COLLABORATIVE TRAJECTORY OPTIONS PROGRAM: PRESENT AND FUTURE SCOPE

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New aircraft demand by region 2015 – 2034

1.150

7.310

7.890

14.330

3.180

3.020

1.170

TOTAL: 38.050

BOEING, 2015

Introduction

- **Global hubs:** some cities are expected to concentrate the air demand with long-haul and regional traffic;
- **Latin America:** since 2007, 45% of the traffic growth is accounted by just 10 airports.


Source: LITTLE, 2013

Introduction

- **Delay:** is one of the consequences of this flight concentration**;**
- **Europe:** in 2014, the **average delay per delayed flight** was **26 minutes** per flight;
- **Brazil: 7.9%** of all flights were delayed more than 30 minutes. **3.1%** were delayed more than 60 minutes;
- **USA:** in 2010, more than **18%** of all flights were delayed more than 15 minutes.
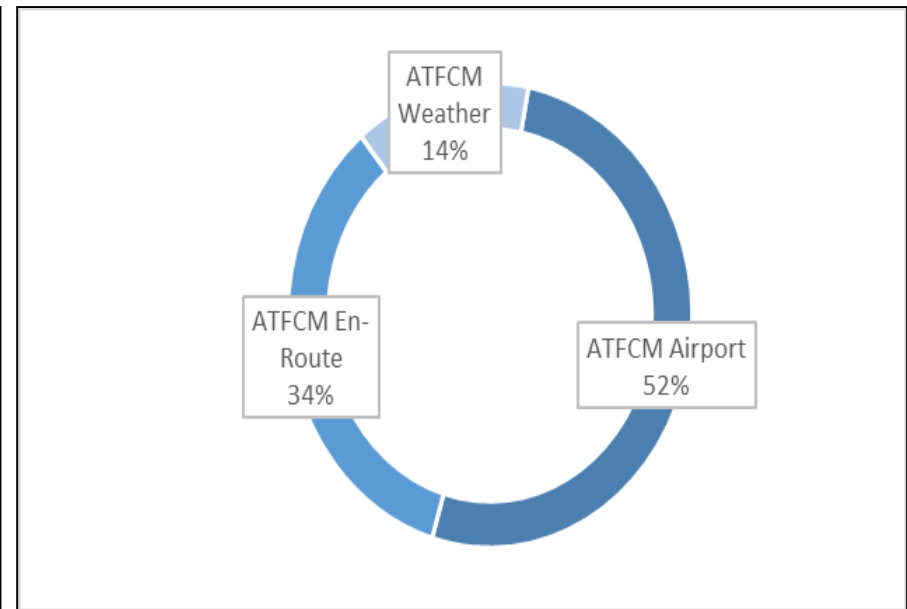
Introduction

Primary delay causes in Europe in 2014
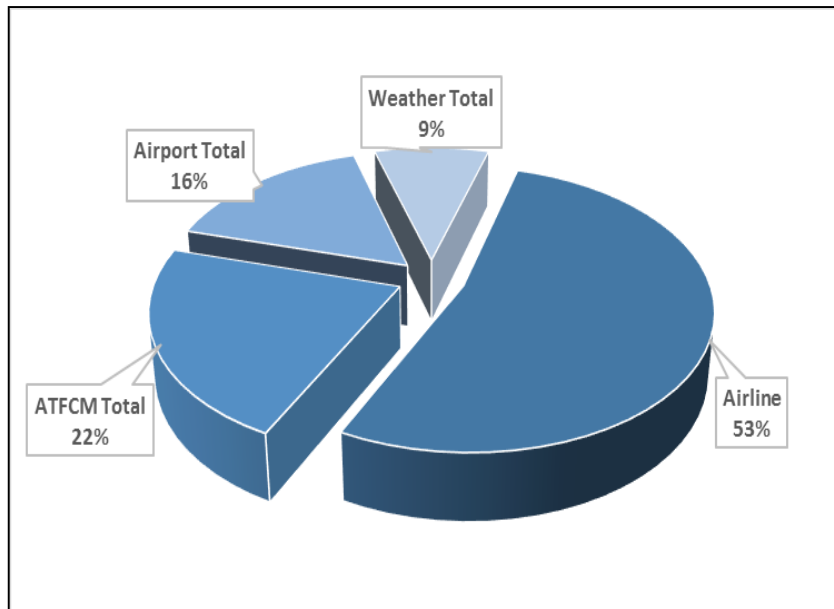
Source: Adapted from Eurocontrol, 2015
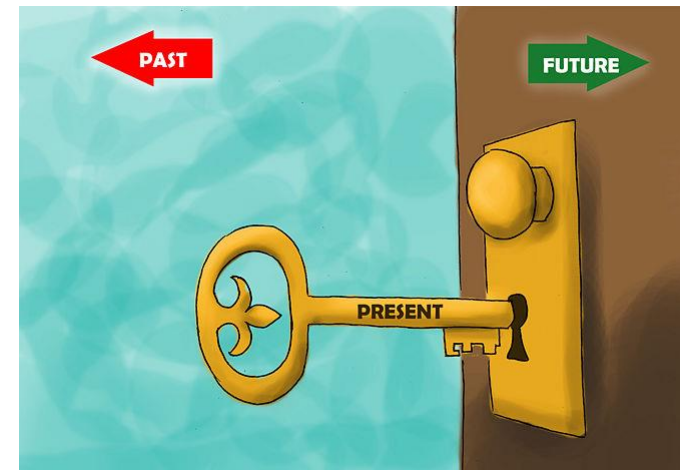
ATFCM delay in Europe in 2014

