

# An Integrated Aerial Telecommunications Network that Supports Emergency Traffic

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# Outline

- Introduction
- Context of the study
- Considered aerial communication architecture
- Emergency traffic requirements
- Conclusion

# Introduction

**In the wake of a disaster, how can emergency operations rely on an efficient emergency communications system?**

- Terrestrial networks may be compromised.
- Alternative communications systems may themselves prove suboptimal.
- Network failures and interoperability issues can hinder rescue effort.

**Aerial platforms are seen as a possible extension or alternative to traditional terrestrial and satellite emergency networks.**

## Aerial equipments: examples of form factors

Aerostats, a.k.a. "Lighter Than Air" (LTA)

Aerodynes



Tethered balloons

Aerostats

Unmanned aircrafts

Manned aircrafts

Unmanned Aerial Vehicles (UAV)

### LAPs:

- Low Altitude Platforms, altitudes of 100s to 1000s meters.
- Each LAP can cover a few km wide.
- Low starting costs

### HAPs:

- High Altitude Platforms a.k.a. stratospheric vehicles, generally positioned at 17-22 km altitude.
- Each HAP can cover 60-400+ km wide.
- Expected cost per unit 4-50 M€.

## Motivations

- Design an integrated and dynamic multi-purpose aerial infrastructure that can be extended with fast-deploying airborne platforms.
- Assert the impact of typical emergency services needed by rescuers on the required capacity and coverage of the considered network.

## Related works

Several studies identified the benefits of aerial platforms for the support of emergency communications:

Low altitude:

- LAPs represent a fast and convenient way to experiment telecommunications payloads with relatively inexpensive aerial vehicles.
- LAPs can also address actual scenario requirements where limited coverage, due to low altitude, is acceptable.
- A performance evaluation in Indonesia of a simple tethered balloon, flying at a maximum altitude of 440 m, covering an area of about 72 km<sup>2</sup> and carrying a 802.11a/g payload.

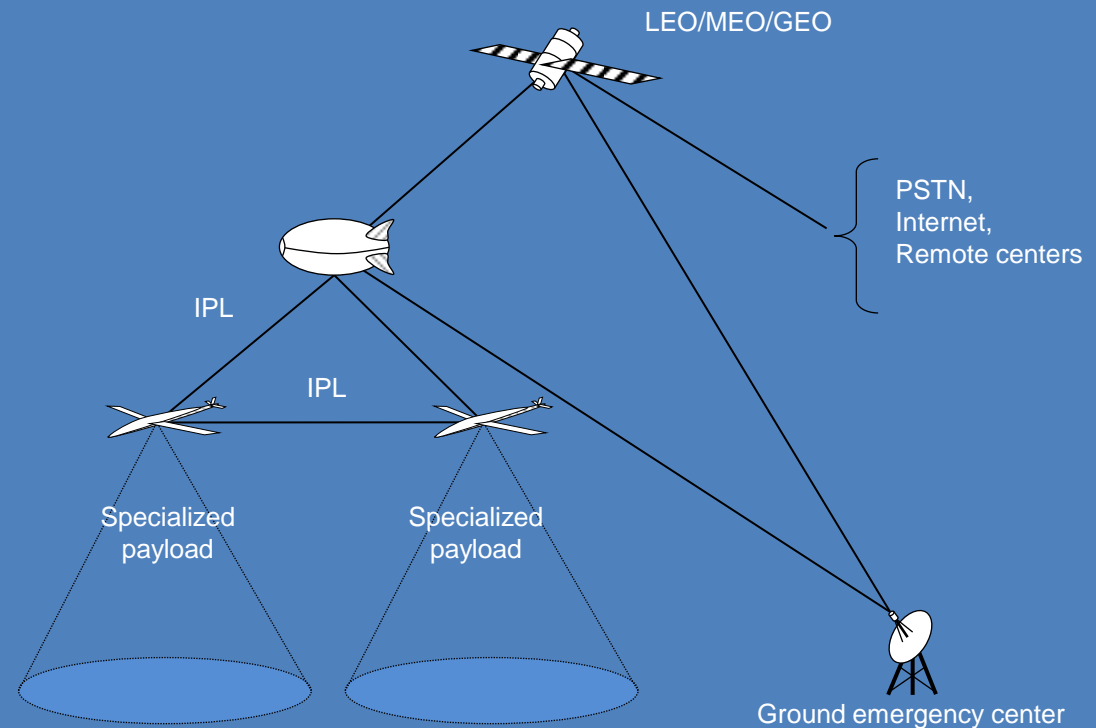
High altitude:

- HAPs can complement satellites to recover communications in disaster-affected areas
- An investigation on the use of aerial networks for the support of emergency communications for electric power systems. HAPs can favorably meet the stringent needs of power grid security in terms of both bandwidth and especially delay.

## A flexible aerial telecommunications architecture

Aerial telecommunications network (ATN):

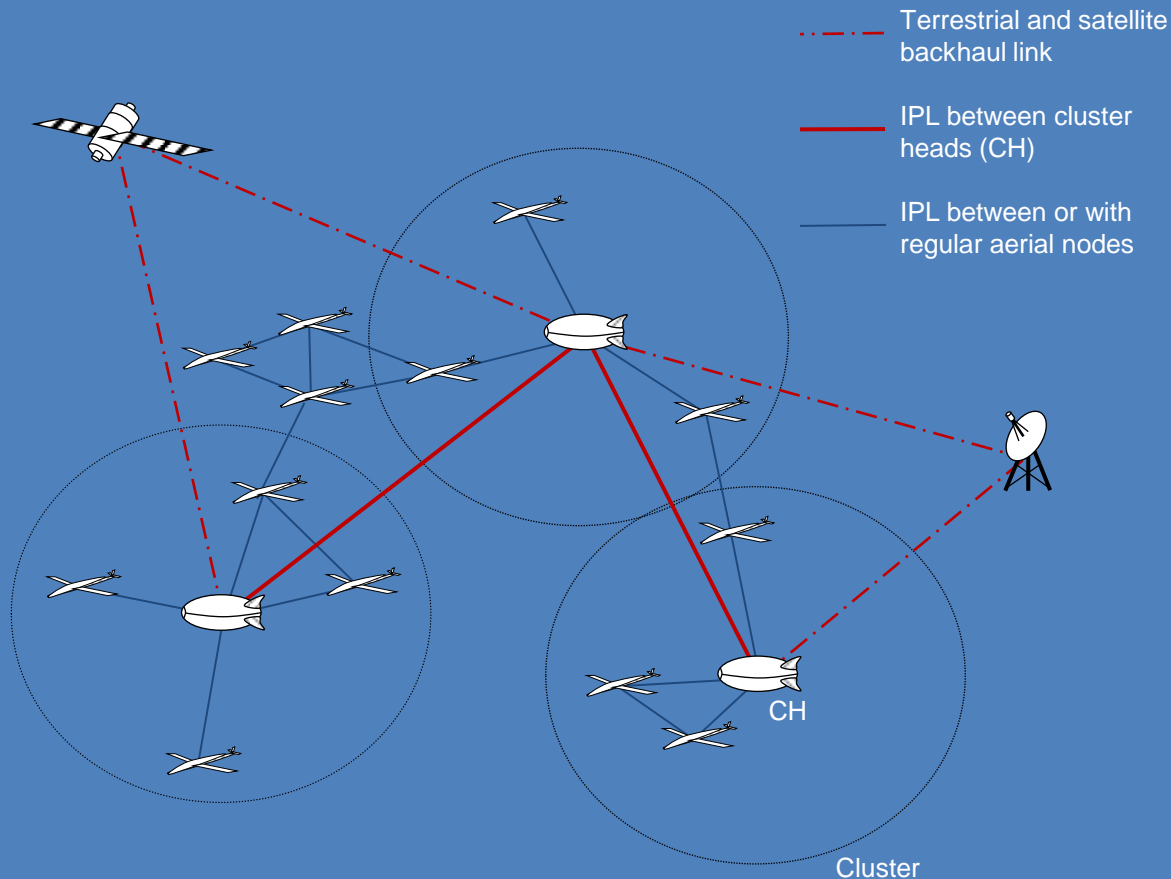
- A collection of aircrafts able to communicate with other nodes through adapted payloads.
- A multi-level hierarchical aerial topology, e.g.:
  1. Higher level: 1+ quasi-stationary aerial vehicle(s), integrated to satellite and terrestrial networks via high-capacity links.
  2. Lower level: all the nodes that are set up and deployed for specific recovery missions.



