network [6]: Call Processing Server/IP PBX (Soft Switch); User End-Devices: Media/VOIP Gateways, and IP network

Call Processing Server / IP PBX (Soft Switch) is the main part of a VoIP phone system as it manages all VoIP control connections. Call processing servers are usually software-based and can be deployed as a single server, cluster of servers, or a server farm with distributed functionality. It is worth noting that call processing servers do not handle VoIP payload (which is the RTP stream carrying voice itself) traffic, but only manages the VoIP control traffic follows. VoIP payload flows in a peer-to-peer fashion – from every VoIP terminal to every other VoIP terminal. In this case, the VoIP terminals determine traffic flows and the call processing servers negotiate those flows within the control messages.

The user end-devices consist of VoIP phones and desktop-based devices. VoIP phones maybe software based („softphones") or hardware based („hard phones" or „handsets", like traditional phones) [6]. VoIP phones use the TCP/IP stack to communicate with the IP network, as such, they are allocated an IP address for the subnet on which they are installed. Softphones are software application running on notebook computers, usually targeted towards mobile users, which are particular interesting in the case of HAP network scenario, where users are traveling with high-speed trains. They have the same base features as VoIP phones.

The major function of *media / VoIP gateways* is analog-to-digital conversion of voice and creation of voice IP packets (CODEC functions) [6]. In addition, media gateways have optional features, such as voice (analog and/or digital) compression, echo cancellation, silence suppression, and statistics gathering. The media gateway forms the interface that the voice content uses so it can be transported over the IP network. Media gateways are the sources of bearer traffic. Typically, each conversation (call) is a single IP session transported by a Real-time Transport Protocol (RTP) that runs over UDP or TCP.

The *IP network* must ensure smooth delivery of the voice and signaling packets to the VoIP elements. Due to their dissimilarities, the IP network must treat voice and data traffic differently. If an IP network is to carry both voice and data traffic, it must be able to prioritize the different traffic types, as VoIP traffic is extremely sensitive to latency. An example of VoIP architecture for HAP sce-

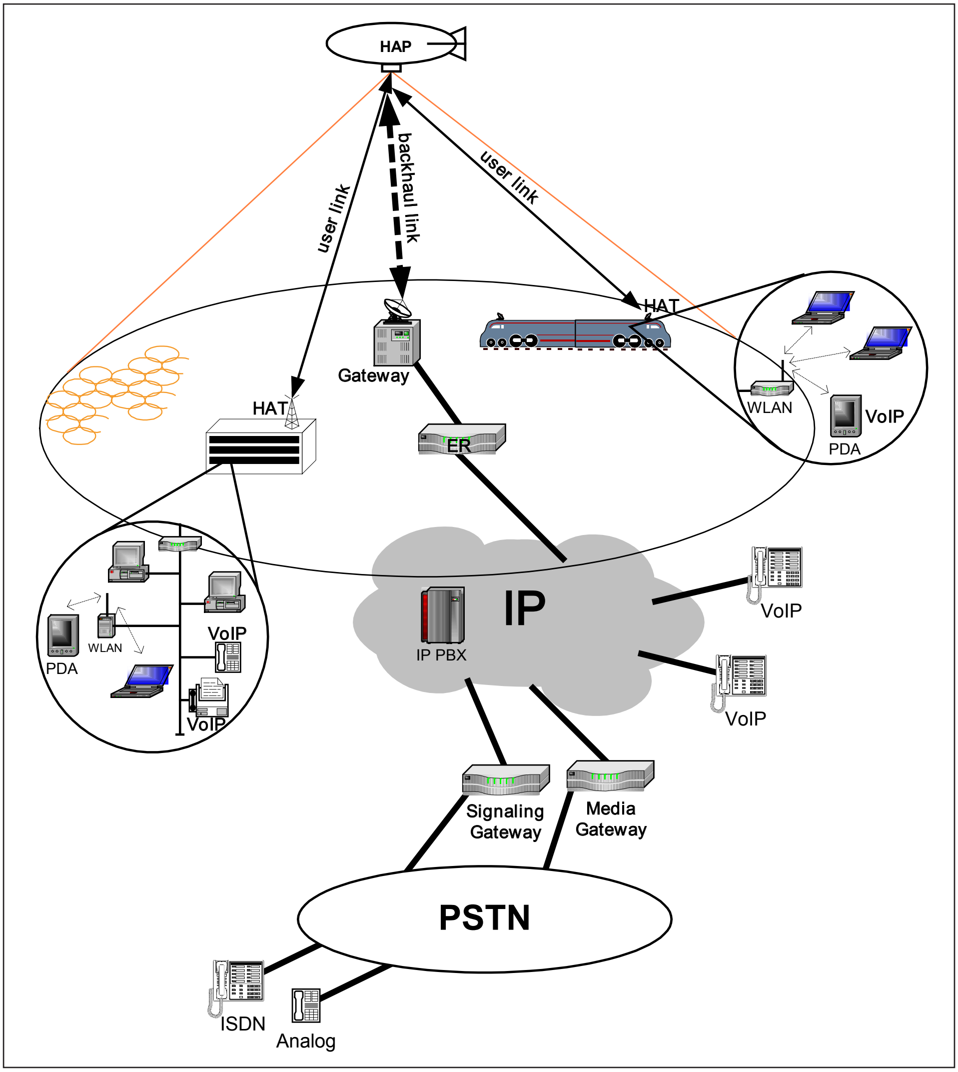

Fig. 2. VoIP System Architecture for HAP Network

nario is depicted in Fig. 2. In general the VoIP users within the HAP network can communicate with VoIP users connected to the IP network or to users, which are connected to PSTN network (ISDN or analog) via Media and Signaling gateways. As the HAP network fully supports IP there is no additional network elements required within the HAP network for support of VoIP. However, as there are more stringent requirements for the delay in VoIP networks the HAP network should provide differentiation of classes in order to fulfill the delay requirements.

