ATM automation and integration
Index

Presentation 1
Automation Systems 2
Automation Development 3
AIDC-NAM Integration 4
Presentation

• Corporation
• Indra Air
• Solutions and services
• Innovation
• References
Corporation

Indra is one of the leading global technology and consulting companies and the technological partner for core business operations of its customers world-wide. It is a world-leader in providing proprietary solutions in specific segments in Transport and Defence markets, and the leading firm in Digital Transformation Consultancy and Information Technologies in Spain and Latin America through its affiliate Minsait.

+3,000 M€
In revenues

+43,000
Professionals

+140
Countries

+210M€
R&D

(2018 Data)
Indra Air
Creating Skies Together

+ 4,000
Facilities in over 160 countries

+ 100
Years of Experience in ATM solutions

+ 85%
World passenger travel making use of Indra ATM technology at any time of flight

Key member of SESAR

SESAR1 (2008-2016)
Co-lead in “En Route & Approach ATC”, & “Airport Systems”

SESAR2020 (2016-2021)
Participation in 25 of the 27 awarded projects
Leader in projects: PJ15 (Common Services) & P18 (Trajectory Management)
Solutions y Services

**Indra Air Automation**
We are your reliable partner in ATM business

**Indra Air Communication**
We implement Full VoIP Dual Dissimilar VCCS solutions

**Indra Air Navigation**
We enable more than 100,000,000 safe landings

**Indra Air Surveillance**
We have deployed over 400 surveillance systems

**Indra Air Drones**
Connecting Drones safely, creating a better airspace

**Indra Air Information**
We guarantee the right digital Aeronautical information at the right time
GBAS
Ground Based Augmentation System for safer landings

IRTOS
Digital remote tower system enhanced with AI capabilities

Indra Air Drones
End-to-end drone traffic management platform

Space based CNS
All-in-one CNS system from a satellite constellation
References

Deployments in more than 160 countries

Automation/Simulation
400 deployments

Navigation
2,800 deployments

Surveillance
400 deployments

Communications
550 deployments

Information
100 deployments

ATC ACC/APP
TWR, COM, NAV y SUR
No presence
Automation Systems

- ATM Automation system
- Remote towers
- Tower system
- Flow tools
- IFPS
- UTM
ATM automation system

Mission

• To enhance the safety of the flights by providing ATCOs with information of air movements from Surveillance Sensors such as Radars, ADS-B, Multilateration (WAM/MLAT) and Weather data along with Planning information such as Flight Plans, Airspace availability and Flow Management in order to provide control via Voice or Data Link.

• The Indra Solution, the latest Indra ATM solution, is one of the most advanced, safe and reliable Automation air traffic control system and in a continuous evolution path.

• It operates in more than 180 ATS units worldwide, integrating the latest & most advanced ATC functionalities.
ATM automation system

Hardware + Software

- Flexible and modular architecture
- TCP/IP & UDP communication protocols
- ATM LAN based in standard Ethernet
- Red-Hat Enterprise Linux OS
- Compatible with high-resolution screens (up to 4K)
- Use of commercial database managers (PostgreSQL & MySQL)
- Compiled using high-level languages: ADA & C
- Optimized graphics and HMI
- Contingency and redundancy
ATM automation system

Sub-systems Index

RDCU
Radar Data Compressor Unit

SDP
Surveillance Data Processor

FDP
Flight Data Processor

SNET
Safety Nets

D/AMAN
Departure and Arrival Manager

CWP
Control Working Position

EFS
Electronic Flight Strips

DLS
Data Link Server

FDS
Flight Data Server

DAT
Data Analysis Tool

DRF
Data Recording Facility

BIL
Billing Facility

CMD
Control & Monitoring Display

DBM
Database Manager
ATM automation system

The highlight of the automation functions

<table>
<thead>
<tr>
<th>4D Trajectory</th>
<th>ATC Tools</th>
<th>AOI – Area of Interest</th>
<th>Concepts:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based Operations</td>
<td></td>
<td></td>
<td>FRA – Free Route Airspace</td>
</tr>
<tr>
<td>Strategic Constrains</td>
<td>Silent Coordination</td>
<td>PBN – Performance Based Navigation</td>
<td></td>
</tr>
<tr>
<td>VPW – Vertical Progression Window</td>
<td>GRIB – Meteorological Information</td>
<td>Incidence Evaluation Tool</td>
<td></td>
</tr>
<tr>
<td>CDM – Collaborative Decision Making</td>
<td>Multi-sector Planner</td>
<td>ADS-B Server</td>
<td>Integrated Billing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cyber-security</td>
</tr>
</tbody>
</table>

