

Status of Telecommunication in W-band and possible applications: satellite broadband connection and networks of mobile phones

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- **Motivation**
- **Challenges**
- **SoA and on-going activities**

Motivation

The new generation of High Throughput Satellite is based on the use of Ka-band and multi-beam coverage **(in 500MHz of bandwidth for the user terminal, the total throughput can go beyond 70Gbps in case of KA-SAT.)**

The demand for more capacity per home will continue to increase

For satellite systems to remain attractive and keep up with the expectations of consumers, next generation HTS will be designed:

- to deliver higher and higher capacity (terabit?)
- with a quality comparable to FTTH and
- **at the current consumer price.**



Need to go towards higher frequency bands to increase the available bandwidth

Which frequencies bands we are talking about?

KA-BAND

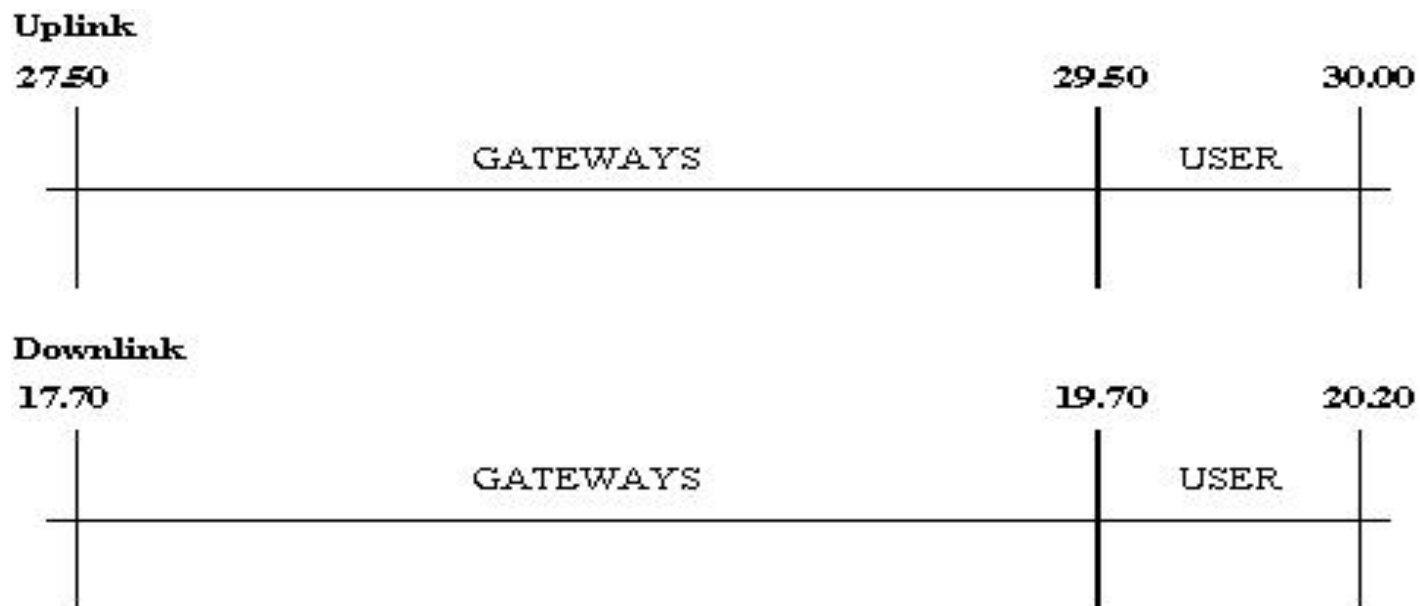


Illustration of **Ka-band** Frequency Spectrum in ITU Region 1



2.5 GHz uplink and 2.5 GHz downlink

Which frequencies bands we are talking about?

