ACARS

Aircraft Communications Addressing and Reporting System

Presented by

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ALTRAN on behalf of ENAC

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Objectives

- Introduce AEEC standardization body
- Describe ACARS protocol
- List the available sub networks
- Describe FANS 1/A related protocols

Content

- Introduction
- AEEC (Airline Electronic Engineering Commission)
- ACARS
  - Network
  - DSP
  - Protocol
  - Subnetworks
  - Routing
- FANS 1/A additional protocols
- AOA
- Performances
- Conclusion

Introduction

General Introduction

AEEC standardization

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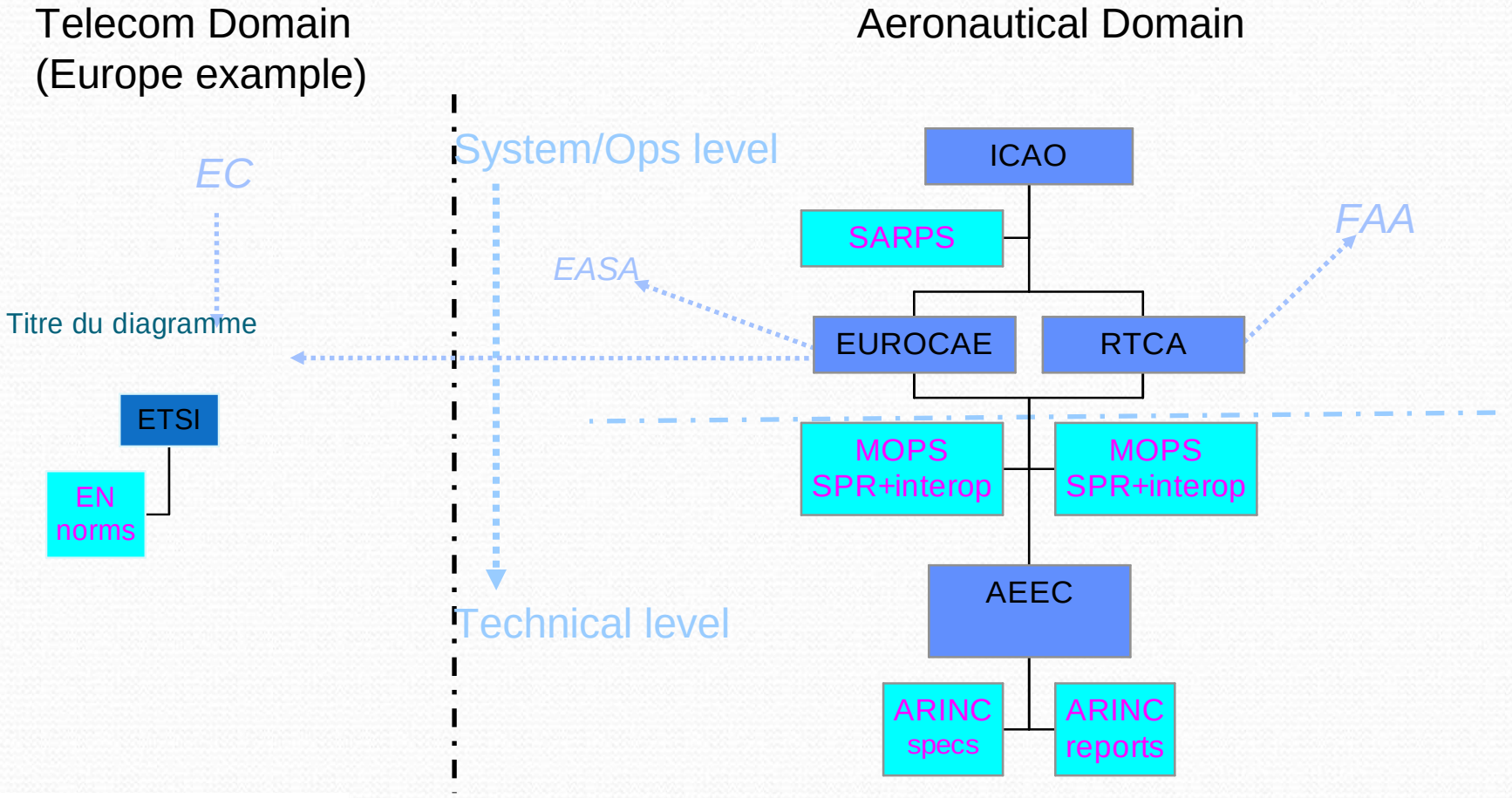
Introduction

- ACARS (Aircraft Communication Addressing & Reporting System)
- Developed in the late 70's by ARINC
- First for airline needs (OOOI)
  - Out of gate, Off ground, On ground, In gate
- Major airline use in the 80's
- A teletype-like service: connectionless, character oriented
- Developed for airline needs (AOC)
  - Initially no QoS requirements

Introduction

- Additions made to support (to a certain extent) ATC requirements
- Worldwide coverage through several sub-networks
  - VHF
  - Satcom
  - HFDL
- Standardized in ARINC documents
  - Interfaces oriented description: ground-ground and air-ground

Standardization map



AEEC General objectives

- “Helps create a favorable economic environment for airline procurement of avionics systems by developing voluntary standards”
- Mechanisms :
  - interchangeable equipments
  - interoperable systems
- Benefits :
  - reduced cost → open competition
  - reliability → marketplace pressure
  - coherence → airplane and avionics architecture
- Promote safety with reasonable international regulations

ARINC and AEEC

- Aeronautical Radio INC. created in 1929
- ARINC belongs to airlines but has some obligations:
  - A rationalization goal
  - A role of standardization body for airlines
  - Therefore a role as AEEC secretary
- A standard written by ARINC for AEEC = an ARINC standard
- “ARINC standards do not belong to ARINC”

Partners for standardization

- Airlines and their associations (IATA...)
- Service providers (ARINC, SITA ...)
- Avionics manufacturers (Rockwell-Collins, Thalès...)
- Aircraft manufacturers (Boeing, Airbus ...)
- Aeronautical regulation authorities indirectly

ACARS Network

Network Architecture

DSP

Protocol

Subnetworks

Routing

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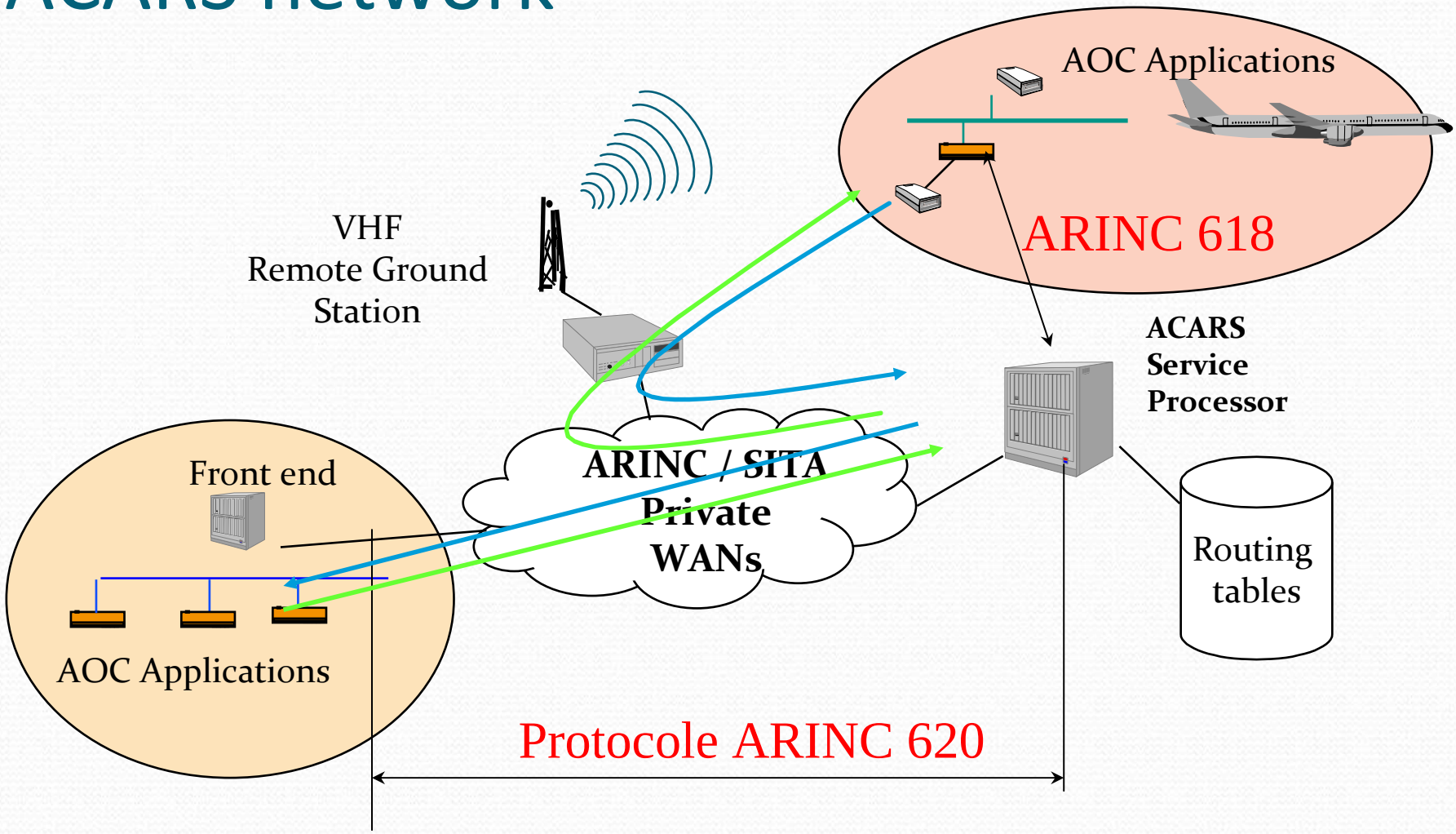
ACARS network



