ATM automation and integration

February 2020
Ciudad de México, México

Index

Presentation

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

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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€	+43.000	+140	+210M€
In revenues	Profesionals	Countries	R&D

(2018 Data)

Key member of SESAR

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

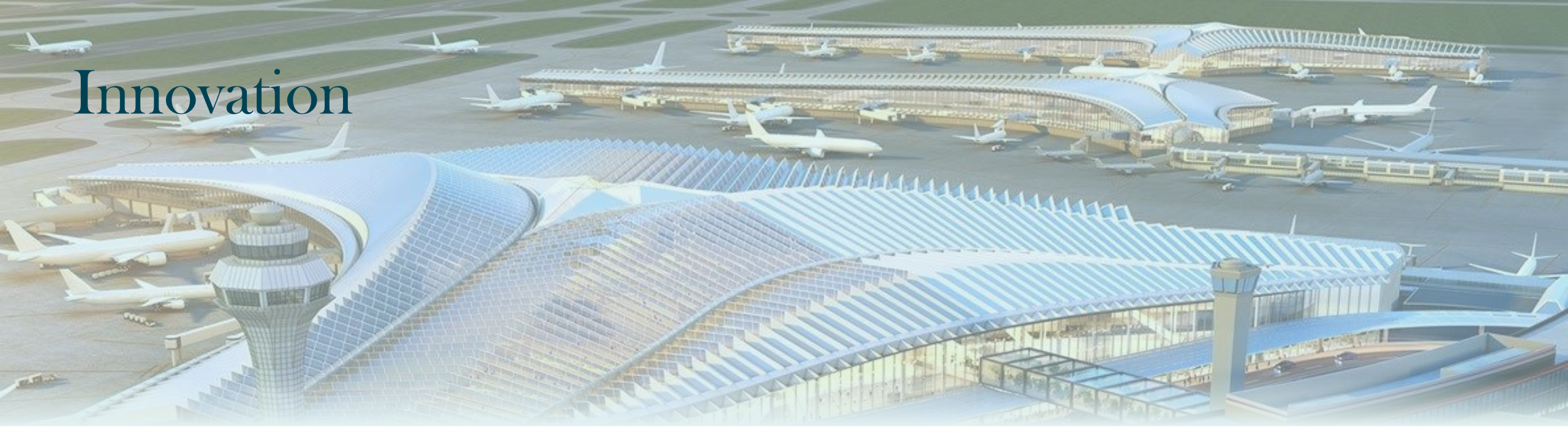
Indra Air
Drones

Connecting Drones safely, creating a better airspace

Indra Air
Information

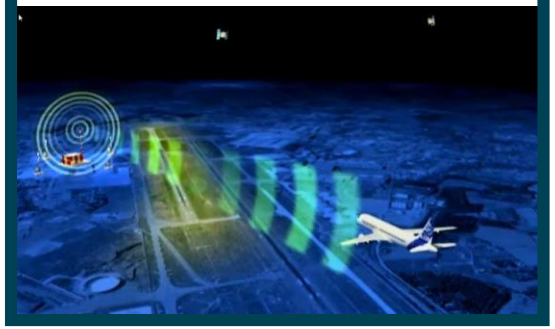
We guarantee the right digital Aeronautical information at the right time