Q/V-BAND

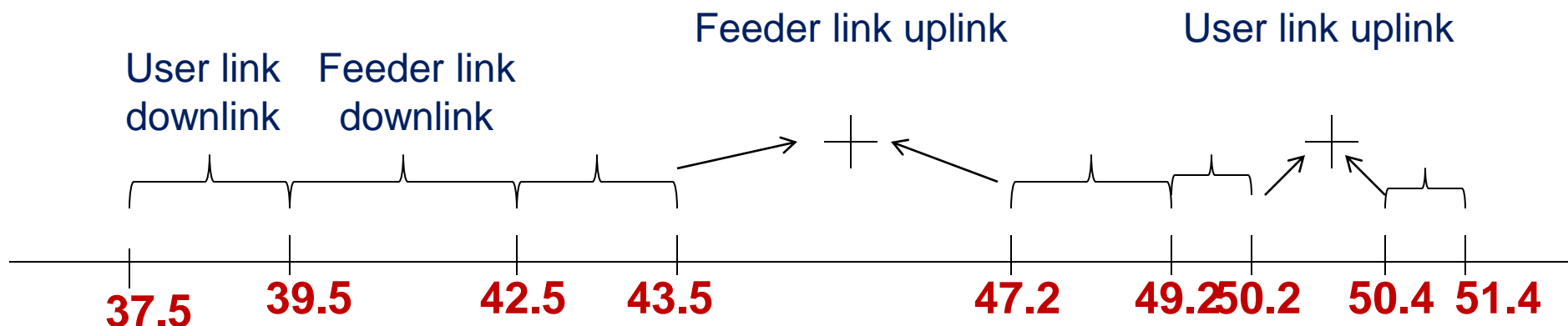
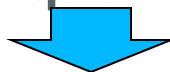


