ATN

Aeronautical Telecommunication Network

Presented by

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Objectives

- Describe data link chains
- Describe ATN

Outline

- Needs
- Integration into data link chains
  - ACARS
  - FANS 1/A
  - ATN

Introduction

Context

ICAO Standardization

ENAC

中国民航大学

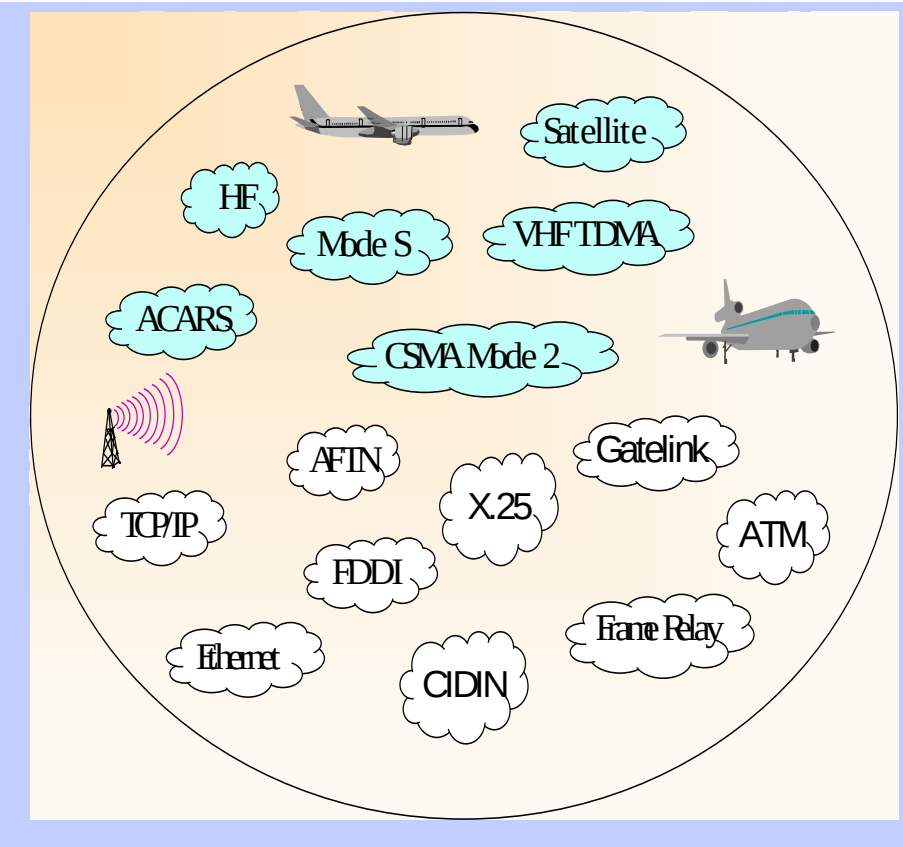
Civil Aviation University Of China

Needs vs. solutions

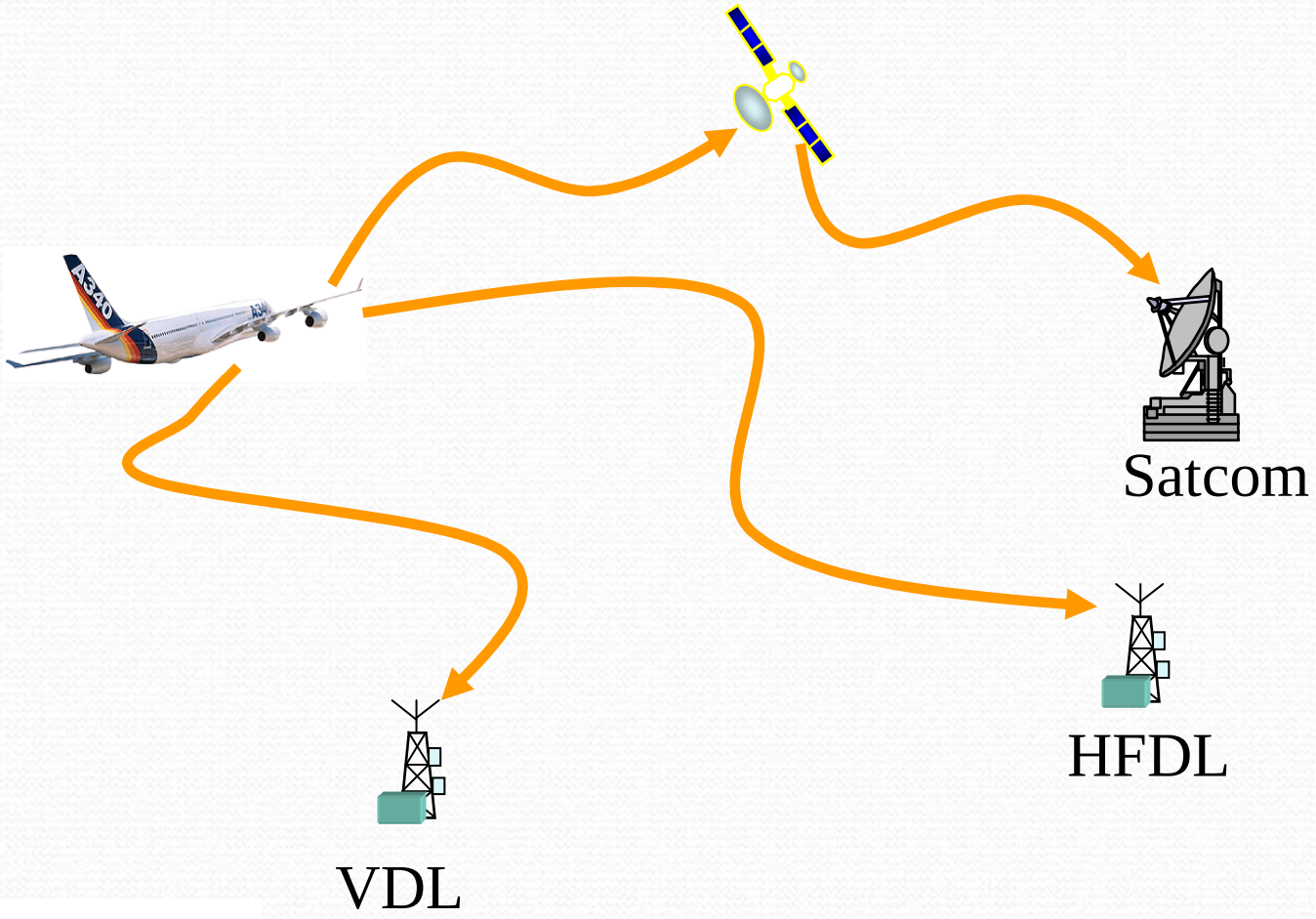
- Air-ground communication means
  - System oriented
  - Data transfer oriented
- Users' needs

For the user

- Network should be transparent
- QoS should be homogenous



Reminder



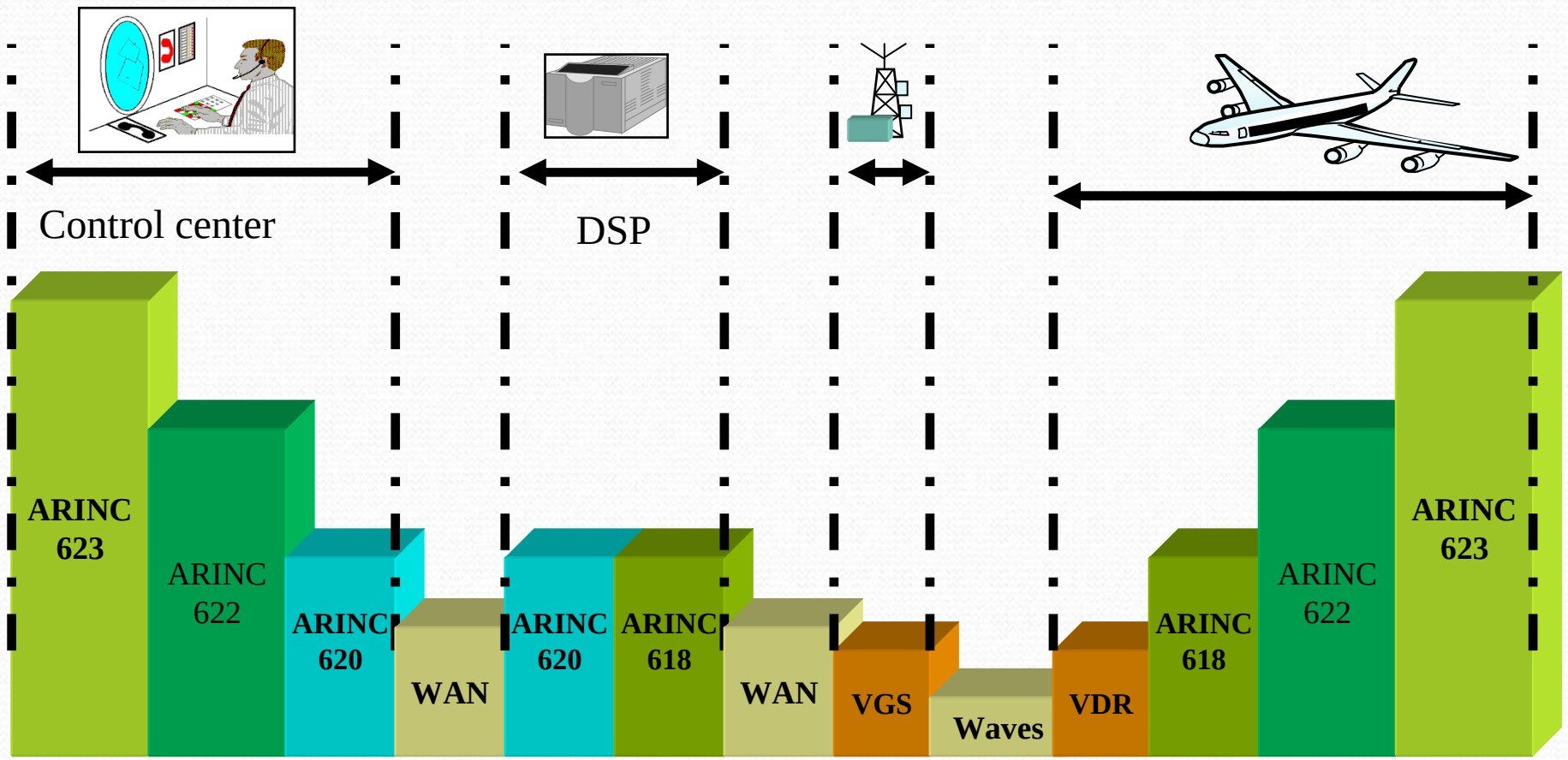
What we want

"How" is NOT their concern

The solutions

- ACARS: what existed (historical)
- FANS 1/A: the improvement
- ATN: the standardization

FANS 1/A transmissions



FANS 1/A performances (reminder)

- Round trip delay (CPDLC application)
  - Measured on MAS reception
  - Reims Trials (2008)
  - About 1700 data
- Min/Mean/Max : 2 / 13,4 / 347 secs
- Standard deviation : 19,1 sec
- Requirement:
  - TT(95%) < 16s
- Actual performances:
  - TT(95%) : 44 sec
  - <16 sec : 79 %

FANS 1/A performances (reminder)

- Due to its centralized architecture
- Depending on the A/G sub-network
- Performances may not comply with
  - ATC requirements
  - In continental regions

Consequences

- No ATC apps on pure ACARS
- ATC seems to be possible on FANS 1/A:
  - In non-dense areas
  - Applications requiring no QoS

ICAO Standardization

- Aims
  - Transparent supporting sub networks
  - End to end connectivity
  - Homogenous interfaces
  - Enhanced Quality of Service
  - ….