Source: Adapted from Eurocontrol, 2015

Introduction
Need for change in Air Traffic System

Clearance-Based Air Traffic Control

Trajectory-Based Air Traffic Control Operations

PAST

FUTURE

PRESENT

Objective

- Analyze the Collaborative Trajectory Options Program in present and future scopes, showing the main components of this program.

Cooperative environment between airlines and air traffic authorities

- In 2003 during the Eleventh Air Navigation Conference, it was agreed upon ICAO members that it was necessary to evolve towards a more **collaborative environment**.
- This new philosophy aims to evolve to a holistic, cooperative and collaborative decision-making environment.
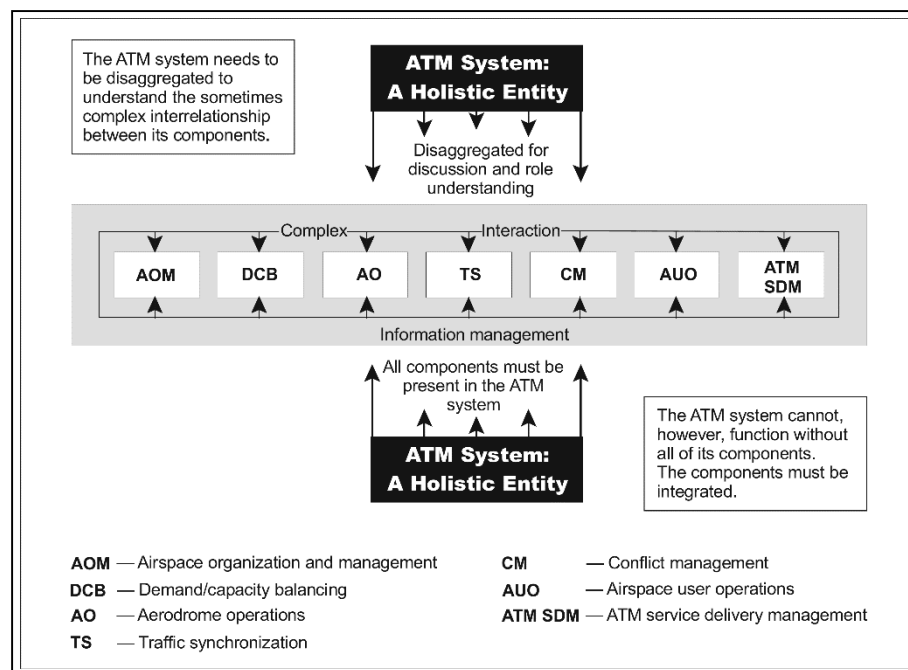
Source: ICAO, 2005

Cooperative environment between airlines and air traffic authorities

- **ATM community**:
    - Aerodrome community;
    - Airspace providers;
    - Airspace users;
    - ATM service providers;
    - ATM support industry;
    - International Civil Aviation Organization;
    - Regulatory authorities; and
    - States.

