



Architecture of an IP-based Aeronautical Network to Integrate Satellite and Terrestrial Data Links

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Outline

- Problem Statement
- Integrated Networking Concept
- Solutions for:
 - Mobility
 - Security
 - Inter Access Network Handover
 - Data Link Selection
 - QoS
- Inputs to Standardization
- Laboratory Test-Bed and Simulations

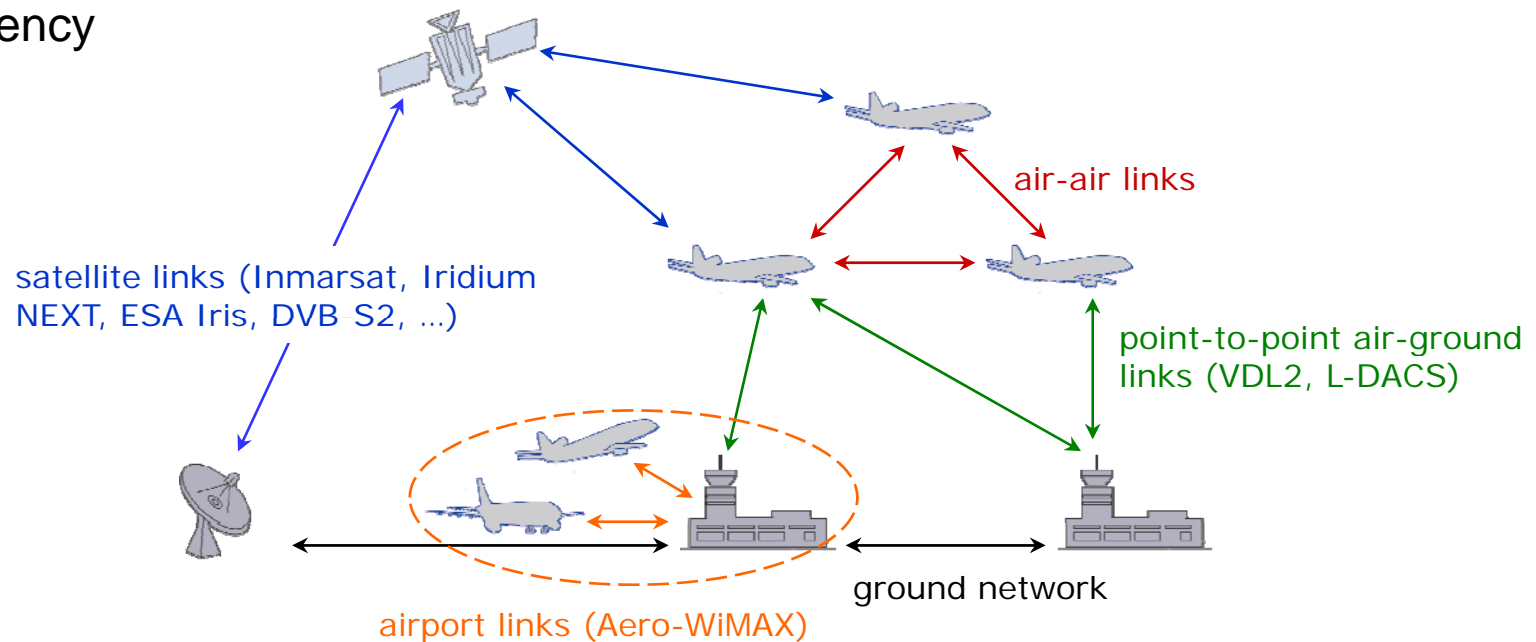
Problem Statement (1): Different Airborne Services

- **Several airborne services** with highly diverse requirements shall coexist:
 - **ATS** (Air Traffic Services) data traffic required to implement new concepts of operation (trajectory based ATM, SWIM, CDM)
 - **AOC** (Airline Operational Communications) data traffic will strongly increase to increase the efficiency of airline operations
 - **APC** (Air Passenger Communications) is foreseen to be further developed to meet passengers' expectations