Illustration of Q/V-band Frequency Spectrum in ITU Region 1



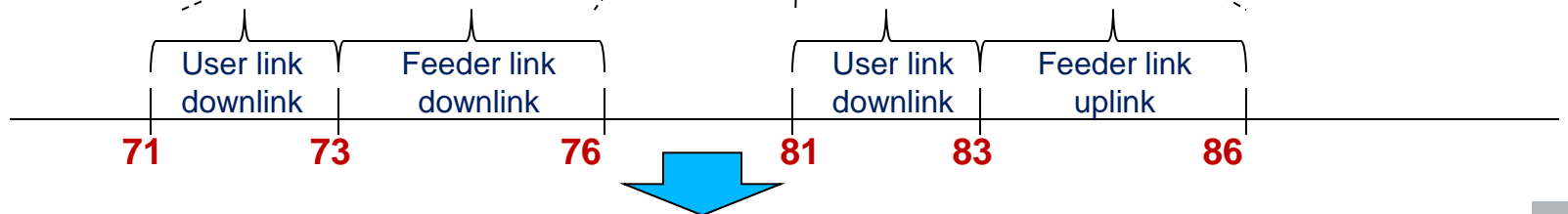
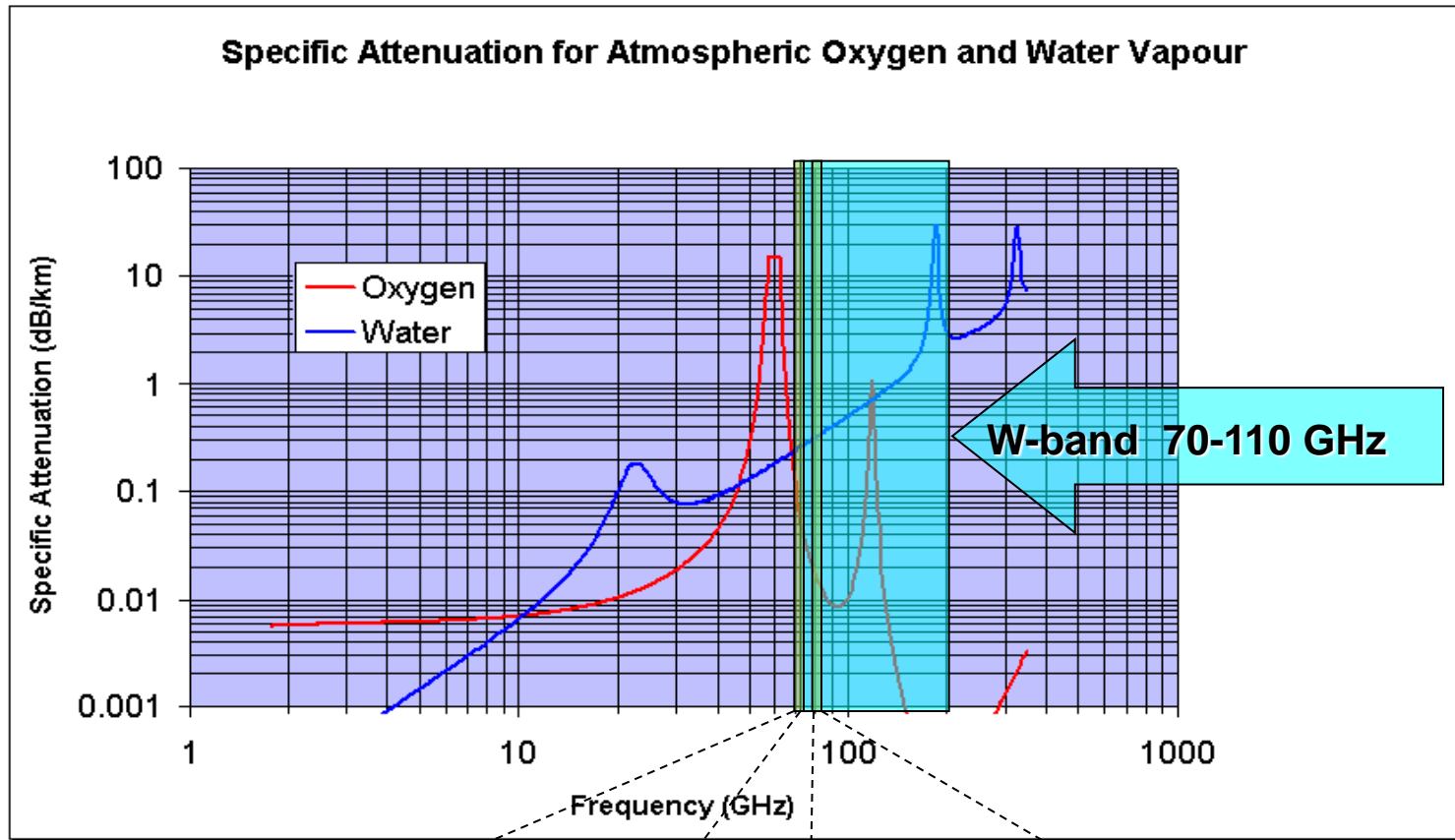
5GHz in uplink and 5GHz in downlink
with some restrictions...

Currently, the use of beyond Ka-band frequencies **ONLY** for the feeder links, is an interesting option as it would overcome the problems related to the still high costs for user terminal at such high frequencies and it would allow a maximization of both the terminal spectrum (with a consequent increase of the system capacity) and the gateway spectrum (with a consequent minimisation of the number of gateways and the associated costs).

In Q/V band there are already ASI/ESA on-going experimental missions (Alphasat TDP#5 'Aldo Payload').

The next step is W-band!

Motivation



5GHz in uplink and 5GHz in downlink can be made available

Challenges

Well known challenges when going to such high frequency bands are:

- **Channel propagation impairments (in particular rain and clouds attenuation);**
- **Need for Propagation Impairments Mitigation Techniques (PIMT);**
- **Power generation, in particular broadband high power amplifiers;**
- **Non linear behaviour of HPA;**
- **Phase Noise;**
- **Unavailability on energy-efficient high resolution A/D converters for bandwidth of several GHz.**