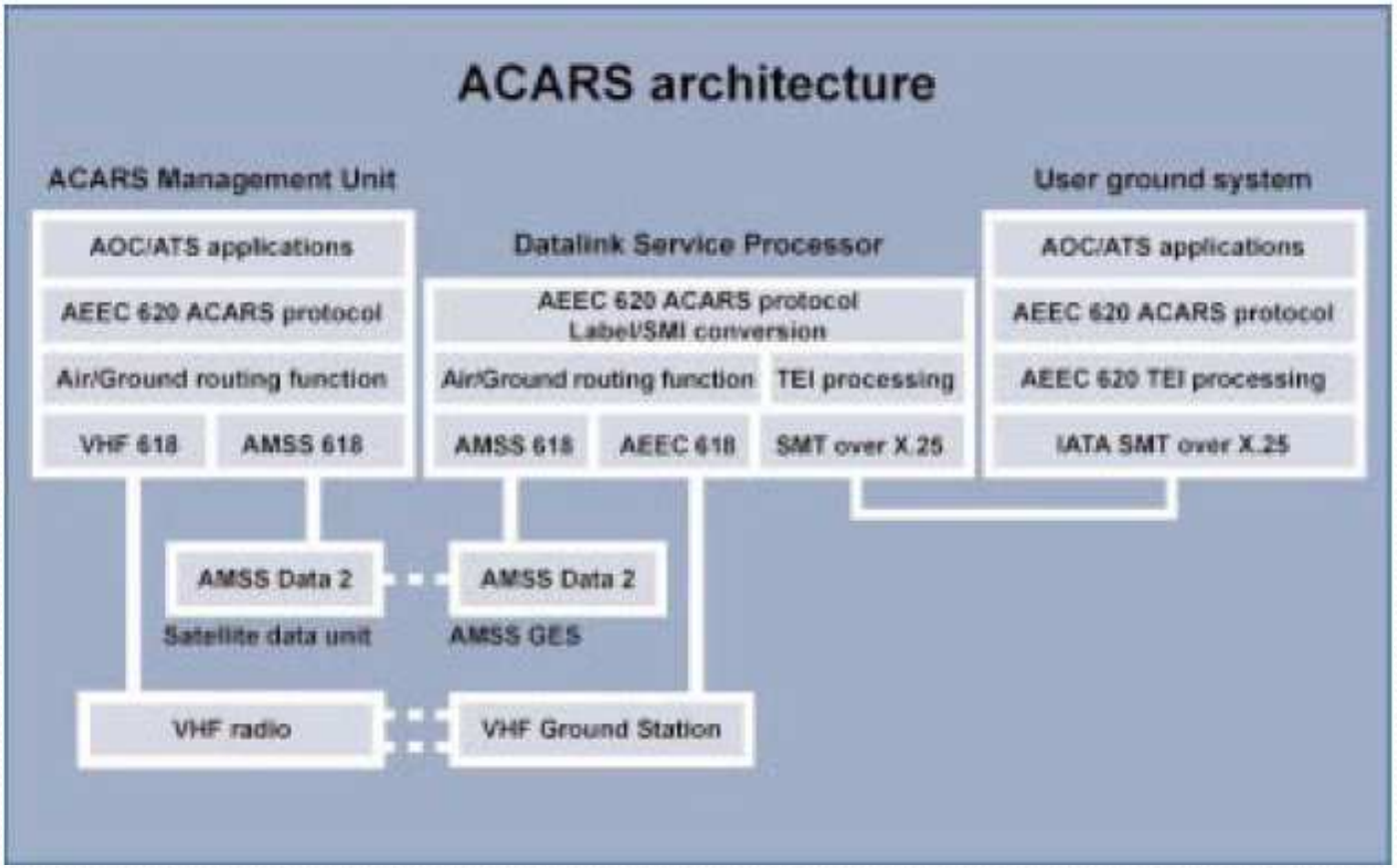
ACARS network

- Two interfaces:
  - Air-ground: A618
  - Ground-ground: A620
- Connecting the aircraft to its airline
  - No destination address sent by the aircraft (ACARS)
- Messages are labeled by their content (application)
- Destination address is determined by:
  - Airline (A/C address registration)
  - Label

DSP (Digital Service Provider)

- A centralized network: a central processor
- Every ground station is connected to the DSP:
  - Knows the ground addresses
  - Knows the « location » of the aircraft
- Reformats messages between the two interfaces
- Provides acknowledgements to the ground user

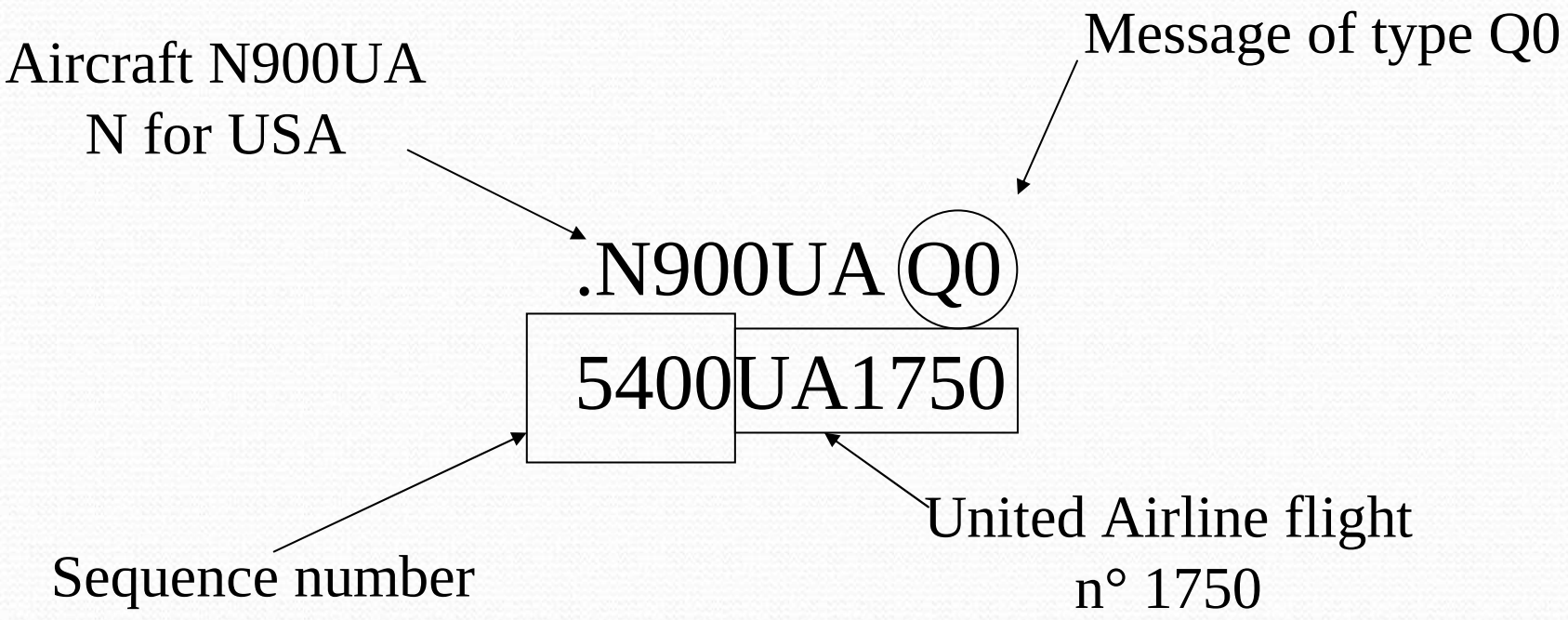
DSP


ACARS architecture
ACARS Management Unit
AOC/ATS applications
AEEC 620 ACARS protocol
Air/Ground routing function
VHF 618
AMSS 618
Datalink Service Processor
AEEC 620 ACARS protocol
Label/SMI conversion
Air/Ground routing function
TEI processing
AMSS 618
AEEC 618
SMT over X.25
User ground system
AOC/ATS applications
AEEC 620 ACARS protocol
AEEC 620 TEI processing
IATA SMT over X.25
AMSS Data 2
Satellite data unit
AMSS Data 2
AMSS GES
VHF radio
VHF Ground Station