In addition, the HAP network should support signaling protocols (e. g. SIP, H. 323, H. 248/MEGACO, MGCP), which are used for call connect / disconnect and management procedures.

The HAP network should also allow common architecture for all real-time services and it should envisage also the future services. The quality, reliability and availability of VoIP services should be comparable to that of PSTN network.

V. CONCLUSIONS

High Altitude Platform networks can be deployed as different architectures, from a standalone platform to a mesh of connected platforms with inter-platform and also platform to satellite links, and used in different communication scenarios. The High Altitude Platforms can be well suited for provision of communication services to areas with low user density, short-term large-scale events or disaster relief missions. In this paper we focused on different network architectures, describing network requirements for provision of IP based services over HAP network. As an example we present also the requirements for VoIP System Architecture for HAP Network.

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Mobile and Wireless Communications: State of Art and Perspectives

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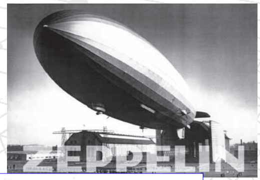
Outline

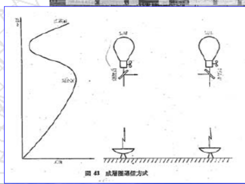
- Introduction
    - Historical milestones
    - High altitude platforms for communication systems
    - Critical HAP system design issues
- Spectrum allocation and services
    - Frequency bands allocated to HAP system applications
    - Potential services in HAP systems
- System and network architectures
    - HAP system design alternatives
    - Network architectures
- R&D projects and Trials

Historical milestones

- 1783 - Montgolfier brothers invented and demonstrated hot-air balloons



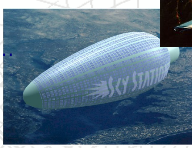
- 1900 - Initial flight of the airship invented by and later named after Count Ferdinand von Zeppelin

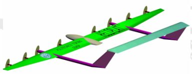


- 1970s – Feasibility study on wireless link using multiple balloons conducted in NTT, Japan (NTT R&D Report, vol.24, no.7, 1975)
- 1983 - Classified flight test of a solar-powered unmanned aerial vehicle (UAV) HALSOL

Historical Milestones

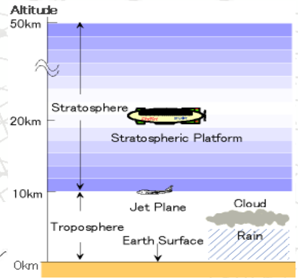
- 1990s – Intensified programmes and projects concerned with aeronautics and mission payloads, with special emphasis on provision of broadband communication services via HAPs
  - USA
    - ⇨ NASA/AeroVironment (Helios, Pathfinder)
    - ⇨ Commercial initiatives – HALO, Sky Station, …
    - ⇨ …
  - Europe
    - ⇨ ESA – HeliPlat
    - ⇨ EC Framework Programmes – HeliNet, Capanina, USEHAAS, SatNEx, …
    - ⇨ ESF – COST 297
    - ⇨ Commercial initiatives – Stratxx (CH), …
    - ⇨ …
  - Japan
  - Korea
  - China
  - …

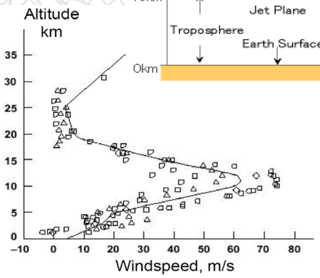


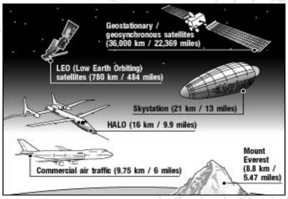


High altitude platforms

- HAPs are airhips or planes typically flying in the lower stratosphere between 17 and 22 km
- Most meteorological phenomena (clouds, rain, …) concentrated below 10 km (troposphere)
- Commercial flights bellow 15 km







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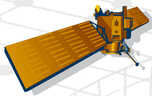
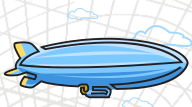
Motivation for using HAP based communication system

- Quasistationary position
- Low propagation delays
- High elevation angles and line-of-sight links
- Nearly free-space radio propagation
- Large coverage area
- Broadcast/multicast capability
- Broadband capability with cellular architecture
- Small size of antenna and user terminal equipment
- Rapid and incremental deployment (supporting phased roll-out)
- Easy maintenance and upgrading of the payload
- Flexibility to be reprogrammed in case of emergency





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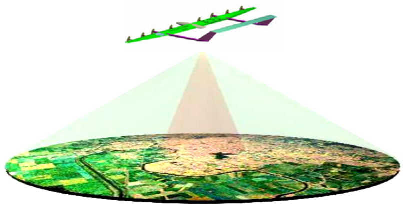
HAP based communication system - benefits

- High Altitude Platforms as an alternative/complement to terrestrial and satellite infrastructure for providing broadband wireless access in remote and hard to reach areas
- Based on unmanned airships and manned/unmanned aircrafts
- Particularly well-suited for temporary provision of basic or additional capacity requirements, e.g. for short-term large-scale events and establishment of ad-hoc networks for disaster relief.