Status of the Art and on-going Activities

Alphasat TDP5 “Aldo Payload” on-going experiments

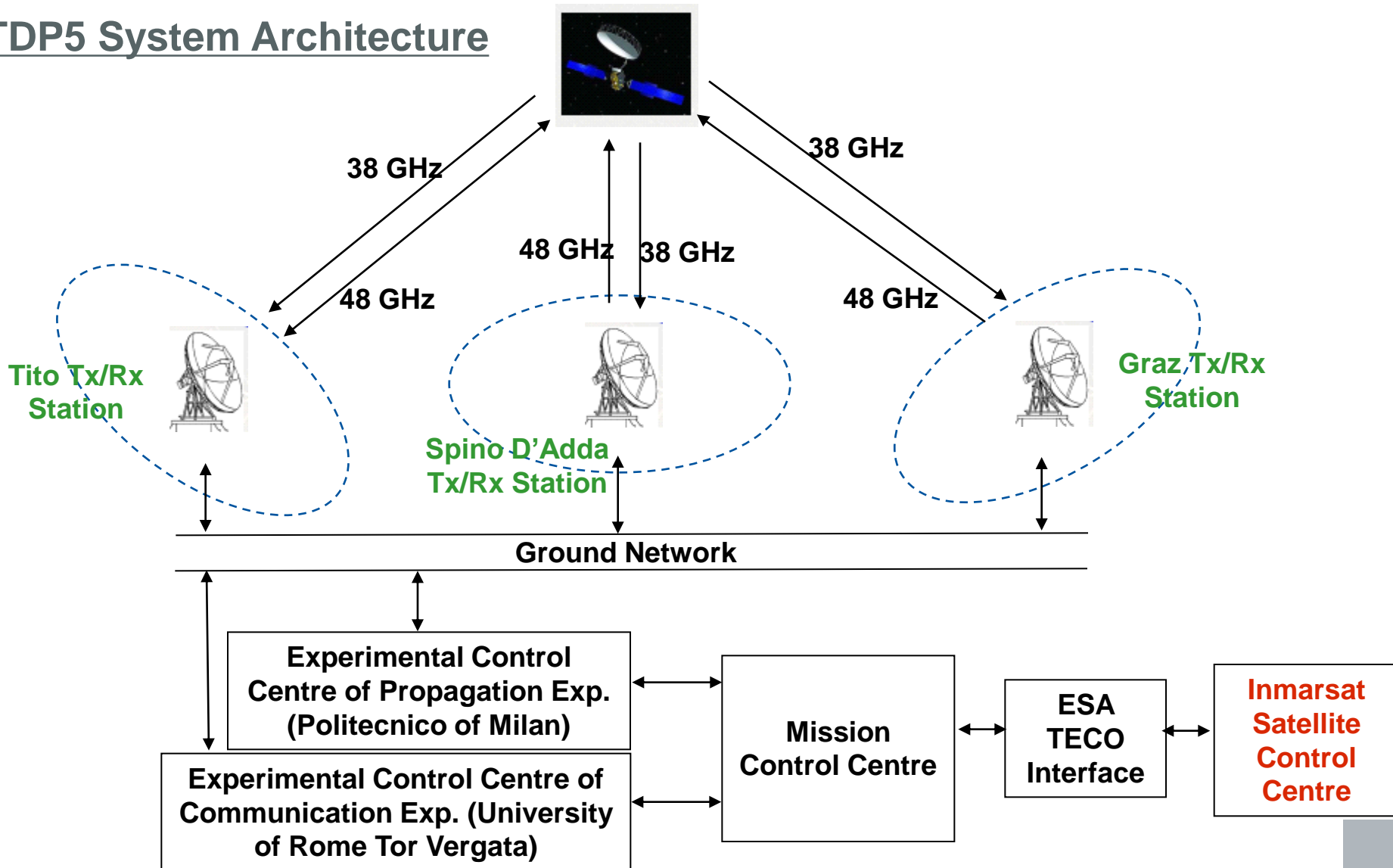
The main objective of the **telecommunication experiments of TDP5** mission is to demonstrate the feasibility of broadband satellite communications in Q/V band, **optimizing and assessing, over-the-air, the performance of the indispensable adaptive access techniques.**

- Alphasat was successfully launched on July 25, 2013, from the European Spaceport in Kourou (French Guiana) via the Ariane 5 rocket;
- IOT phase completed at the end of 2013;
- **Scientific experiments started at the beginning of 2014**



