# STORE 2019:
# IP Mobility in Aeronautical Communication

## Alexandre Tran

JANUARY,  2019

ENAC Thesis supervisors:
Alain Pirovano
Nicolas Larrieu

Collins Aerospace Thesis supervisors:
Stéphane Pelleschi
Alain Brossard

Collins Aerospace

# Content

1. Introduction
   a. Safety Aeronautical communication
   b. ATN/IPS: Issues and challenges: *mobility, multilink and addressing*

2. Solutions
   a. Native IP(v6)
   b. Achieving Inter-Domain Handoff + Multilink:

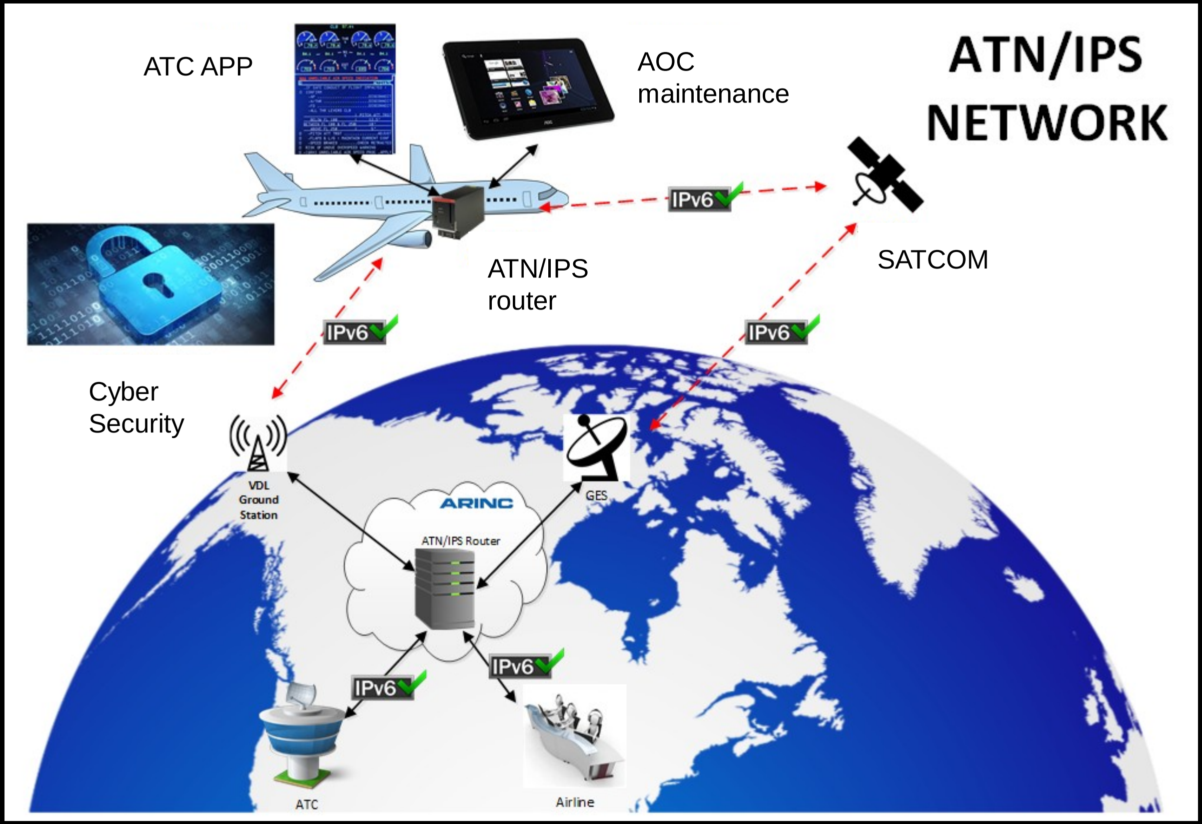
3. Simulations
   a. OMNeT++
   b. Roadmap
   c. *PMIPv6 simulation*