ACARS messages

- Address part:
  - 7 characters long
  - Tail number, right justified, padded with '.' on the left
- Label part: 2 letters
  - Defines the type of data
- Message number:
  - 4 characters long
- Flight number:
  - 6 characters long

ACARS message



Air-ground protocol

- Defined in A618
- Use of VHF (VHF 3)
- Modulation: Minimum Shift Keying 2400 bits/s
- A618 block:
  - 240 characters per blocks,
  - 220 characters of application data,
  - Possibility to bind A618 blocks into one message.
- Connectionless protocol

Onboard architecture

- Digital radio: VDR (VHF Data Radio) mode A
  - Standardized
  - Medium access control
  - CMU (Communications Management Unit) managed for the frequency selection
- Connection through ARINC 429 bus
  - 100 kbps

A620 message

- Ground-ground segment
- Text format
- End of line mark <CR/LF>

Table 3.2.1-1 - General Format of Ground-Ground Messages

Line	Contents	Example
1	Priority/Destination Address	QU ADRDPAL
2	Signature/Transmission time	.DSPXXXX 121212
3	Standard Message Identifier (SMI)	AGM
4-m	Text Elements	FI XX0001/AN N123XX
m-n	Free Text	- UPLINK OR DOWNLINK

A620 message

- Line 1
  - Priority: 2 characters identifier
    - Only one defined: QU (followed by SPACE)
  - List of destination addresses
    - 7 characters
    - maximum : 16 addresses

A620 message

- Line 2
  - Starts with <.> (dot)
  - Source address (7 characters)
  - Date and time (optional)
  - SPACE

A620 message

- Line 3
  - SMI: List of identifier bound to content (label)
  - Relation between the label and the SMI defined in the standard

A620 message

- Line 4
  - Text
    - TEI : identification code – 2 characters
    - SPACE then text
    - End of line symbol: <CR/LF> or < / >
  - TEI may describes an aircraft
    - FI : Flight Identifier
    - AN : Aircraft Number
  - Or other events (OOOI, fuel)

A620 message

- Line 5
  - localization of the receiving antenna
- Example:
  - DT DSP RGS 121212 M01A
    - DSP : DSP code on 3 characters
    - RGS : Receiving ground station
    - UTC time (ddhhmm)
    - Message sequence number

ACARS ack

- Uplink:
  - Message assurance (MAS)
  - Only up to the ACARS MU
- Downlink
  - Technical ACK (TACK)
  - DSP acknowledges the downlink message

Message assurance (uplink)

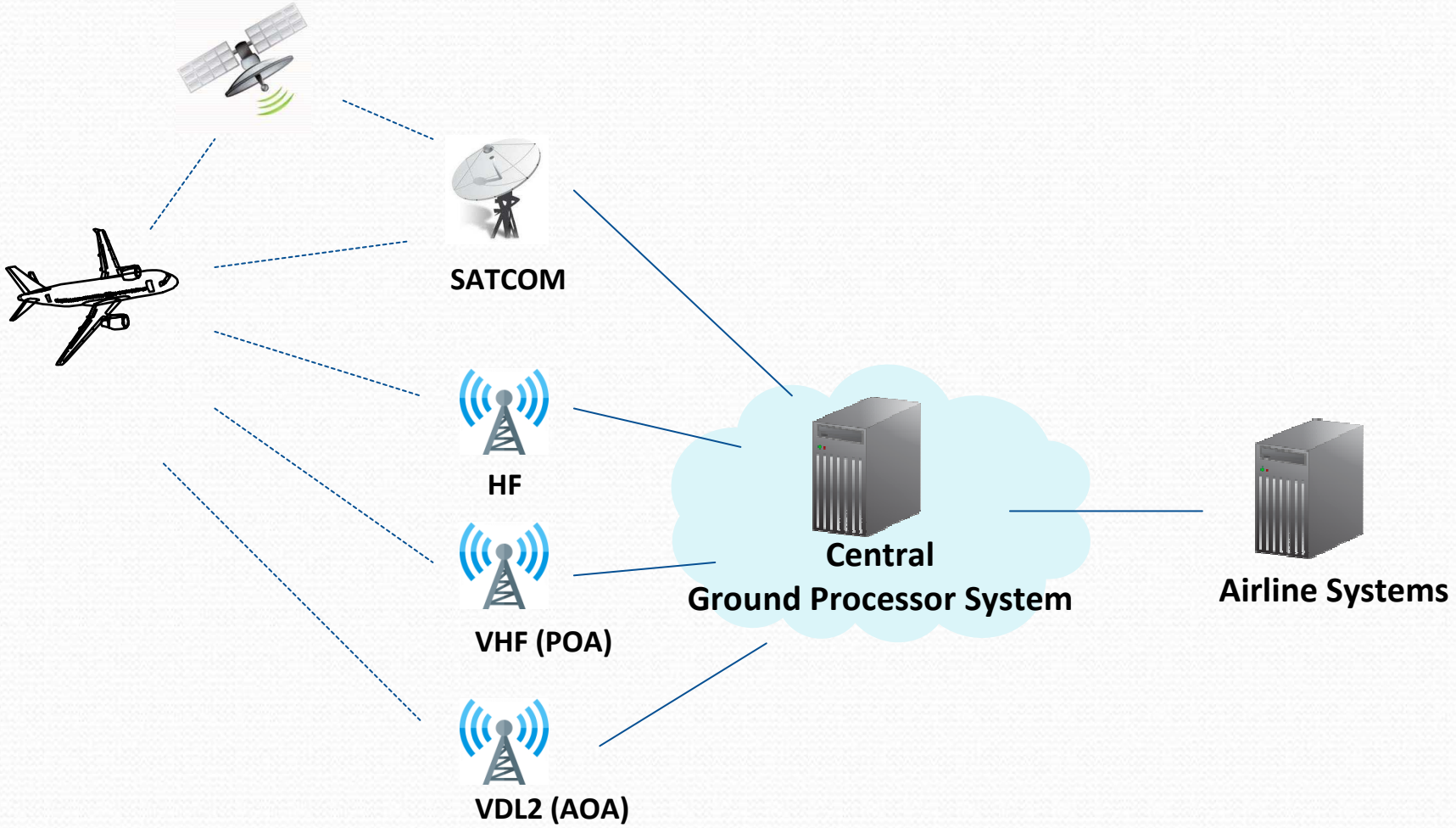
- Optional message acknowledgement
  - Add to line 4 (AN and/or FI)
  - MA : message assurance or MAS
  - Not transmitted to the aircraft
  - Coded on 3 digits (000 à 999)
  - Acknowledge:
    - Aircraft only, or
    - Aircraft + DSP

Message assurance (uplink)

- For the DSP: on reception of a message:
  - Send a service message
- On ACARS MU acknowledgement

Successful delivery is interpreted to mean that all the ACARS blocks resulting from the uplink message sent to the DSP were positively acknowledged by the aircraft. The delivery confirmation simply indicates that the uplink message was received by the ACARS Management Unit. Receipt of Uplink Message Delivery Confirmation does not provide an indication of receipt or acknowledgment by the flight crew or any avionics subsystem.