Innovation



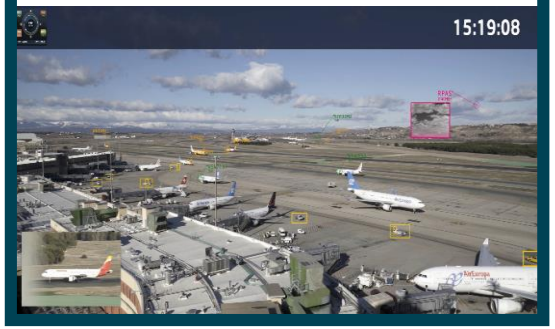
GBAS

Ground Based Augmentation System for safer landings



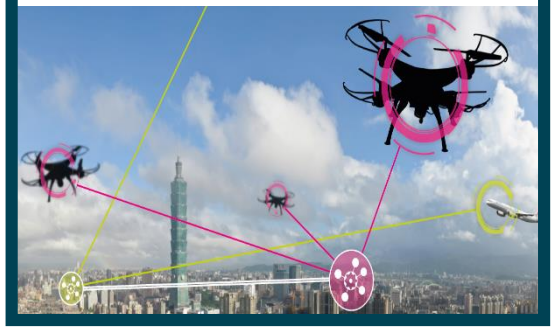
IRTOS

Digital remote tower system enhanced with AI capabilities



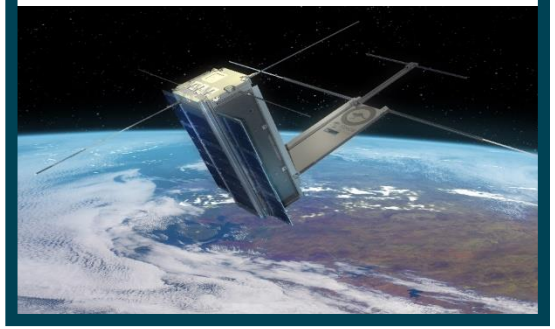
Indra Air Drones

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

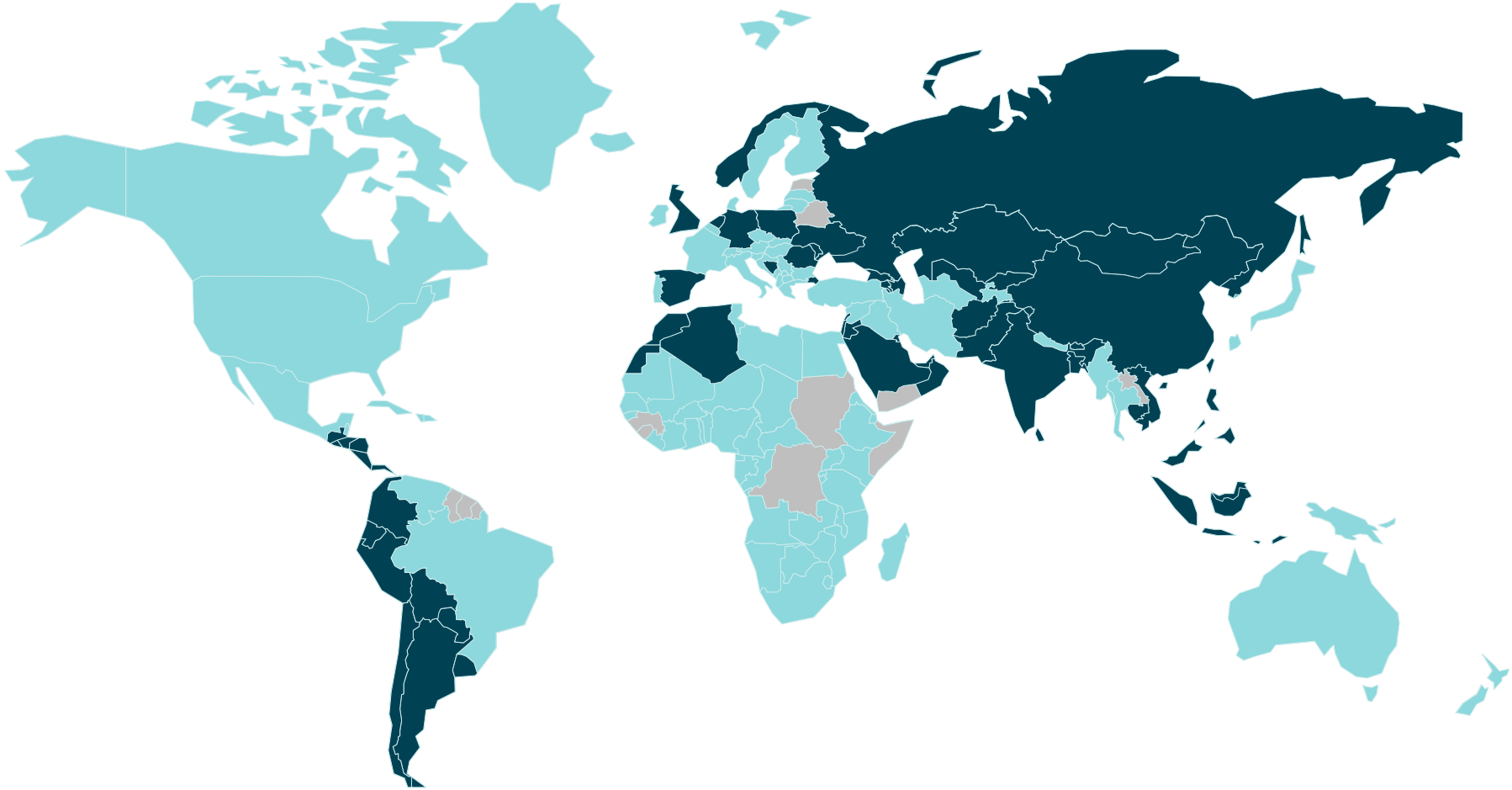
Automation/Simulation
400 deployments

Navigation
2.800 deployments

Surveillance
400 deployments

Communications
550 deployments

Information
100 deployments



Automation Systems

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

2

ATM automation system

Mission

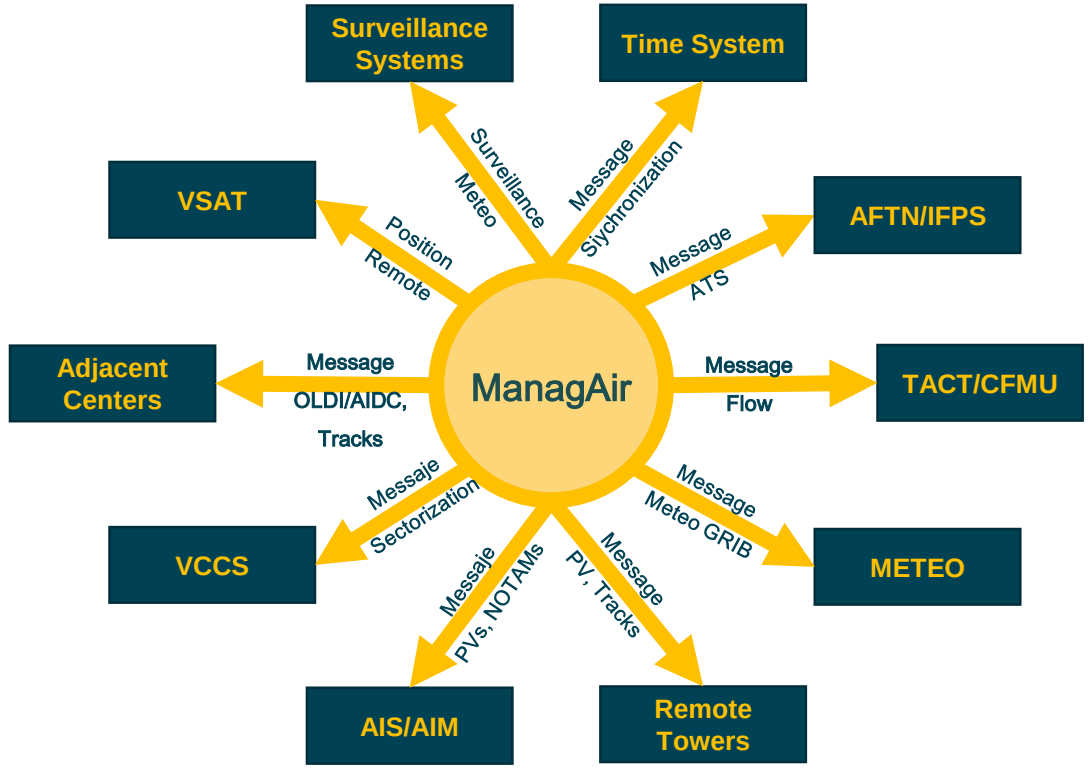
- To enhance the safety of the flights by providing ATCOs with information of air movements from Surveillance Sensors such as Radars, ADS-B, Multilateration (WAM/MLAT) and Weather data along with Planning information such as Flight Plans, Airspace availability and Flow Management in order to provide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

External Interfaces



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

4D Trajectory – Based Operations	**ATC Tools**	**AOI** – Area of Interest	**Concepts:** **FRA** – Free Route Airspace **FUA** – Flexible Use of Airspace
Strategic Constrains	**Silent Coordination**	**PBN** – Performance Based Navigation	**Incidence Evaluation Tool**
VPW – Vertical Progression Window	**GRIB** – Meteorological Information	**ADS-B Server**	**Integrated Billing**
CDM – Collaborative Decision Making	**Multi-sector Planner**	**Contingency**	**Cyber-security**

Remote towers

Classification and selected references

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

Contingency
- Backup of Real Tower
- One Real Torre – 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

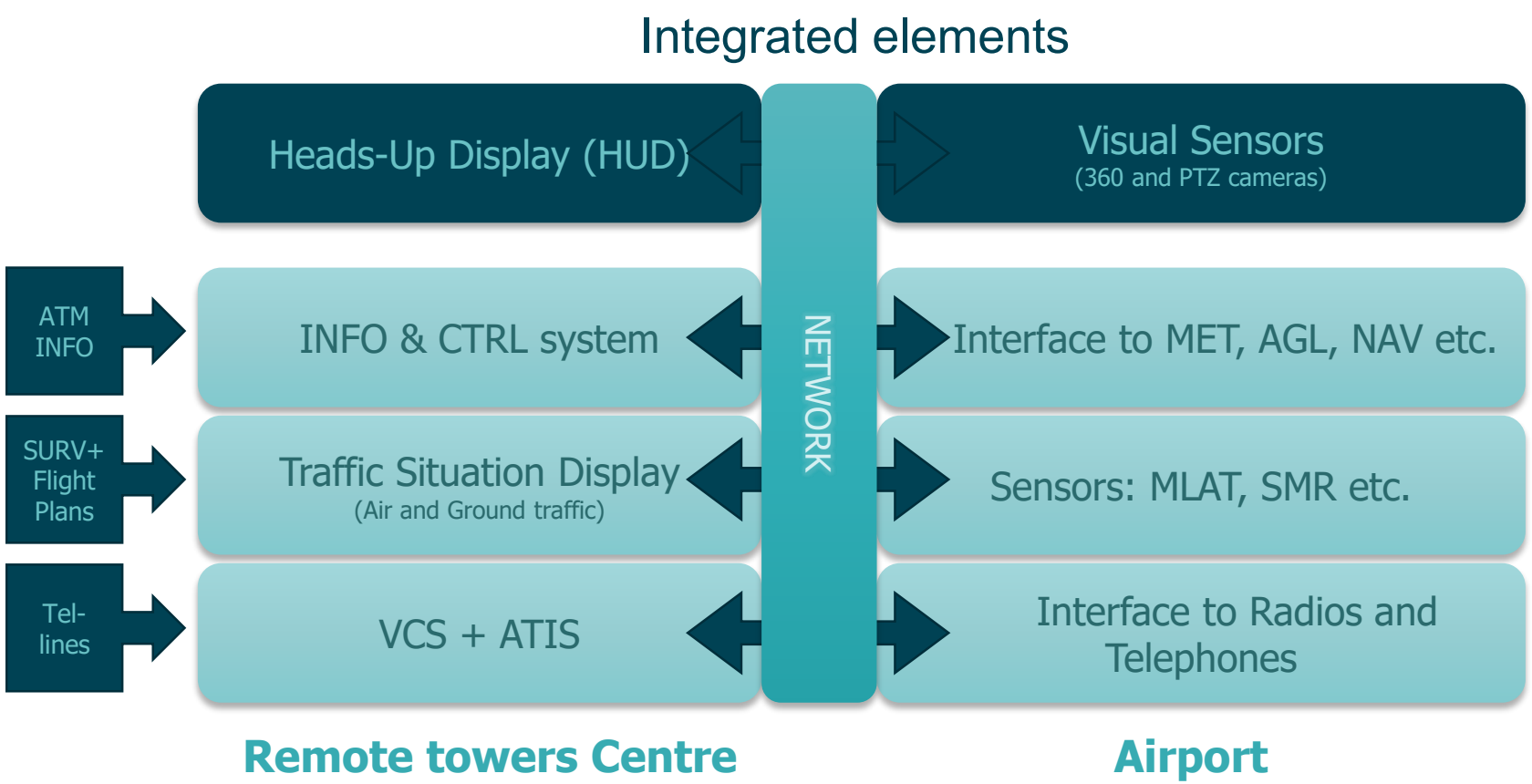
Wide range of options according to operational needs