4. Future Work

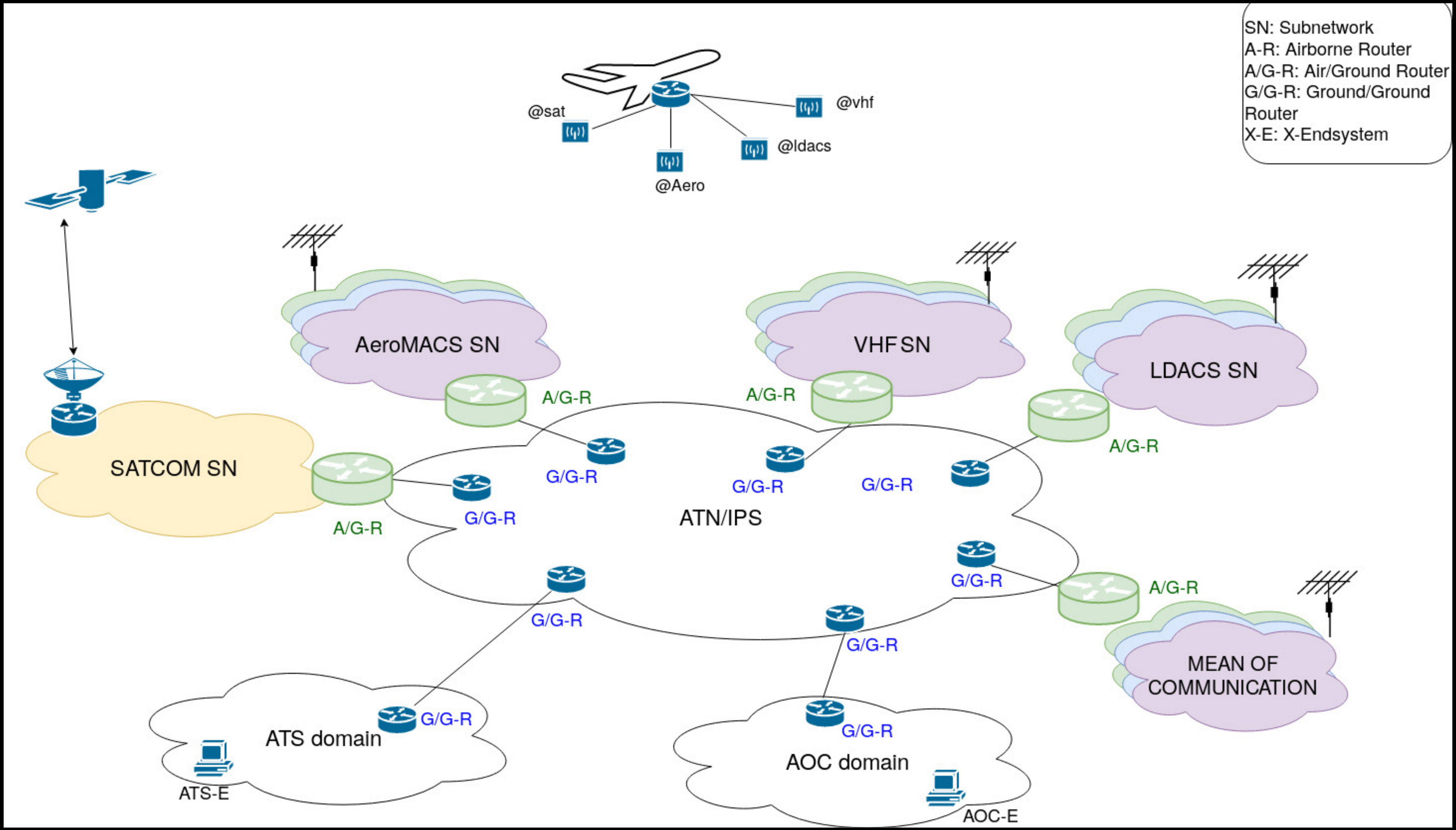
Collins Aerospace

# 1.a. Safety Aeronautical Communication

- **Air Traffic Control**: *communication between the pilot and the controller* to ensure aircraft operations along the flight.
- Primary use of voice over VHF, HF and SATCOM
- *1980s:* Digital communication over ACARS network
  - short messages character-oriented (max 3.5kB)
  - used for ATC and AOC applications
- *2000: ATN/OSI network in Europe*
  - *bit-oriented messages*
  - *VDLm2: VHF network for datalink in Europe (32Kbps)*
- *>2020: ATN/IPS network*



# 1.b. ATN/IPS: network architecture



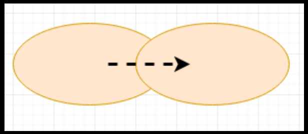
# Content



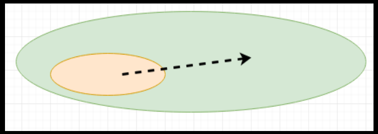
Collins Aerospace

# 1.b. ATN/IPS: Issues and Challenges

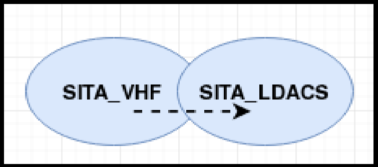
- **Aircraft Mobility**: to ensure a seamless communication between the aircraft and the ground
  - To handle the horizontal and vertical handoff.
  - To handle the intra and inter-mobility scenario.
  - To provide a single IPv6 address for the aircraft.