  - A requirement based approach

ICAO Standardization

- The choices
  - An aeronautical internet: ATN
    - One aircraft = one network
    - Routers between networks
  - At least same services
  - End-to-end connection
  - Sub network independent interface
  - ISO protocol based compliant with OSI model

ICAO Standardization

- Definition
  - The ATN is a global internetwork architecture providing a unique service for all the digital communications:
    - **Reliable** end to end COM services
    - **Transparent** to the end-user
    - Common for **all** the COM service types (ATC, AOC, AAC, APC)
    - A **single interface** for the applications
    - Integrating **dissimilar** networks (existing or emerging)

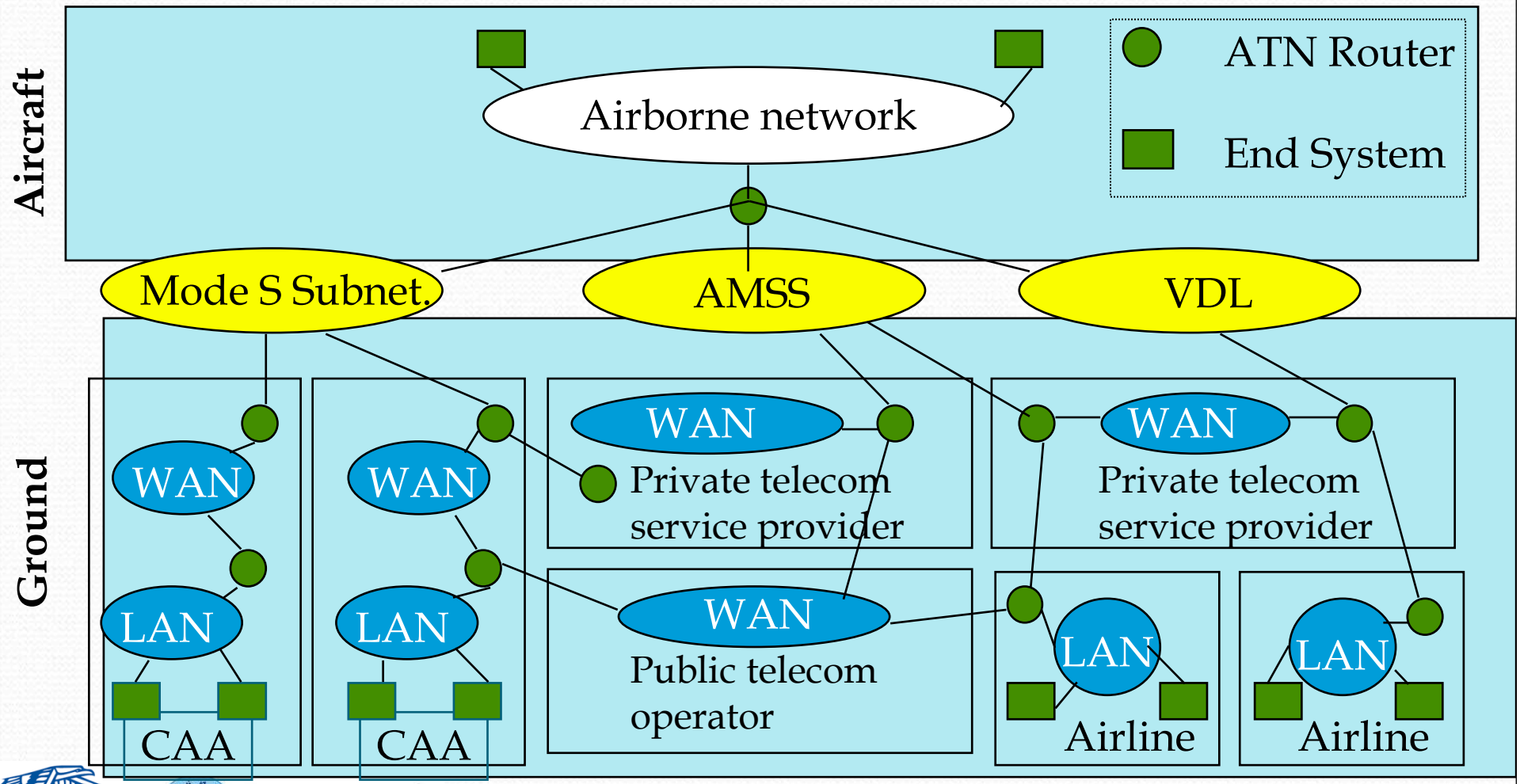
ATN Network

Network Architecture

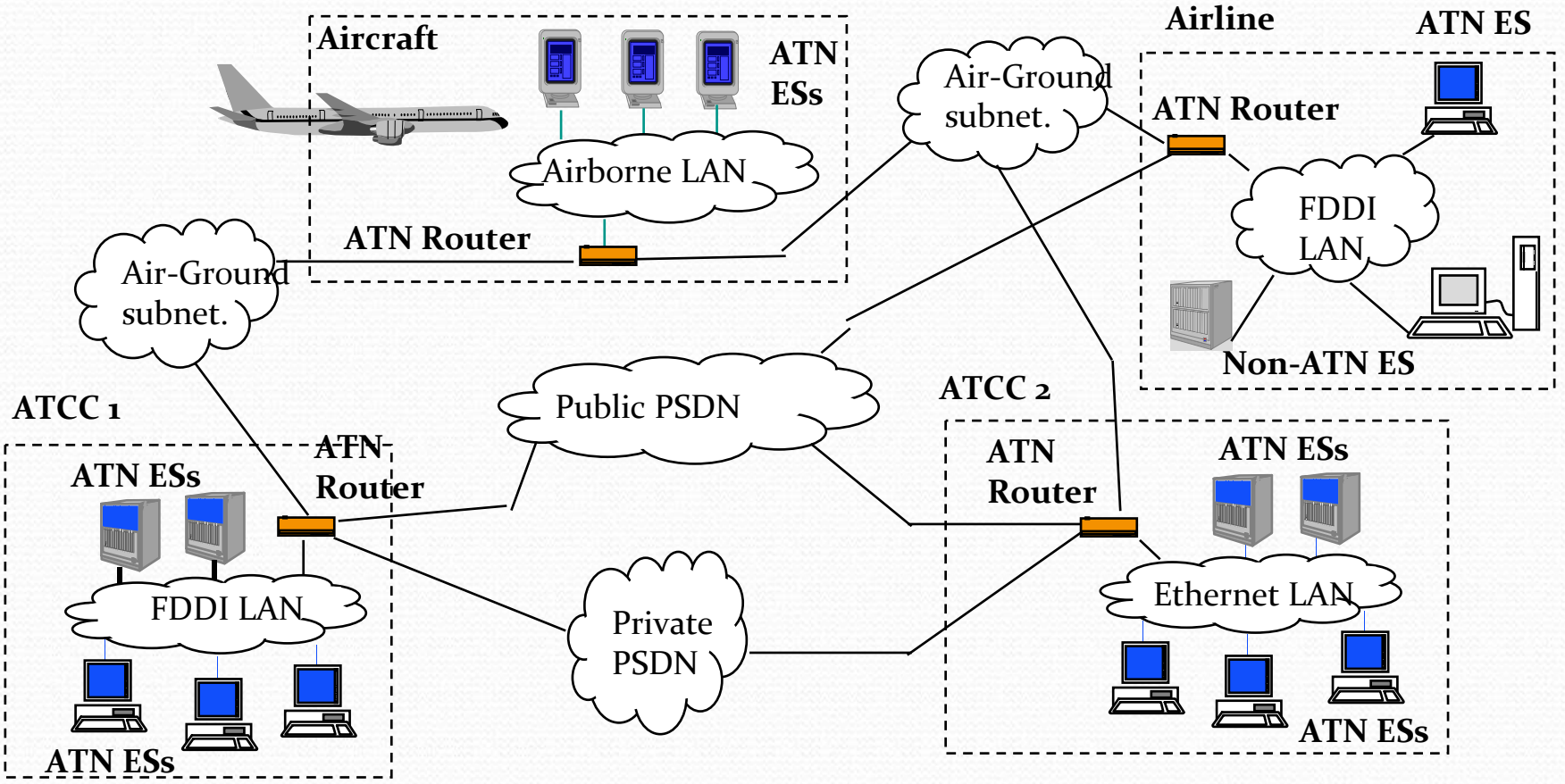
Subnetworks

Protocol