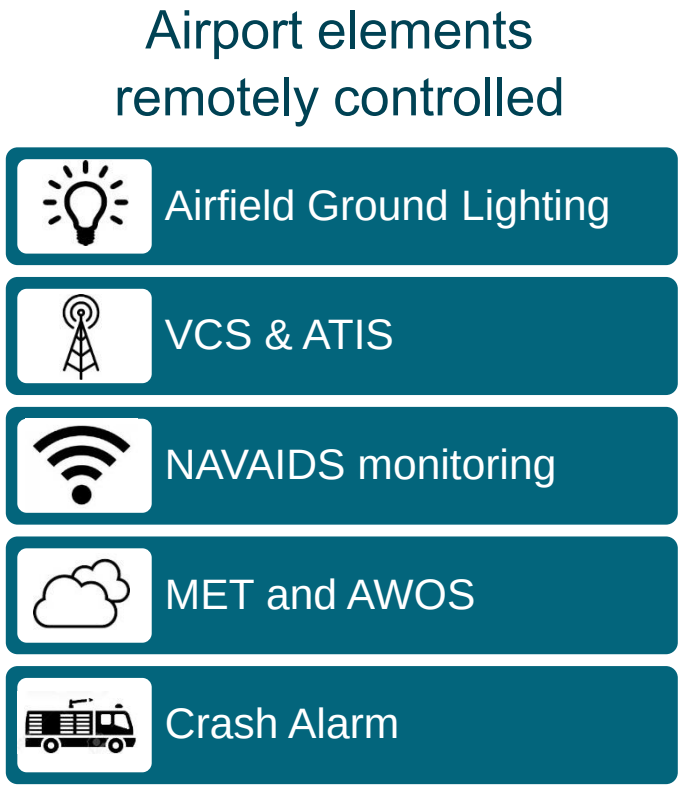
- Rotational and/or fixed camera
- Ocular resolution
- Low intervention at the airport
- Panoramic view (360° or less)
- Pan-Tilt-Zoom Camera
- Signal Light Gun
- Adaptive bandwidth according to functionalities

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



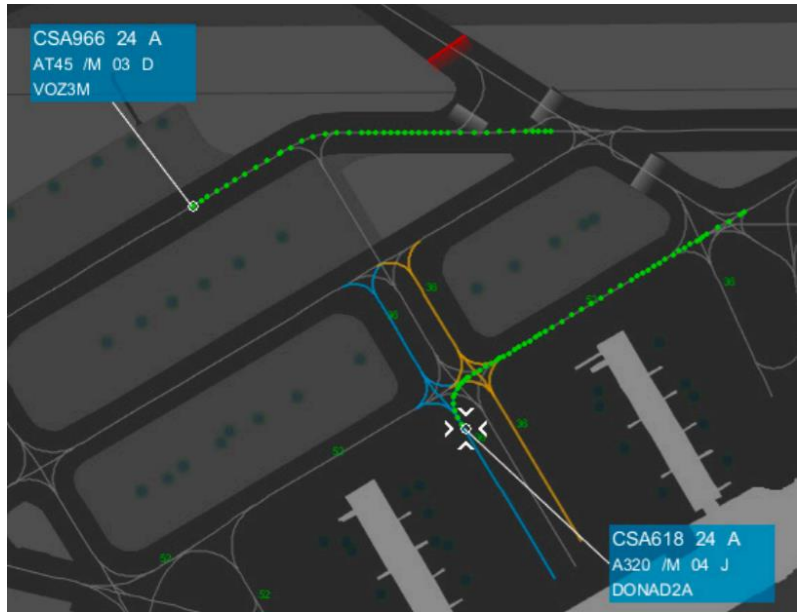


Tower system

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.