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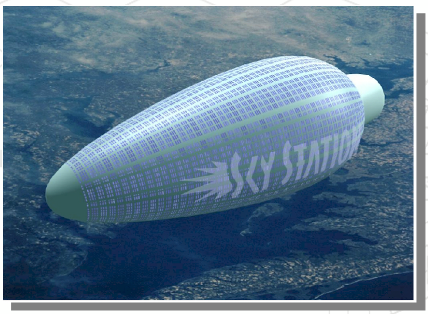
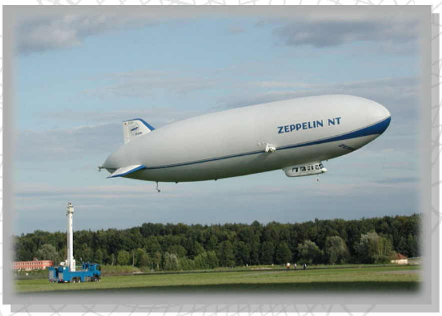
Types of high altitude platforms (1)

- Lighter-than-air
  - Unmanned solar- / fuel-cell powered baloons and airships
    - ⇨ Stay aloft from several days to several months
    - ⇨ Large available power and weight for the payload





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Types of high altitude platforms (2)

- **Heavier-than-air**
  - Manned piston- and jet-powered airplane
    - ⇨ In operation only from several hours to several days at the time
    - ⇨ Medium available power and weight for the payload
  - Unmanned solar- / fuel-cell powered vehicles resembling airplane
    - ⇨ Operational for several months
    - ⇨ Small available power and weight for the payload

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Critical HAP system design issues (1)

Aeronautics development

- Movement of the aerial platform around stationary position
  - Flight trajectory
  - Drift due to winds and pressure variations
- Aerodynamics of the platform
- Energy source
  - Fossil fuel
  - Combination of solar and fuel cells or solar cells and bateries

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Critical HAP system design issues (2)

Payload development

- Capacity / bandwidth (link budget for uplink and downlink)
  - Multiple access technique
  - Modulation and coding techniques
  - Size of antenna on the aerial platform
  - Cellular architecture, antenna beam shapping and resource mngt.
  - HAP antenna directivity (pointing, acquisition and tracking)
  - Intra and inter cellular interference
- Feasibility of interplatform links and links to satellites
  - Link budget
  - Pointing, acquisition and tracking requirements

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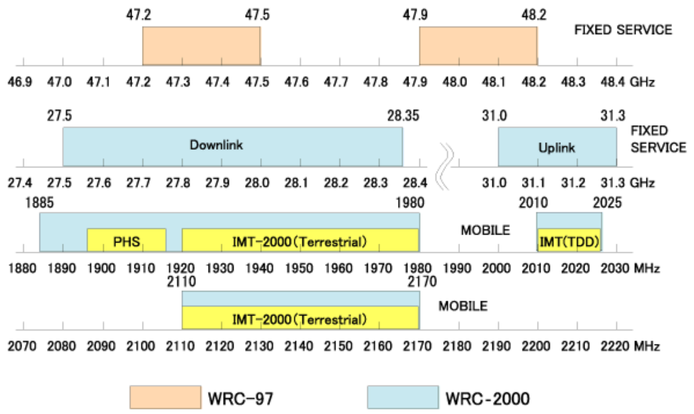
ITU-R spectrum allocation



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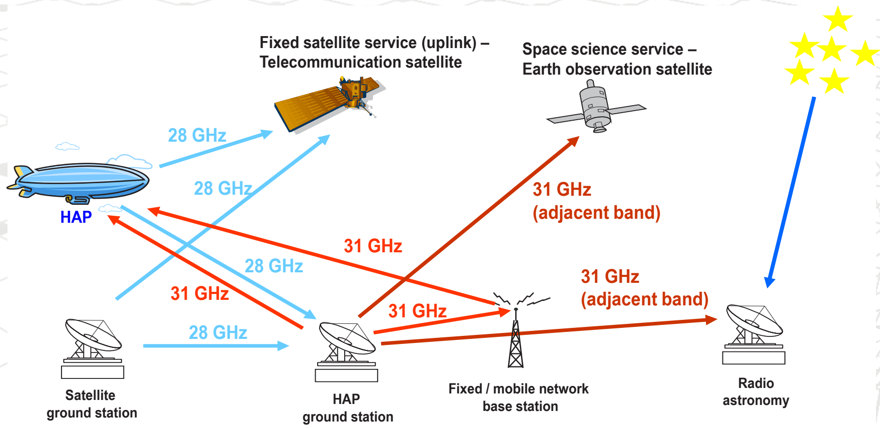
In-band and adjacent band interference



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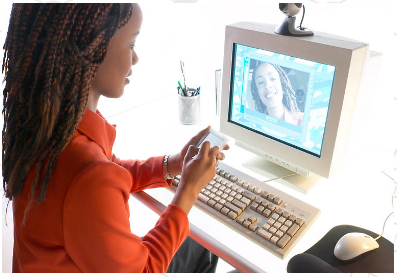
Potential services in HAP systems (1)

- Fixed network services
  - Broadband internet access
  - VoIP
- Interactive broadcast / multicast services
  - DTV and HDTV
  - VoD
  - News
  - ...