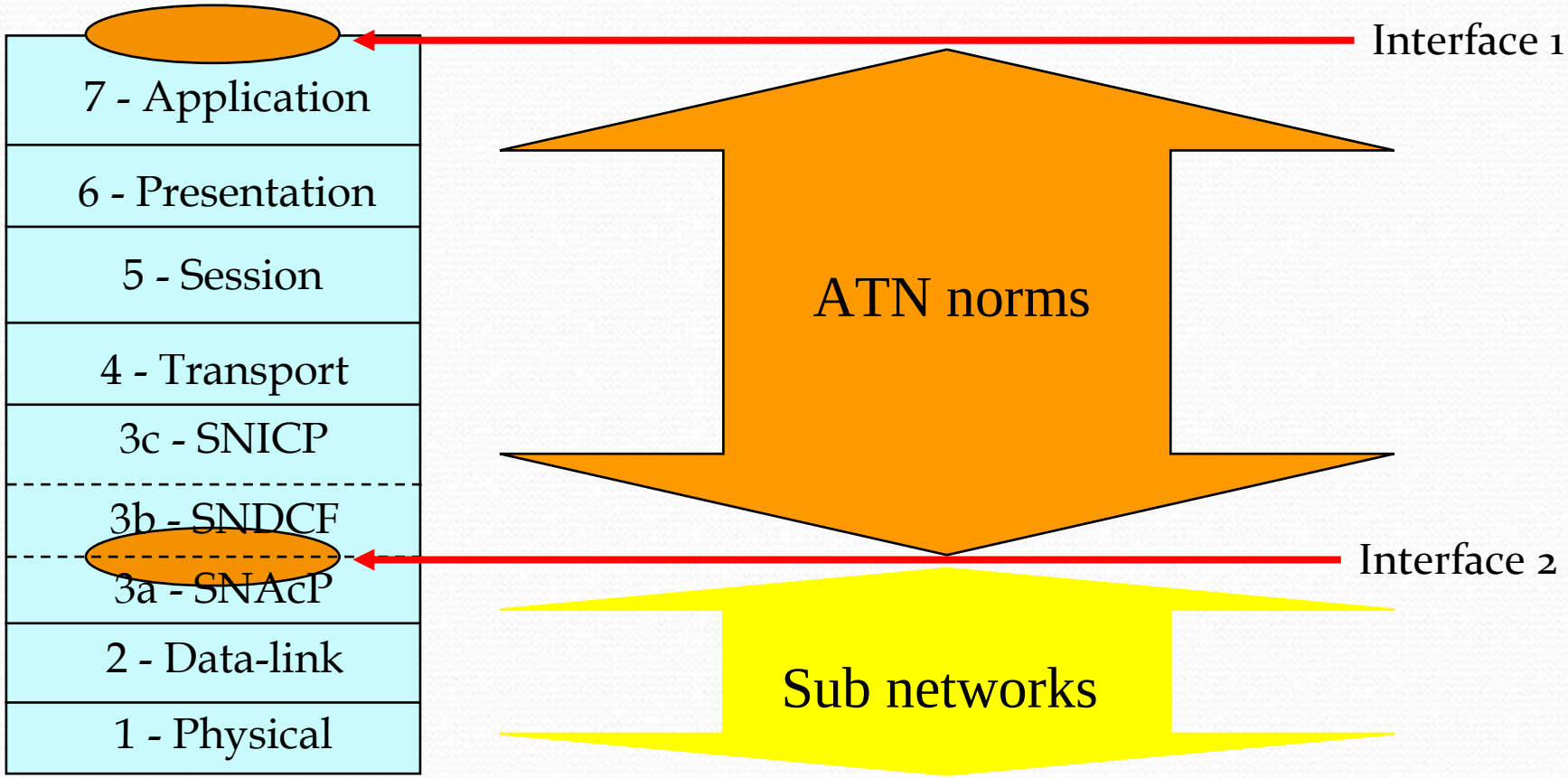
ATN architecture



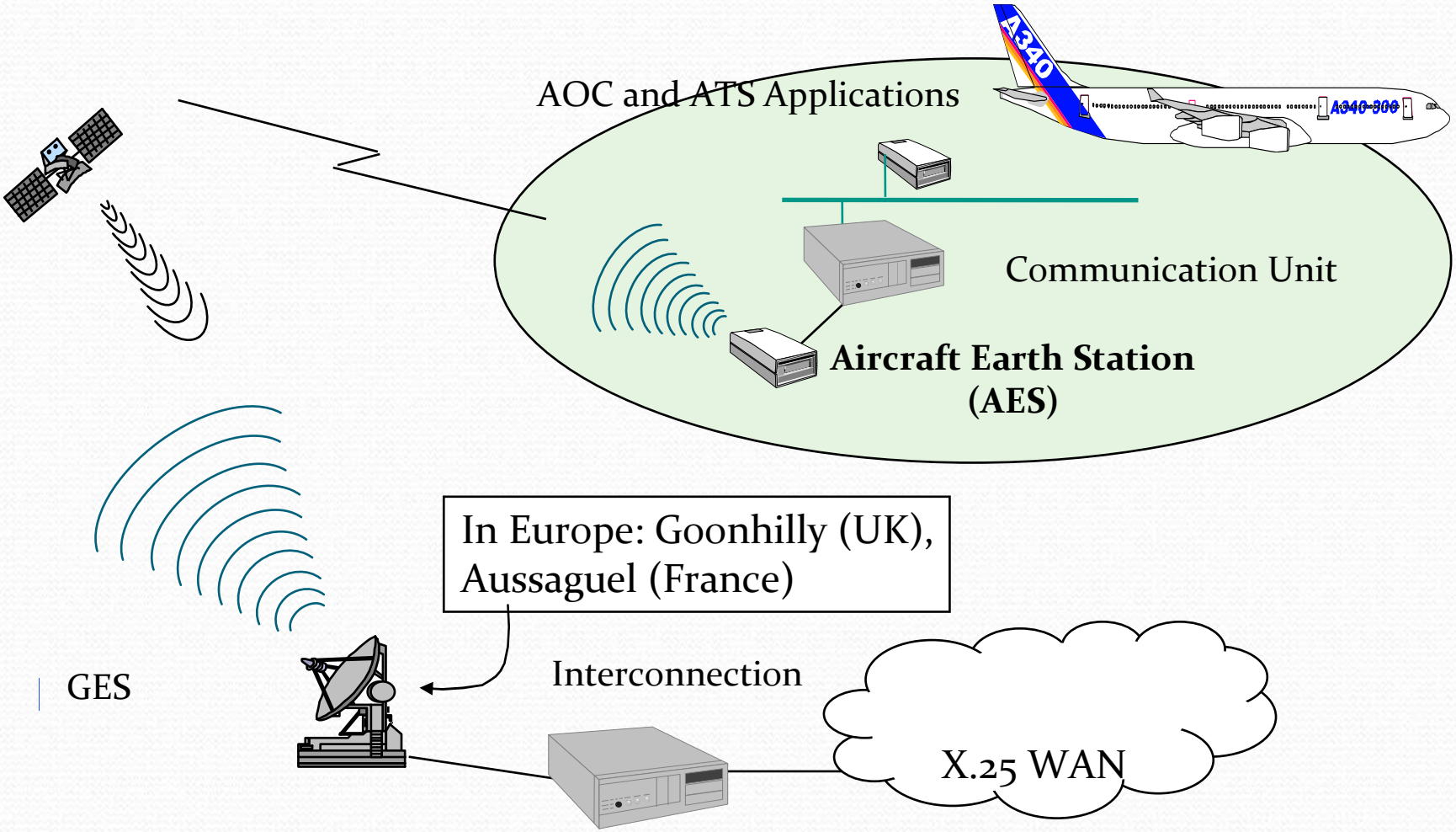
Functional principles of ATN



ATN and OSI model



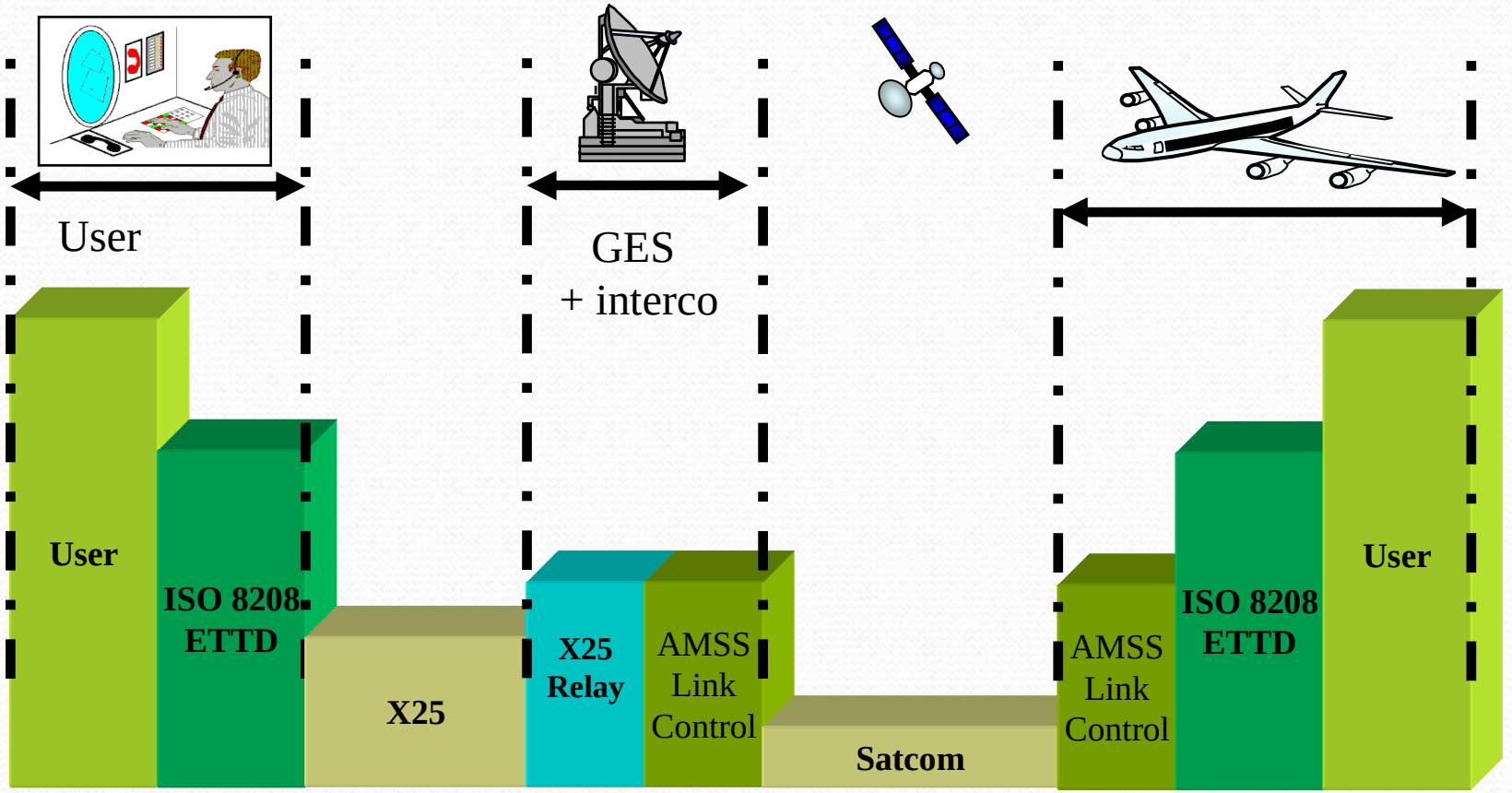
AMSS Data 3


AOC and ATS Applications
A340
Communication Unit
Aircraft Earth Station
(AES)
In Europe: Goonhilly (UK),
Aussaguel (France)
GES
Interconnection
X.25 WAN

AMSS Data 3

- The aircraft declares itself on the network
- The communication is
  - X.25 type (ISO 8208)
  - Masking the communication node

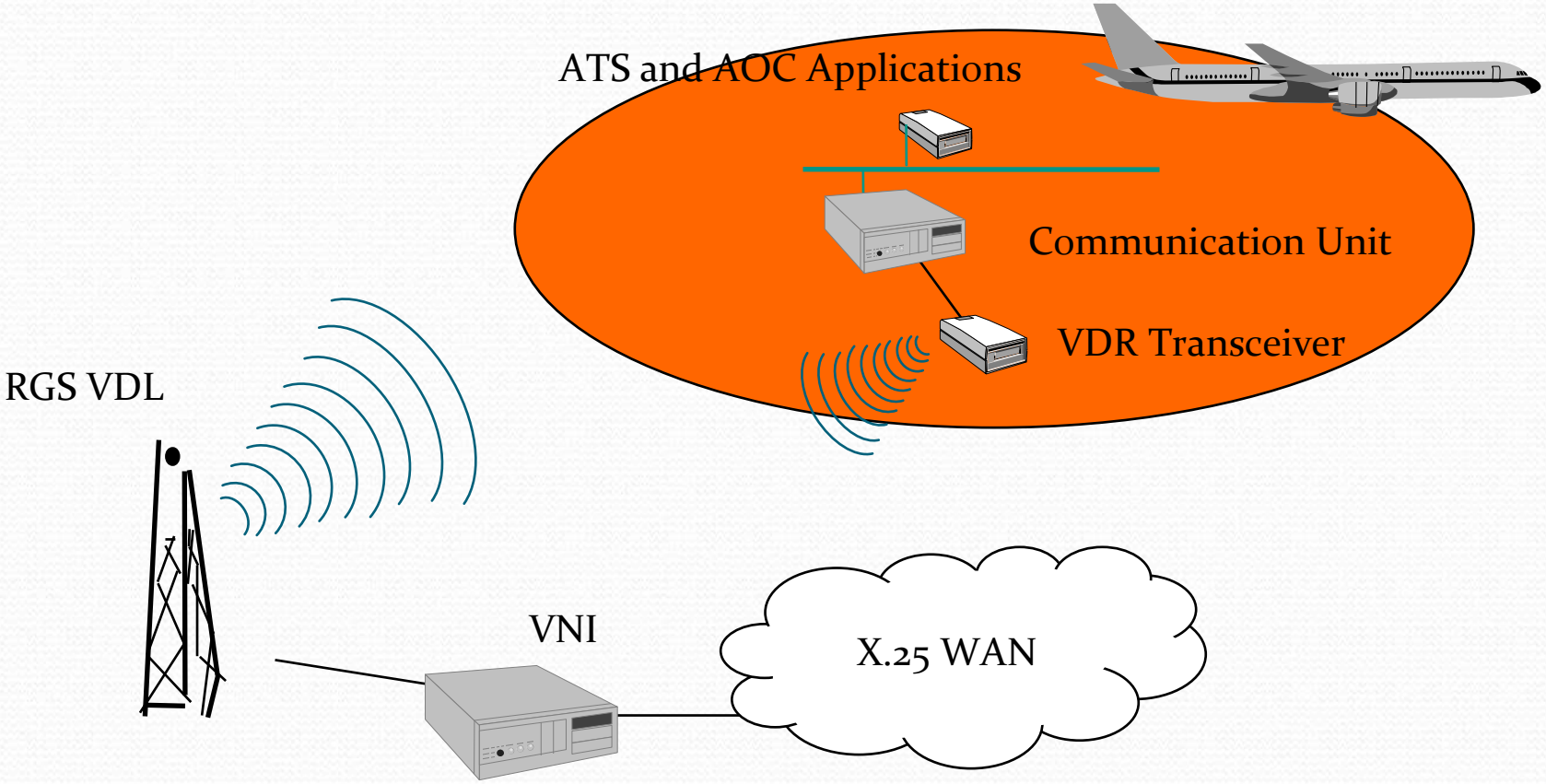
AMSS Data 3


User
GES
+ interco
User
ISO 8208
ETTD
X25
X25
Relay
AMSS
Link
Control
Satcom
AMSS
Link
Control
ISO 8208
ETTD
User

VDL

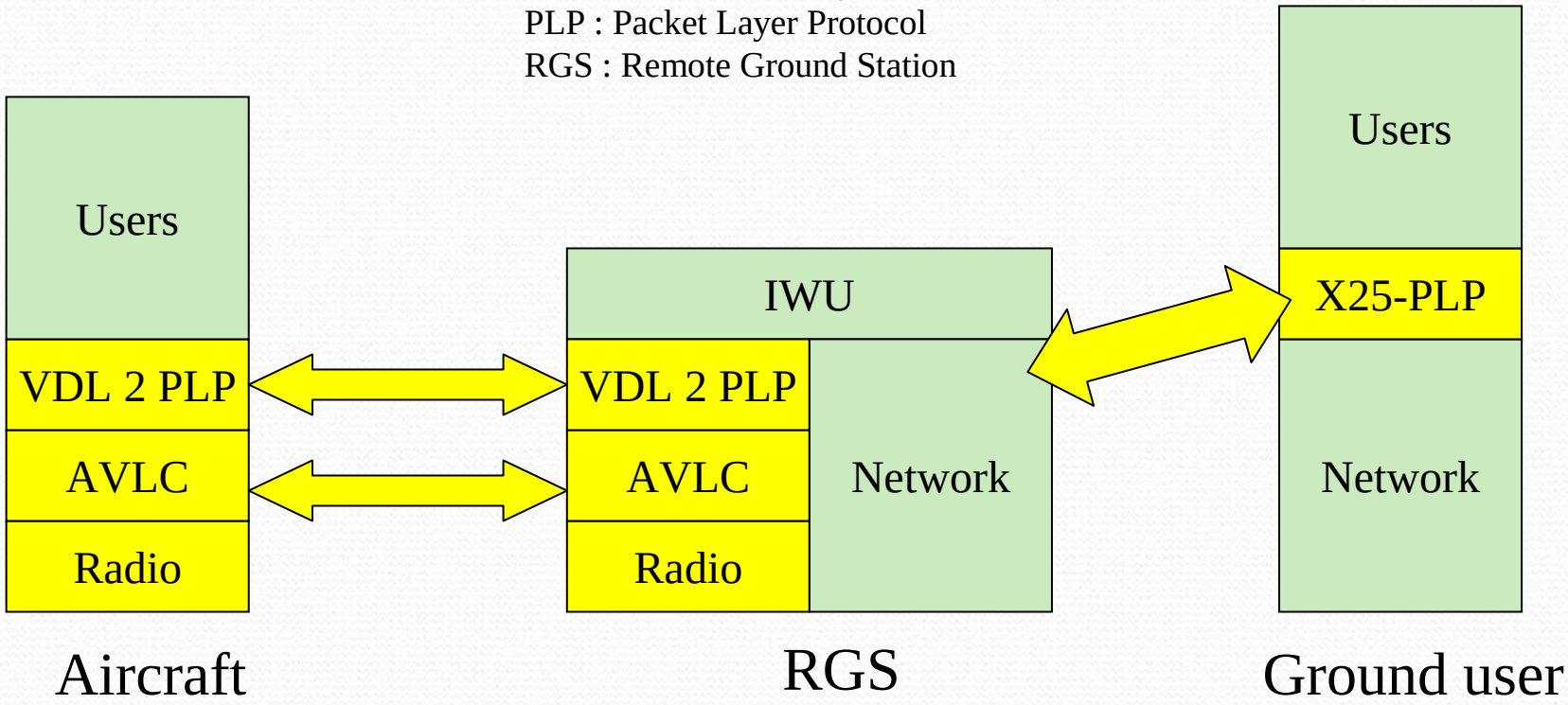
- Mask the VDL sub network as in AMSS
- Use of an ISO8208 interface
  - Transparent to the user
  - Similar to AMSS (homogenous)