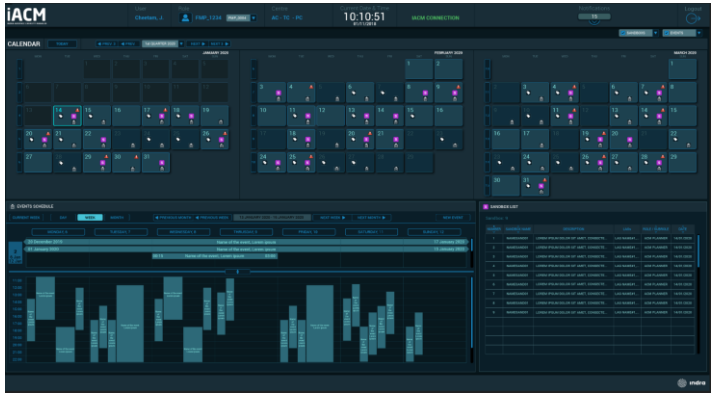
Flow tools

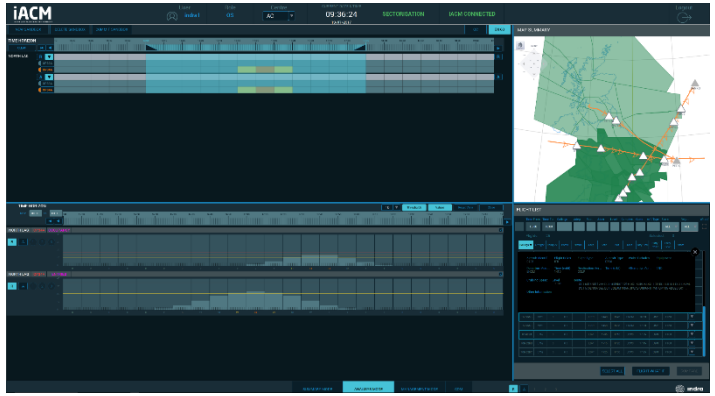
iACM: Indra Airspace Complexity Manager

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

Planning Phase → Tactical Phase





Benefits

iACM goes beyond the classic flow tools

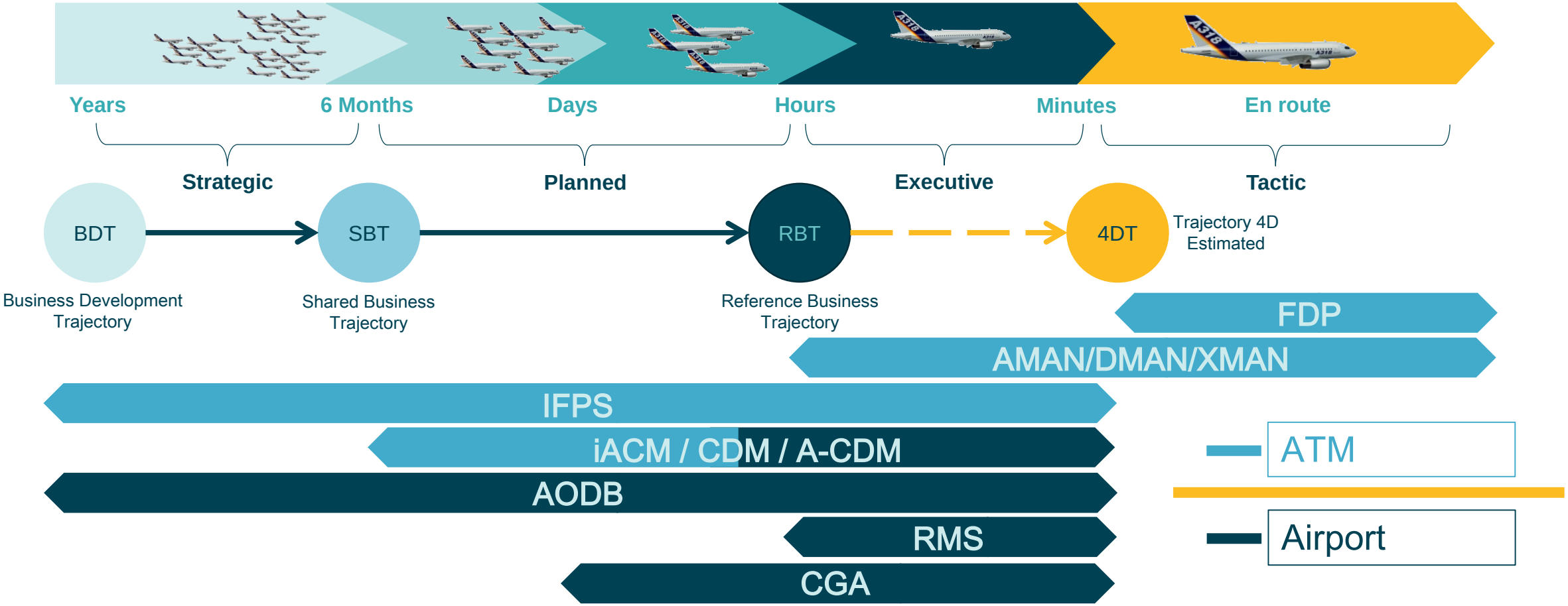
- Safety is the first objective
- New objectives related to the perception of society, such a as environmental or accumulated delay, are added

Integrated concept from the planning phase to the tactical phase

- Interactive assessment of situations base on expected traffic
- Assessment of the impact of the application of alternative scenarios

Flow tools

Others ATFM tools



IFPS

Conflicts detected in the validation of flight plans

Corrupt Data:

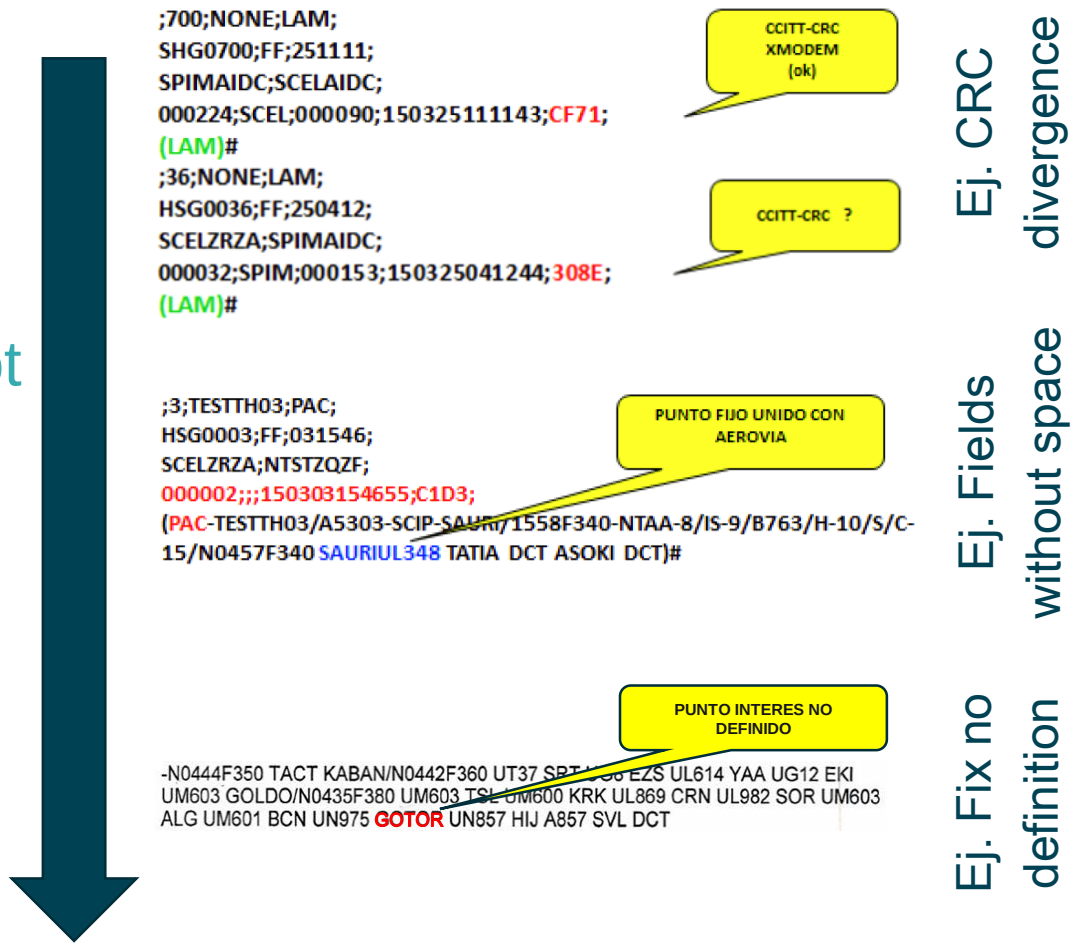
- Data is not “legibly” to system

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



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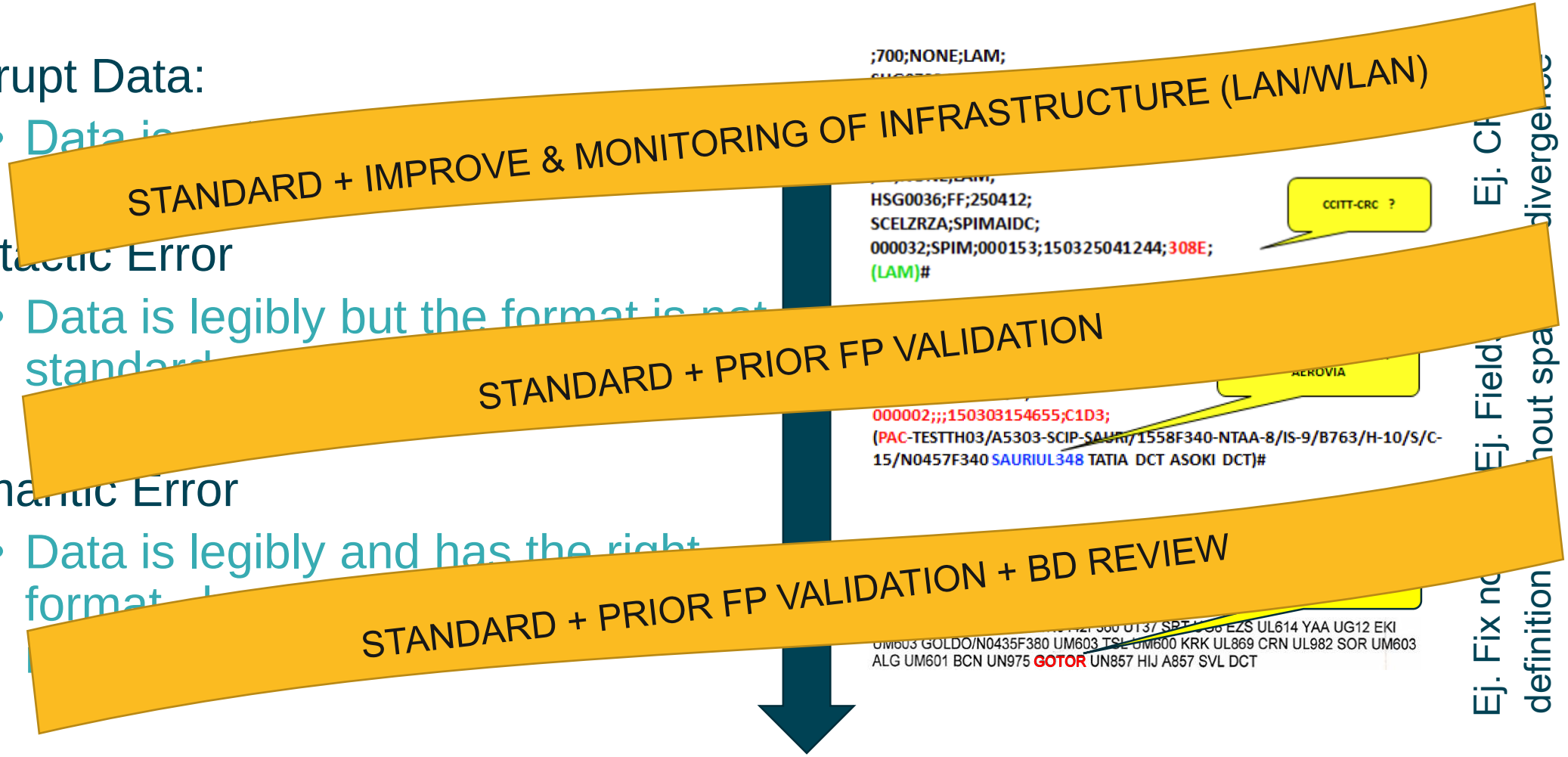
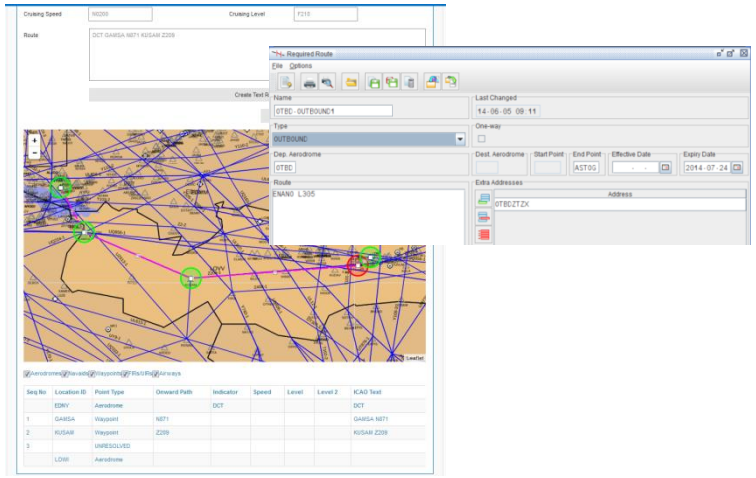


IFPS

IFPS: Advanced flight plan validation

Flight Plan without error

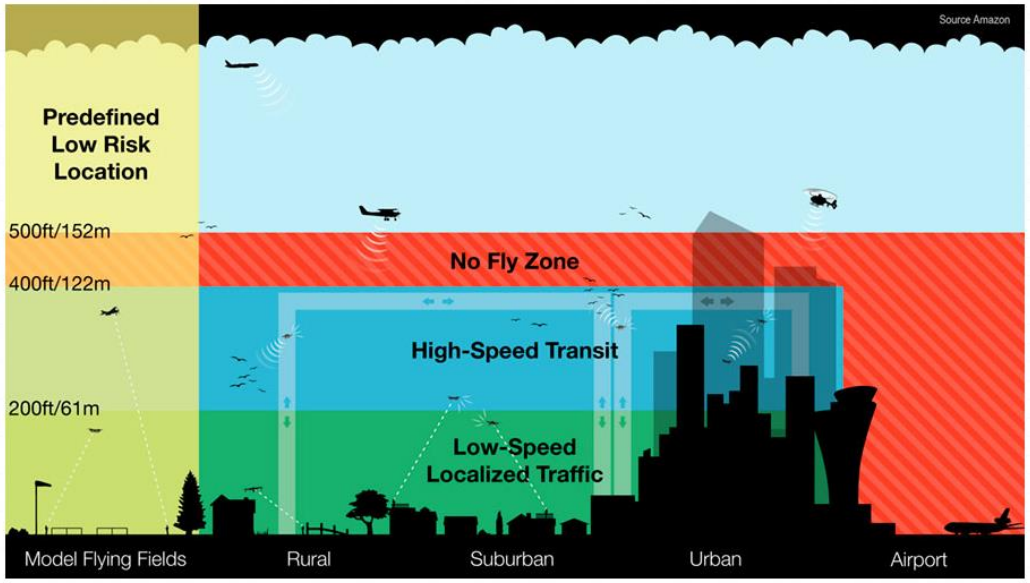
- Centralized BD to ensure the optimization of flight plans
- Approval, forwarding or automatic rejection (configurable) of flight plans and related ATS messages, based on ICAO rules (global and regional eAIP information)
- Operational Response Messages (ORM), designed for advanced flight plan validation:
  - Format and content check
  - ORM are based on EUROCONTROL specifications, eg. 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