- New **communication systems – data links and networks – are key enabler** for the implementation of these services

Problem Statement (2): Different Technologies

- **Several current and future data links** are foreseen to fulfil the communication requirements of global information availability and sharing
- **Complex network architecture** evolution: ACARS, ATN/OSI, ATN/IPS(IPv6) for ATS/AOC, IPv4 for AOC/APC
- **Disparate communication systems** result in high costs and low system efficiency



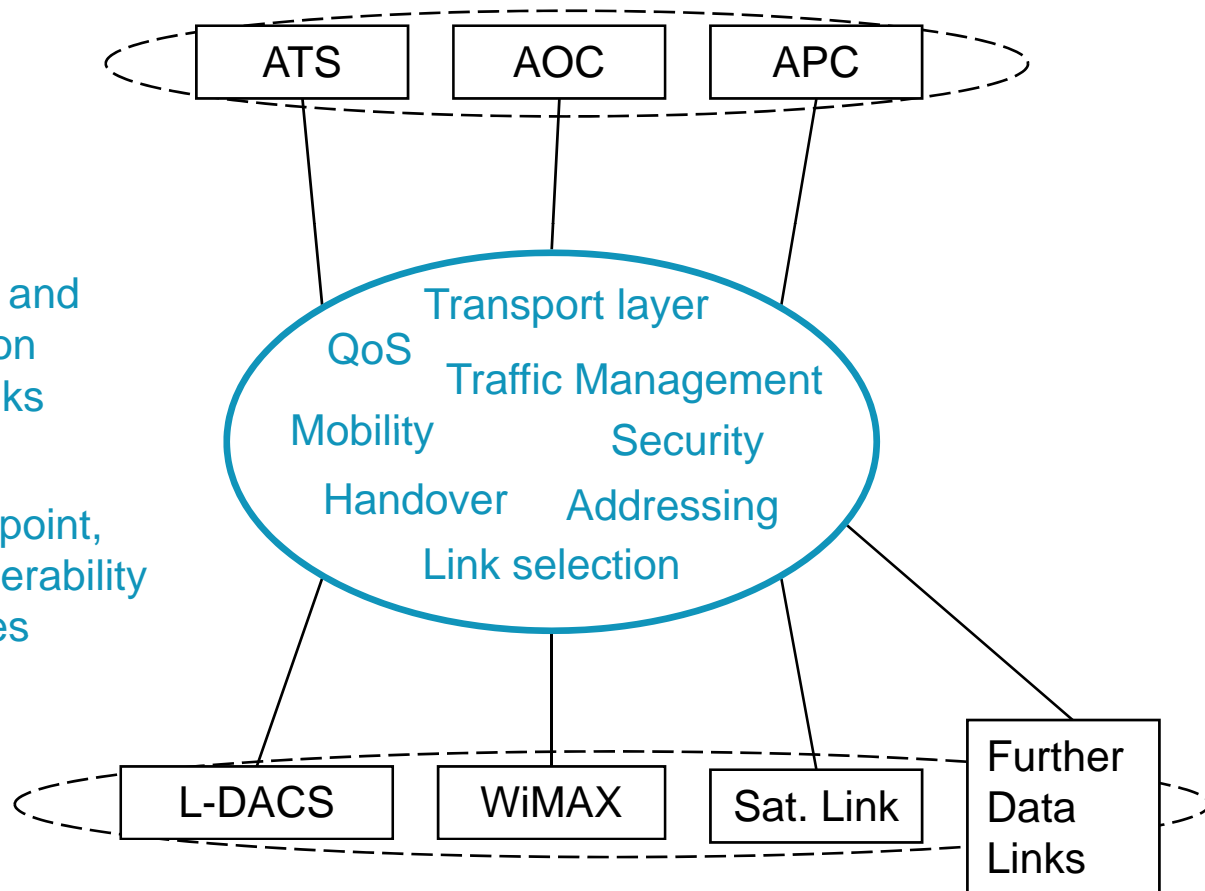
NEWSKY Project: Integrated Networking Concept