## A clustered aerial telecommunications architecture

Optionally, the ATN may be hierarchically partitioned:

- This topological representation offers many advantages, e.g. an adapted large scale routing protocol could differentiate links (backhaul links and Inter-Platform Links, IPL)
- Adapted when higher- and lower-level IPL do not use the same radio technologies and the same types of antennas





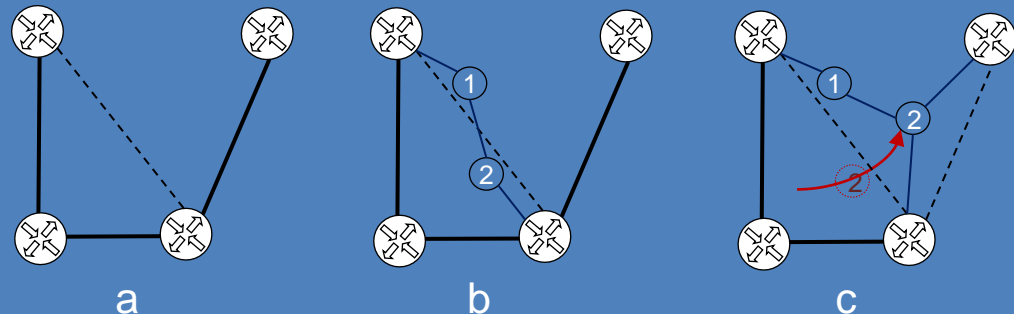
## A dynamic aerial telecommunications architecture

### Controlled mobility:

- A base network, experiencing troubles may be temporarily supplemented with additional wireless dirigible nodes.
- Ground staff can be partially relieved of remote topology control and vehicle guidance tasks.

### Several deployment schemes, e.g.:

- LAPs as base network, while controlled mobility is applied to the HAPs. HAPs are then moved to provide maximum coverage and bandwidth to the base network.
- HAPs as base networks, while controlled mobility is applied to the LAPs. LAP default mobility patterns will be altered to extend the base network capacities where it is best needed.



### The concept of controlled mobility:

- Case a: a communication link (dotted lines) cannot meet the traffic demand.
- Case b: mobile nodes are moved so that an additional multi-hop route is established between the nodes with the mentioned link.
- Case c: If another link experiences troubles, the mobile nodes can be moved accordingly.