UTM

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

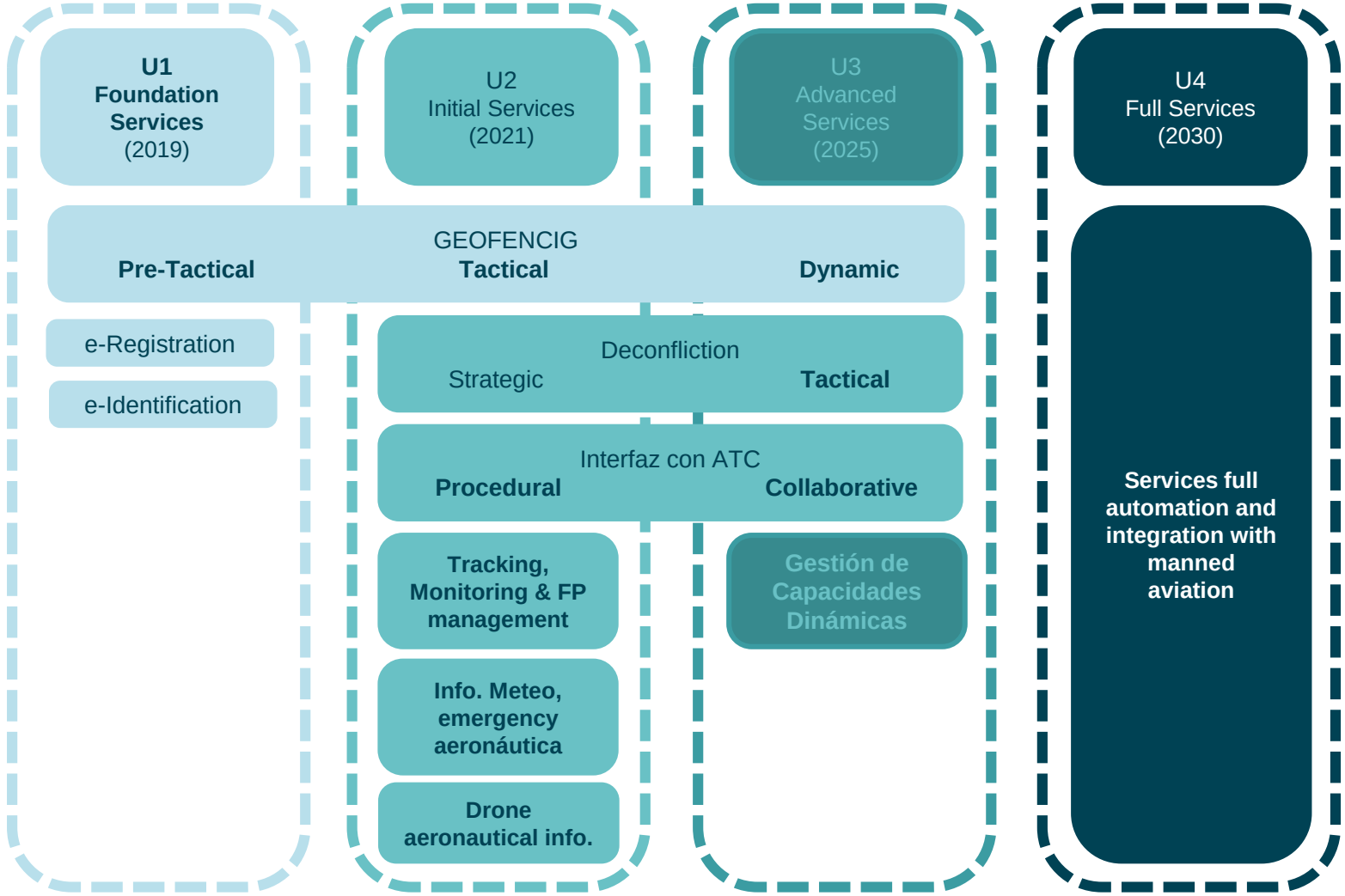
Integrate Vision

UTM

Roadmap: U Space

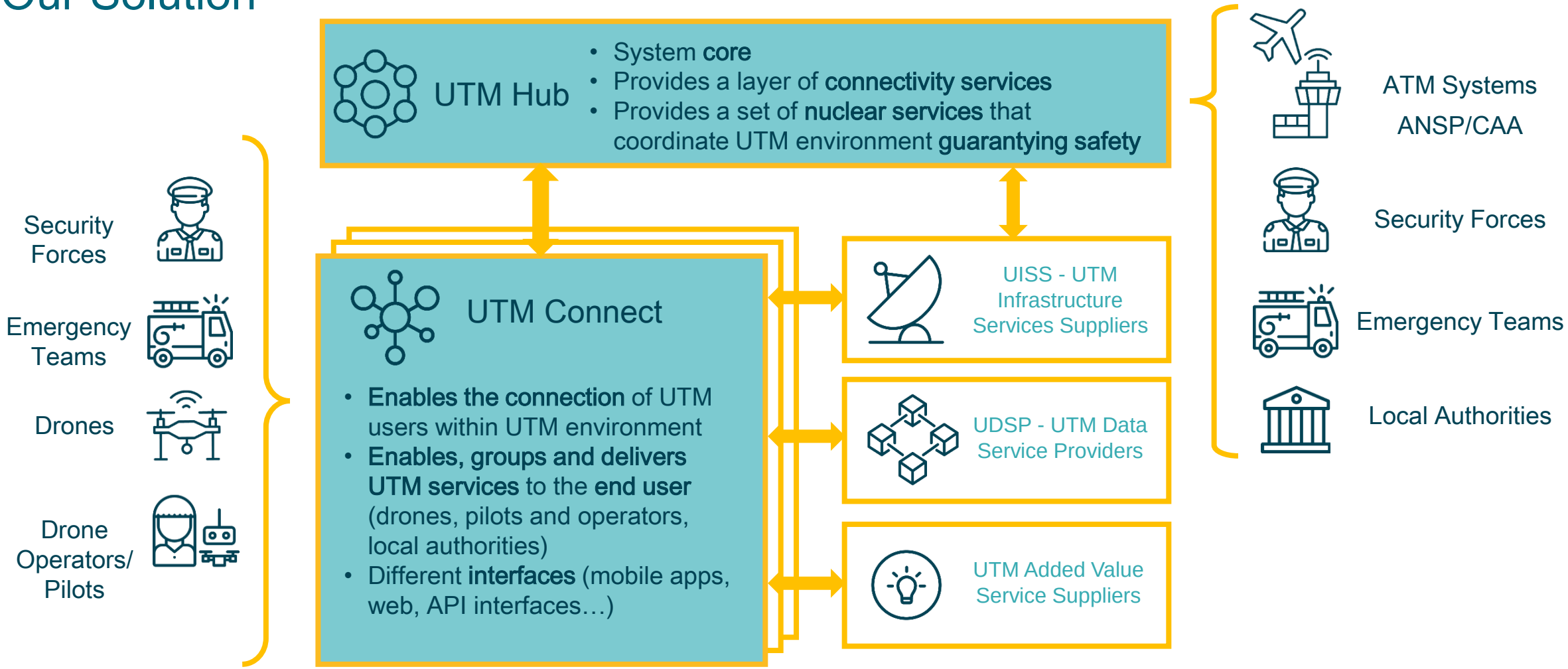
U-space is a ser of new services and specific procedures designed to Support safe, efficient and secure access to airspace for large numbers of drones

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

Security solution

ARMS
Anti RPAS
Multisensor System

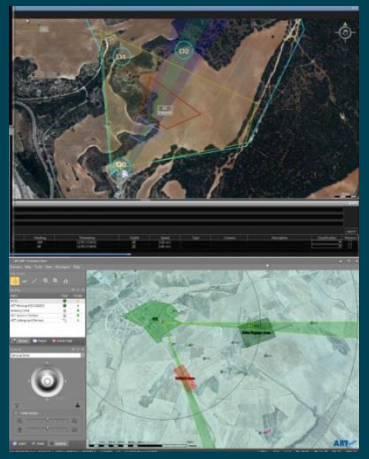
Detection → Tracking → Recognition → C4I → Countermeasure

Radar
- 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

- Alarms
- Management resources
- Messenger service



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

Automation development

- Roadmap
  - ASBU OACI
  - SESAR
- iTEC example

3

Roadmap

Since Aircon to ManagAir

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

ICAO

Aviation System Blocks Upgrades (ASBUs)

ICAO 2016-2030 Global Air Navigation Plan (GANP v5)

