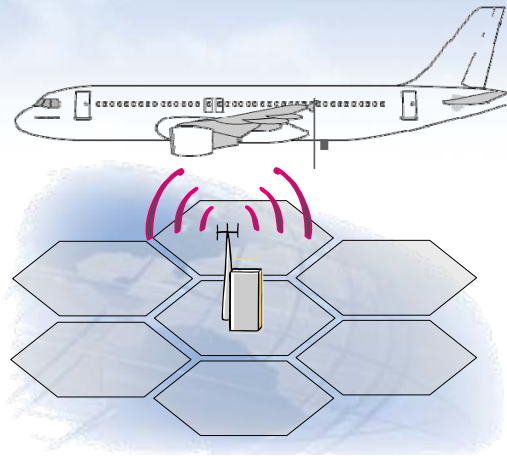


Direct Air-to-Ground Communication – Broadband for Planes (DA2GC – B4P)

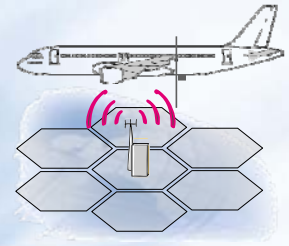


Broadband Direct Air-to-Ground Communication
Trial flight set-up and results

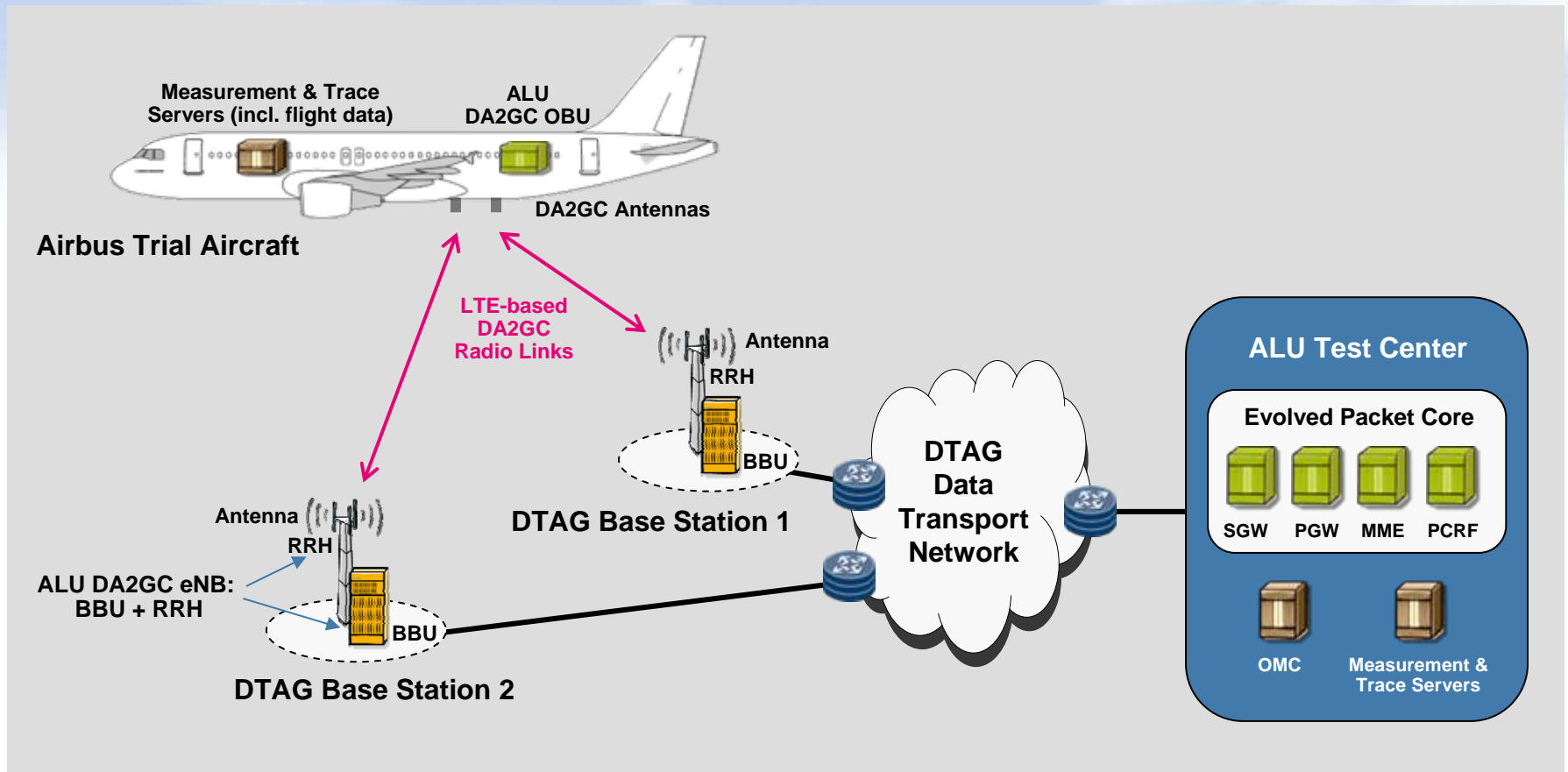


Broadband DA2GC Trial Flight.