Collaborative Air Traffic Management (CATM)

- An attempt to accommodate aircraft operator preferences to the maximum extent possible with restrictions imposed only when an actual operational need exists (NOLAN, 2011);

- Give the aircraft operator the opportunity to participate in the decisions rather than the Air Traffic Control Authority arbitrary defines the restrictions;

- First implementation of CATM is the Collaborative Decision-Making (CDM).

Collaborative Decision-Making (CDM)

Collaborative Decision-Making (CDM)

- In US, began in 1993;

- The milestone of CDM was when **industry agreed to share its information**, providing real-time, day-of-operations schedules;

"In February of 1993, a demonstration was arranged at the Headquarters building of the Air Transport Association (ATA) involving representatives of all the major airlines and FAA personnel from both the operational and system development communities.

This meeting is widely viewed as the beginning of CDM. **It started with many fireworks; airlines not trusting their competitors and all of them absolutely despising FAA. And the FAA considering the airlines a nuisance, and a bunch of cheaters who did not care about the system.**
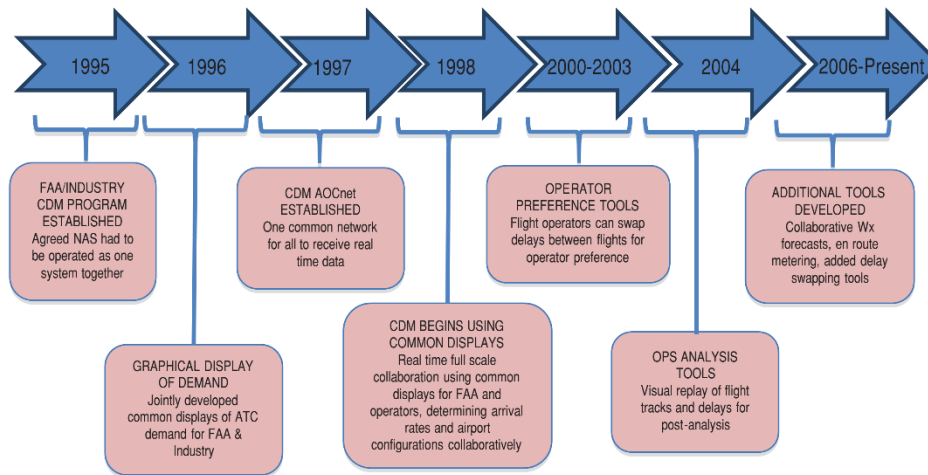
But at this meeting something changed, and the notion that booth the service provider (FAA) and system users (airlines) could benefit from cooperation first took hold. "

Source: WAMBASGANSS, page 02; 2001

Collaborative Decision-Making (CDM)

CDM program development timeline

Source: TRB, 2015

The pillars of CDM
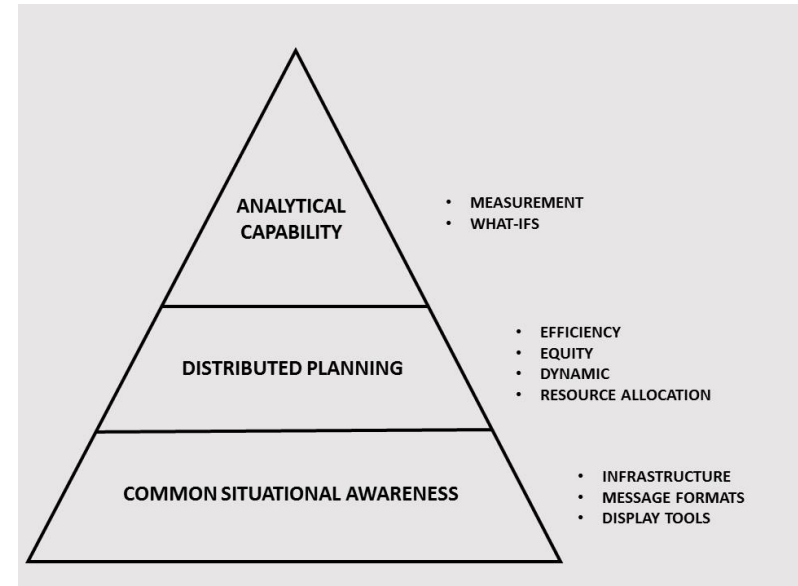
Source: WAMBASGANSS, 2001

- In Europe, CDM was implemented in early 2000´s as Airport CDM (A-CDM).
- Difference is due virtually all European airports have slot controls and scheduled operations generally are within airport capacities.