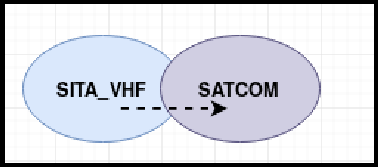
*Horizontal handoff*



*Vertical handoff*

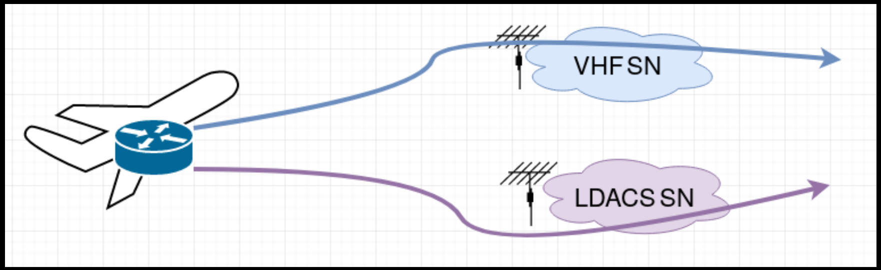



*Intra-domain handoff*




*Inter-domain handoff*

- **Multilink Capabilities**:
  - To be able to use different links at the same time
  - To use the links efficiently in order to avoid network congestion = load balancing

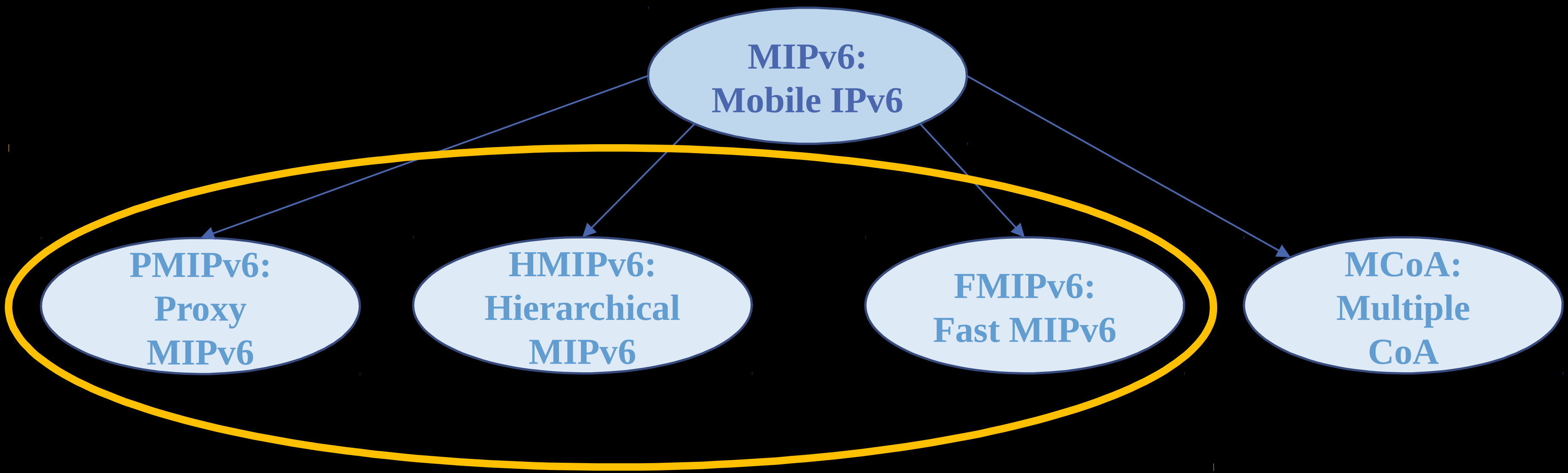



*Multilink*

- **Constraints:**
  - Low radio link resources
  - Onboard cost implementation

# 2. Solutions: Native IPv6 extensions

- **Identification with 2 addresses:**
  - ***Home Address* (HoA)*:*** Mobile Node's (MN) permanent address, attached to its Home Agent
  - ***Care-of-Address* (CoA)*:*** Mobile Node's visiting address
- **Binding Association with 2 messages**:
  - **Binding Update**: from MN to Home Agent to announce its CoA
  - **Binding Acknowledgement:** reply to confirm the binding