VDL Mode 2

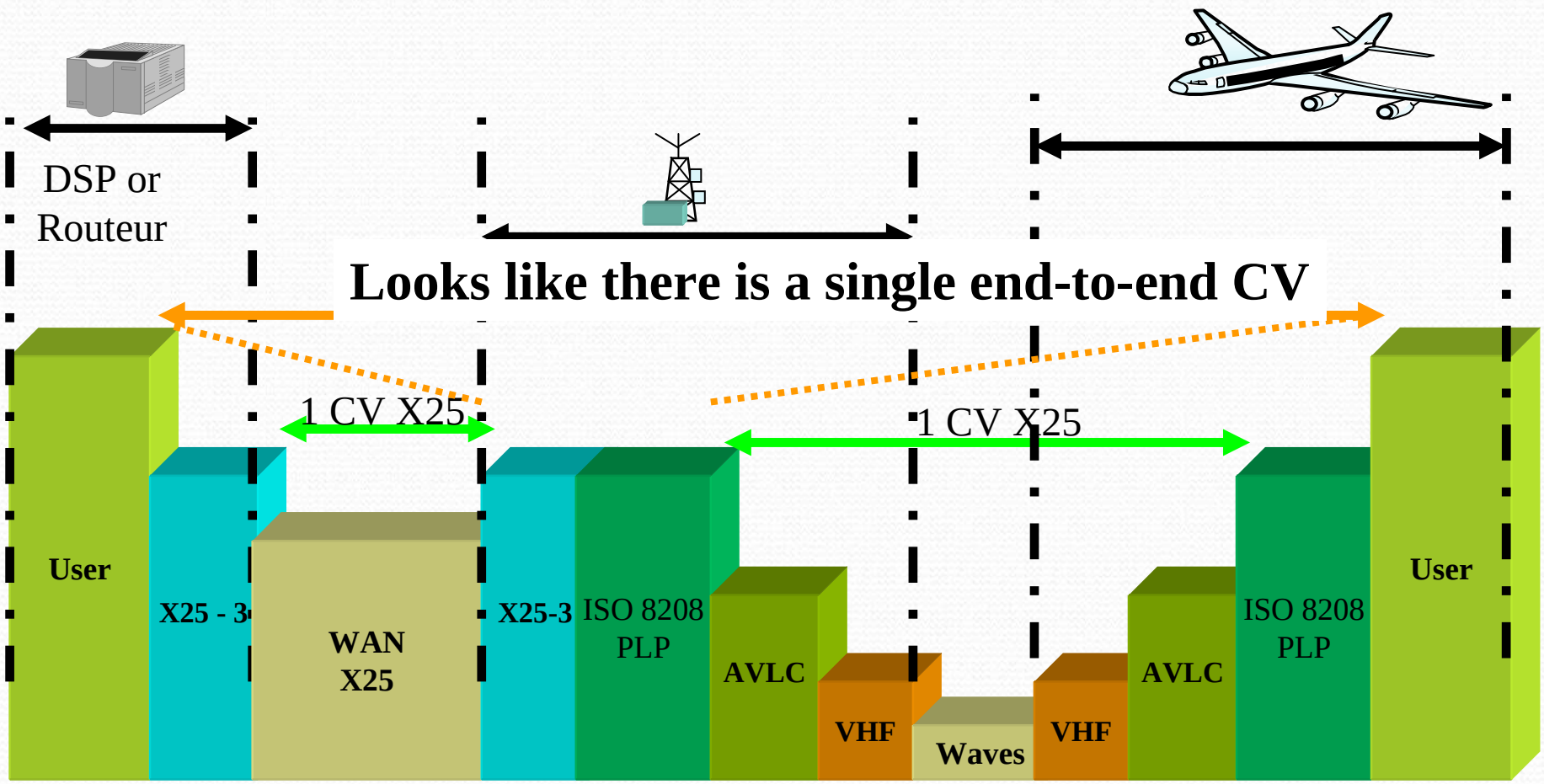

ATS and AOC Applications
Communication Unit
VDR Transceiver
RGS VDL
VNI
X.25 WAN

VDL Mode 2

AVLC : Aviation VHF Link Control
IWU : Internetworking Unit
PLP : Packet Layer Protocol
RGS : Remote Ground Station



VDL Mode 2


DSP or
Routeur
Looks like there is a single end-to-end CV
1 CV X25
1 CV X25
User
X25 - 3
WAN
X25
X25-3
ISO 8208
PLP
AVLC
VHF
Waves
VHF
AVLC
ISO 8208
PLP
User

But

- When to trigger an X25 cnx request?
- Options:
  - By polling:
    - Always possible (ex. Satcom)
  - Event triggered:
    - Presence/absence declaration of the mobile network

Establishment

- The aircraft has the knowledge
  - Example with the GSIFs (Ground Station Information Frame) in VDL
  - It will initiate the X25 connection
  - Onboard sub network management
    - IS-SME (Intermediate System – Subnetworking Management Entity)

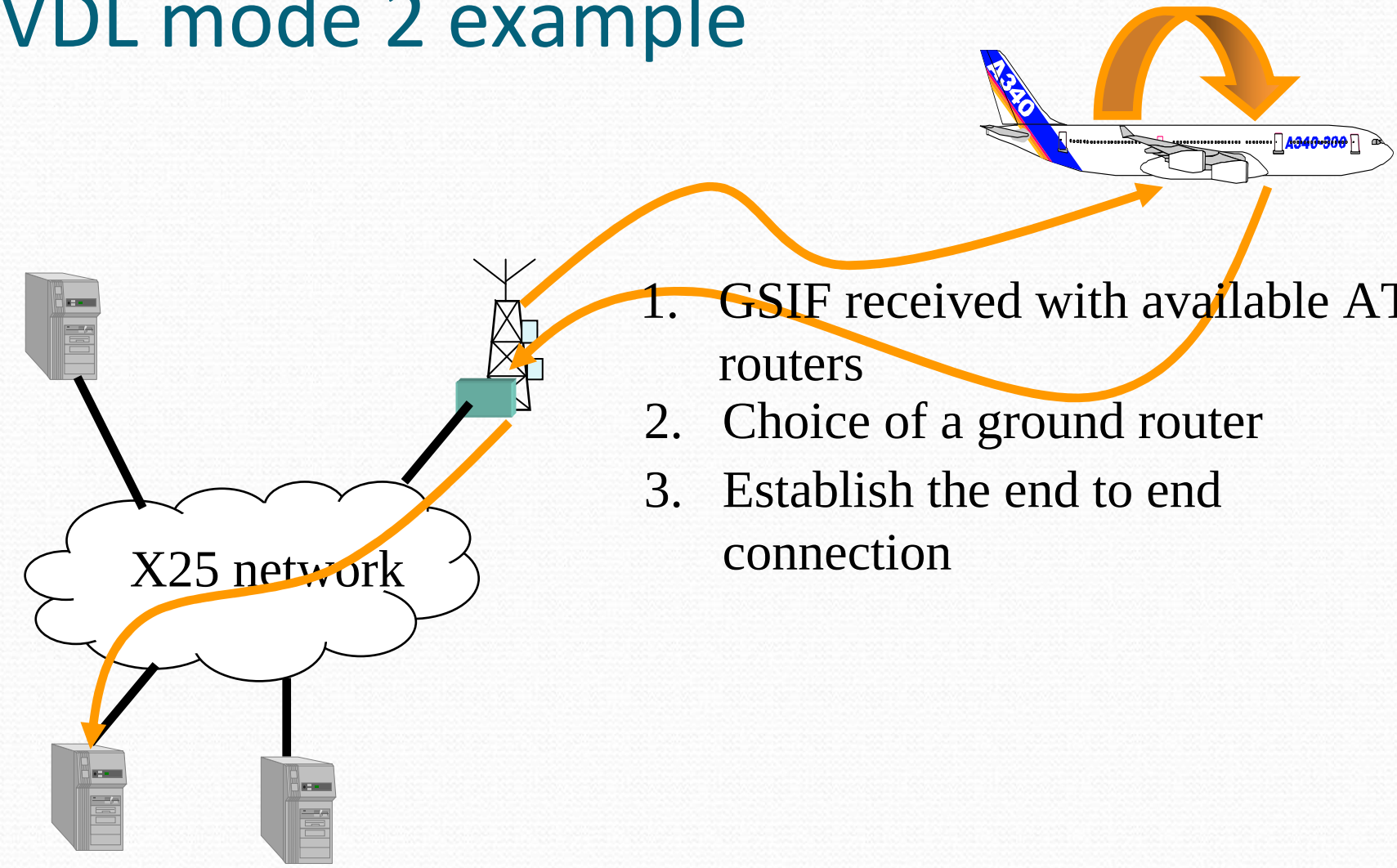
IS-SME

- The IS-SME is responsible for the selection of specific A/G route based on owner preference and initiating subnetwork connection establishment
- Bound to
  - At one end to the sub network
  - On the other end, to the communication stack

VDL mode 2 example

- In the GSIF
  - Available ATN routers' @
  - The router choose among these
  - A « join event » is triggered and sent to IS-SME
- IS-SME request the X25 connection
- When the aircraft leaves the VDL coverage:
  - A « leave event » is triggered

VDL mode 2 example



1. GSIF received with available ATN routers
2. Choice of a ground router
3. Establish the end to end connection

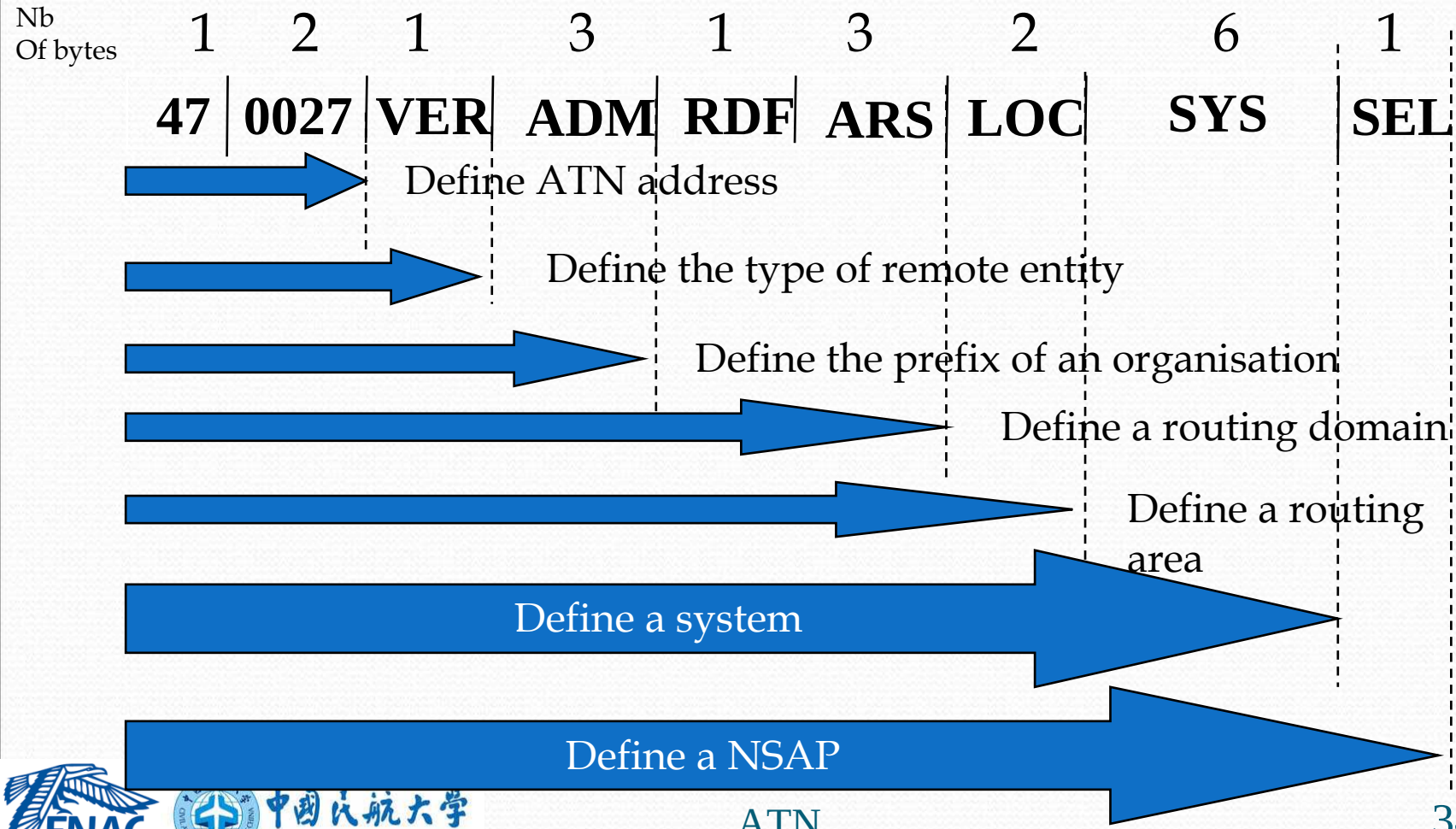
ATN specificities

- Mobile connection (aircraft)
  - A single identifier for the router : the NSAP (Network Service Access Point)
  - Dynamic routing
  - End-to-end integrity problem
  - Application data encoding
  - Mobile SNDCF and routing to the aircraft
  - The mis-direction and the PM (Protected Mode)