GRIB – GRIB – Meteorological Information
ADS-B Server – ADS-B Server
PBN – PBN – Performance Based Navigation
AOI – AOI – Area of Interest
FRA – FRA – Free Route Airspace
FUA – FUA – Flexible Use of Airspace
CDM – CDM – Collaborative Decision Making
Remote towers

Classification and selected references

Virtual Tower
- Replace of Real tower
- One Real Tower – One Airport

Contingency
- Backup of Real Tower
- One Real Tower – one Airport

Centre
- Remote Towers Modules
- Multiple Airports
- Regional / National

NATS London Heathrow
- A-SMGCS
- ATM
- VCF

HungaroControl - Budapest Airport
- A-SMGCS
- rTWR

Avinor
- 1 Centre – 15 airports
- Ocular resolution
- Heads-Down technology
Remote towers

NINOX

Consortium formed by Indra – Avinor - Kongsberg:
- Developed by Indra and Kongsberg to Avinor
- The largest project in the world that is currently being deployed
- Indra evolves its NOVA 9000 family, control tower automation solution, in the new InNova family, which can also manage remote towers

IRTOS

Indra Remote Tower Optical System:
- Developed and updated by a multidisciplinary team of electro-optical specialist and ATM systems engineers
- The IRTOS solution integrates sophisticated image processing algorithms with proven ATM functions
- In 2015, at the Girona airport (Spain), the first IRTOS was developed and validated for SESAR tower contingency tests
- The second generation of IRTOS provides an important performance and functional jump with respect to the previous generation.
Remote towers

Cameras Systems

Wide range of options according to operational needs
- Rotational and/or fixed camera
- Ocular resolution
- Low intervention at the airport
- Panoramic view (360° or less)
- Pan-Tilt-Zoom Camera
- Signal Light Gun
- Adaptive bandwidth according to functionalities

For remote tower use a width between 40 Mbps to 300 Mbps is needed with a 360° panoramic view. Then within the airport there are other solutions such as secondary/provisional tower or provide augmented reality to a tower, where bandwidth is resolved in another way.
Remote towers

Elements

- Heads-Up Display (HUD)
- Visual Sensors (360 and PTZ cameras)
- INFO & CTRL system
- Traffic Situation Display (Air and Ground traffic)
- VCS + ATIS
- Interface to MET, AGL, NAV etc.
- Sensors: MLAT, SMR etc.
- Interface to Radios and Telephones

Network

Remote towers Centre

Integrated elements

Airport

Airport elements remotely controlled

- Airfield Ground Lighting
- VCS & ATIS
- NAVAIDS monitoring
- MET and AWOS
- Crash Alarm
Tower system

Integrated systems

The system allows to integrate the air traffic display (A-SMGCS with ATM function) with the following functions:

- Electronic flight strips
- Automatic taxi routing and guidance
- Control and monitoring of stop bars and taxiway centerline lighting
- Display of meteorological information and statistics, METAR messages
- Departure, pre-departure and arrival sequencing

Integrated Tower Systems offer the following benefits:

- Improved situational awareness with one harmonized HMI for all necessary functionality
- Reduced workload for controllers
- Improved communication and information sharing capabilities
- Increased safety due to the combined safety nets
- In case of remote towers, improved cost-efficiency
Tower system

Collaborative Tools

By having the right information, better decisions can be made. The same applies to stakeholders involved in airport operations.

Our Airport Collaborative Tool provides a presentation of real-time and stored information of aircraft movements and statistics to users of system and other parties, such as airlines, security, fire stations and ground handlers. This allows for better planning, less delays and improved operational efficiency, benefiting all stakeholders, including the passengers.