ACARS Subnetworks



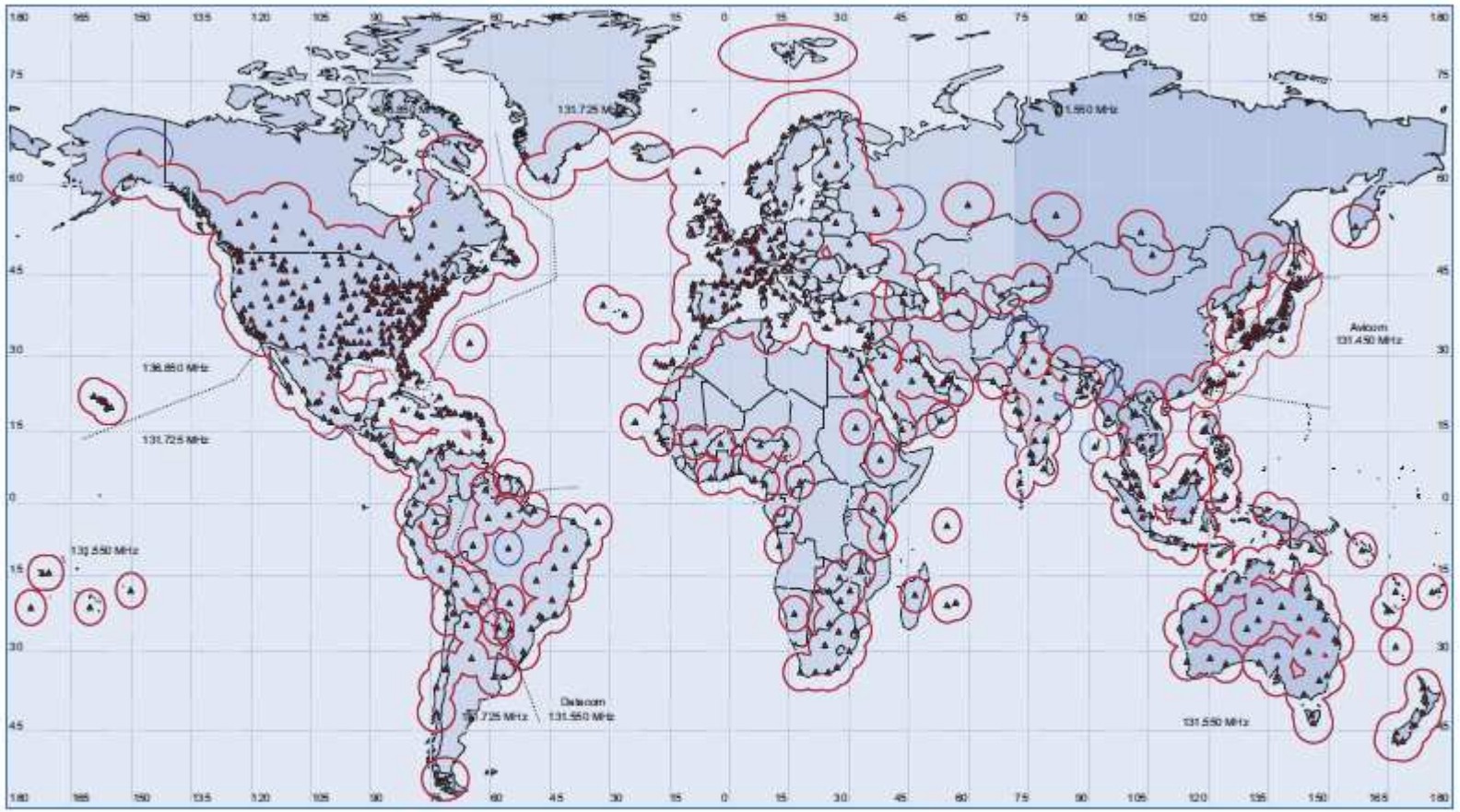
ACARS subnetworks

- ACARS is available on
  - VHF
  - Satcom
  - HFDL (ARINC only)
- Choice is not standardized
- May be made based on the applications (QoS):
  - AOC: VHF, HFDL, Satcom
  - ATC: VHF, Satcom, HFDL

VHF

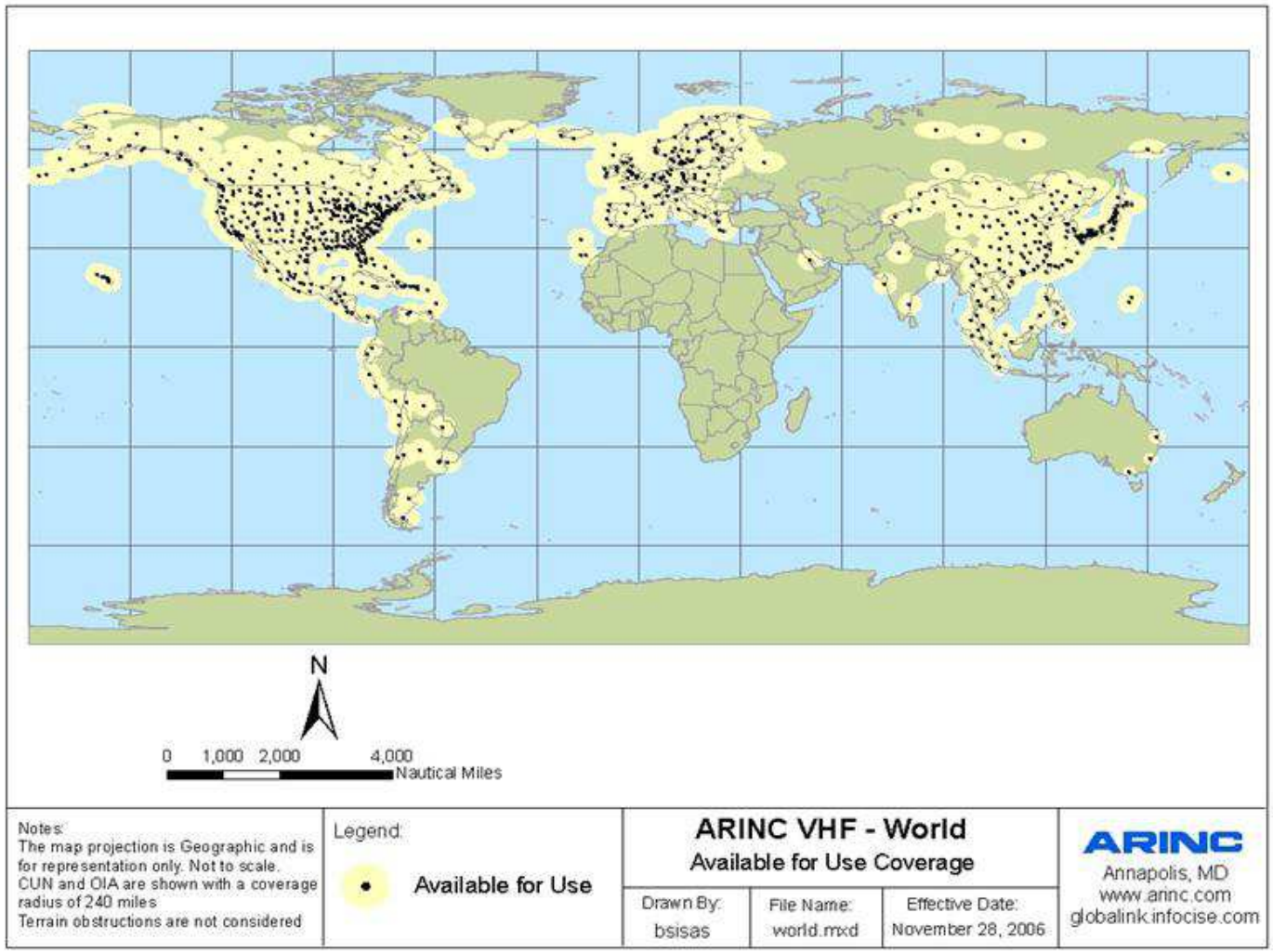
- The VHF ACARS network service providers :
  - ADCC China, SITA, ARINC, DECEA Brazil…
- Very High Frequency (VHF) ACARS
  - Depending on countries AND service provider
  - SITA 131.725 - 136.750 - 131.525 for European airspace
  - ARINC Less client => less frequencies in Europe
  - The initial VHF ACARS media is also referred to as Plain Old ACARS (POA)