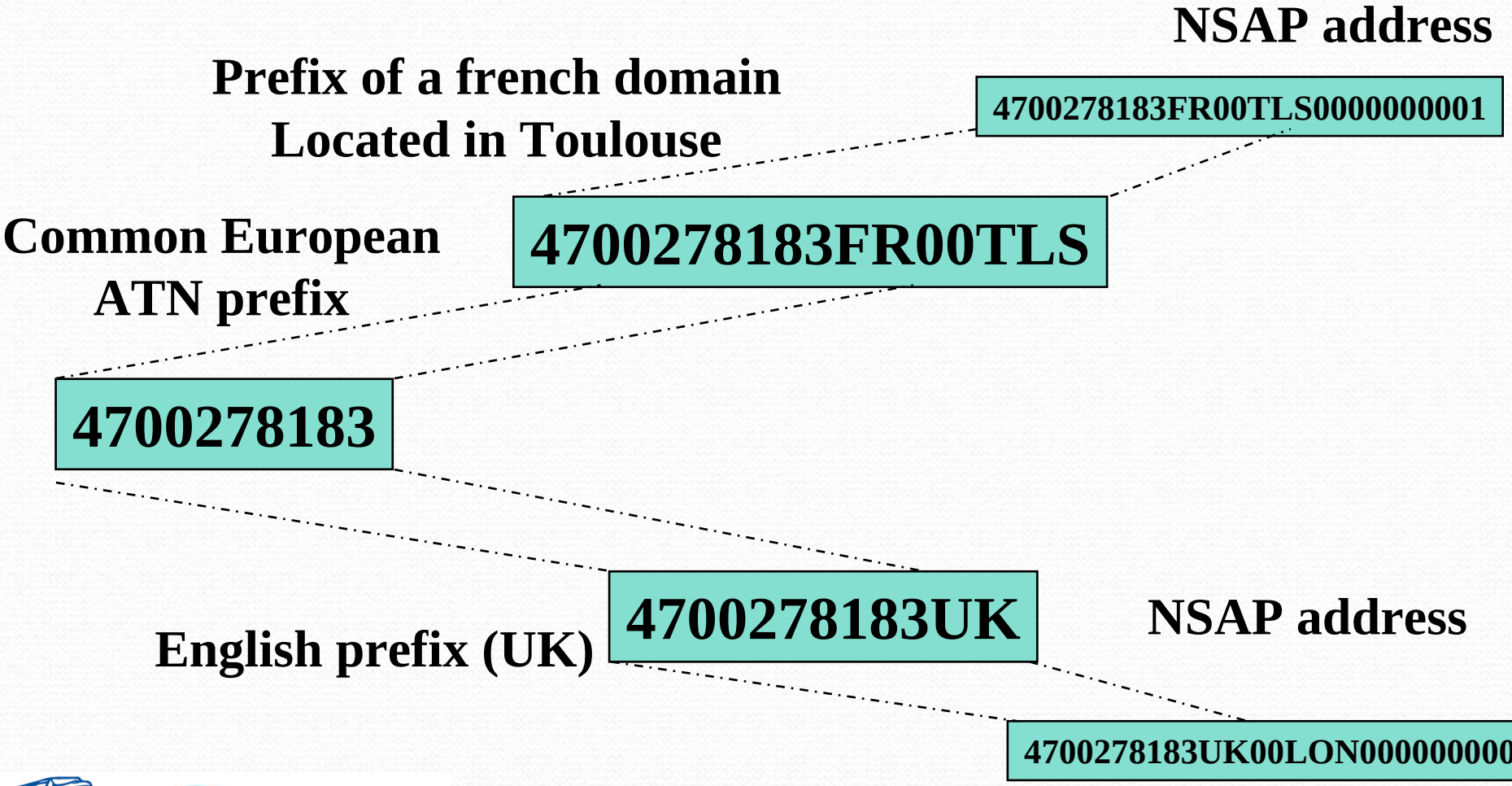
ATN address format

VER : Version
ADM : Administration Identifier
RDF : Routing Domain Format
ARS : Admin Region Selector
LOC : Location
SYS : System Identifier
SEL : NSAP Selector

Total : 20 bytes



A hierarchical address scheme



A hierarchical address scheme

- Prefix for China:
  - Asia region: 4700278181ZB00 (Hexadecimal Code of the ADM Field : 5A42)
  - Asia/Pacific/NAM: 4700278191ZB00

ATN network addressing

- Advantages
  - Facility determine Air/Ground/ATC/other
  - Hierarchy facilitating the responsibilities
  - Routing optimization
    - Reduces number of ground routes
    - Routing policy is eased

ATN dynamic routing

- IDRP (Inter domain Routing Protocol)
  - ISO 10747
  - Equivalent to BGP (Border Gateway Protocol) / Internet
    - « path vector »
    - Loop detection
    - Route aggregation
    - QoS routing
    - …

End to end integrity

- Undetected erroneous message < 10^{-8}
- For a CRC, P < $2^{-\text{length of CRC}}$
- Length of CRC > 26 bits
  - Choice of a 32 bits CRC (4 bytes)
  - P < 2.10^{-10}

Application data encoding

- Presentation layer of the OSI model
  - PER : packet encoding rules
  - No redundant/unused data
  - Coherent with the sub network performances
- Drawback: not easy to read or decode

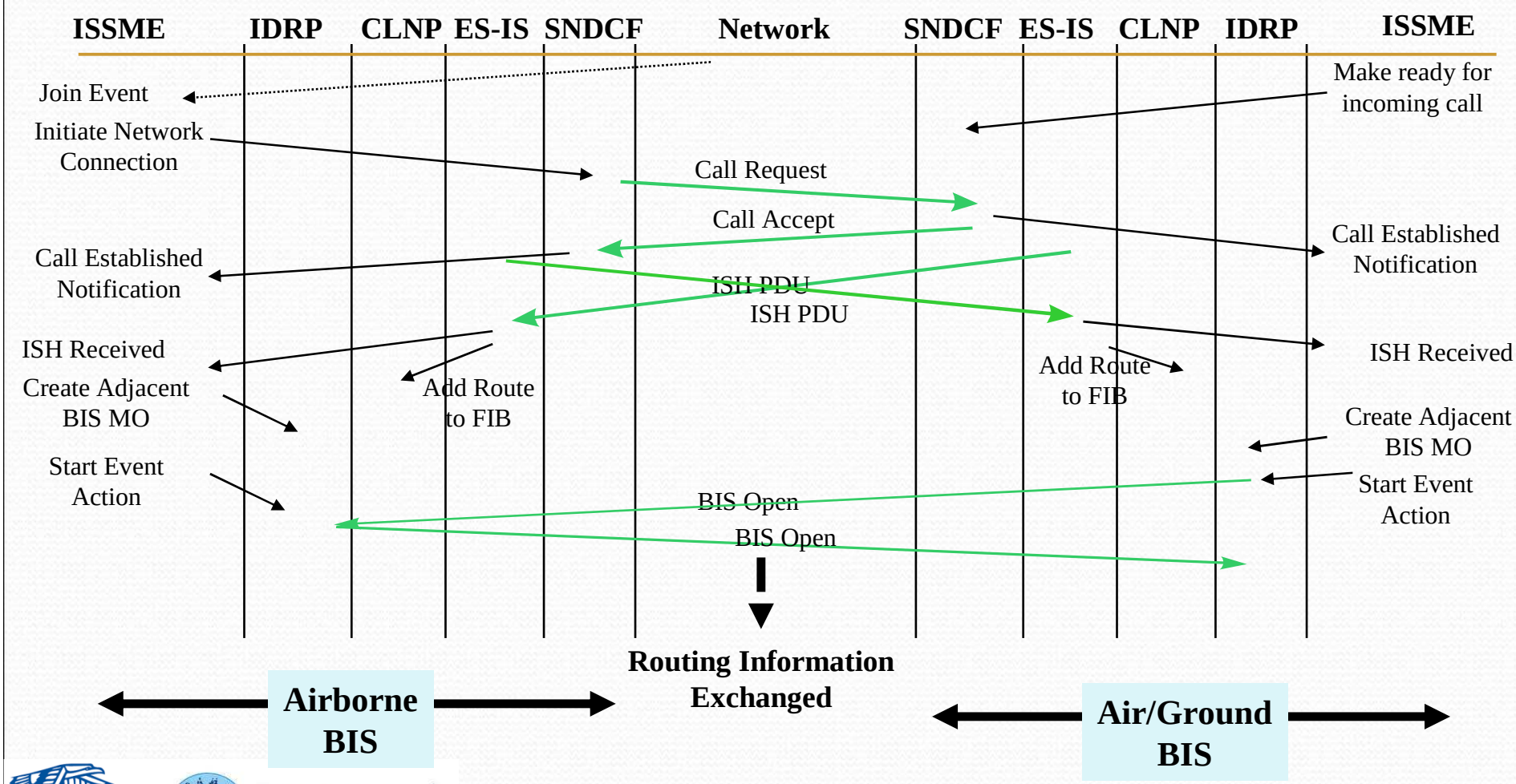
The mobile SNDCF

- Why?
  - For accommodation purposes
    - Mobile sub network with ISO8208 interface
    - An internet type of protocol stack
  - Reduce the limits of mobile sub network compared to RCP
    - In particular capacity

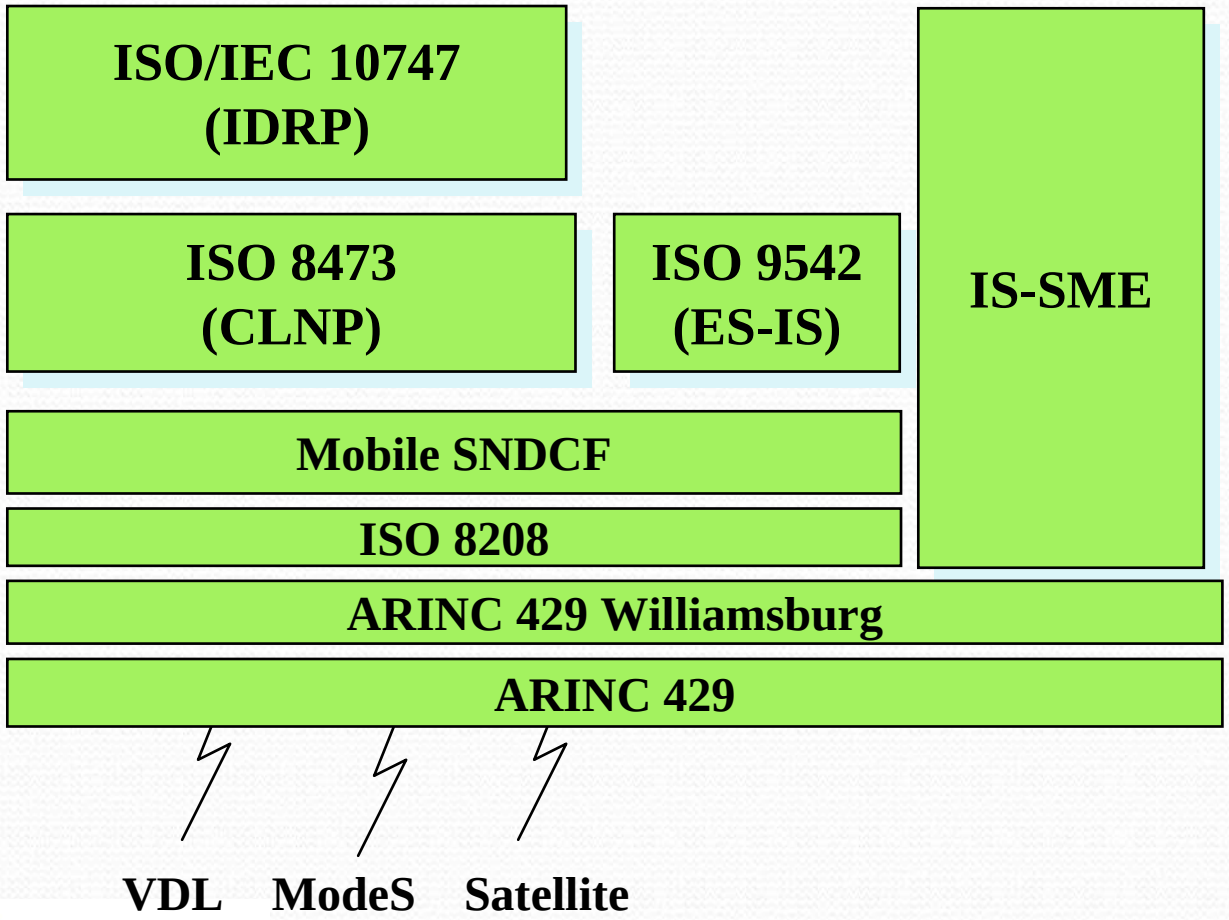
The mobile SNDCF

- Requests X25 PLP cnx establishment
- Negotiates compression algorithms
  - LREF
  - Deflate