# 2. Existing solutions: Native IP solutions

| | MIPv6 | HMIPv6 | FMIPv6 | PMIPv6 |
|---|---|---|---|---|
| **Inter-domain handoff** | yes | yes | **yes** | **no** |
| **Handover delay** | | ++ intra-mobility | ++ | ++ intra-mobility |
| **Signalling** | | ++ intra-mobility<br>-- inter-mobility | -- routers | ++ access link |
| **Deployment** | Home Agent, Mobile Node | Home Agent, Mobile Node, Anchor Point | Mobile Node Home Agent, Access routers | LMA, MAGs |

PMIPv6 is a promising solution regarding:

- the absence of any additional mechanisms inside the mobile entity
- the absence of signalling messages on radio links
- the already existing architecture based on PMIP for LTE.

Collins Aerospace

# Content

1. Introduction
    a. Safety Aeronautical communication
    b. ATN/IPS: Issues and challenges: *mobility, multilink and addressing*

2. **Solutions**
    a. Native IP(v6)
    b. **Achieving Inter-Domain Handoff + Multilink:**

3. Simulations
    a. OMNeT++
    b. Roadmap
    c. *PMIPv6 simulation*

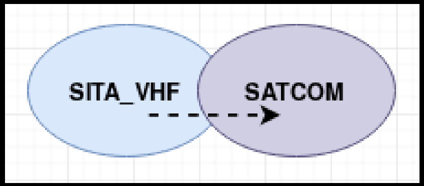
4. Future Work

# 2. Solutions: Achieving inter-domain handoff with PMIPv6

- MIPv6 (rfc 6275):
  - global mobility is achieved via a unique address (home address) which is attached to a home network.
  - multilink with MCoA extension

- LISP (Locator Identifier Separation Protocol, rfc 6830):
  - Separation of IP Address as an Identifier (EID) and as a locator (RLOC)
  - Allow the mobile node to use a unique address.
  - Compatible with multilink scenarios.

- HIP (Host Identity Protocol, rfc 7401):
  - Separation of IP Address as an Identifier (HIT) and as a locator
  - Provide a multihoming and mobility solution for End Systems
  - Ensure security through IPSec
  - A new shim layer to map the network address and the HI.