VHF AIRCOM Coverage

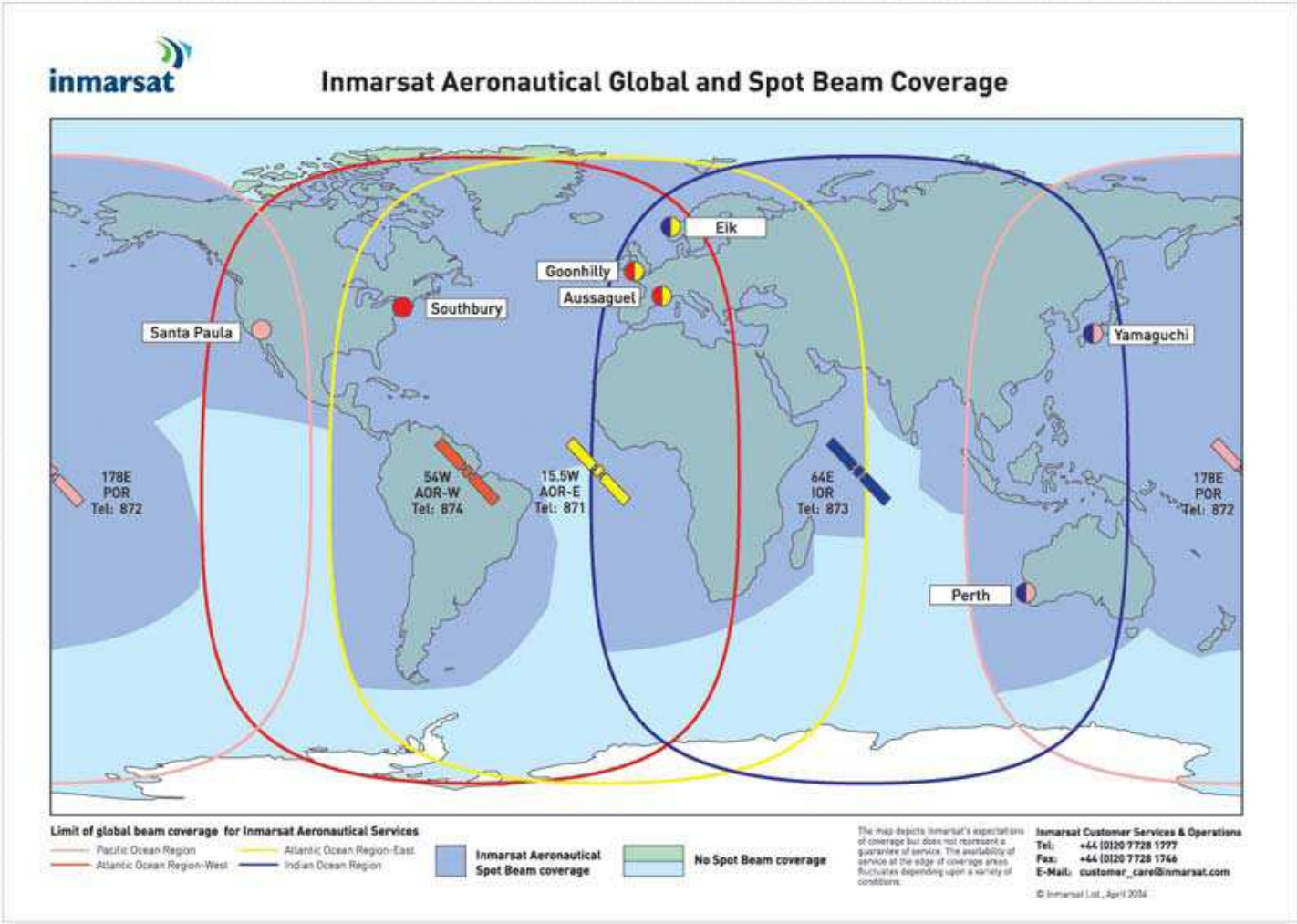


SITA

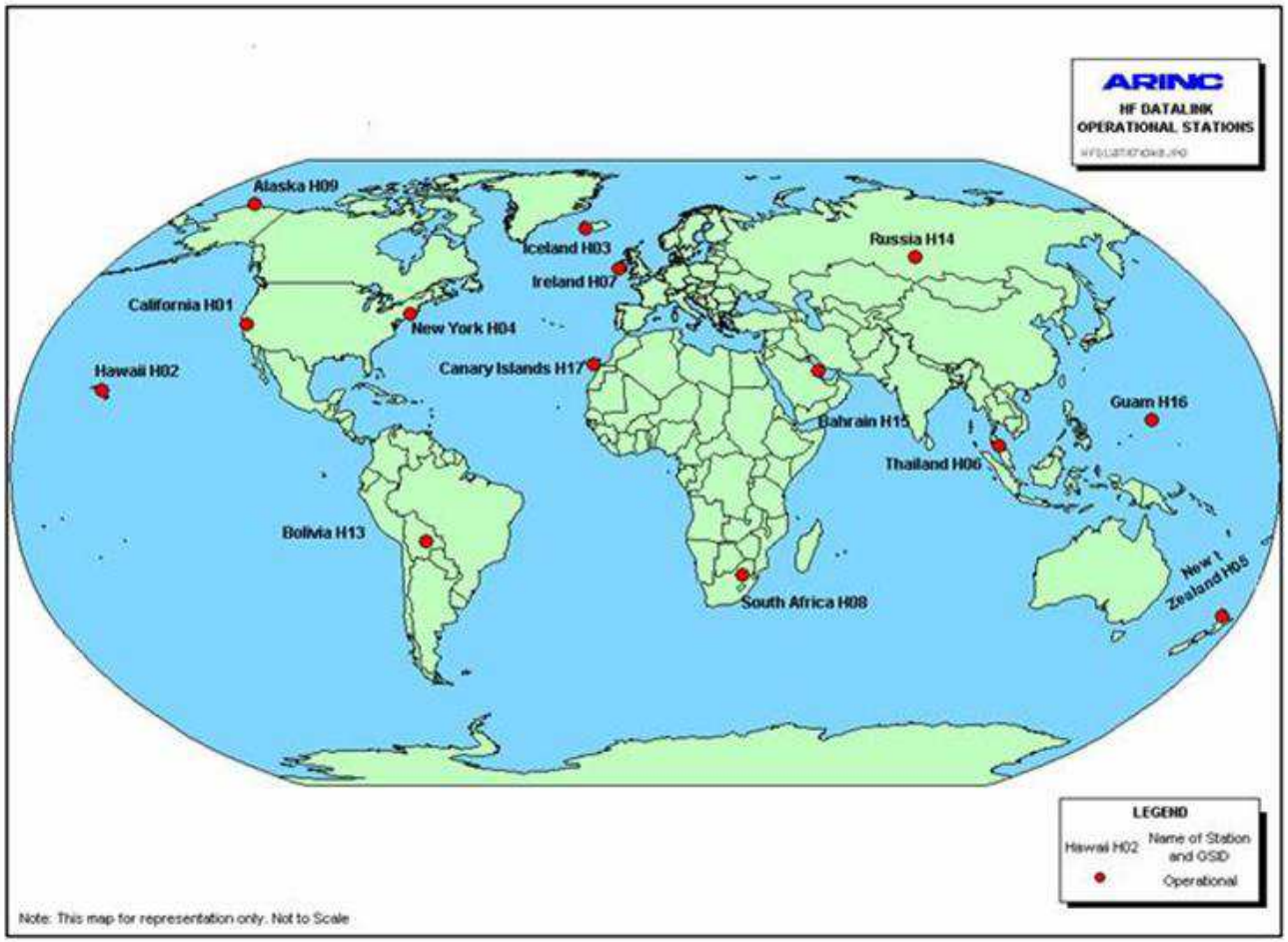
ARINC VHF Coverage



SATCOM - Inmarsat Coverage

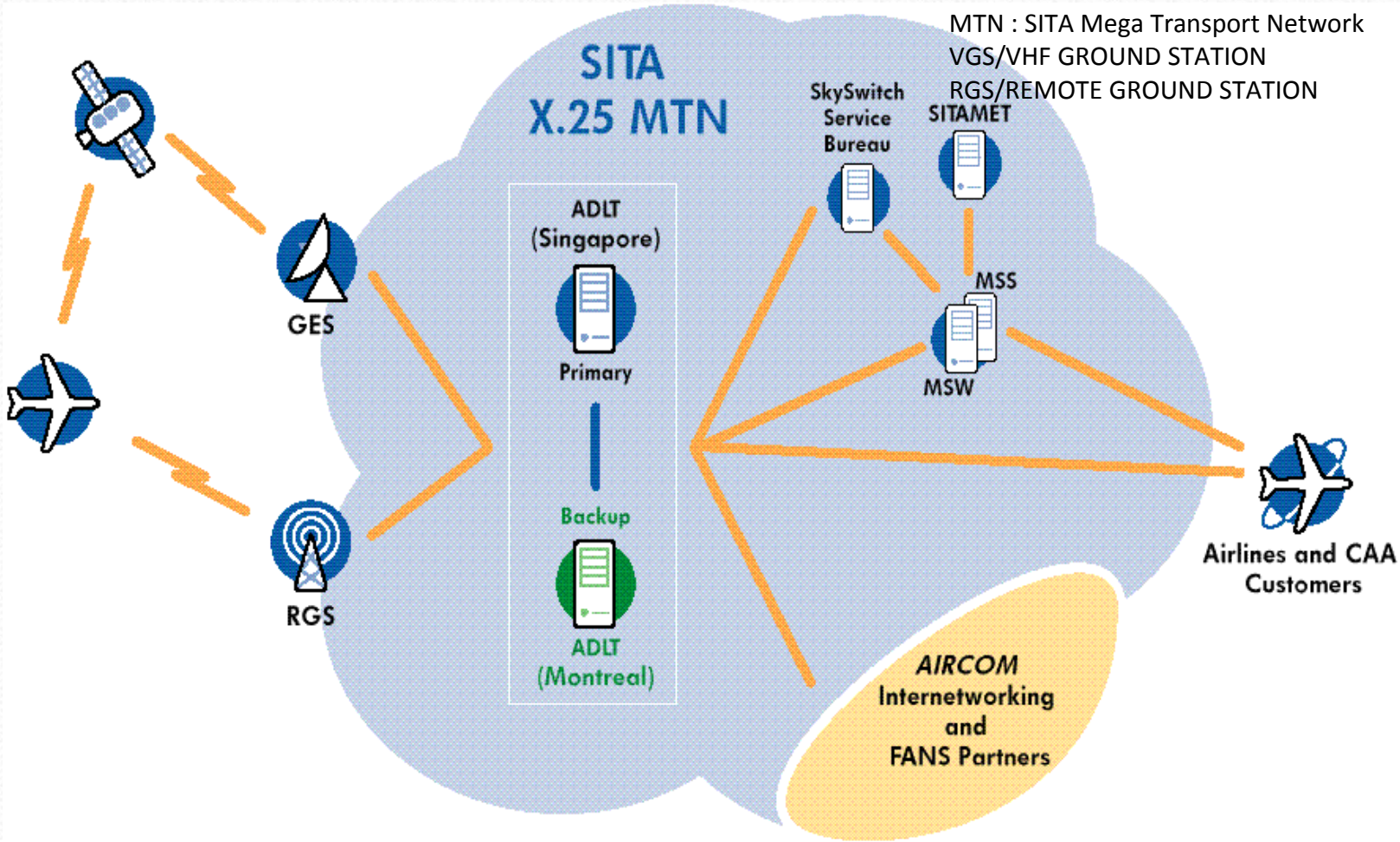


ARINC HFDL Operational Stations



Ground routing

GES: GROUND EARTH STATION
ADLT: AIRCOM DATALINK TRAFFIC SYSTEM
MTN : SITA Mega Transport Network
VGS/VHF GROUND STATION
RGS/REMOTE GROUND STATION



Ground routing

- Aircraft broadcasts down-link message
- GSs within range:
  - Receive the downlink,
  - Validate and forward it to the DSP

Ground routing

- DSP:
  - Receives and validates the downlink,
  - Converts it from A/G to G/G format
  - Inserts in its chart the media and stations
  - Decodes agency and message label which determines the addressing
  - Sends the message to recipients (destinations)

Ground routing

- Customer sends an G/A up-link message to DSP
- DSP validates the message and converts the format
- DSP processes the uplink aircraft address if logged in its chart
- DSP develops an uplink delivery “scorecard” based on
  - stations from which aircraft has been heard
  - signal strength
  - length of last signal
- Provides a list of best-to-less GS from which to try delivery

Ground routing

- DSP tries delivery of the uplink based on scorecard, number and order of attempts
- Attempts are completed by aircraft ACK or exhaustion of scorecard
- DSP sends a Message Assurance to the customer

Ground routing

Routing databases

Aircraft	VHF-1 VHF-2 VHF-3	AMSS GES
F-GGEA	ORY2 CDG2 LIL1	Not equipped
TU-TAF	DKR1 - -	AOR-E
VH-OJL	SYD1 NOU1 NAN1	POR
N176UA	SYD1 NOU1 NAN1	via ARINC

The routing function stores the routes of downlinks