In addition to the traffic window, the following information is typically presented:

- **Time calculations**: runway occupancy time, taxi to/from stands and runways, time on stand, de-icing time, departure queue time and arrival waiting time for stand
- **Event counts**: number of movements for each threshold and for the entire airport
- **Cumulative counts**: average time spent on stand, taxiway and runway usage

Benefits of collaborative tools:

- **More efficient traffic flow**, as air traffic controllers are enabled to predict and monitor the flow, delays and possible bottlenecks
- **Efficient planning and communication to customers**, as key stakeholders get the latest information about the traffic and expected delays
- **Improved planning of maintenance by airport operations**: tarmac, runway inspection, etc.
Flow tools

iACM: Indra Airspace Complexity Manager

ICAO & UE promote the adoption of flow management tools as a measure to increase capacity and quality of service

- ICAO ASBUs: Network Operations (NOPS) Thread
- UE Pilot Common Project 4: Network Collaborative Management

Benefits

iACM goes beyond the classic flow tools

- Safety is the first objective
- New objectives related to the perception of society, such as environmental or accumulated delay, are added

Integrated concept from the planning phase to the tactical phase

- Interactive assessment of situations based on expected traffic
- Assessment of the impact of the application of alternative scenarios
Flow tools

Others ATFM tools

Years 6 Months Days Hours Minutes En route

Strategic Planned Executive Tactic

BDT SBT RBT 4DT

Business Development Trajectory Shared Business Trajectory Reference Business Trajectory Trajectory 4D Estimated

FDP AMAN/DMAN/XMAN

IFPS iACM / CDM / A-CDM

AODB RMS CGA

ATM Airport
Conflicts detected in the validation of flight plans

**Corrupt Data:**
- Data is not “legibly” to system

**Syntactic Error**
- Data is legibly but the format is not standard

**Semantic Error**
- Data is legibly and has the right format, but any field is out of range

**Ej. CRC divergence**

**Ej. Fields without space**

**Ej. Fix no definition**
IFPS

Conflicts detected in the validation of flight plans

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Ej. CRC divergence
Ej. Fields without space

STANDARD + IMPROVE & MONITORING OF INFRASTRUCTURE (LAN/WLAN)

STANDARD + PRIOR FP VALIDATION

STANDARD + PRIOR FP VALIDATION + BD REVIEW

GOTOR
PUNTO INTERES NO DEFINIDO

Ej. Fix no definition
IFPS: Advanced flight plan validation

Flight Plan without error

- Centralized BD to ensure the optimization of flight plans
- Approval, forwarding or automatic rejection (configurable) of flight plans and related ATS messages, based on ICAO rules (global and regional eAIP information)
- Operational Response Messages (ORM), designed for advanced flight plan validation:
  - Format and content check
  - ORM are based on EUROCONTROL specifications, e.g., IFPS User Manual Edition 18.0 (long/short ACK, REJ, MAN)
  - Configurable response (manual/automatic) based on the originator profile
  - Message forwarding based on address replacement
- Advanced function including:
  - Loading of predefined/preferred routes, national or regional (OACI CAR or SAM)
  - Automatic Check of Element 15 of FPL & CHG message against routes
  - Advanced statistics & monitoring of system
  - Message forwarding based on predefined routes
  - Scalable for regional use through collaboration between countries.
  - Centralize airspace management of different regions
- It is the key to a future airflow management system
The Challenge and our vision

- How to coordinate the operation between UTM & ATM worlds?
- What happens to the UAV business when its airspace is very restricted?
- What to do when a drone invades a forbidden space?