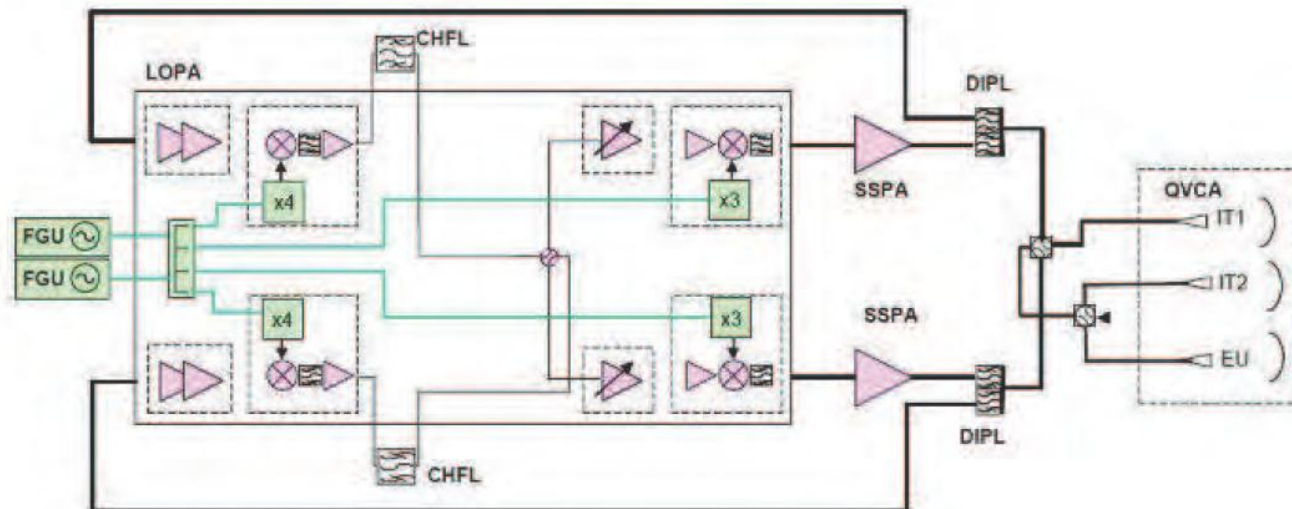
Status of the Art and on-going Activities

TDP5 System Architecture



Status of the Art and on-going Activities

Communication Experiment Payload



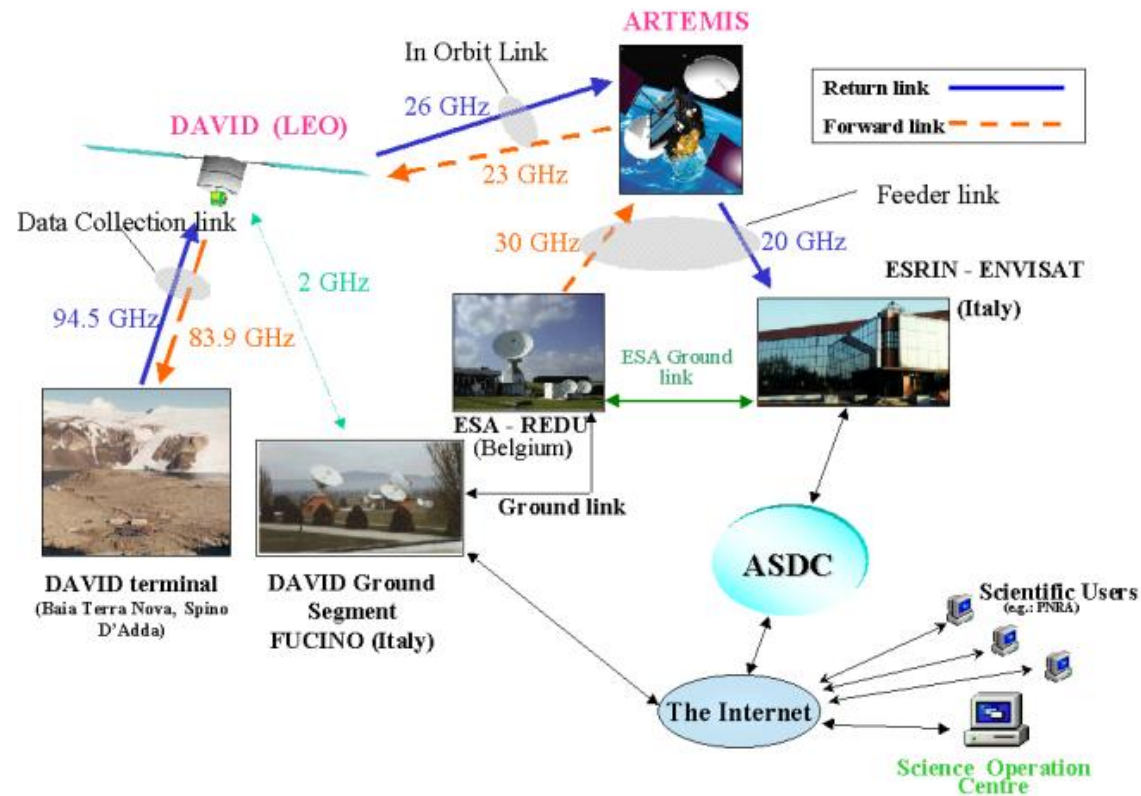
Status of the Art and on-going Activities