DSP chooses the route towards destination aircraft in database

DSP routes downlinks towards predefined addresses and for ATS towards supplementary explicit addresses

ACARS link control

VHF DTE

AMSS DTE

Gnd DTE X.25

Ground routing

- Use of specific downlink messages:
  - Q0 for testing the link (used in routing)
  - SA « media advisory » for sub-network changes

Ground routing

Example :

A618 Frame

Aircraft	Label	seq N°	flight N°	Grnd Systm Add	Data
F-GGEA	BA	M32A	IT0326	/TLSLDYA.	Information

SMT/A620 Message

Destination	QU TLSLDYA
Source	.QXSXMXS 231015
Identifier	ATC
Flight/Registn N°	FI IT0326/AN F-GGEA
Grnd Stat/seq N°	DT QXS NCE 231015 M32A
Data	- Information

ACARS limitations

- Low throughput and centralized routing
- Ordering of messages and late delivery
- Character oriented service
- No end-to-end connection or checksum
- No destination address
- Aircraft limited to DSP boundary

FANS 1/A

Enhancements

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FANS 1/A

- Future Air Navigation System
- FANS committee established by ICAO on 80's
- FANS concept : CNS/ATM
- Products
  - FANS-1 : Boeing (747/777/767/787)
  - FANS-A : Airbus (A330/A340/A380)
- Standards : ARINC 622 and EUROCAE ED-100/RTCA DO-258
- Applications
  - AFN (ATS Facility Notification)
  - CPDLC (Controller Pilot Data Link Communication)
  - ADS-C (Automatic Dependant Surveillance - Contract)

FANS 1/A

- ACARS enhancements
  - Add a new communication « layer »
    - Bit oriented protocol
    - End-to-end service
    - Checksum
    - Destination address (ATSP)
    - LOGON service

ATS messages

- ACARS labels for ATS:
  - Uplink
    - A0 to A9 and AA to AF
  - Downlink
    - B0 to B9 and BA to BF