An integrated vision to share the information and thus allow operation of UAVs in controlled airspace (ATM zones)

ATM
- Evolutionary trend
- Regulated and directed by those involved in the ATM world
- Strong presence of ANSP, regulators, etc..
- Same business model, with greater focus on automation
- Mature sector

UTM
- Disruptive trend
- Incipient or uncertain regulation
- Entry of new companies and institution
- Some ANSPs want to manage the UTM world
- New business models
- Under development Sector
Roadmap: U Space

U-space is a set of new services and specific procedures designed to support safe, efficient and secure access to airspace for large numbers of drones. These services rely on a high level of digitalization and automation of functions, whether they are on board the drone itself, or are part of the ground-based environment.
UTM

Our Solution

UTM Hub

- System core
- Provides a layer of **connectivity services**
- Provides a set of **nuclear services** that coordinate UTM environment **guarantying safety**

UTM Connect

- **Enables the connection** of UTM users within UTM environment
- **Enables, groups and delivers** UTM services to the **end user** (drones, pilots and operators, local authorities)
- **Different interfaces** (mobile apps, web, API interfaces...)

UISS - UTM Infrastructure Services Suppliers

UDSP - UTM Data Service Providers

UTM Added Value Service Suppliers

ATM Systems
ANSP/CAA
Security Forces
Emergency Teams
Local Authorities
UTM

Security solution

**Detection**
- Medium Range Detectors (Ku Band)
- Long Range Detectors (X Band)

**Optronic**
- Selection of devices of a wide range
- IR Long and medium range
- Camera model (IR & CCD)
- Integration of cameras in average images
- UAV confirmation, classification, tracking and 3D positioning

**Tracking**

**Recognition**

**C4I**
- Alarms
- Management resources
- Messenger service

**Countermeasure**
- Data Link Jamming
- GPS/GLONASS/Beidou Jamming
- Data Link Inhibition
- GPS/Glonass Inhibition
- GPS Spoofing
- RF address search (RDF)
- Jammer multiband portable

ARMS
Anti RPAS Multisensor System
Automation development

- Roadmap
  - ASBU OACI
  - SESAR
- iTEC example
The evolution to managAir is one of the most advanced, safe and reliable solution available today. It is in constant evolution with a roadmap aligned with the standards from ICAO ASBU, SESAR Master plan and NextGen, along with local requirements from every of our customers.

ICAQ
Aviation System Blocks Upgrades (ASBUs)
ICAQ 2016-2030 Global Air Navigation Plan (GANP v5)

EUROCONTROL
SESAR Master Plan
including SESAR 2020
ASBU OACI

Current status of ASBU

ASBU OACI is composed:

- Block 0 (2013): 100% implemented
- Block 1 (2019): 100% implemented
- Block 2 (2025): 50% implemented
- Block 3 (2030): Developing

(1) Developed and implemented, but not yet implemented in the region
(2) Not yet implemented, in line with ASBU OACI (2025)
SESAR

¿What is SESAR (Single European Sky ATM Research)?

- It is the European Air Traffic management (ATM) modernization program. Basically the current situation has the following problem:
  - Airspace is inefficient by design
  - Airspace capacity is not being maximized
  - Automation levels are limited
  - Lack of harmonization (interoperability, standardization, etc.)
- It combines technological, economic and regulatory aspects within the Single European Sky (SES) policy:
  - Framework (1), Service Provision (2), Airspace (3) and Interoperability (4)
- It implies the synchronization of the plans actions of the different stakeholders and federation of resources for the development and implementation of the required improvements throughout Europe
Indra key member

- Present from the first steps of SESAR
- Active member of the operational and transversal Work Packages (WPs)
- Indra is part of 124 of the 302 projects
- 97% of projects submitted have been awarded
- Co-lead WP 12 – Airports Systems
- Main technological partner in WPs 8 & 14 - System Wide Information Management (SWIM)
- Technological partner in WPs 13 & 15 – Network Information Management & Non-avionics (CNS)
- Co-lidera WP 10 – En Route & Approach ATC
- iTEC – Advanced System of automation aligned with WP 10

Interoperability Through European Collaboration

iTEC is an ATM system collaboratively developed by ENAIRE, DFS, NATS, (original ANSPs), LVNL, AVINOR, ORO NAVIGACIJA y PANSA and Indra as technological partner and supplier.
The objective is to deliver improved operational performance and increased cost efficiency through the introduction of a common:

- **Concept of operations** based on SESAR, including 4D-trajectory management
- **Airspace structure** aligned with FABS and based on common airspace types
- **System architecture** that features improved interoperability via FOs and SWIM
- **ATS system** with interchangeable ATS components supported by open standards

**iTEC ATM Benefits**

- Increase in capacity by minimizing routine tasks while increasing safety and productivity
- Interoperability between ATM systems using SESAR data interfaces
- Trajectory-based operations reduce flight diversions, flight time, fuel consumption and CO2 emissions
Ejemplo iTEC

History and unification concept

- **2007**: iTEC Kick-Off: DFS, ENAIRE, NATS, Indra
- **2011**: LVNL joins iTEC alliance
- **2014**: 1° Version of iTEC ready
- **2015**: Signing of the iTEC CWP collaboration agreement. The new CWP generation integrates seamlessly with iTEC
- **2016**: iTEC enters into operation in Prestwick (UK)
- **2017**: Avinor joins iTEC alliance
- **2017**: iTEC Centre. Automation System (iCAS) goes live in Karlsruhe (DE)
- **2017**: ORO NAVIGACIJA 6 PANSA joins iTEC alliance

**Timeline**

- **Precedent**
  - SACTA - ENAIRE
  - P1/VAFORIT - DFS

**Diagram**

- iTEC common $V_0$
- iTEC common $V_i$
- Plan iTEC a Target
- Adaptation ENAIRE
- Adaptation DFS
- Adaptation NATS
- New ANSP
- iTEC Target Definition
- $V_0$
- $V_{ANSP}$
- $V_i$
AIDC-NAM integration

- Exchange ATS data
- Systems & links
- Analysis & experience
Exchange ATS data

Historical context

As Air Traffic grows, the needs of support systems for the Controllers become more sophisticated, particularly to maintain operational safety. Therefore, the Exchange of information between Controllers to coordinate the responsibility change over an aircraft, which was formerly done by voice, is essential.

For this reason, the OLDI (On-Line Data Interchange) messaging protocol is born to respond to the European need to maintain its operational safety under a growing air traffic flow in a complex airspace. The air traffic flow continues to grow and it is required that the messages Exchange be carried out automatically. The OLDI protocol becomes the bases of different initiatives that adopt regional particularities, in this way AIDC (ATS Interfacility Data Communications) is born in ASIA/PACIFICO (ASIA/PAC) region and ICD NAM of common coordination is defined in NORTH AMERICA (NAM) region.
Exchange ATS data

CAR/SAM definition to implement AIDC

The ICD AIDC of ASIA/PACIFIC (ASIA/PAC) region and the “Guide for the implementation of AIDC through the interconnection of adjacent automated centers (AIDC)” publication define the AIDC implementation in the Region. Since 2008 Indra, for its part, begins to work in the region with AIDC ASIA/PAC protocol for each new Project and updating according to customer requirements.

<table>
<thead>
<tr>
<th>Message</th>
<th>Meaning</th>
<th>Message Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABI</td>
<td>Advance Boundary Information</td>
<td>Notification</td>
</tr>
<tr>
<td>CPL</td>
<td>Current Flight Plan</td>
<td></td>
</tr>
<tr>
<td>EST</td>
<td>Coordination Estimate</td>
<td>Coordination</td>
</tr>
<tr>
<td>PAC</td>
<td>Preliminary Activate</td>
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<tr>
<td>MAC</td>
<td>Cancellation of Notif./Coord.</td>
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<tr>
<td>CDN</td>
<td>Coordination Negotiation</td>
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<tr>
<td>ACP</td>
<td>Acceptance</td>
<td></td>
</tr>
<tr>
<td>REJ</td>
<td>Rejection</td>
<td></td>
</tr>
<tr>
<td>TOC</td>
<td>Transfer of Control</td>
<td></td>
</tr>
<tr>
<td>AOC</td>
<td>Acceptance of Control</td>
<td></td>
</tr>
<tr>
<td>LAM</td>
<td>Logical Acknowledgement Msg</td>
<td>Application</td>
</tr>
<tr>
<td>LRM</td>
<td>Logical Rejection Msg</td>
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**Set of core messages**