Air Traffic Flow Management (ATFM) Programs

- Allied with the collaborative environment;

- ATFM Programs were created to reduce the scale and cost during times of **adverse weather** and **heavy traffic demand**.
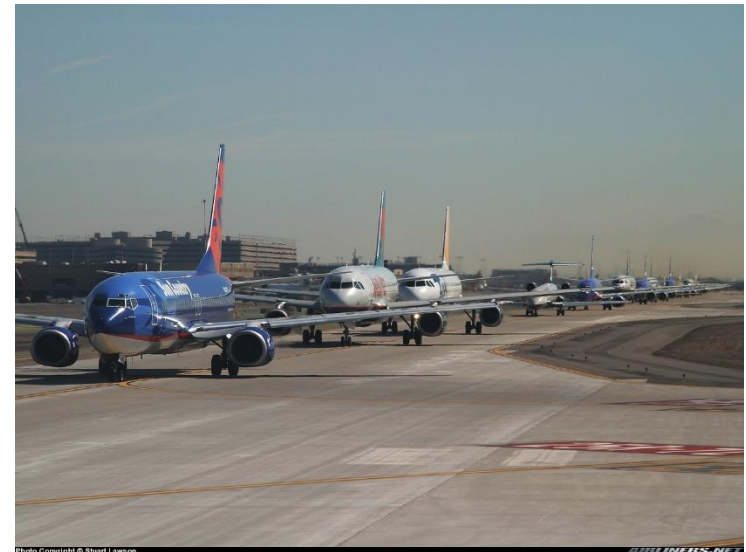
Air Traffic Flow Management (ATFM) Programs

- Function of ATM

Air Traffic Management

Air Traffic Control

Airspace Management

Air Traffic Flow Management

- separate aircraft to avoid collisions
- organize air traffic flow
- provide information for the pilots when necessary

- provide airspace structure (control sectors, airways, Terminal Area), in a certain level of air traffic demand

- balance air traffic demand with airspace and/or capacity
- ensure the most efficient use of the airspace system

Source: ICAO, 2005

Air Traffic Flow Management (ATFM) Programs

Air Traffic Flow Management Phases

Strategic Planning (2 to 6 months ahead)
- Implemented with ATC and Aircraft operators
- Adjust (re-routing) certain traffic flows
- Scheduling or rescheduling flight as necessary
- Considers seasonal changes of weather and major weather phenomena
- Basis for predictable scheduling

Pre-Tactical Planning (day before)
- Adjust certain traffic flows
- Coordination in certain off-load routes
- Evaluate current allocation against projected demand
- Publish and make available the ATFM plan for the next day