- Adds a requirement for DSP interconnection

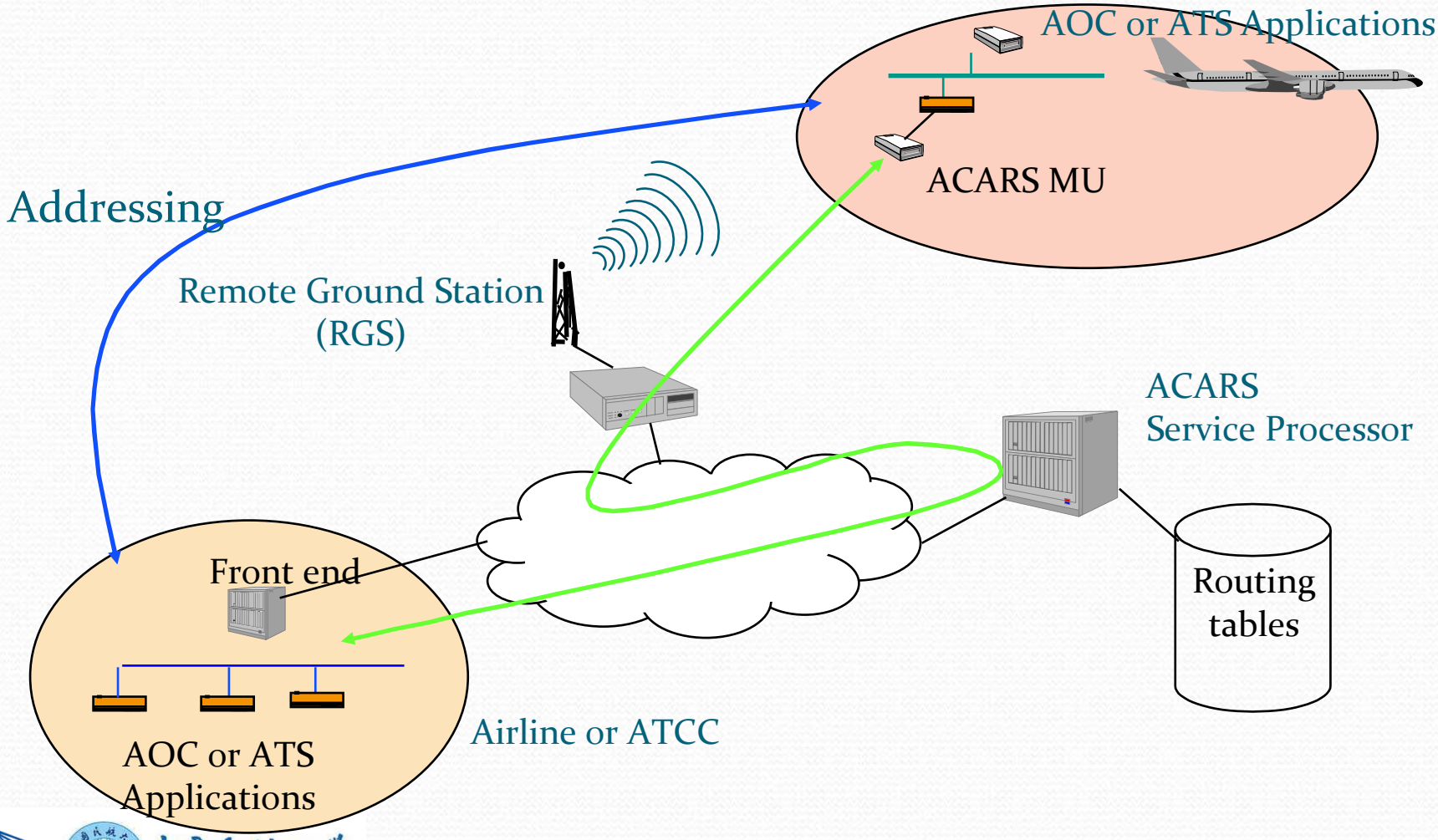
DSP interconnection

- ANSP (Air Navigation Service Provider):
  - A public or a private legal entity providing Air Navigation Services
  - A ground user communicating with all the aircraft
  - ex : CAAC/China, FAA/USA, DSNA/France, …)
- Without interconnection:
  - ANSP to contract with each service provider
- With interconnection:
  - Single contract
  - BUT no guarantee on global QoS
    - Service level agreement

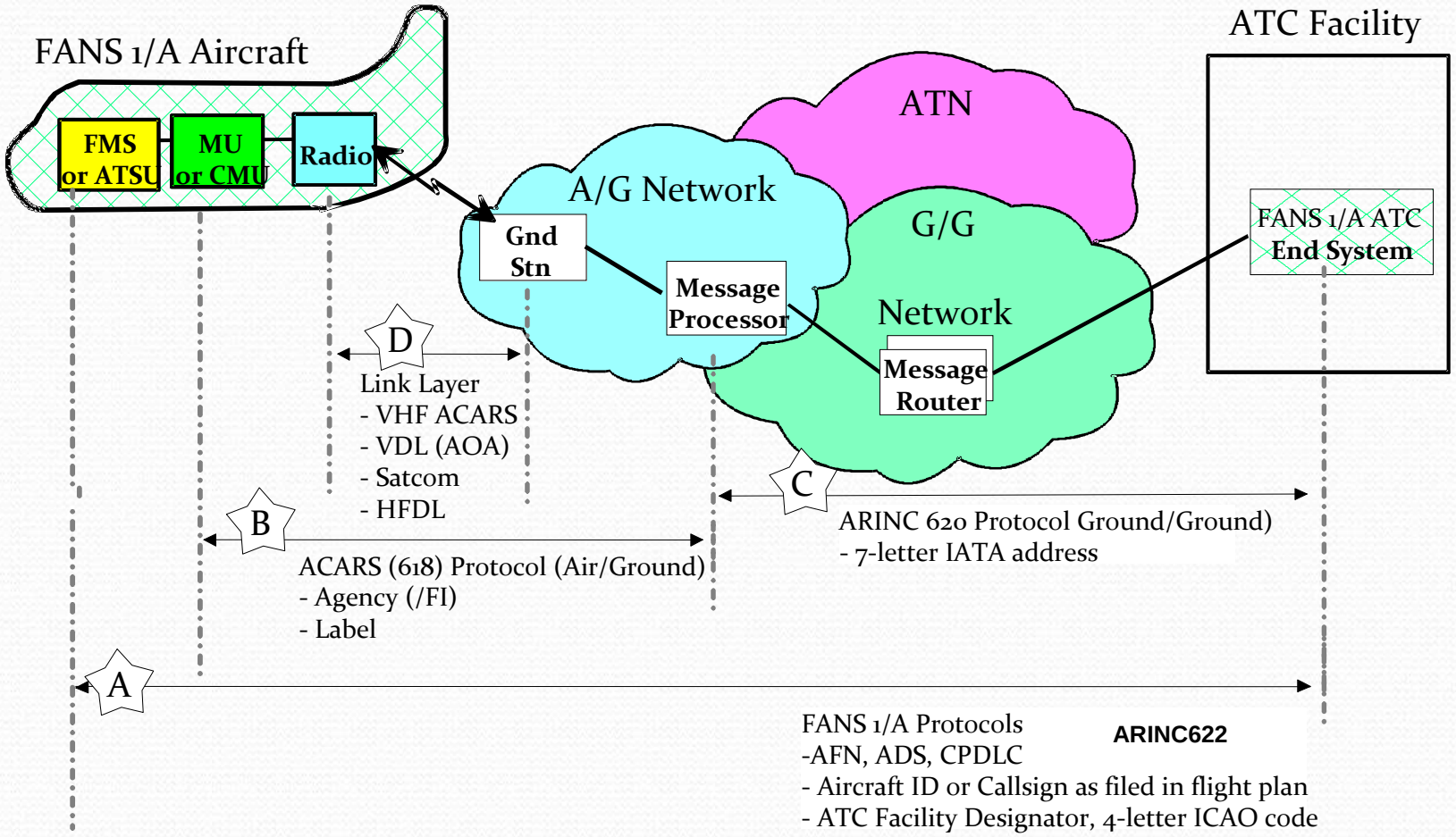
Bit oriented

- Transport binary data in a character oriented protocol:
  - Encode binary data in a text form
    - Binary value: 11010111
    - Hexadecimal representation: “C7”
  - Send this textual representation
- Divides the throughput by a factor of 2
  - Each 4 bits value is sent in a 7+1 bits character