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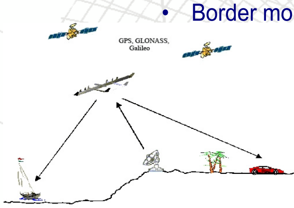
Potential services in HAP systems (2)

- Mobile network services
  - 3G mobile services and beyond
  - Broadband wireless access from public and private transport means
- Other potential services
  - Environmental monitoring
  - Traffic montoring and navigation
  - Weather observation
  - Remote sensing
  - Emergency and disaster relief communications
  - Radiolocation,
  - Border monitoring, …



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Candidate broadband communication standards (1)

- IEEE 802.11 standards
  - Short range if using non-modified equipment
  - Low operating frequencies (2.4 GHz and 5 GHz)
  - Low data rates - nominally up to 54 Mbps, in reality below 30 Mbps
- IEEE BWA standards
  - IEEE 802.16-SC provides high data rate and supports HAP operating frequency bands (10-66 GHz) but has no support for mobility management and requires LOS
  - IEEE 802.16a supports moderate to high data rates, it does not require LOS conditions, but operates at frequencies below 11 GHz
  - Standards supporting mobility (IEEE 802.16e and IEEE 802.20; under development) will support significantly lower data rates

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Candidate broadband communication standards (2)

- ETSI BWA standards
  - ETSI HiperACCESS provides high data rate, supports operation in lower HAP-designated frequency band (31/28 GHz), has no support for mobility management and requires LOS
  - ETSI HiperMAN supports moderate to high data rates, operates at frequencies below 10 GHz and it does not require LOS; there is no support for mobility management
- DVB-S/S2/RCS/SH
  - Supports operating frequency bands but highly asymmetric UL / DL
  - Sufficient data rates supported in the downlink (particularly with DVB-S2) but very low data rates on the uplink
  - No mobility management and LOS operation only
  - DVB-SH particularly suitable for hybrid satellite-stratospherc-terrestrial system deployment

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System and network architecture

- System design alternatives
  - standalone vs. multiple platform constellations
  - transparent payload vs. switching payload
- Network architectures
  - standalone platform scenario
  - scenario with the network of platforms connected via:
    - ⇨ ground stations (GSs)
    - ⇨ interplatform links (IPLs)
  - integrated satellite/HAP/terrestrial scenario with interplatform and platform-to-satellite links (PSLs)

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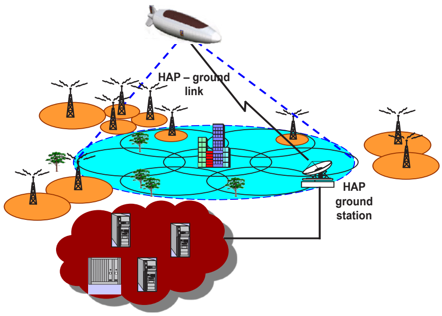
Standalone platform



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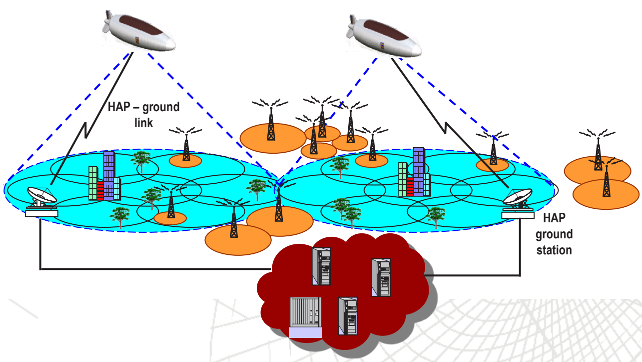
Network of aerial platforms without IPLs