Applications
and Services

NEWSKY Project:
Focus on transport and
network layer and on
interface to data links

Technology:
IPv6 as unification point,
considering interoperability
and transition issues

Data Links

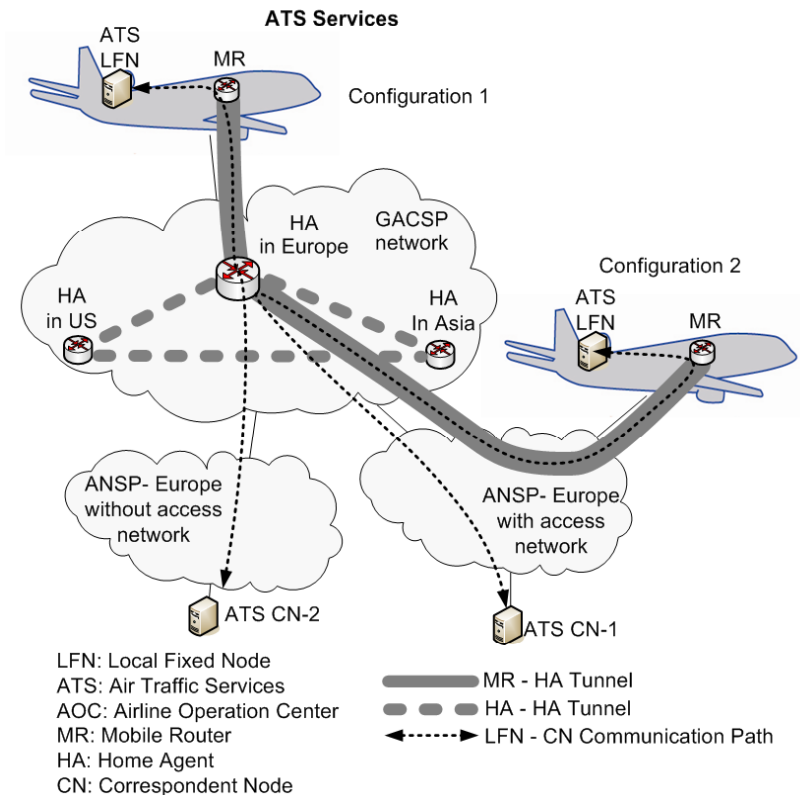


Mobility Architecture based on Mobile IPv6

- NEWSKY mobility management framework is based on **Mobile IPv6** (MIPv6) and several extensions.
- Mobile IPv6 introduces an entity called **Home Agent** (HA) that is used as anchor point on the ground for the mobile node.
- Locate Home Agents in Global Air/ground Communication Service Provider (GACSP) network considering their global presence in the ATN.
- Key Mobile IPv6 extensions for aeronautics:
 - Network Mobility (NEMO)
 - Network-based Localized Mobility
 - Multihoming

Need for Network Mobility Route Optimization

- Network Mobility (NEMO) Route Optimization (RO) required to meet delay requirements
- Proposed RO mechanism for aviation: Global Home Agent – Home Agent Protocol (Global HAHA)
 - Mobile Router selects closest HA to reduce end-to-end delay
 - Inter HAHA protocol to share mobility information of Mobile Routers