Tactical ATFM operations (present)
- Execute the agreed tactical measures when facing capacity problems
- Monitor the evolution of air traffic situation
- Initiate corrective actions when long delay are reported
- Adjust imbalances – weather; capacity; infrastructure; disruptions
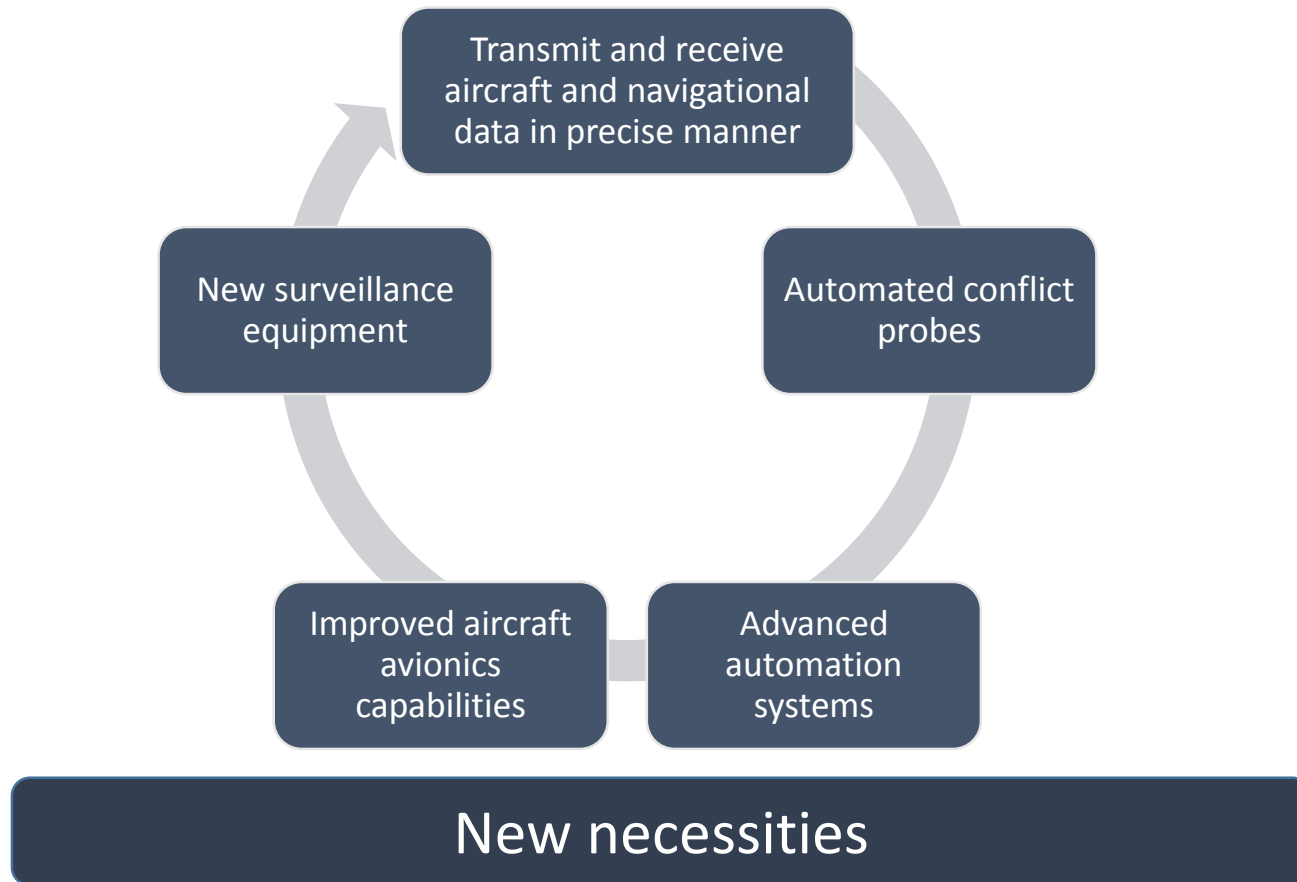- Dynamic adjustments

Trajectory-Based Operations

- Trajectory = a four dimension flight path of an aircraft through space and time (4D)