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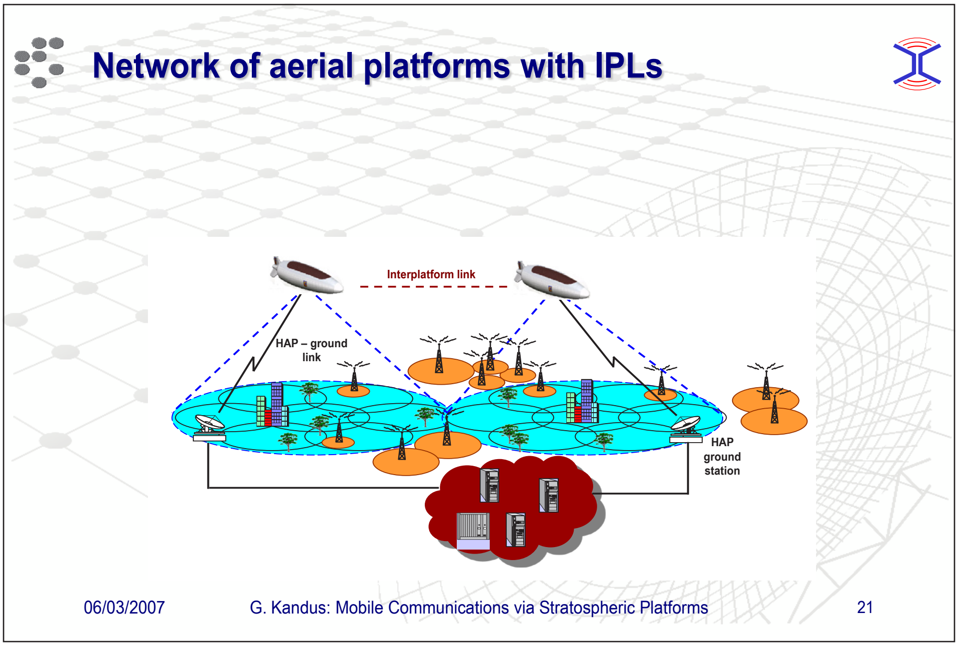
Network of aerial platforms with IPLs
Interplatform link
HAP – ground link
HAP ground station
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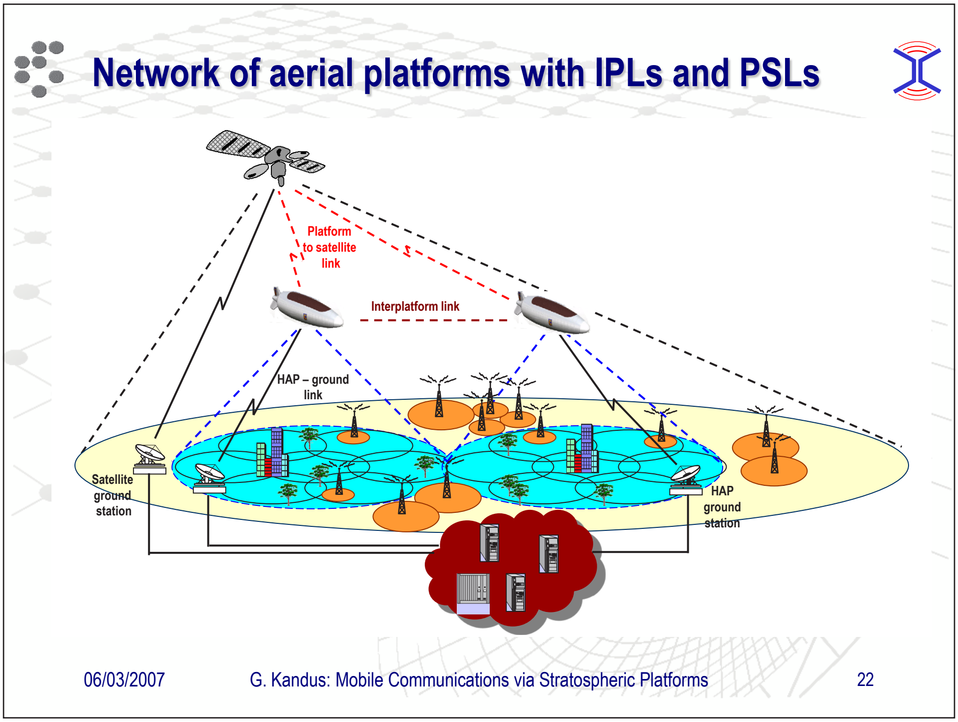
Network of aerial platforms with IPLs and PSLs
Platform to satellite link
Interplatform link
HAP – ground link
Satellite ground station
HAP ground station
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Constellations of multiple aerial platforms

- Motivation for deployment of a network of HAPs
  - Increase system coverage area – interesting for phased deployment of the network
  - Increase system availability using the concept of site diversity, i.e. several HAPs transmitting the same signal on DL, for UL the ground terminal needs to be equipped with multiple transmission chains – particularly interesting for the emergency and disaster relief communications (counteract unfavourable propagation conditions in *mm* wave bands)
  - Increase system capacity through the use of highly directional antennas (making use of spatial discrimination) – interesting for densely populated areas

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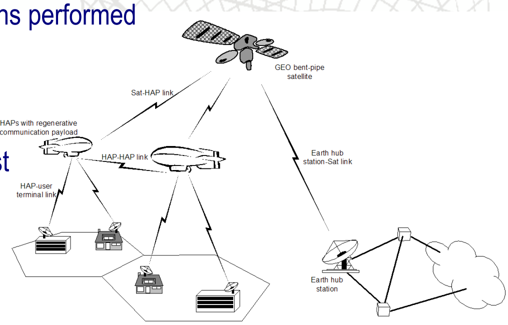
Integrated satellite/HAPs/terrestrial network

- Motivation for integration of multiple communication segments:
  - for different coverage areas from pico cells to macro cells
  - to provide intermediate communication segment between the satellite and mobile users allowing the use of smaller terminal equipment
  - for the provision of reliable multicast with local/regional retransmissions performed by HAPs using cached data
  - to implement a broadcast/ multicast layer for Satellite Digital Multimedia Broadcast (SDMB) to 3G terminals