Trial set-up.

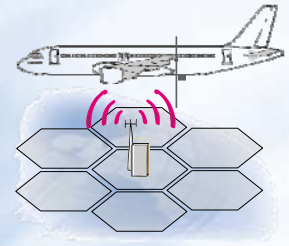


General overview of trial flight set-up:



Broadband DA2GC Trial Flight.

Trial set-up details.



Ground:

- **2 DTAG sites** in Saxony-Anhalt (Germany) with resulting **inter-site distance of about 98 km**
 - Each site equipped with **LTE-based DA2GC eNBs of ALU** consisting of **baseband unit (BBU)** and **remote radio head (RRH)**.
 - Each site with **3 antenna sectors**.
- **Trial frequency** within **2.6 GHz LTE FDD band** of DTAG with signal **bandwidth of 10 MHz**.
- Applied **BS antennas** provided by **Kathrein** based on commercial X-pol types for LTE usage, but with inverse installation incl. **up-tilt for sky coverage**:
 - Antenna characteristic used in the trial not finally optimized for commercial rollout due to lack of time for development (only null-filling of side lobes, ...).
- Sites connected with **LTE packet core (ePC)** and **measurement & data trace servers** in **ALU test center** in Stuttgart via **DTAG broadband data transport network**.
- Except of **cell size, BS antenna orientation, and parameter adaptation for synchronization/hand-over processes** in eNBs **no difference of DA2GC ground network to usual terrestrial LTE networks**.

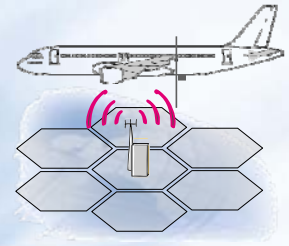
Aircraft:

- Use of **Airbus A320 ATRA** (Advanced Technology Research Aircraft) of DLR Braunschweig (**provisioning and flight control by Airbus**).
- In the passenger area:
 - **DA2GC Onboard Unit** (LTE-based modem).
 - Trial OBU based on flexible demonstrator platform.
 - **Measurement equipment** (data trace servers incl. storage of flight information).
- **RF amplifier** place in the cargo area:
 - **Max. Tx power of 37 dBm** (except of synchronization features main difference to LTE standard modems).
- **2 DA2GC antennas** below aircraft fuselage:
 - **2 Rx / 1 Tx** (no antenna selection).
 - **Omnidirectional** characteristic in H-plane.
 - Antennas not optimized for later commercial rollout (due to requirement to use available aircraft-certified types).
 - Much **easier & cheaper installation compared to satellite antenna**.



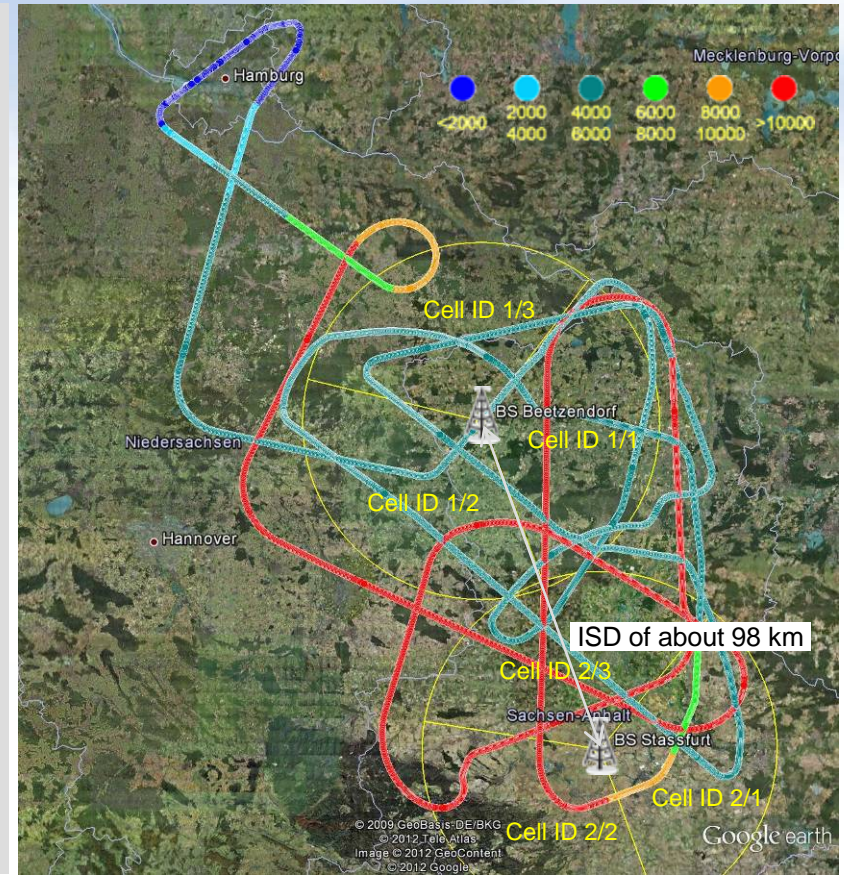
Broadband DA2GC Trial Flight.