EUROCONTROL

SESAR Master Plan

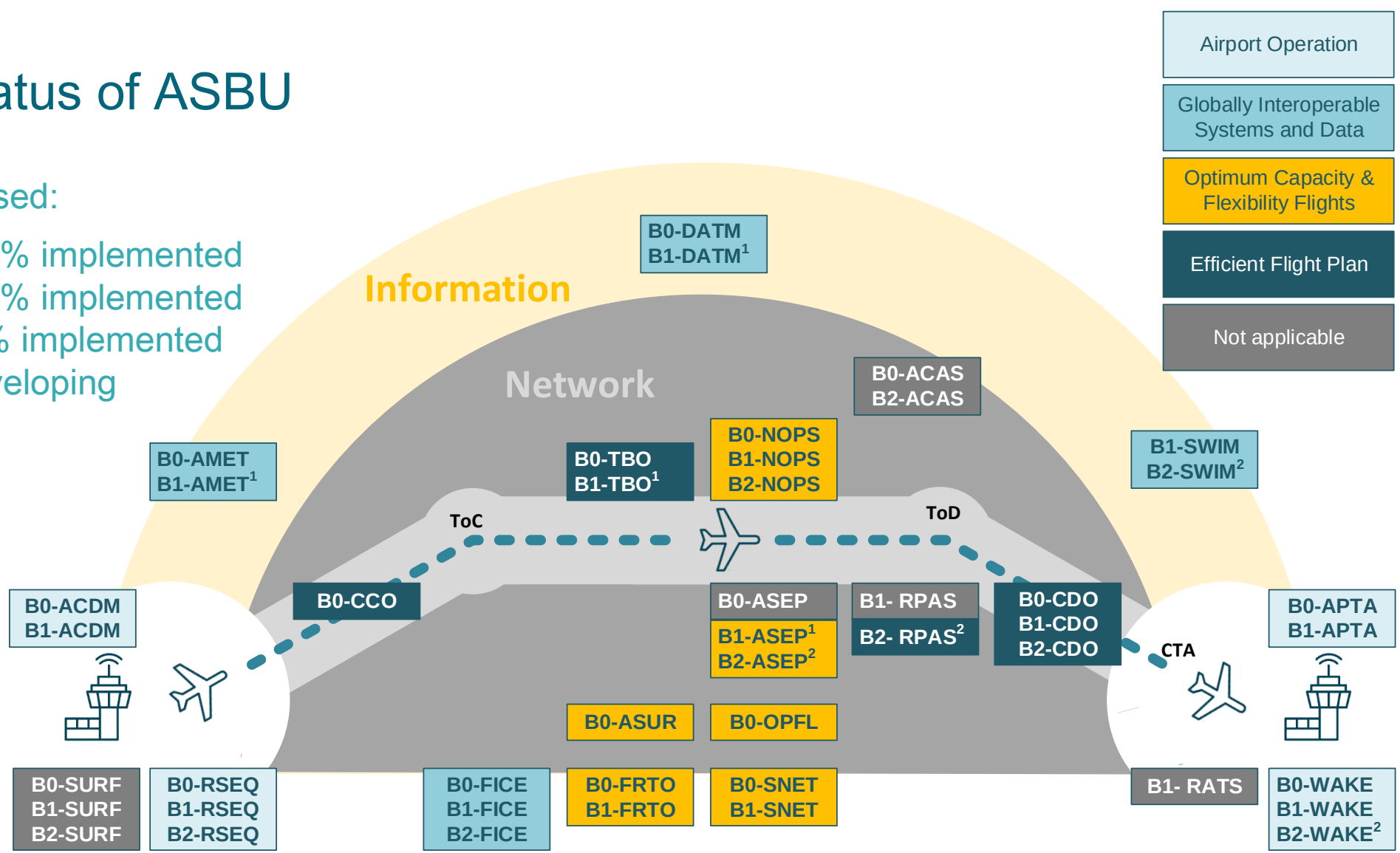
including SESAR 2020

ASBU OACI

Current indra 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



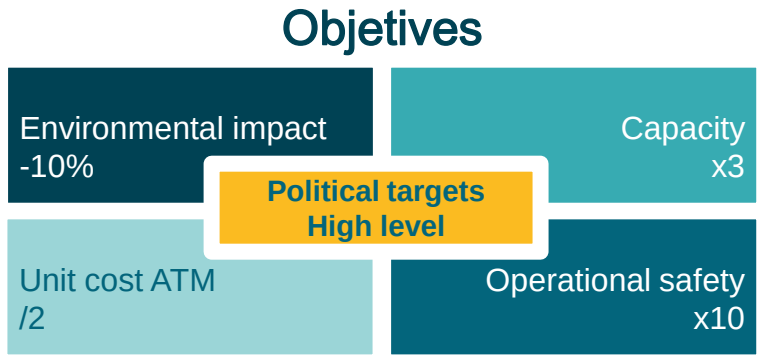
([1]) Developed and implemented, but not yet implemented in the region

([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



It implies the synchronization of the plans and actions of the different stakeholders and the federation of resources in a performance partnership for the development and implementation of the required improvements throughout Europe

All agents participate

SESAR

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

ENAIRE + DFS Deutsche Flugsicherung + NATS + indra = iTEC

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

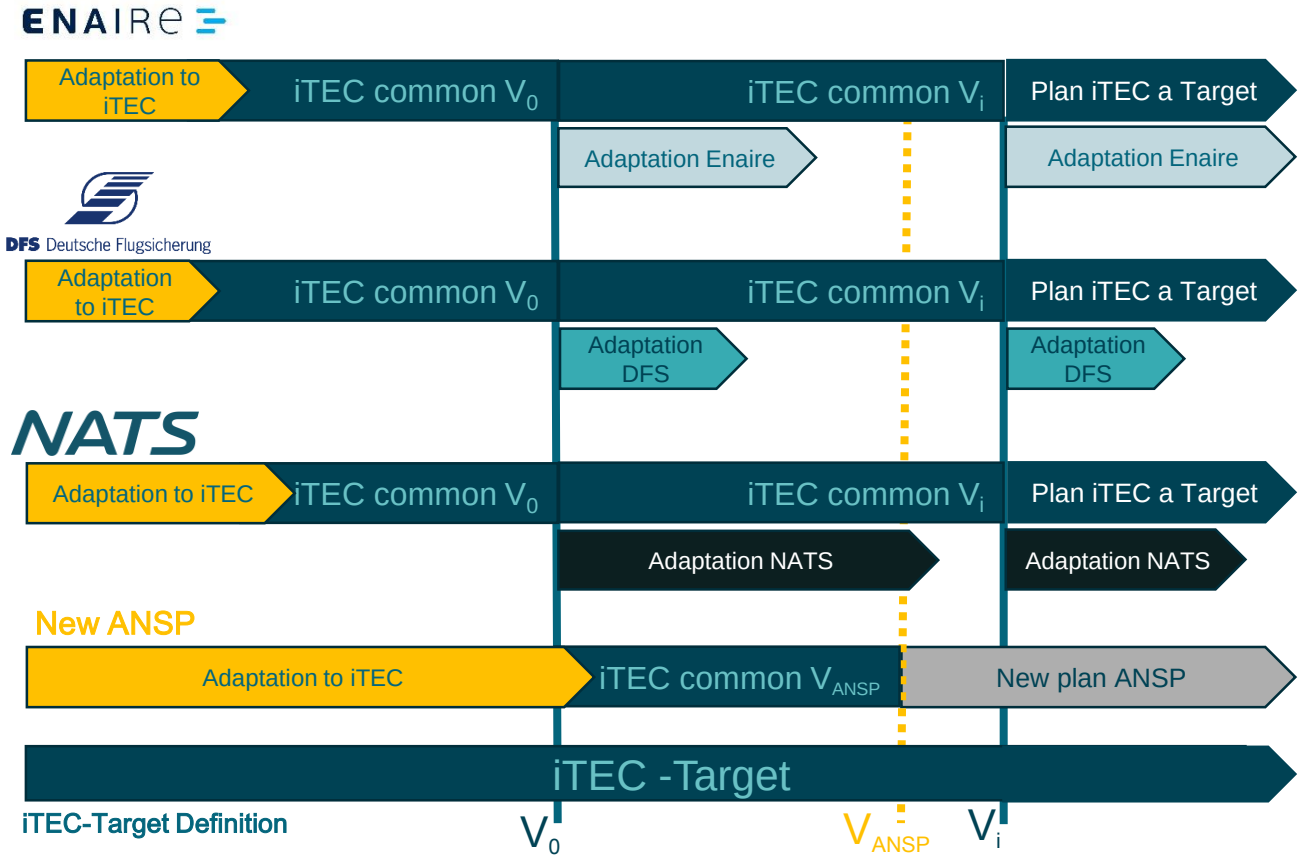
Ejemplo iTEC

History and unification concept

SACTA - ENAIRE

P1/VAFORIT - DFS

Precedent



- **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)
  Avinor joins iTEC alliance
- **2017** — iTEC Centre. Automation System (iCAS) goes live in Karlsruhe (DE)
  ORO NAVIGACIJA 6 PANSA joins iTEC alliance

AIDC-NAM integration

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

4

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 (**O**n-**L**ine **D**ata **I**nterchange) 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 (**A**TS **I**nterfacility **D**ata **C**ommunications) 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.