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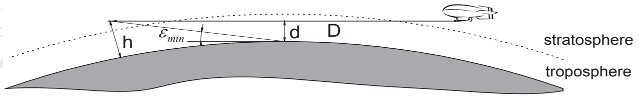
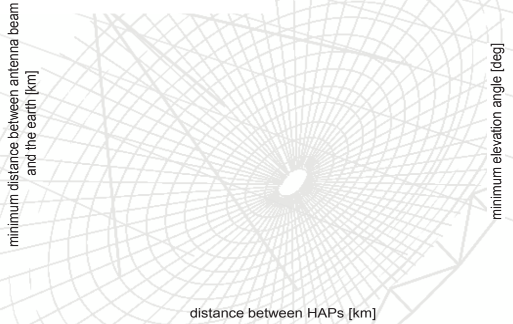
Interplatform Links



D - distance between HAPs
d - minimum distance between antenna beam and surface of the earth
h - HAP altitude
ε_{min} - minimum elevation angle

PROs and CONs

+ independent of terrestrial network infrastructure
+ reducing the traffic load in terrestrial network
+ flexibility w.r.t. coverage area
+ reduced e2e delay
- payload complexity, weight and power consumption
- demanding antenna PAT requirements



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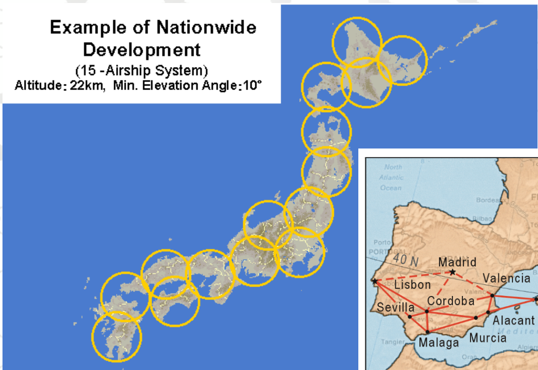
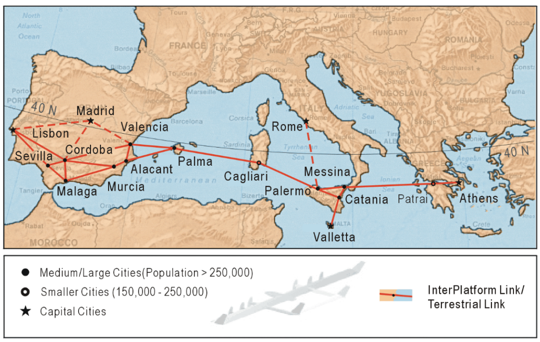
Network of HAPs for basic communication services





Example of hot-spot coverage with interlinked HAPs

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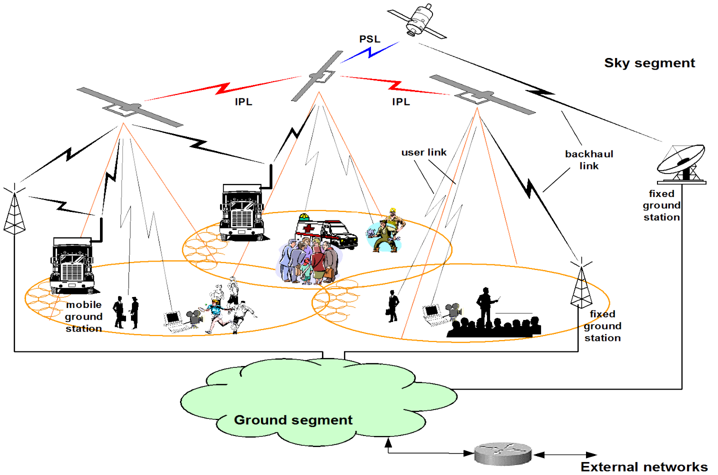
HAP system for event servicing and emergency communications

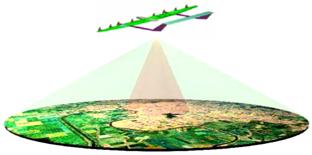


R&D projects related to communications via HAP

- Major R&D investments in HAP communications:
  - Europe
    - ⇨ FP5 project HeliNet
    - ⇨ FP6 project CAPANINA
    - ⇨ private initiative by Stratxx (see www.stratxx.com)
  - Japan
    - ⇨ NICT, JAXA and JSC (cooperation with NASA and AeroVironment Inc.)
    - ⇨ Emphasis on trials and demonstrations
  - Korea
    - ⇨ ETRI, KARI and SK-Telecom

EU FP5 IST project HeliNet (1)

- Network of Stratospheric Platforms for Traffic Monitoring, Environmental Surveillance and Broadband Services
  - January 2000 – May 2003
  - The consortium
    - ⇨ Academics: Politecnico di Torino, Universita Politecnica de Catalunya, University of York, Ecole Politechnica Federale de Lausanne, Technical University of Budapest, Jozef Stefan Institute
    - ⇨ Industries: Carlo Gavazzi Space, EADS/CASA, Enigmatech, Fastcom
  - Main features
    - ⇨ Operating altitude ~ 17 km
    - ⇨ Position; quasi-stationary circular flight with small (~ 1 km) diameter
    - ⇨ Payloads mass ~ 100 kg
    - ⇨ Available power for payloads ~ 800 W



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EU FP5 IST project HeliNet (2)