# Emergency traffic requirements

## Approach:

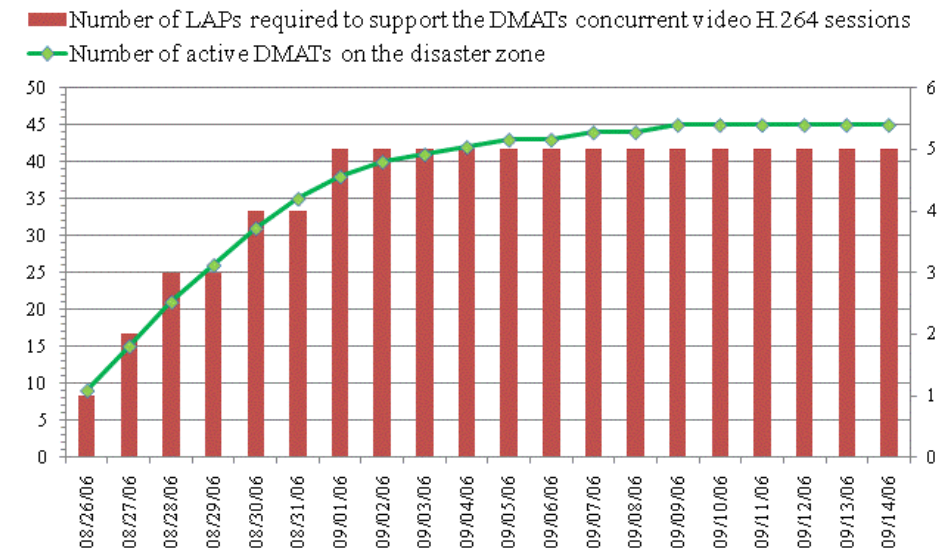
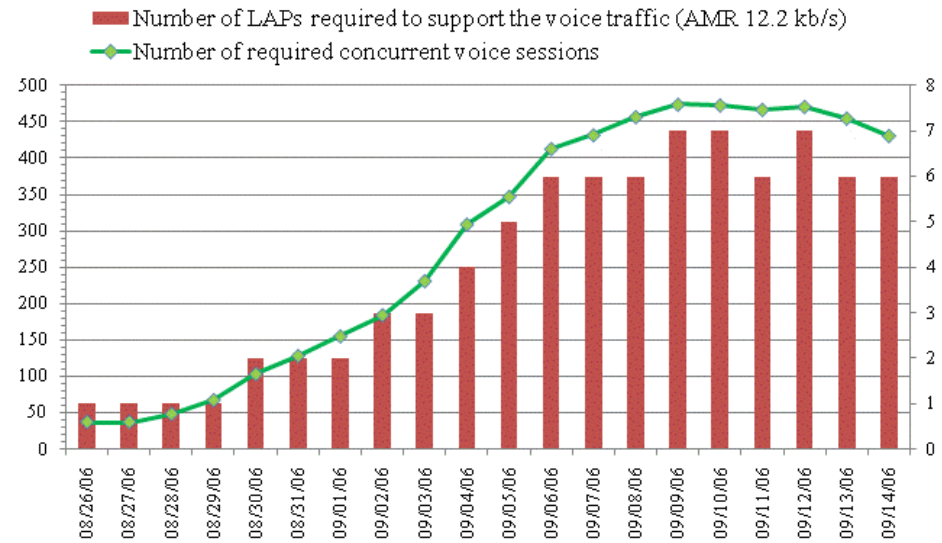
- We chose to estimate the global voice emergency and medical care video traffics.
- Contextualized estimation. Parameters consistent with the 2005 Hurricane Katrina disaster.
- Aerial platforms chosen for the estimation: LAPs evolving at an altitude of 440 m with an achievable capacity of 54 Mb/s over IEEE 802.11g links, each LAP able to cover a zone of 47.39 km<sup>2</sup>.

## Voice emergency traffic estimation

- Defined as the total number of emergency voice calls passed by the public and first responders.
- Based on the traffic pattern estimated in [Deaton, 2008].
- Daily traffic normalized (daylight rescue), busy hour traffic calculated and taken as a conservative value.
- Based on the support of AMR codec @ 12.2 kb/s, a sample period of 20 ms and a MOS of 3.8.

## Video emergency traffic estimation

- Defined as the video traffic generated by the Disaster Medical Assistance Teams (DMATs).
- 2 active video streams per DMAT at any time.
- 9 DMATs active at day 1, eventually 45 DMATs on site.
- video sessions based on the H.264 codec with a bit rate of 384 kb/s.



## Conclusion

- ☺ Capacity: a maximum 12 LAPs are required to support the aggregated traffic.
- ☹ Coverage: in our example, the maximum covered LAP area without overlap is 568.68 km<sup>2</sup>, and covers less than 0.25% of the overall disaster area.

- This low ratio can always be balanced with several arguments (During Katrina rescue teams were concentrated in a few key locations, disaster zones are generally smaller, LAPs could be operated at higher elevations for a larger coverage, more LAPs could be used, and so on)
- However, the sustained performance of the considered architecture thus relies on the ability to take advantage of the integrated multi-platform network and to enforce controlled mobility. **These aspects are currently researched in the ANR RESCUE project (2011-2013)**

Thank you

Laurent Reynaud