Initiation procedure

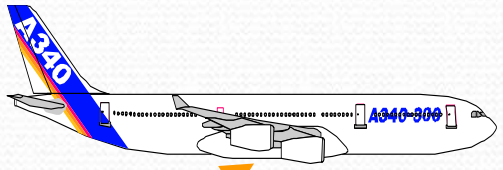


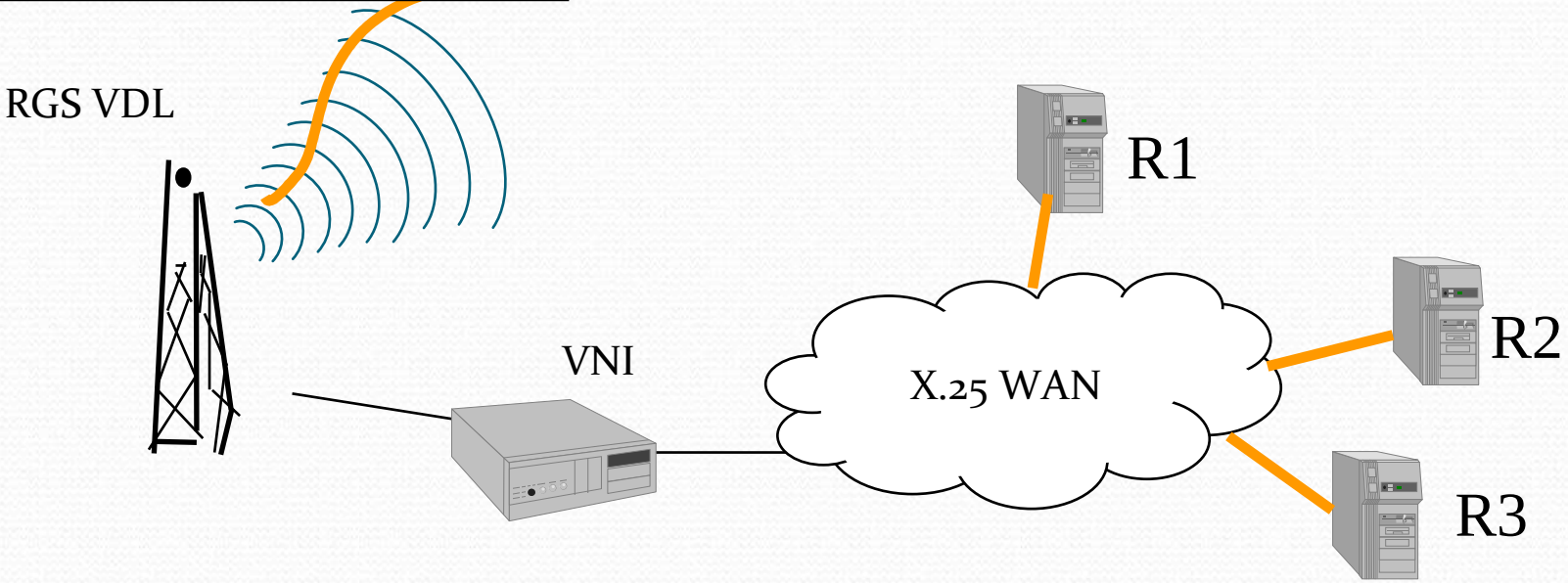
Airborne BIS with IDRP



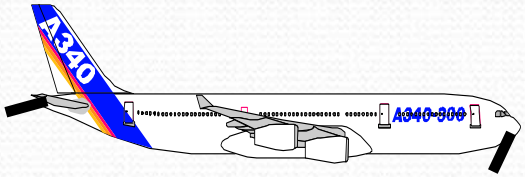
Application to VDL 2

Periodical broadcast of GSIF:
« I am connected to »
•ADM1/ARS1
•ADM3/ARS3





Application to VDL 2



VDR Transceiver
Decodes the GSIF
Chooses the router
Provides ADM + ARS

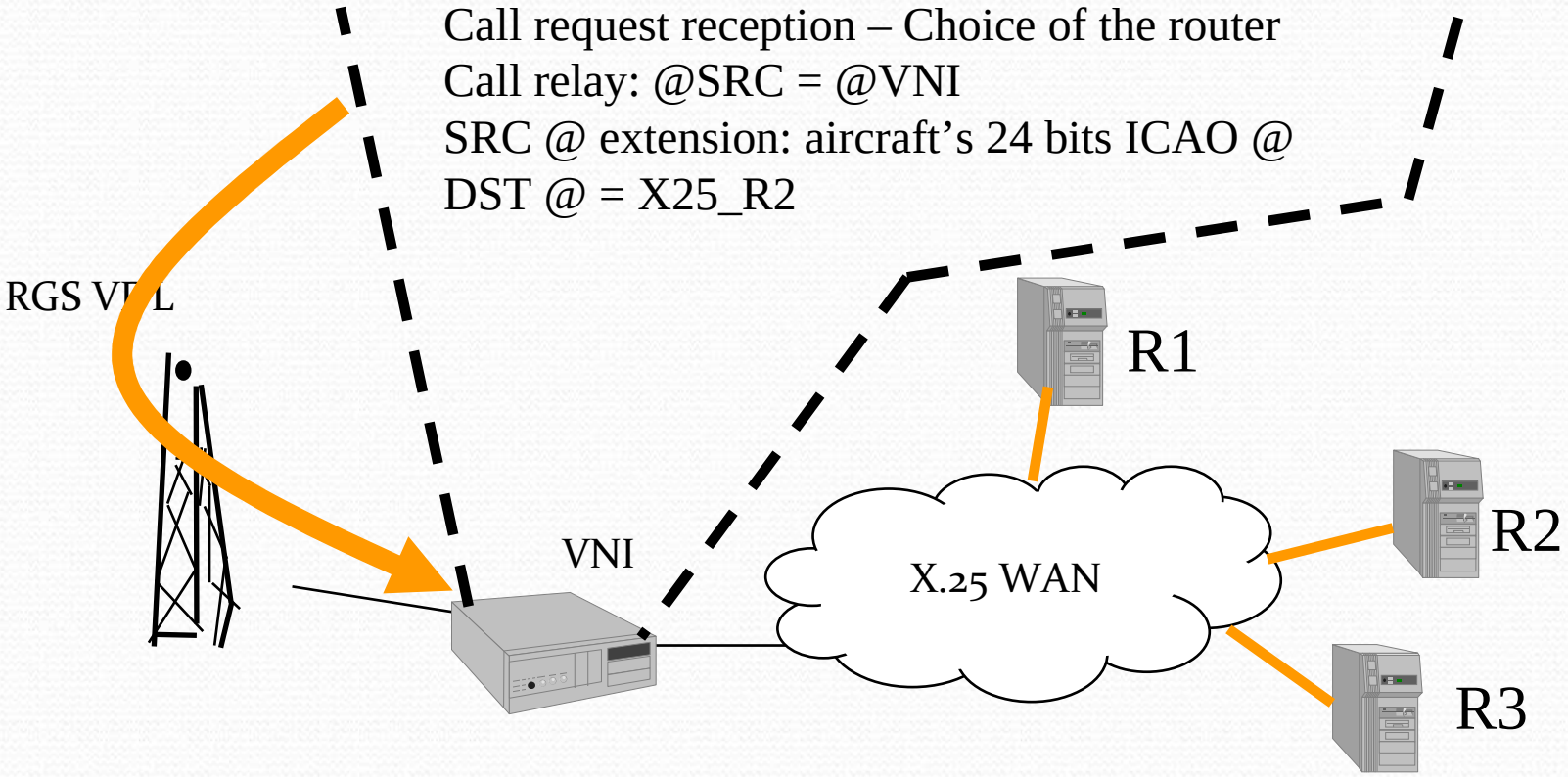
Join event sent
By IS-SME
Triggers ISO8208
Connection

RGS VDL

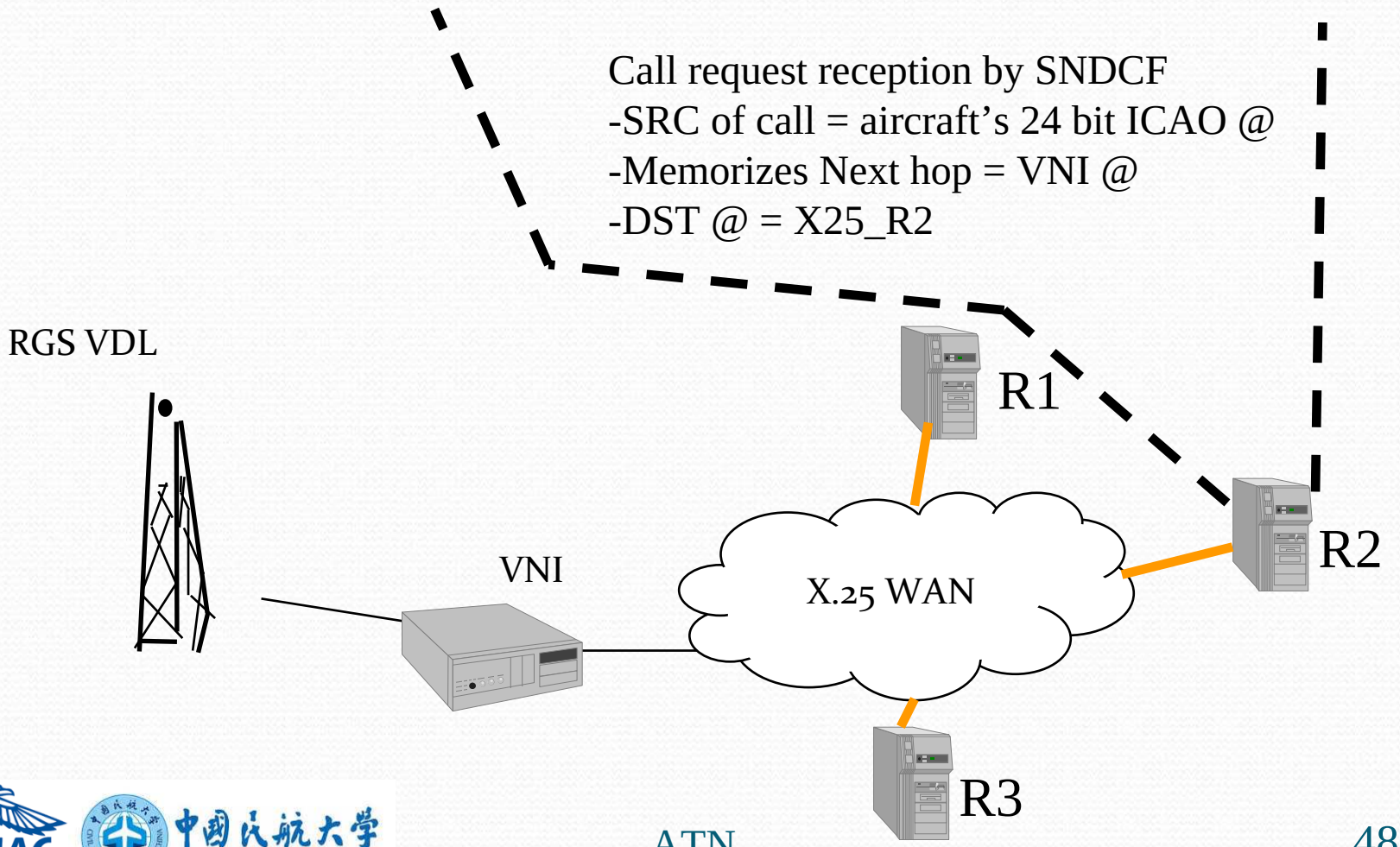
ARINC 429 W avionic bus

Call Request X25: destination @: ADM + ARS
source @: aircraft's 24 bits ICAO @
Data: ISH (Intermediate System Hello) of aircraft's router