<table>
<thead>
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<tbody>
<tr>
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<tr>
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<tr>
<td>PCM</td>
<td>Profile Confirmation Message</td>
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<tr>
<td>PCA</td>
<td>Profile Confirmation Acceptance</td>
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<tr>
<td>TRU</td>
<td>Track Update</td>
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<td>ASM</td>
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<td>FAN</td>
<td>FANS Application Message</td>
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<td>FCN</td>
<td>FANS Completion Notification</td>
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<td>NAT</td>
<td>Organized Track Structure</td>
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</table>

**Set of extra messages**

ICD NAT y APAC messages

**Set of core messages**
Exchange ATS data

Definición NAM de una interfaz de comunicación común (NAM ICD)

Since August 2000 to September 2008, when the North American (NAM) Common Coordination Interface Control Document (ICD) revision A appears, the NAM members worked on different draft of this document. Then the next revisions are adding members and messages to the class. At 2015 the revision E is reached. The deployed systems by Indra in CAR Region are Class 3 revision D

<table>
<thead>
<tr>
<th>Category</th>
<th>Message</th>
<th>Meaning</th>
<th>Class</th>
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<tbody>
<tr>
<td>Pre-takeoff coordination (1)</td>
<td>FPL</td>
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<tr>
<td></td>
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<td>Estimate</td>
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<td>Active flight coordination</td>
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<td>ABI</td>
<td>Advance Boundary Information (3)</td>
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<td>General Information (3)</td>
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<td>Miscellaneous</td>
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<td>Interface Management (4)</td>
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<td>IRS</td>
<td>Initialization Response</td>
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<td>TRS</td>
<td>Termination Response</td>
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<td>Application Status Monitor</td>
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<th>Meaning</th>
<th>Class</th>
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<tr>
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<td>RTI</td>
<td>Radar Transfer Initiate</td>
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<td>RTU</td>
<td>Radar Track Update</td>
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<td></td>
<td>RLA</td>
<td>Radar Logical ACK</td>
<td>3</td>
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<tr>
<td></td>
<td>RTA</td>
<td>Radar Transfer Accept</td>
<td>3</td>
</tr>
<tr>
<td>Point Out (5)</td>
<td>POI</td>
<td>Point Out Initiate</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>POA</td>
<td>Point Out Accept</td>
<td>3</td>
</tr>
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<td></td>
<td>POJ</td>
<td>Point Out Reject</td>
<td>3</td>
</tr>
<tr>
<td>Transfer (3)</td>
<td>TOC</td>
<td>Transfer of Control</td>
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<tr>
<td>ACK</td>
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<tr>
<td></td>
<td>LRM</td>
<td>Logical Rejection</td>
<td>(3)</td>
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</tbody>
</table>

Note: Difference between Revision D & E, in yellow messages introduced in revision E.

(1) ICAO Doc.4444  
(2) New message  
(3) PAN ICD  
(4) Based on CAATS protocol  
(5) Complementary messages are not Class 1, 2 & 3
## Systems & links

### ICD implemented in the region

The protocols implemented in the Region are:

<table>
<thead>
<tr>
<th>PAÍS</th>
<th>LOCACION</th>
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Note: there are NAM interfaces they operate as Class 1

Note: Paraguay is not updated
Analysis & experience

Problems according to our experience

**Rejection of Messages:** The messages have a clear definition, according to the standard, but situations are not standardized when connecting to other systems (non-standard) or there are different sources generating the same message.

**Understanding of optional/mandatory:** Within the messages, there are fields declared as Optional or Mandatory, as there are multiple existing formats of use for the same fields (e.g., Lat./long or fix). The system must be able to accept these particularities.

**Parametrization and requirements definition:** Define according to criteria and standards, know the reality of the cases before designing and parameterizing.

**Other external factors:**
- Connectivity between centers and systems
- Previous protocols and agreements
- Continuous training

Ex: Divergent CRC
Ex: Badly written fields
Ex: ADEXP vs ICAO format
Ex: Duplicate messages

Ex: The PAC message may include field 15 (optional)