DAVID (Data and Video DAta and Video Interactive Distribution) Project

“Small Missions for Science and Technology”
Programme of the Italian Space Agency

Pioneering the use of W-band for an experimental collection of high data volume

Phase B completed (2003)

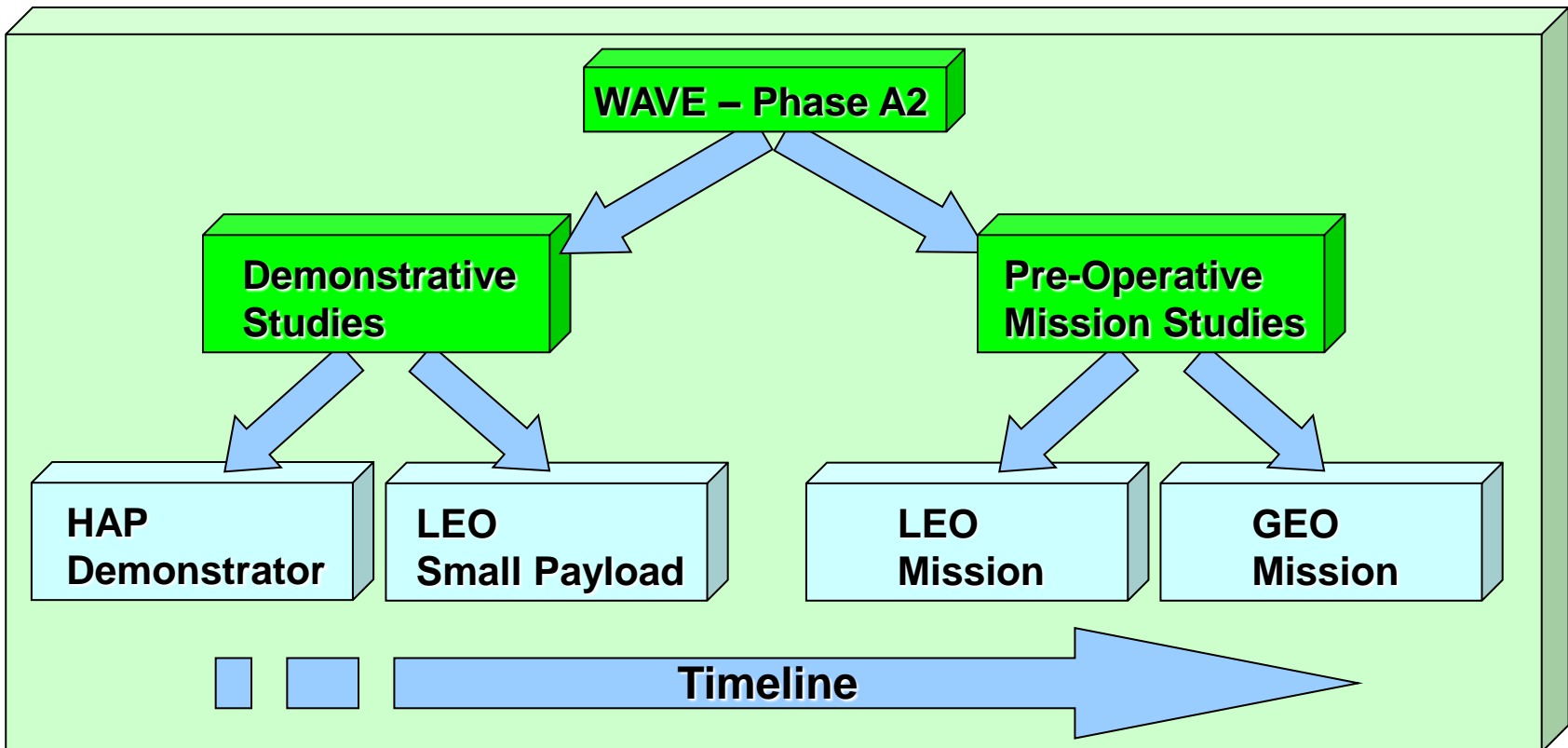


Status of the Art and on-going Activities



WAVE (W-band Analysis and VERification) Project (2008)

Feasibility Study for Telecommunication Payloads operating in the W band (Phase A & A2).



Status of the Art and on-going Activities

Together with the design of the GEO Mission the following studies have been carried out:

- **HAP** (High Altitude Platform) **demonstrative payload** aiming to provide a first atmospheric channel characterisation in W band → Aero-WAVE Project;
- small **LEO payload** aiming to **perform the first in-orbit test of W band hardware** → IKNOW (In-orbit Key test and validation Of W-band) Project ;
- LEO payload, a pre-operative mission with the same objectives of the GEO payload with a Ground-LEO-Ground link type → WAVE-LEO Mission;

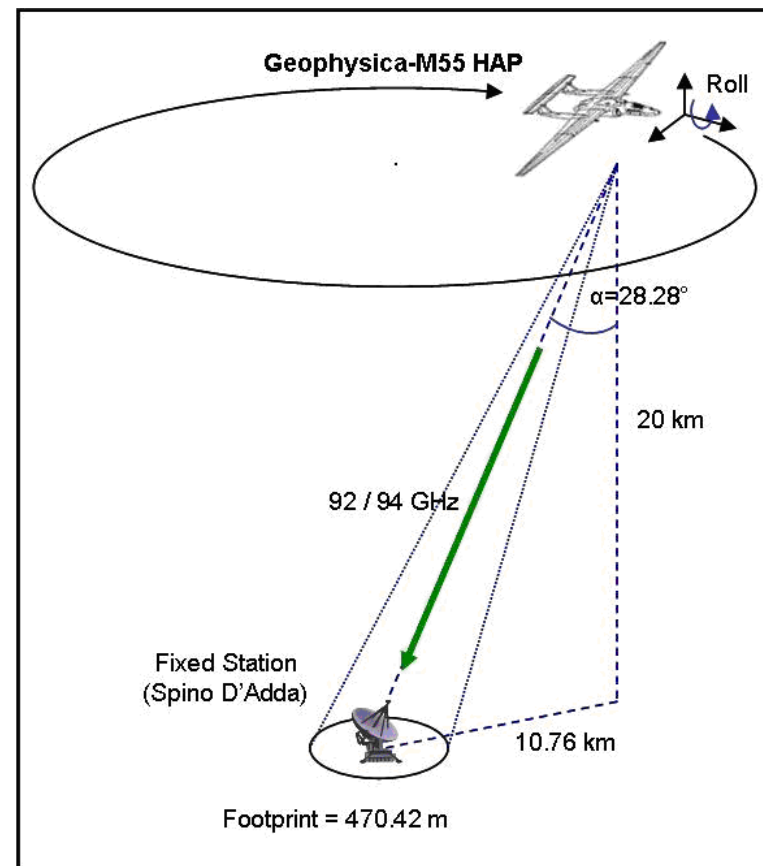
The feasibility study provided a complete W band P/L development line.