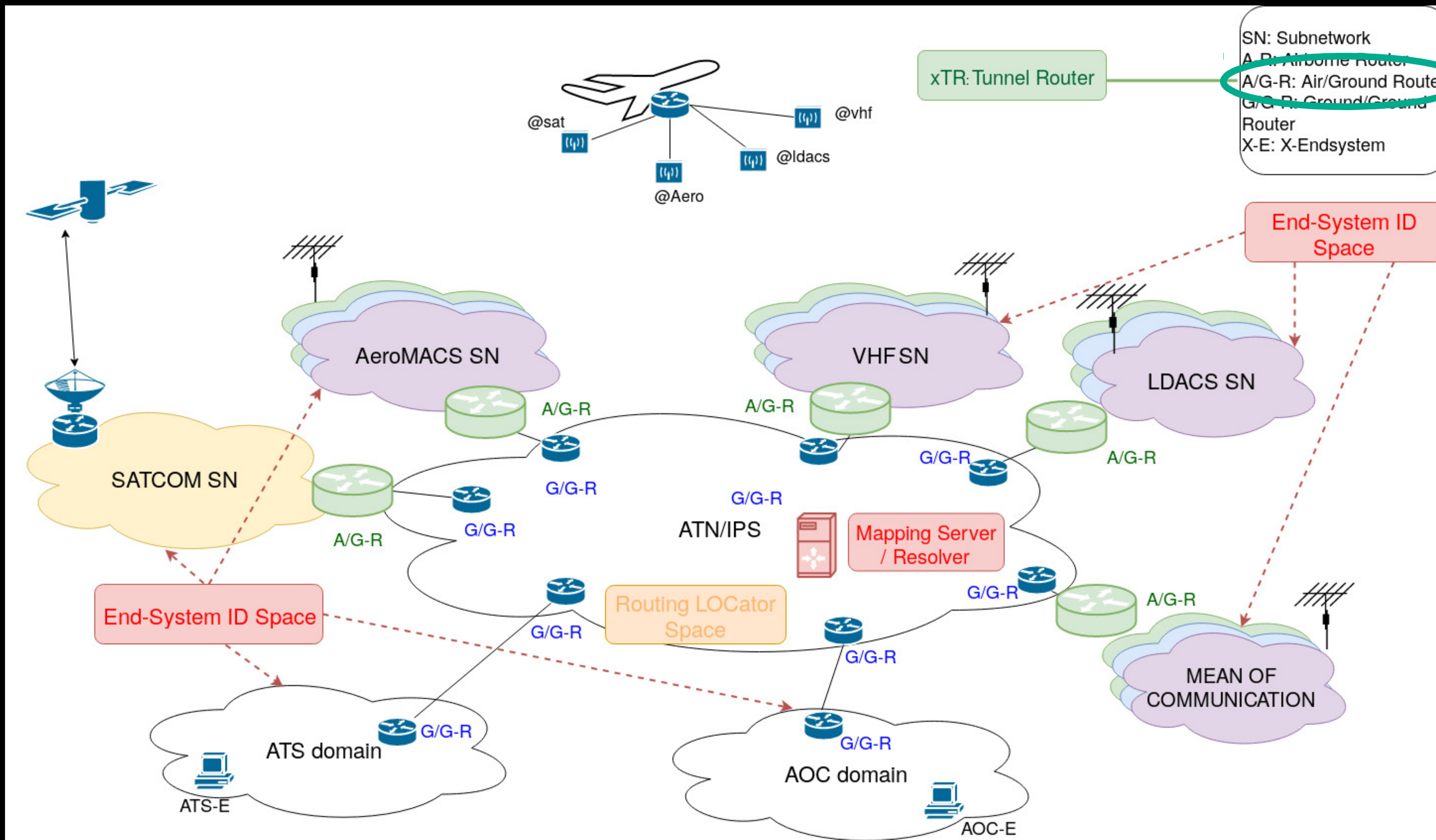

*Inter domain mobility*

**Why LISP ?**

- **Network mobility solution, no additional stack onboard.**
- **Multilink properties.**

Collins Aerospace

# 2. Solutions: LISP presentation



# 2. Solutions: LISP summary

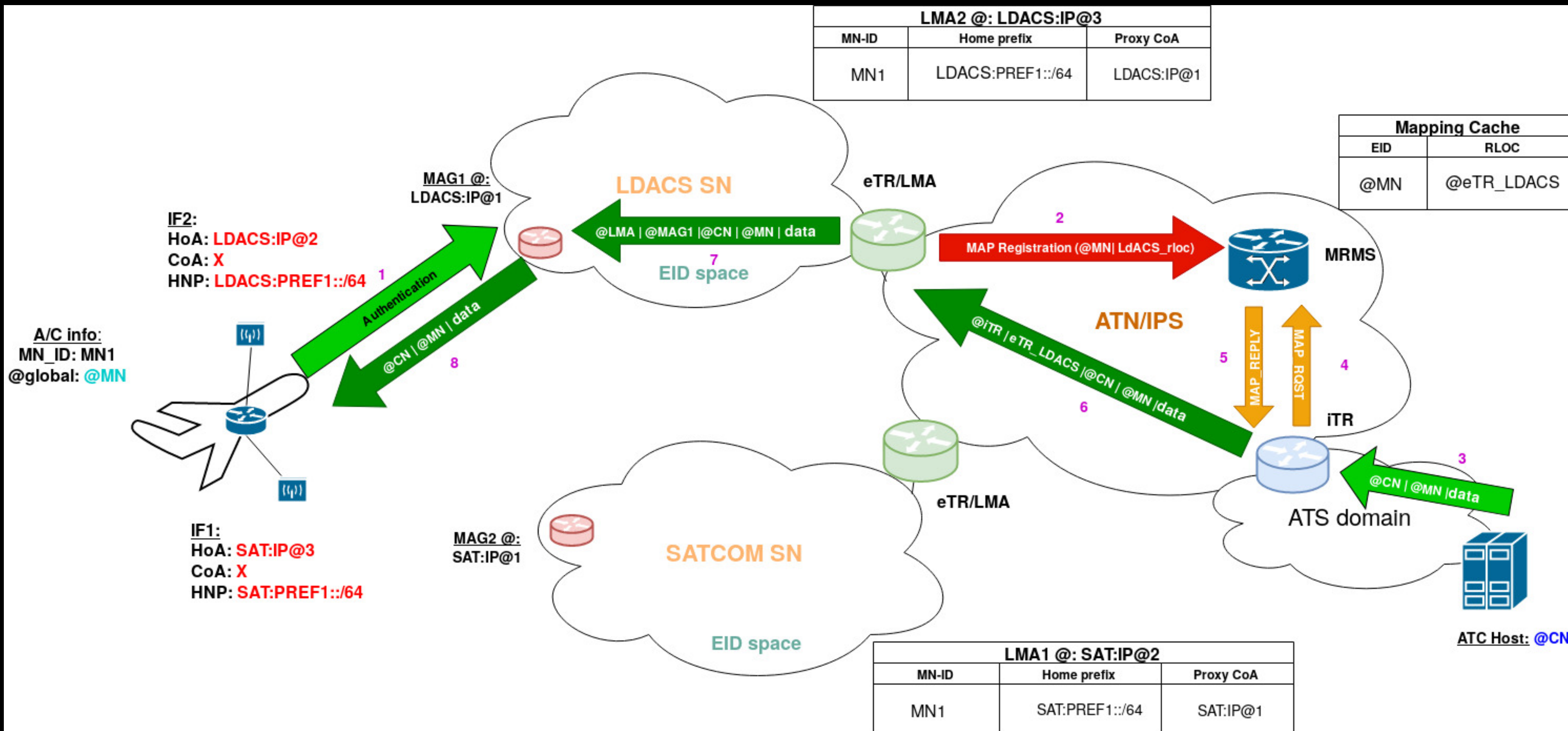
- **Entities**:
  - ***Egress Tunnel Router (eTR)***: inform the MR/MS of a new EID-to-RLOC mapping. Decapsulate packets that are directed toward its RLOC. Respond to MAP-RQST message.
  - ***Ingress Tunnel Router (iTR)***: Find the corresponding EID-TO-RLOC for an incoming packet. Then encapsulate the packet and route it toward the corresponding eTR.
  - ***Map Resolver/Map Server (MR/MS)***: Central unit that stores all the EID-to-RLOC mapping and is in charge of processing the LISP control messages.