Security Architecture

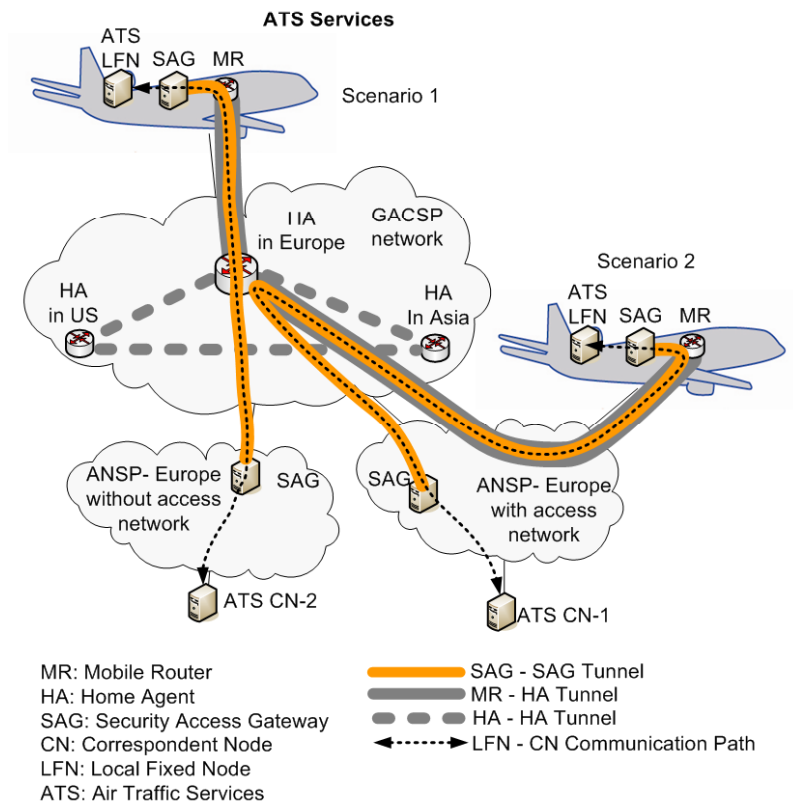
- Segregation of data traffic
 - **Physical segregation** of operational and non-operational data traffic in the short term
 - **Segregation using security tunnels** as long-term option

- Security
 - Security tunnels used for integrity, authentication, encryption
 - **Security Access Gateways** form the security tunnel endpoints

Mobility and Security Integration

- Security tunnels
 - Security tunnel endpoints: **Security Access Gateways**
 - Security Access Gateways shall be within the sub-network of the correspondent node

- Mobility tunnels
 - Mobility tunnel endpoints for NEMO signaling: **Home Agents**
 - Home Agents are located in the GACSP network
 - Mobility tunnels can thus hardly be re-used as security tunnels



Handover Framework

- The handover framework shall provide:
 - **Generic interface** to provide link layer intelligence and network information to upper layers.
 - Optimized **data link selection**
 - Optimization of **handovers** between different access networks and link technologies

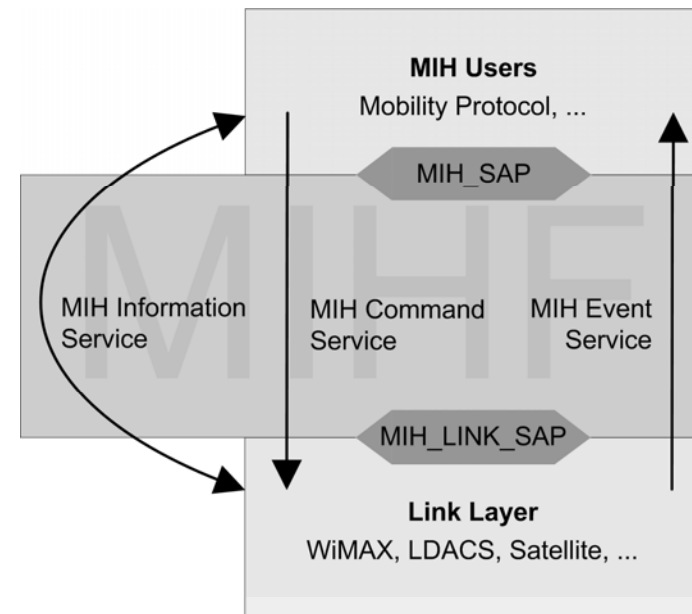
- Solution based on **IEEE 802.21 Media Independent Handover Services**

IEEE 802.21 Services

- Logical entity between the link and the network layer:
 - ➔ **Media Independent Handover Function (MIHF)**
- MIHF provides services for collecting link information and for link control

- Three service categories:

- **Event Service**
Initiates events from local/remote interfaces and detects link layer property changes
- **Command Service**
Controls link properties relevant for handovers and link switching
- **Information Service**
Provides information about networks and services