- Aeronautics and energetics design
  - Platform design (advanced composite structures)
  - Fuel cells, solar cells, electric motors and propellers efficiencies
  - Manufacturing of a scale-sized (1:3) technological demonstrator
- Applications
  - Traffic monitoring, positioning and navigation
  - Environmental surveillance, intelligent on-board data processing
  - Broadband communication

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EU FP6 IST project CAPANINA

- EU FP6 IST project CAPANINA
  - November 2003 – January 2007
  - 13 partners + Japanese collaborator
- Objectives
  - To develop broadband technology from HAPs aimed at providing efficient ubiquitous coverage to users marginalised by:
    - ⇨ geography,
    - ⇨ distance from infrastructure,
    - ⇨ those travelling inside high-speed public transport vehicles
  - To deliver burst data rates of up to 120 Mbit/s to fixed users and to vehicles travelling at up to 300 km/h
  - To consider mm-waveband and free-space optical communications technologies

CAPANINA

University of York (UK)
- York Electronics Centre
- Department of Electronics

Jozef Stefan Institute (SL)
Politecnico di Torino (I)
Universitat Politecnica de Catalunya (ES)
Carlo Gavazzi Space (I)
Budapest University of Technology & Economics (HU)
DLR (D)
BTexact (UK)
SkyLINC Ltd (UK)
EuroConcepts Srl (I)
CSEM (CH)
Contraves AG (CH)
National Institute of Information and Communications Technology of Japan

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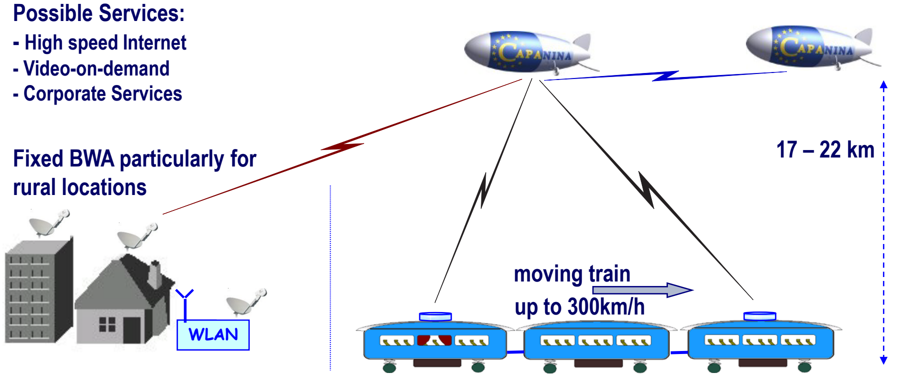
The CAPANINA scenario

Up to 120Mbit/s

31/28GHz, (47/48GHz)
+ optical backhaul & interplatform

Possible Services:
- High speed Internet
- Video-on-demand
- Corporate Services

Fixed BWA particularly for rural locations



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Trials related to communications via HAP

- Selected recent successful trials involving HAP communications:
  - Pathfinder, 2002 (NASA, AeroVironment, CRL) - part of Japanese project
  - SkyNet, 2004 (JAXA) - part of Japanese project
  - CAPANINA, FP6 IST Project
    - ⇨ Pershore, UK, 2004
    - ⇨ ESRANGE, Kiruna, Sweden, 2005
    - ⇨ Camp Roberts (CA), USA, 2006

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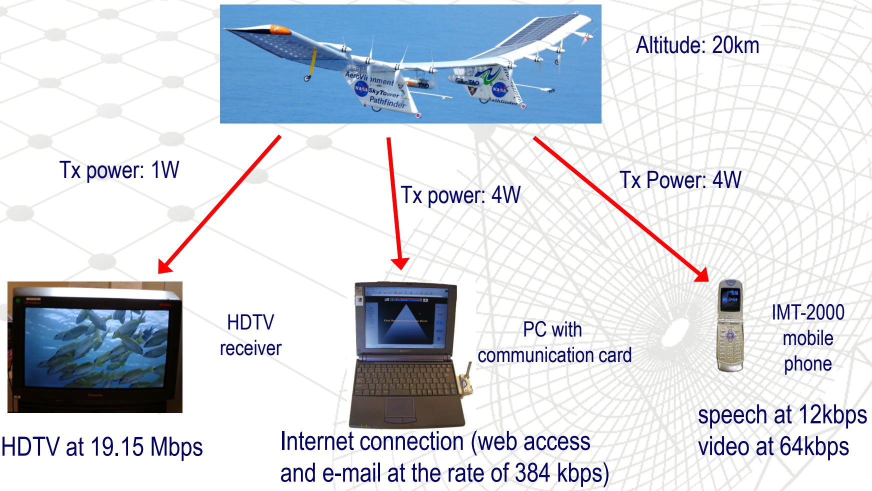
Pathfinder trial, 2002 (NASA, AeroVironment, CRL)

World first stratospheric telecommunication (3G mobile) and broadcasting (HDTV) test



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SkyNet trial, 2004 (JAXA)

- Testing optical interplatform link
- Digital signal broadcasting in UHF band
- Station-keeping flight test