A622 connection



Onboard architecture

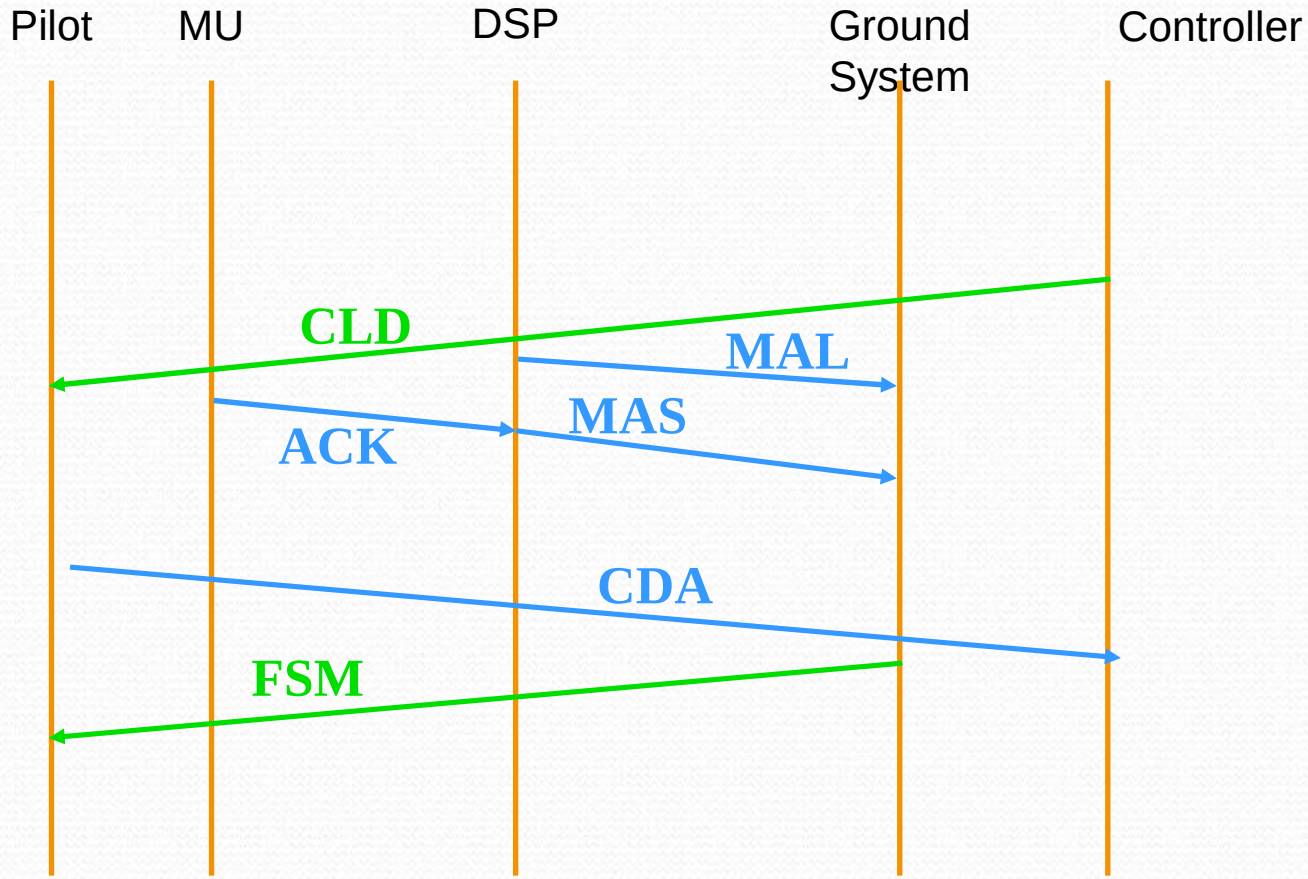


Courtesy of ARINC

Some other ATS applications on ACARS: A623

- A623 defines the following applications:
  - D-ATIS (ED-89)
  - DCL (ED-85A)
  - OCL applications
  - On top of A622 (do not use binary conversion)

A623 example (not FANS 1/A)



A623 example: CLD

- Departure clearance

- QU QXSXMXS
- .TLSLDYA 241553
- CLD
- AN .C-GZZX/MA 003I
- - /TLSLDYA.DC1/CLD 1254 970301 LFPG PDC 003
- ITF0632 CLRD TO EIDW OFF 09 VIA LPG6A
- SQUAWK 1025 ADT 1300 NEXT FREQ 121.600 ATIS E
- PLEASE ACK
- 8211

A623 example : MAS

- Technical aknowledgements

- QU TLSLDYA
- .QXSXMXS 241550
- MAS
- AN .C-GZZX/MA 003L

- QU TLSLDYA
- .QXSXMXS 241551
- MAS
- AN .C-GZZX/MA 003S
- DT QXS YHU1 241550 S35A

A623 example: CDA

- Operational acknowledgement

- QU TLSLDYA
- .QXSXMXS 241551
- CDA
- FI BU3333/AN C-GZZX
- DT QXS YHU1 241551 M36A
- - DC1/CDA 1254 970301 LFPG PDC 003
- ITF0632 CLRD TO EIDW OFF 09 VIA LPG6A
- SQUAWK 1025 ADT 1300 NEXT FREQ 121.600 ATIS E
- PLEASE ACK
- 75B7

A623 example: FSM

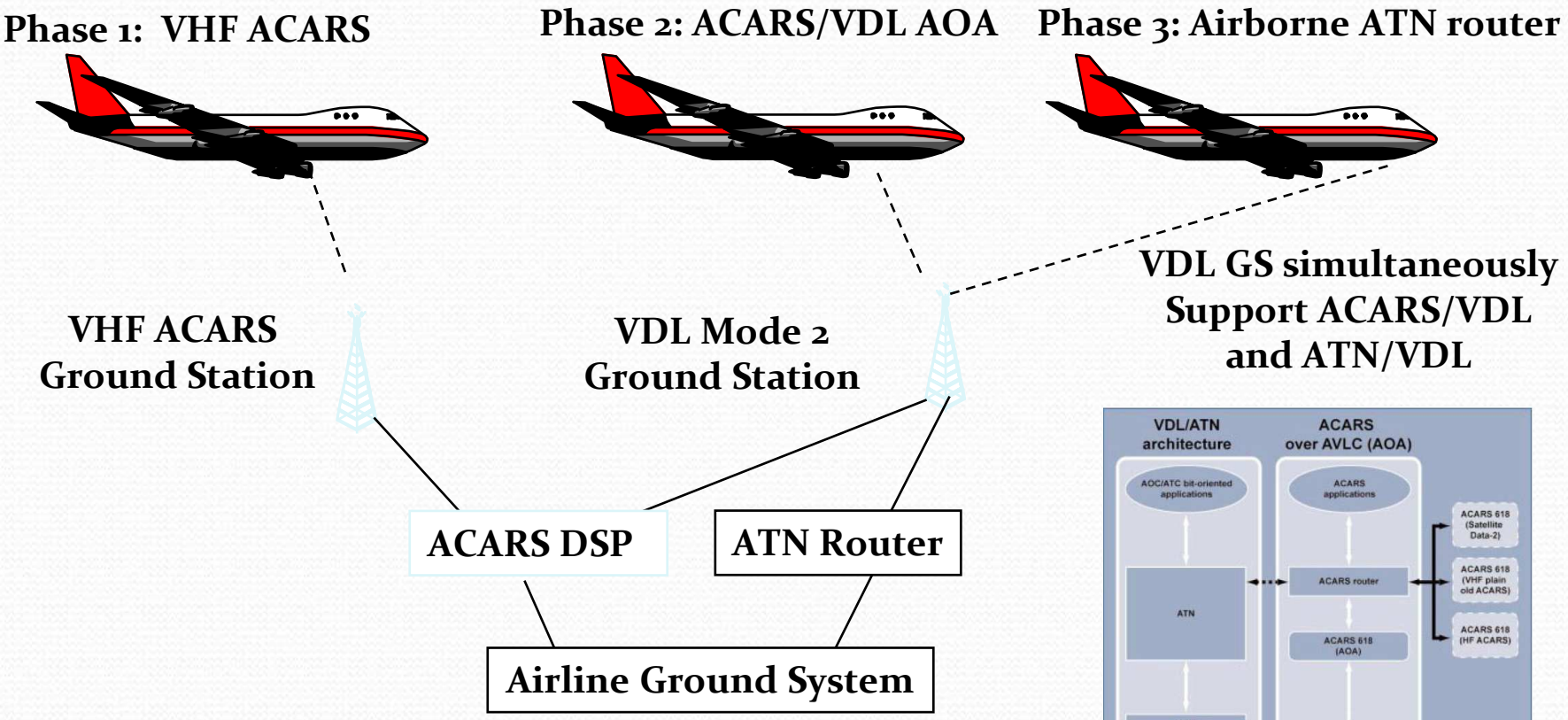
- Logical acknowledgement

- QU QXSXMXS
- .TLSLDYA 241554
- FSM
- AN .C-GZZX
- - /TLSLDYA.FS1/FSM 1255 970301 LFPG
- ITF0632 CDA REJECTED
- ERROR IN MESSAGE -REVERT TO VOICE PROCEDURES
- 08C7

Radio enhancements

- How to provide a better throughput?
  - Use VDL mode 2 physical and link layers
  - Tunneling ACARS A618 into AVLC (AOA)
  - Pragmatic but not the most efficient…
- Also promotes VDL mode 2 deployment
  - To support ATN
  - BUT throughput to be shared!

Radio enhancements



AOA (ACARS Over AVLC)

- Oversold
  - The solution for all the ACRAS traffic
  - ‘Up to twenty times’ ACARS throughput
- BUT still single channel
- In Europe :
  - AOC mainly on ground VS ATC in En-route
  - Put AOC on ‘airport’ datalink technology

Some Figures

- Round trip delay (CPDLC)
  - Computed with the MAS
  - 1er trimestre 2008
  - Around 1700 data

  - Min : 2 secs
  - Ave : 13,4 secs
  - Max : 347 sec
  - Deviation : 19,1 sec
  - TT(95) : 44 sec
  - <16 sec : 79 %

Conclusion

- A standardized system but customized to airline needs
- A centralized system
- Field-proven and attractive system
- But an old system
- AOA to provide a better throughput before a transition to a new system

Conclusion

- No real ATC on POA

- ATC on FANS 1/A possible
  - Non dense area (especially for oceanic regions)
  - Applications with low Qos need