- **Benefits:**
  - No change in the IPv6 stack of aircraft => network centric solution
  - No additional signalling for aircraft
  - Allow use of multiple RLOCs for an End-System => multilink capability
  - Compliant with the requirement of one single address to identify the aircraft.

**Idea:**

- **PMIPv6 coupled with LISP for managing inter-domain mobility and multilink scenario**

# 2. Solutions: PMIP+LISP Data Exchange




Collins Aerospace

# Content

1. Introduction
   a. Safety Aeronautical communication
   b. ATN/IPS: Issues and challenges: *mobility, multilink and addressing*

2. Solutions
   a. Native IP(v6)
   b. Achieving Inter-Domain Handoff + Multilink:

3. **Simulations**
   a. OMNeT++
   b. Roadmap
   c. *PMIPv6 simulation*

4. Future Work

# 3. OMNeT++

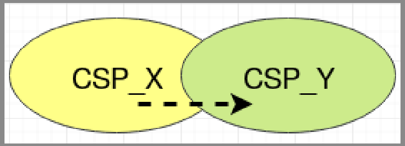
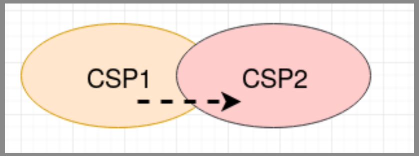
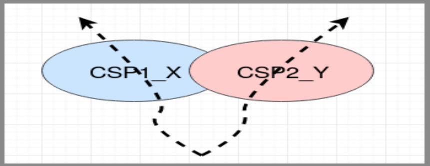
- **OMNeT++ (5.2)**: Discrete Event Network simulator
  - More and more popular in the research area
  - Models are based on a modular architecture
  - Easy to reuse existing components/framework
  - Programmed in C++

- **INET framework (3.6)**:
  - Open source library for OMNeT++
  - Provides Internet protocols from PHY layer to APP layer
  - Mobility management