Status of the Art and on-going Activities

WAVE – Aero-WAVE System Configuration

Main Goals:

- To provide a **first atmospheric channel characterisation** by transmitting a beacon at ~95 GHz and data at ~94 GHz;
- hardware payload designed using **COTS components**, already existing and employed for terrestrial applications (e.g. radar); development time will be short and costs relatively low.

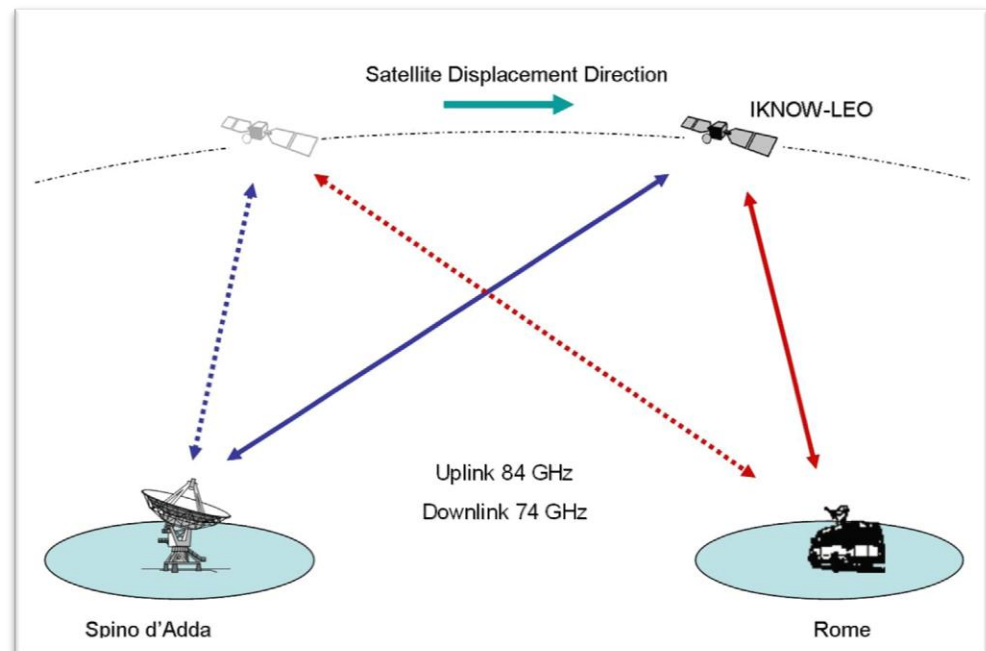


Status of the Art and on-going Activities

WAVE – IKNOW System Configuration

Main Goals:

- To gather a measurements dataset related to the **signal propagation in W band**, in order to develop a significant statistics on additional attenuation contributions (like rain and clouds); testing of W-band communication links
- To test **W band hardware and space qualification methodologies**, so getting first results to be used for future missions (LEO and GEO payload).



Status of the Art and on-going Activities

WAVE – IKNOW Payload full configuration

The full payload configuration foresees for the receiving section the **reception of a W band modulated signal to be used both to derive BER measurements and to carry out RF power measurements in uplink.**

Moreover, the addition of an **on-board radiometer** for data-gathering is foreseen as optional.

The **transmitter chain** is basically composed of a frequency generator which generates a modulated signal with Split-Phase (SP) Manchester-coded BPSK modulation, an up-conversion stage, a SSPA and finally a beacon generator.

Beyond Ka-band Satellite Communication Market Opportunities

The future beyond Ka-band satellite telecommunication applications will exploit the **large bandwidth availability**, that turns into a high system capacity, and the **antenna reduced dimension** (both on-board the satellite and on the user terminal).

The following future applications have been identified:

- Fixed Services:
 - **Broadband Multimedia Satellite Systems (BMSS)**, feeder link in Q/V/W band, service/user link in Ka band
 - **Backbone Connectivity Network (BCN)**;
- Mobile Services, in particular aeronautical ones (including UAV and HAPs);
- Space Services, in particular inter-satellite link for data relay;



Network for Mobile Applications