Application à la VDL 2



Application à la VDL 2



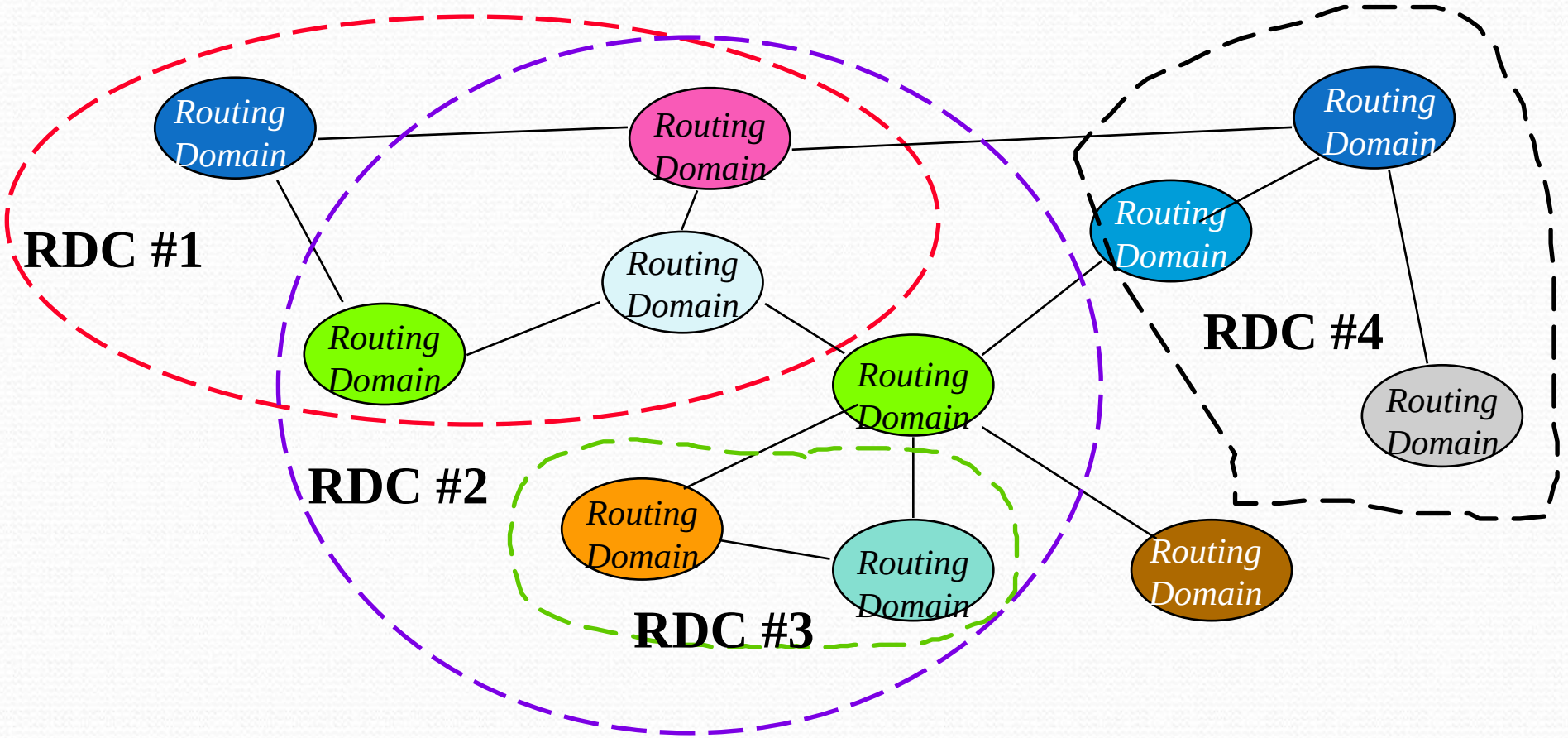
Routing to mobiles

- Island definition
- ATC Backbone definition
- Home Mobile Routing Domain definition
- Routing set up…

The Island concept

- Confederation:
  - A group of one or more routing domains (RD)
  - Sharing the same routing policies.
- A confederation not including mobile domain: an Island
  - This means: without aircraft
- The Backbone Island
  - The interconnection part, boundary for aggregation
  - Transmissions from one island to another REQUIRES transiting through the backbone

Island/confederations



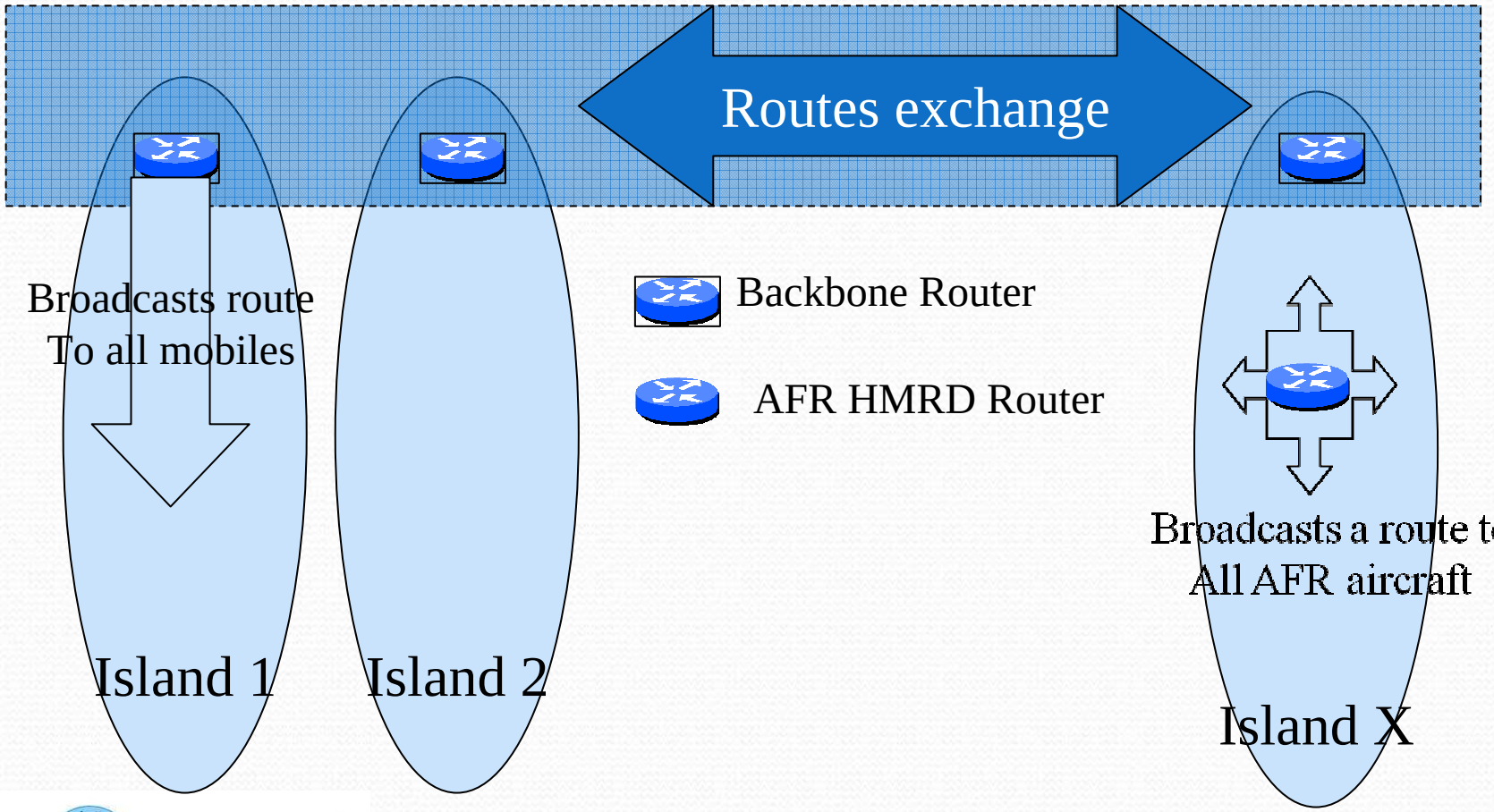
HMRD

- Each aircraft is a mobile RD
  - A network, not a single host
    - A huge difference with mobile IP
- A mobile RD is associated to a ground RD
  - Can be shared with other mobile RD
  - Provides a route (common prefix)
    - e.g. all A/C fo an Airline
    - e.g. general aviation from the ‘region’
  - The only use: stability and rapidity of routing convergence

Routing rules

- HMRD shall be declared to the BB
  - Sends route to the aircraft
- When an aircraft connects
  - The RD connected with the aircraft shall send the information to the aircraft's HMRD