Collins Aerospace

# 3. Roadmap

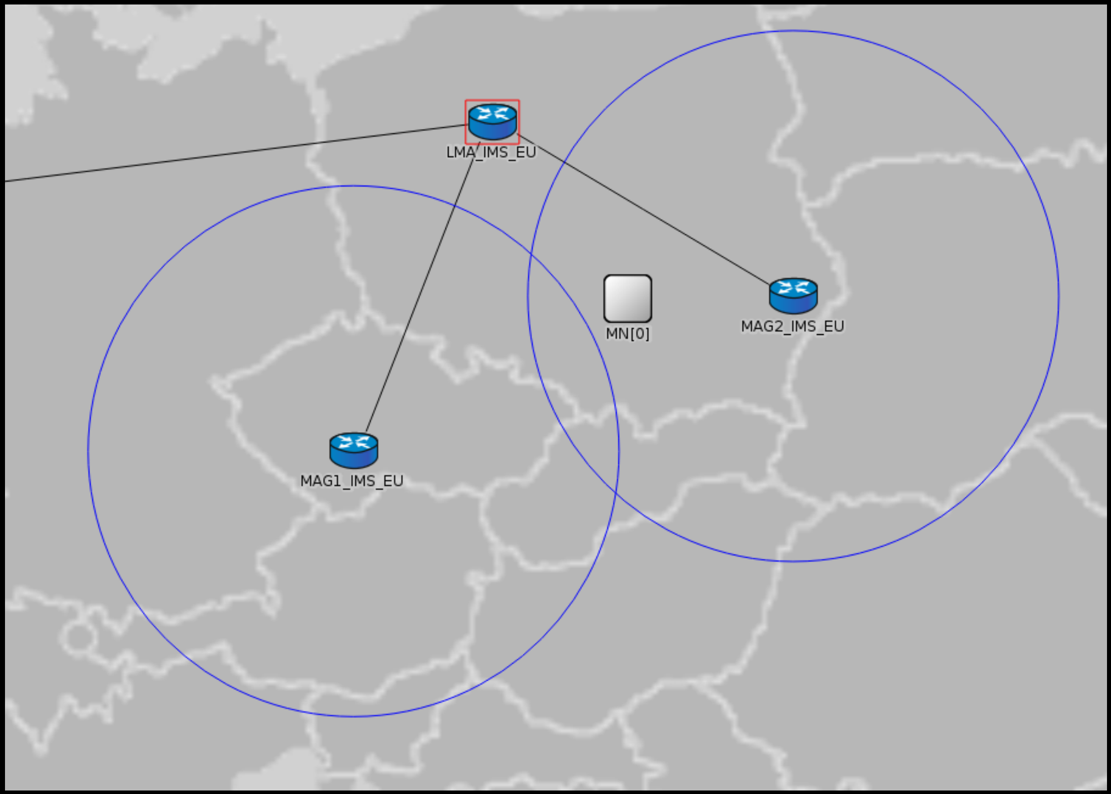
PMIPv6 → LISP+PMIPv6 → Multilink scenario

| Intra-domain mobility | Inter-domain mobility | multiple links |
|---|---|---|
|   |   |   |
| PMIPv6 adaptation | Implementation | Future work |
| Results | In process | To be done |

# 3. PMIPv6 Simulation

| | |
| --- | --- |
| APP | UDP App: AOC/ATC En-route traffic model based on a NASA study* |
| TRANSPORT | |
| NETWORK | PMIPv6 Implementation |
| MAC | Ethernet / CSMA + HO manager |
| PHY | Ideal Radio propagation |

- **Scenario**:
  - time: 700sec
  - node speed: 550km/h
  - overlapping area: 25km
  - 1 horizontal handoff performed
  - ~ 10 APP pkts are sent




***PMIPv6 Intra-domain mobility***

* https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20140017049.pdf

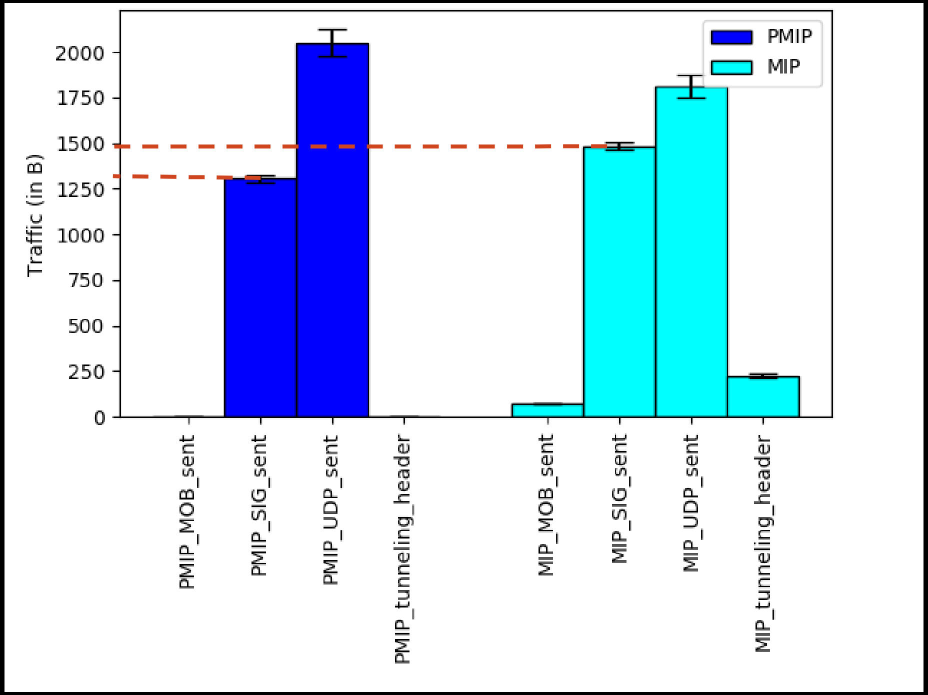
# 3. PMIPv6 simulation: Signalling Analysis