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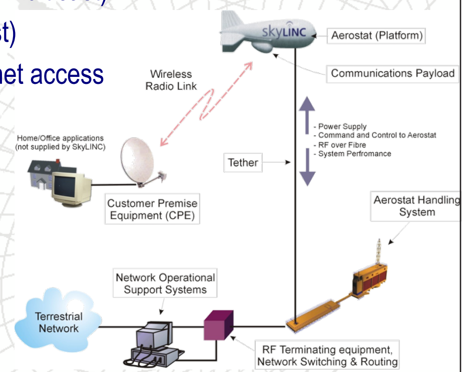
CAPANINA Trial 2004, Pershore, UK

- 300 m altitude 15 m tethered aerostat
- Fixed Wireless Access test + applications:
  - Internet access
  - Streaming audio/video media (IP multicast)
  - Constent distribution (IP multicast)
  - WiFi backhauling and WiFi Internet access
- Optical communications test
- Propagation measurements



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CAPANINA Trial 2005, Kiruna, Sweden (1)

- Stratospheric balloon at 24 km for 9 hours
- Mm-wave communication system (Experiment A)
  - to demonstrate broadband mm-wave wireless access from a stratospheric balloon with data rates up to 11 Mbit/s (using modified off-the-shelf IEEE 802.11b equipment)
  - to demonstrate adaptive coding and modulation
  - to demonstrate a range of applications:
    - ⇨ Video streaming
    - ⇨ Audio download
    - ⇨ Video download
    - ⇨ Web browsing
    - ⇨ Email
    - ⇨ File upload
    - ⇨ Webcam (surveillance)

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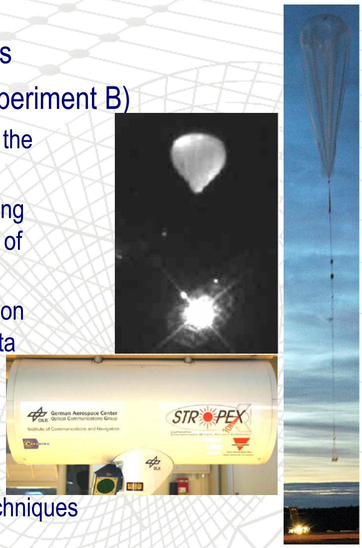
CAPANINA Trial 2005, Kiruna, Sweden (2)

- Stratospheric balloon at 24 km for 9 hours
- Laser-optical communication system (Experiment B)
  - verified robustness and proper functioning of the onboard FSO communication subsystem
  - validated the Pointing, Acquisition and Tracking (PAT) system for the automatic maintenance of the FSO link
  - first known successful optical data transmission from the stratosphere to a ground station (data rates up to 1,25 Gbit/s, bit error rate better than 10^{-9})
  - several Gbytes of very useful turbulence data gathered: useful in order to simulate inter platform links and develop mitigation techniques



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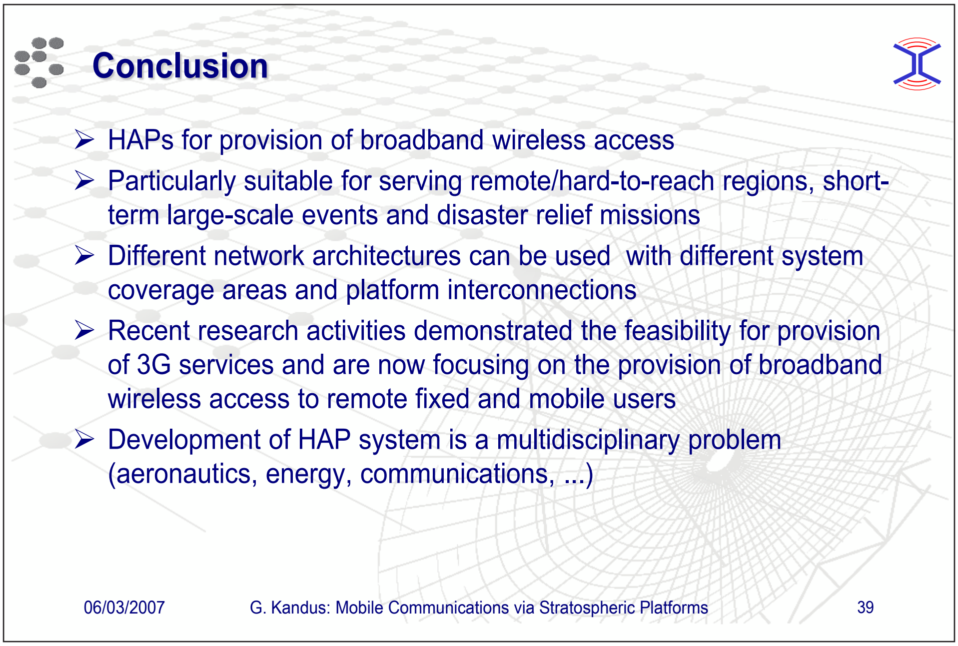
Conclusion
HAPs for provision of broadband wireless access
Particularly suitable for serving remote/hard-to-reach regions, short-term large-scale events and disaster relief missions
Different network architectures can be used with different system coverage areas and platform interconnections
Recent research activities demonstrated the feasibility for provision of 3G services and are now focusing on the provision of broadband wireless access to remote fixed and mobile users
Development of HAP system is a multidisciplinary problem (aeronautics, energy, communications, ...)
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