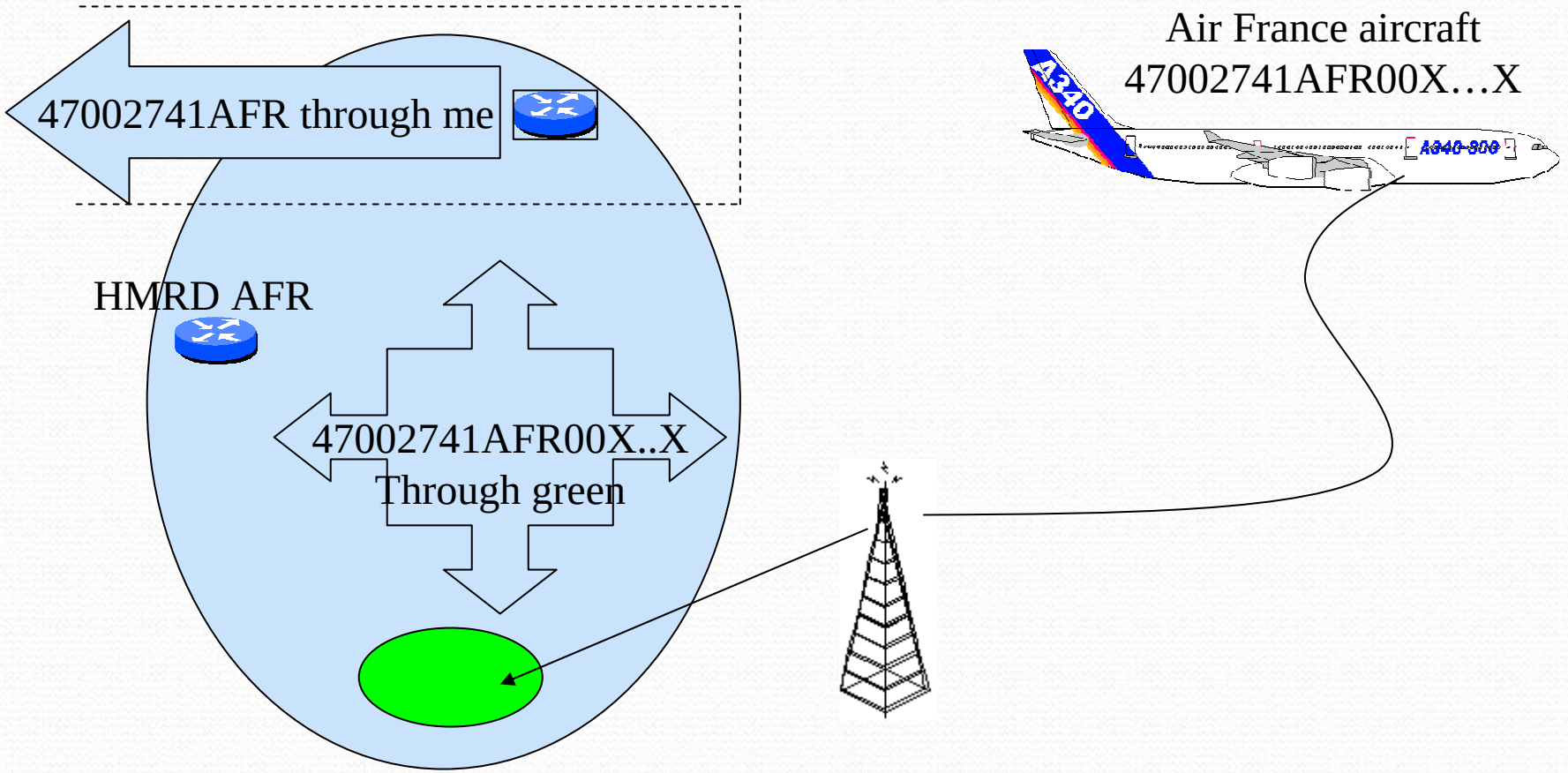
Routing to mobiles



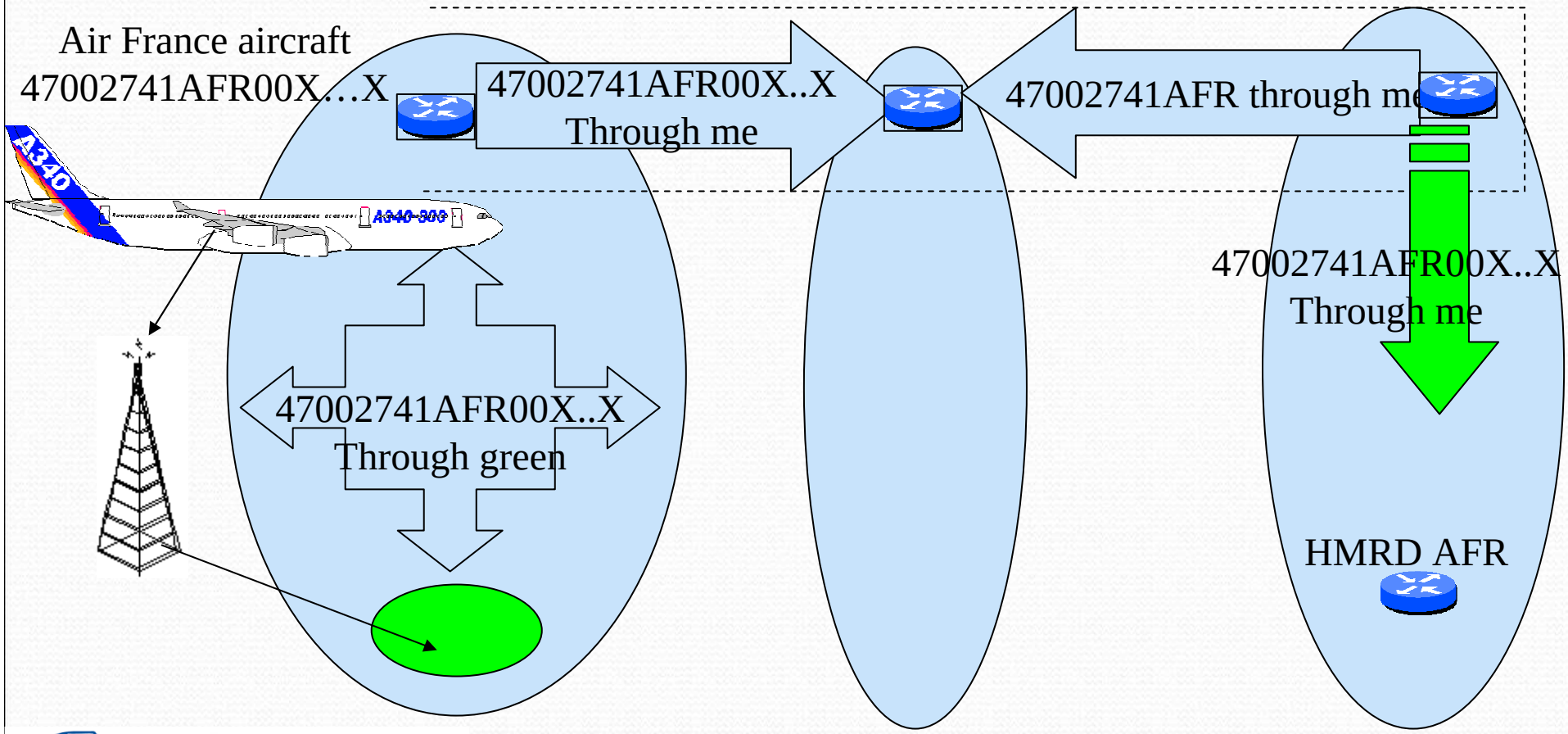
Routing to mobiles

- An aircraft connects to an RD
  - The router receiving the connection broadcasts the route into its island
  - The backbone router receiving the information forwards it after « reduction »
    - The aircraft is within its HMRD island (Island X): nothing changes for this prefix
    - The aircraft is outside its HMRD island: route cannot be reduced by the backbone router

Routing to mobiles



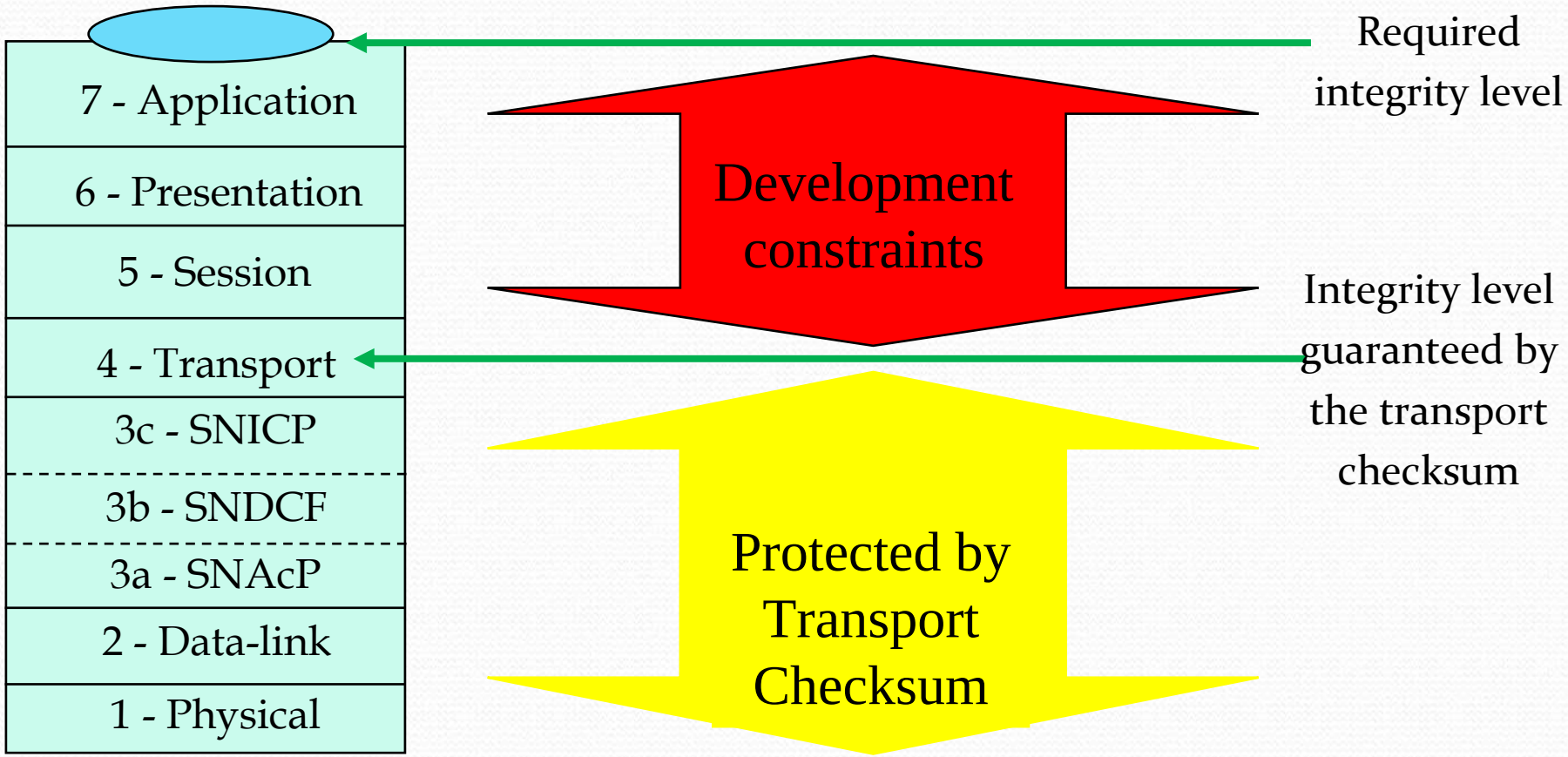
Routing to mobiles



Routing to mobiles (summary)

- In an island
  - Routes to A/C in my island
  - Routes to A/C in another island for which the HMRD is in my island
  - Routes to HMRD in my island
  - All A/C route
- In the backbone
  - Routes to A/C out of their HMRD island
  - Routes to HMRD

Integrity requirement



Development constraints

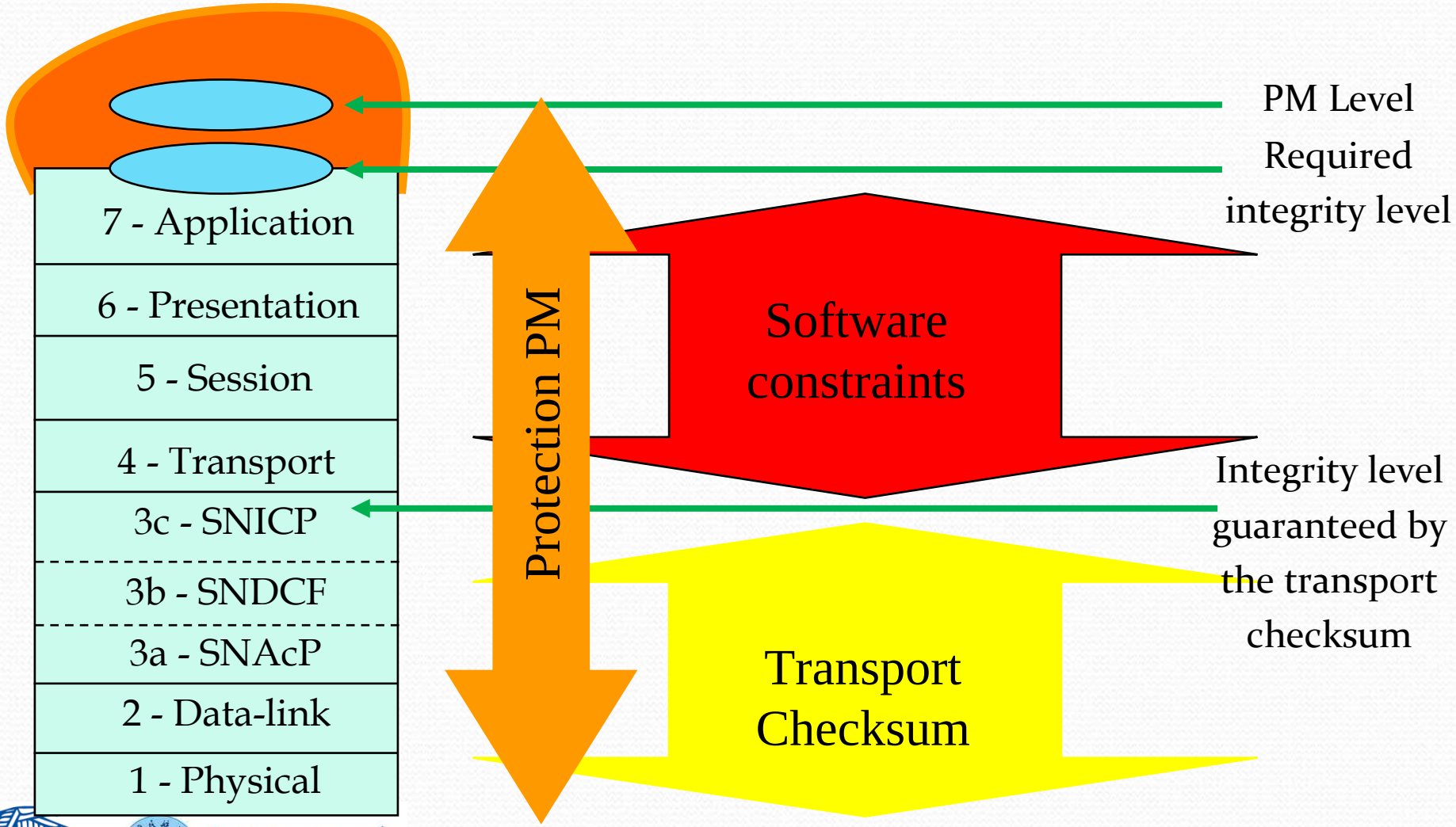
- Requires software assurance level
  - DO178B level C
  - Costs!!!
- Protecting at application level
  - Reduces the costs

→ The Protected Mode (PM)

Protected Mode

- Combine:
  - Application message
  - Aircraft flight number
  - Ground system identifier
- Compute a checksum at application level
  - Digital signature
- Add it to the transmitted message

PM and integrity



Protected Mode

- Pros
  - Cost effective
  - Also mitigates risks outside the scope of the network (e.g. bad configuration)
- Cons
  - No recovery: go back to voice!

The future

- System requirements reinforcement
- Cost effectiveness requirements
- Use of IPv6 like standards

Bibliography

- ARINC 618 – 620 – 622 – 663 – 664
- OACI – Annexe 10 – Volume 3 – Chap 3
- OACI – CAMAL (Comprehensive ATN Manual)
- OACI – Doc 9880 – Manual on ATN technical specifications