IEEE 802.21 for Aeronautical Communications

- Tailoring activities to do:
 - **Selection of useful MIH primitives**
 - **Implementation of media dependent interface (MIH_LINK_SAP)**
 - Mapping of existing primitives to MIH primitives
 - If required, specification of new link-specific primitives

- Deployment options:
 - **Partial 802.21 deployment** with MIH functionality only at the aircraft:
 - No adaptations needed on the ground
 - Only for link related events and commands
 - **Full 802.21 deployment** with information server on the ground:
 - Message exchange with information server for network information and handovers

Data Link Selection

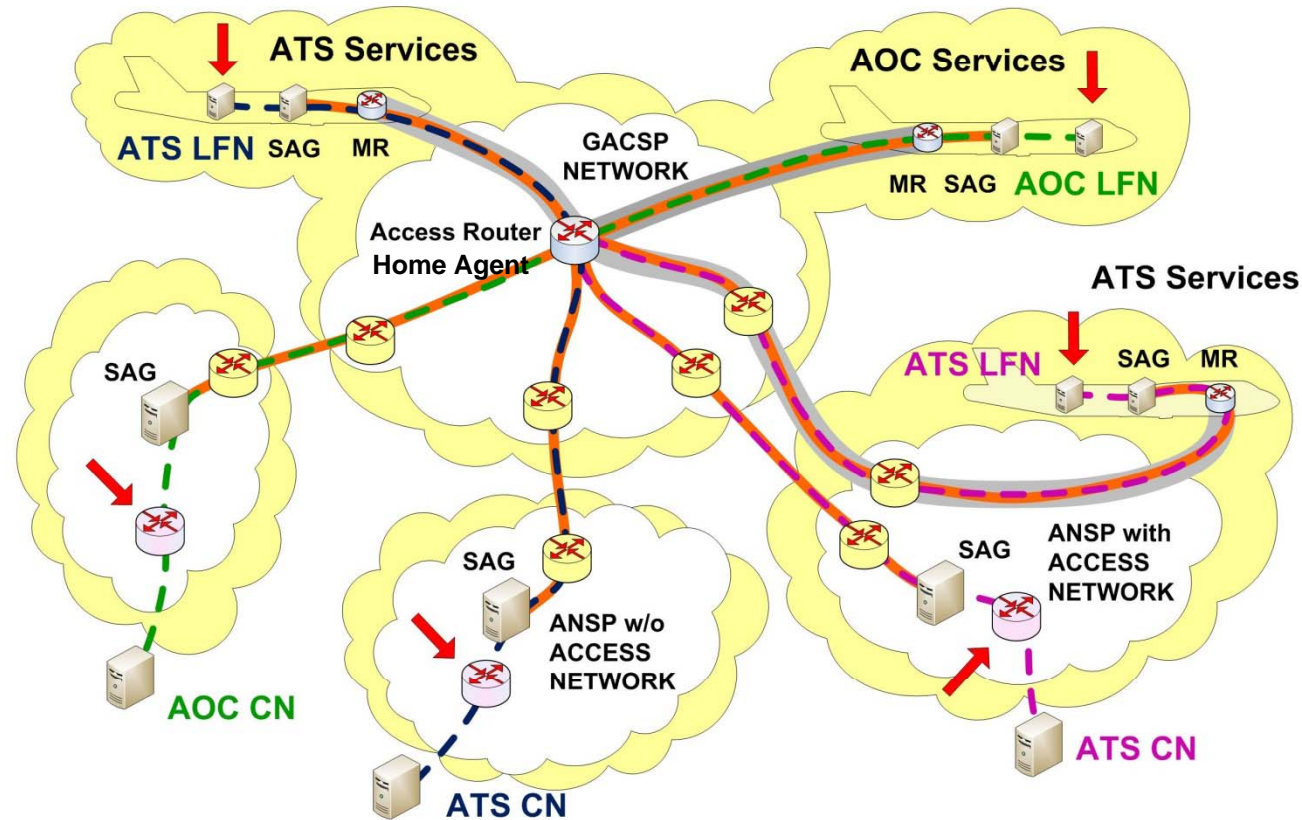
- Short term approach: Selection based on link availability, flight phase and user preference





- Long term approach: Selection based on variable set of more sophisticated link information, including:
 - Flight phase
 - Provider policies / regulatory policies
 - Economical cost
 - Signal strength
 - Bit error rate / packet error rate
 - Delay
 - Available bandwidth / throughput
 - Information on link coverage
 - User preference
 - ...