Message	Meaning	Message Class
ABI	Advance Boundary Information	**Notification**
CPL	Current Flight Plan	**Coordination**
EST	Coordination Estimate	
PAC	Preliminary Activate	
MAC	Cancellation of Notif./Coord.	
CDN	Coordination Negotiation	
ACP	Acceptance	
REJ	Rejection	
TOC	Transfer of Control	**Control transfer**
AOC	Acceptance of Control	
LAM	Logical Acknowledgement Msg	**Aplication Managment**
LRM	Logical Rejection Msg	

Set of core messages

Message	Meaning	Message Class
EMG	Emergency	**Miscellaneous**
MIS	Miscellaneous	
PCM	Profile Confirmation Message	
PCA	Profile Confirmation Acceptance	
TRU	Track Update	
ASM	Application Status Monitor	**Possible future inclusión**
FAN	FANS Application Message	
FCN	FANS Completion Notification	
ADS	Surveillance ADS-C	
TDM	Track Definition Message	**Specifics regional messages**
NAT	Organized Track Structure	

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

Category	Message	Meaning	Class
Pre-takeoff coordination (1)	**FPL**	Filed Flight Plan	1
	CHG	Change	2
	EST	Estimate	2
Active flight coordination	**CPL**	Current Flight Plan (1)	1
	CNL	Cancellation (1)	2
	MOD	Modify (2)	2
	ABI	Advance Boundary Information (3)	(5)
General Information (3)	**MIS**	Miscellaneous	2
Interface Management (4)	**IRQ**	Initialization Request	2
	IRS	Initialization Response	2
	TRQ	Termination Request	2
	TRS	Termination Response	2
	ASM	Application Status Monitor	2

Category	Message	Meaning	Class
Radar Handoff (5)	**RTI**	Radar Transfer Initiate	3
	RTU	Radar Track Update	3
	RLA	Radar Logical ACK	3
	RTA	Radar Transfer Accept	3
Point Out (5)	**POI**	Point Out Initiate	3
	POA	Point Out Accept	3
	POJ	Point Out Reject	3
Transfer (3)	**TOC**	Transfer of Control	(5)
	AOC	Acceptance of Control	(5)
ACK	**LAM**	Logical Acknowledgement (1)	1
	LRM	Logical Rejection (3)	2

Note: ***Diference 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:

PAÍS	LOCACION	TIPO	ICD	VERSION
COCESNA	Tegucigalpa (HN)	Ope/Sim	NAM AIDC	Class 3 rev.D ASIA/PAC V3.0
	Ilopango (SV)	Backup	AIDC	ASIA/PAC V3.0
	Comalapa (SV)	Ope/Sim	NAM AIDC	Class 3 rev.D ASIA/PAC V3.0
	Managua (NI)	Ope/Sim	NAM AIDC	Class 3 rev.D ASIA/PAC V3.0
	La Aurora (GT)	Ope/Sim/Cont	NAM AIDC	Class 3 rev.D ASIA/PAC V3.0
	Mundo maya (GT)	Ope/Sim	AIDC	ASIA/PAC V3.0
	San Pedro Sula (HN)	Ope/Sim	AIDC	ASIA/PAC V3.0
	Belice (BZ)	Ope/Sim/Cont	NAM AIDC	Class 3 rev.D ASIA/PAC V3.0
	San José (CR)	Ope/Sim/Cont.	NAM AIDC	Class 3 rev.D ASIA/PAC V3.0
BAHAMAS	Nassau	Ope	AIDC	ASIA/PAC V3.0
PANAMÁ	Panamá	Sim/Cont	AIDC	ASIA/PAC V3.0

Note: there are NAM interfaces thay operate as Class 1

PAÍS	LOCACION	TIPO	ICD	VERSION
COLOMBIA	Bogota	ACC/APP	AIDC	ASIA/PAC V3.0
	Barranquilla	ACC/APP	AIDC	ASIA/PAC V3.0
	Rio Negro	APP	AIDC	ASIA/PAC V3.0
	Cali	APP	AIDC	ASIA/PAC V3.0
	Villavicencio	APP	AIDC	ASIA/PAC V3.0
ECUADOR	Guayaquil	ACC/APP	AIDC	ASIA/PAC V3.0
	Quito	APP	AIDC	ASIA/PAC V3.0
	Manta	APP	AIDC	ASIA/PAC V3.0
	Shell	APP	AIDC	ASIA/PAC V3.0
PERÚ	Lima	ACC/APP	AIDC	ASIA/PAC V3.0
ARGENTINA	Ezeiza	ACC/APP	AIDC	ASIA/PAC V3.0
	Cordoba	ACC/APP	AIDC	ASIA/PAC V3.0
	Mendoza	ACC/APP	AIDC	ASIA/PAC V3.0
	Resistencia	ACC/APP	AIDC	ASIA/PAC V3.0
	Comodoro	ACC/APP	AIDC	ASIA/PAC V3.0
	Aeroparque	APP	AIDC	ASIA/PAC V3.0
CHILE	Iquique	ACC/APP	AIDC	ASIA/PAC V3.0
	Antofagasta	APP	AIDC	ASIA/PAC V3.0
	Concepción	APP	AIDC	ASIA/PAC V3.0
	Temuco	APP	AIDC	ASIA/PAC V3.0
	Puerto Montt	ACC/APP	AIDC	ASIA/PAC V3.0
	Punta Arenas	ACC/APP	AIDC	ASIA/PAC V3.0
URUGUAY	Carrasco	ACC/APP	AIDC	ASIA/PAC V3.0
PARAGUAY	Asunción	ACC/APP	N/A	N/A

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 generate the same message

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

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 (ex: Lat./long or fix). The system must be able to accept these particularities

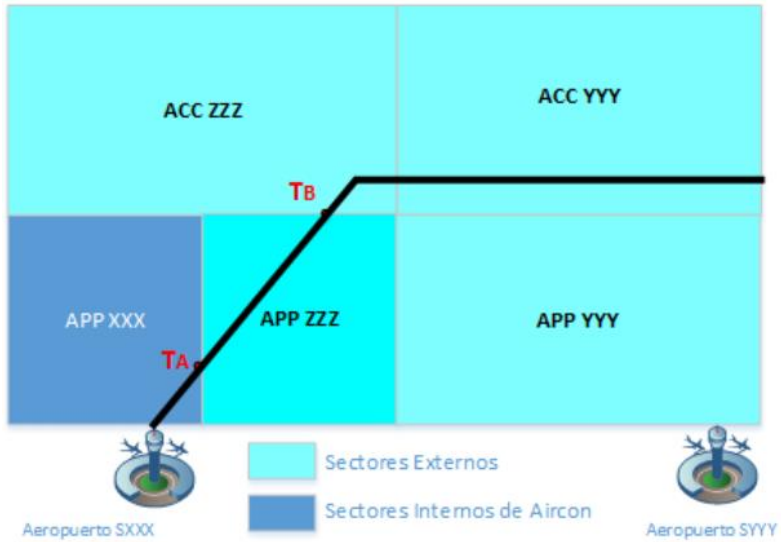
Ex: The PAC message may include field 15 (optional)

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:



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