Flight planning and execution.



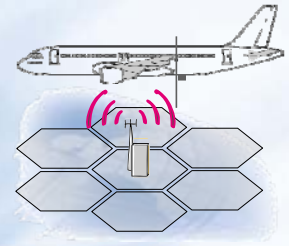
Flight trajectory:

- **Flight duration** about 3 hours.
- Shown **trajectory** based on stored flight information from Airbus.
 - Tracks with **red color** (see legend):
 - **Altitude** of about 10 km (first flight phase).
 - Tracks with **dark green color**:
 - **Altitude** of about 4 km (second flight phase).
- **Yellow circles**:
 - **Areas** around the 2 sites **with radius of 50 km**.
 - **Sectors** are **marked with their cell ID**.
- Typical **aircraft ground speeds** between **500 and more than 800 km/h** in the trial area (dependent on altitude and maneuvers).
- **Trajectory explicitly chosen** to have **flight phases with inter- and intra-site (sector) handover** as well as **phases with large distances to sites**.
 - Aircraft banking during some maneuvers much stronger as during usual commercial passenger flights (**worst case approach**).



Broadband DA2GC Trial Flight.

Trial results and outlook.

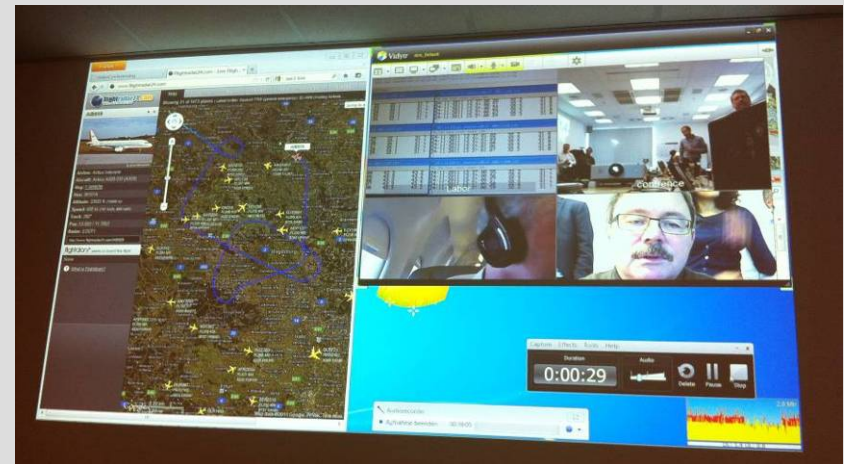


Results of successful trial flight:

- **Radio link established** with present LTE-based DA2GC prototype equipment
 - **at distances of up to more than 100 km** from sites
 - **to the aircraft flying at speeds of more than 800 km/h and altitudes up to 10 km.**
- In addition to **high background data traffic** with
 - **peak rates** of up to more than **30 Mbit/s in forward link** (i.e. base station to aircraft), and **17 Mbit/s in reverse link***

a **video conference** was established **between** the team in the **aircraft and the ALU test center** in Stuttgart which allowed

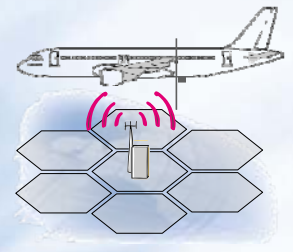
- to follow the flight phases in **real time** and
 - to demonstrate the **low latency** of the overall system
- (see snapshot of the control screen in the ALU test center on right-hand side).



- Trial flight as a **technical milestone** towards the introduction of Broadband DA2GC in Europe.
- Further **trial flights** as well as **demo flights** for interested parties (e.g. airlines) **in preparation.**

* Data rate can be further increased by MIMO transmission (suitable aircraft antenna type not available for the trial)





Thank you for your attention!