Quality of Service (QoS) Architecture

- **DiffServ Architecture** recommended:
 - DiffServ allows prioritization among different classes of services – although it can not guarantee a certain QoS
 - It is assumed that the system dimensioning is done in a way to always provide enough resources for the traffic belonging to different QoS classes.
 - The DiffServ architecture avoids the signaling overhead of resource reservation techniques such as e.g. IntServ
 - DiffServ can cope with constraints from mobility/security architectures (re-tagging necessary at mobility and security tunnel end points)

NEWSKY Overall Architecture



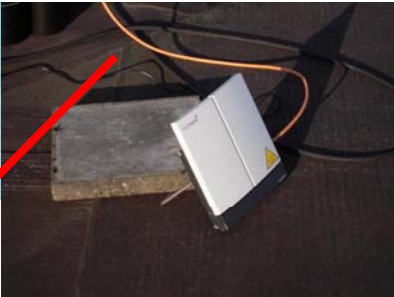
- | | | |
|---|------------------------------|---|
|  DiffServ Domain | LFN: Local Fixed Node | ANSP: Aeronautical Navigation Service Provider |
|  Mobility Tunnel | SAG: Security Access Gateway | GACSP: Global Aeronautical Communication Service Provider |
|  Security Tunnel | MR: Mobile Router | AOC: Aeronautical Operational Service |
|  DSCP Tagging | CN: Correspondent Node | ATS: Air Traffic Service |

NEWSKY Inputs to Standardization

- **ICAO** ACP WG-I (Internet Protocol Suite): Specification of the Aeronautical Telecommunication Network (ATN) based on IPv6 in Doc 9896 "Manual for the ATN using IPS Standards and Protocols".
- **AEEC**: NIS (Network Infrastructure and Security), MAGIC (Manager of Air-Ground Interface Communications) Technical Working Group
- **IETF** MEXT (Mobility EXTensions for IPv6): Building a mobility management protocol (i.e. an RFC for NEMO Route Optimization) that is applicable for aviation.
 - *In general: Shape IETF standards to be applicable for aviation*
 - *Further actions are required here to coordinate networking and network security developments from aeronautical bodies and organizations (ICAO, AEEC, RTCA, Eurocae, FAA, Eurocontrol, SESAR, etc.) with IETF activities*