- **Comparison with MIPv6:**

-PMIPv6 signalling: ~**1280B**
-MIPv6 signalling: ~**1500B**

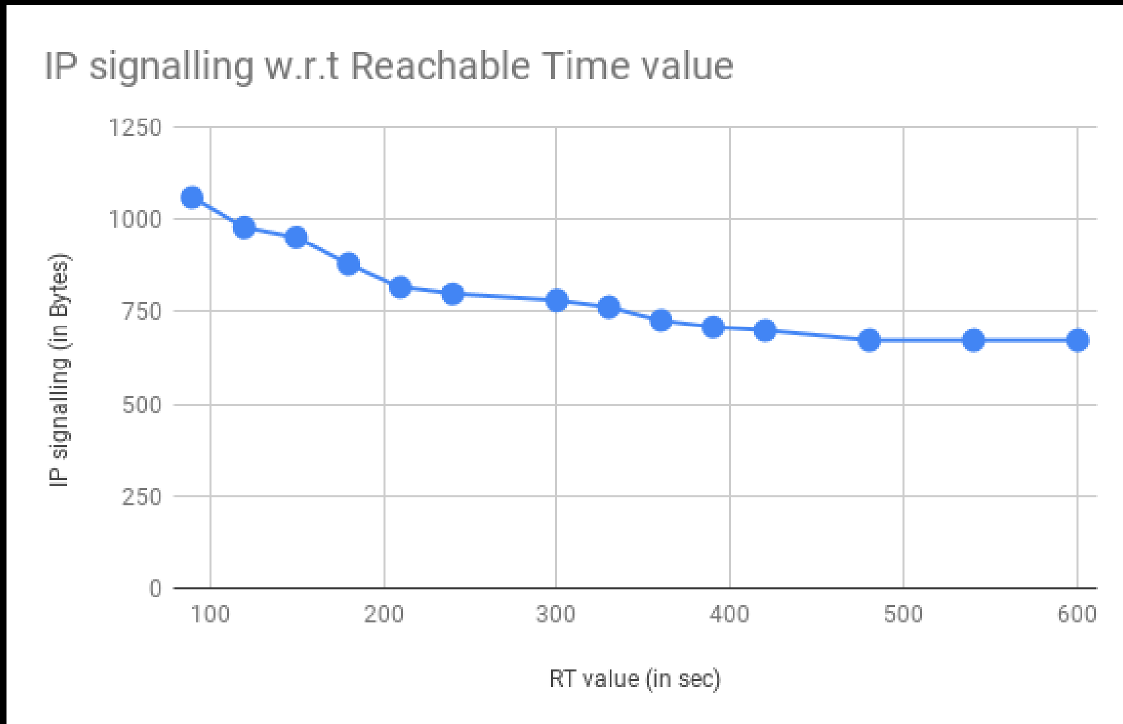
Difference is due to the binding mechanism in MIPv6 and the tunneling packet performed after the handoff.

The rest of the signalling is due to IPv6 protocol (Neighbor Discovery Protocol)




***Traffic sent by the Aircraft (in Byte)***

# 3. PMIPv6 simulation: Signalling Analysis




- By increasing the *Reachable Time* value, we decrease the amount of signalling generated by the aircraft.
- However, we increase the size of the neighbor cache

# 4. Future Work

- This work provides evidences that  PMIPv6 needs some adaptation to fit the aeronautical environment and propose a reasonable solution.

- Future Work:
  - To validate/improve the PMIPv6+LISP model  with the simulation
  - To investigate LISP issues regarding the state of the links
  - Possibility for a collaboration with Pisa University (integration of our solution in their aeronautical framework)

Collins Aerospace

# Thank you for your attention !

Collins Aerospace