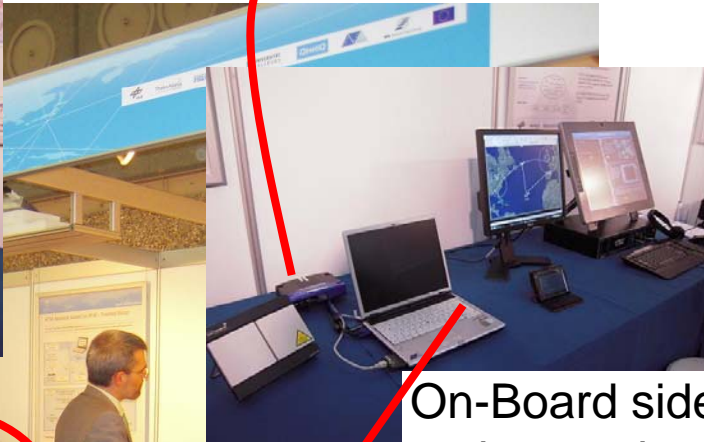
Connection to
BGAN terminal
on the roof



ATC Global, March 2009, Amsterdam



ATC ground side
of the test-bed



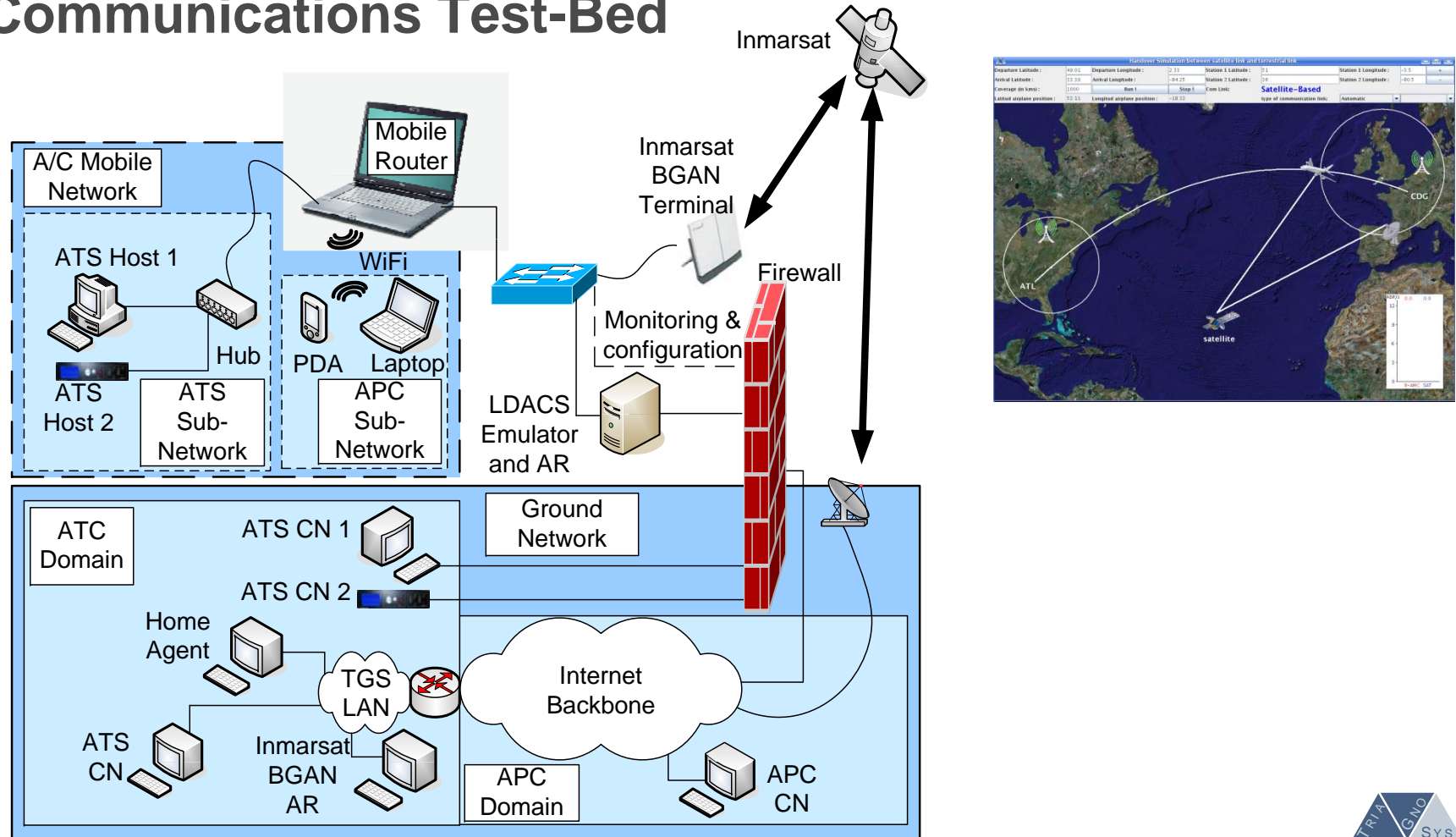
On-Board side of
the test-bed



Simulation area



NEWSKY Integrated Satellite and Air-Ground Communications Test-Bed

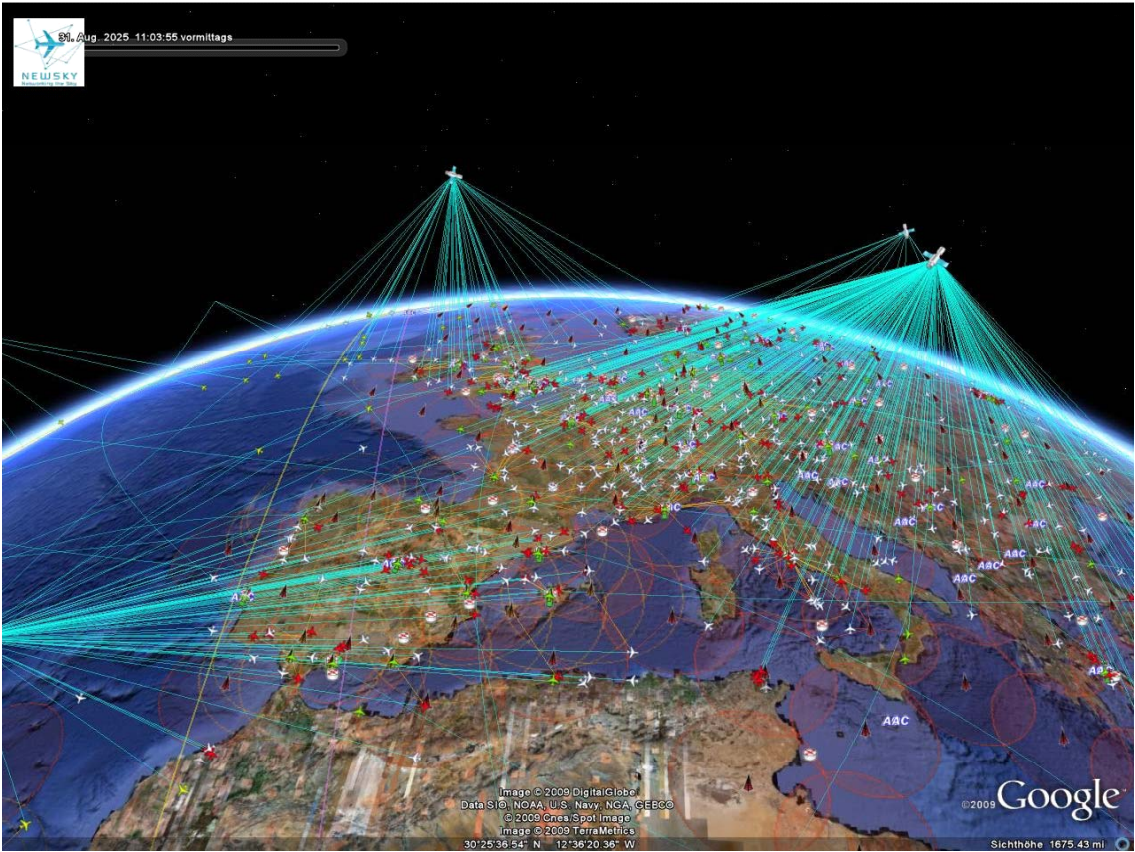


Testbed Components and Features

- Completely **IPv6** based (except satellite portion)
- **Support of all kind of applications** running over IPv6, shown:
 - VoIP (UDP traffic)
 - Weather map download (TCP traffic)
 - CPDLC messages (TCP traffic)
- **Support of all kind of links**, shown:
 - BGAN Inmarsat link
 - Emulated L-DACS link
- Demonstration of **inter-technology handover** and **network mobility**

NEWSKY Network Simulation

➤ Global assessment of NEWSKY protocols and algorithms



Summary

- NEWSKY provides a concept and preliminary design of an **integrated mobile aeronautical communication network** with focus on air-ground communications and IPv6 technologies
- Mobility: Mobile IPv6 and extensions
- Security: Security Access Gateways using IPsec features
- Inter Access Network Handover: Tailored IEEE 802.21
- QoS: DiffServ

- Further information: www.newsky-fp6.eu