- **CTA**: Controlled Time of Arrivals

- **RTA**: Required Time of Arrival
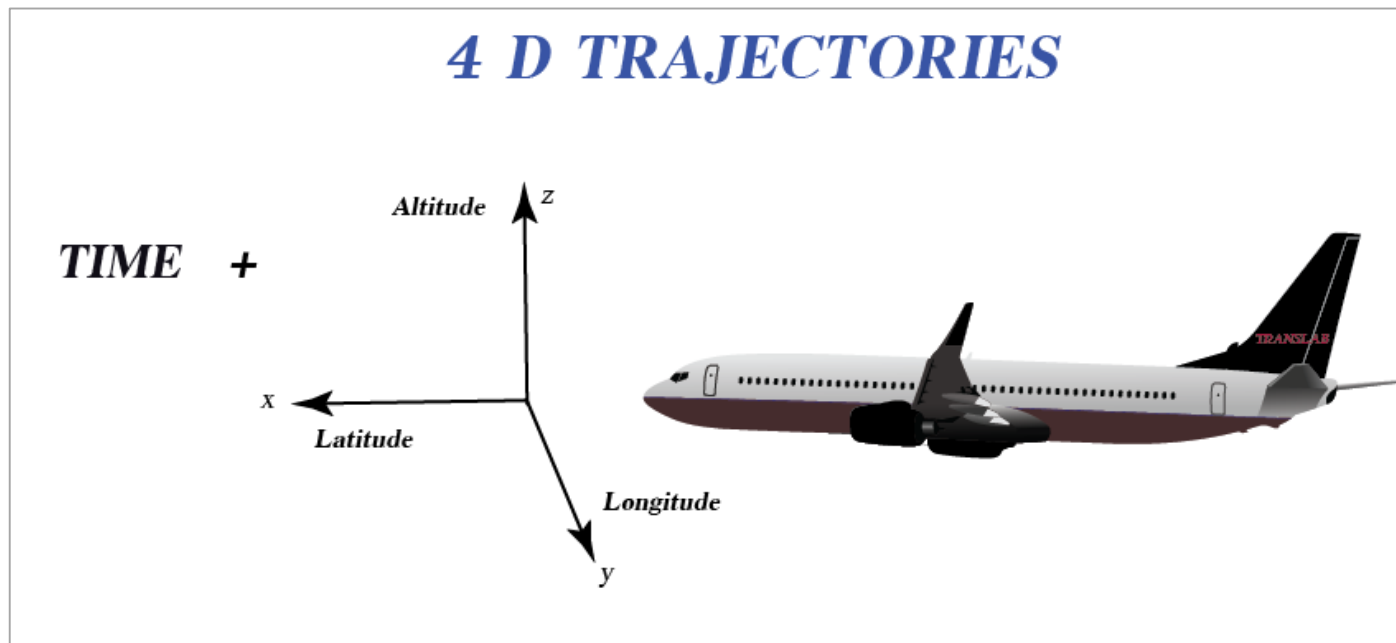
Trajectory-Based Operations

- Aircraft will be assigned flexible and negotiated trajectories;
- ATC will have to manage those routes, with the air traffic controllers performing a strategic traffic flow coordinator;

Transmit and receive aircraft and navigational data in precise manner

Automated conflict probes

Advanced automation systems

Improved aircraft avionics capabilities

New surveillance equipment

New necessities

Trajectory-Based Operations

Hierarchy of the Trajectory-Based Operations Concept

Collaborative Trajectory Options Program (CTOP)

- CTOP connected with the idea of a constrained area;

- New traffic management initiatives;

- In general, CTOP could be summarized as:
  - Given airspace constraints how achieve a better fluency flow considering capacity, improving business goal results for NAS' users and make possible to apply reroute and delay together.

Unique Flight Data

ACID	ORIG	DEST	IGTD	TYPE	ERTD
ABC123	DEN	IAD	05/1945	B757	05/1957

TRAJ_OPTION

RTC	RMNT	TVST	TVET	Route	ALT	SPEED
0				GLD SLN J24 MCI J24 STL J134 FLM J24 HVQ SHNON2	350	435
25				GLD SLN J24 MCI J80 VHP APE AIR J162 MGW VERNI ESL SHNON2	350	435
35				PLAIN4 HCT J128 OBH J10 IOW BDF J64 WHETT J30 APE AIR MGW MGW121 VERNI ESL ROYIL2	310	430
50		1945	2145	YELLO6 HANKI OBH J10 IOW BDF J64 WHETT J30 APE AIR MGW MGW121 VERNI ESL ROYIL2	350	425
65		2030	2200	YELLO6 HANKI ONL J148 MCW J16 BAE J34 AIR MGW MGW121 VERNI ESL ROYIL2	310	430
90	45	1945	2145	PIKES4 PUB J28 ICT FAM J78 HVQ SHNON2 DEN PIKES4 PUB TBE BGD IRW FSM BNA BKW ROYIL2 IAD	350	435
120	45	2045	2245	PIKES4 PUB TBE BGD IRW FSM BNA BKW ROYIL2	350	440

IGTD – Initial Gate Time of Departure; ERTD – Earliest Runway Time of Departure;
RTC – Relative Trajectory Cost RMNT- Required Minimum Notification Time;
TVST – Trajectory Valid Start Time; TVET- Trajectory Valid End Time

Optional values provided by the Flight Operator
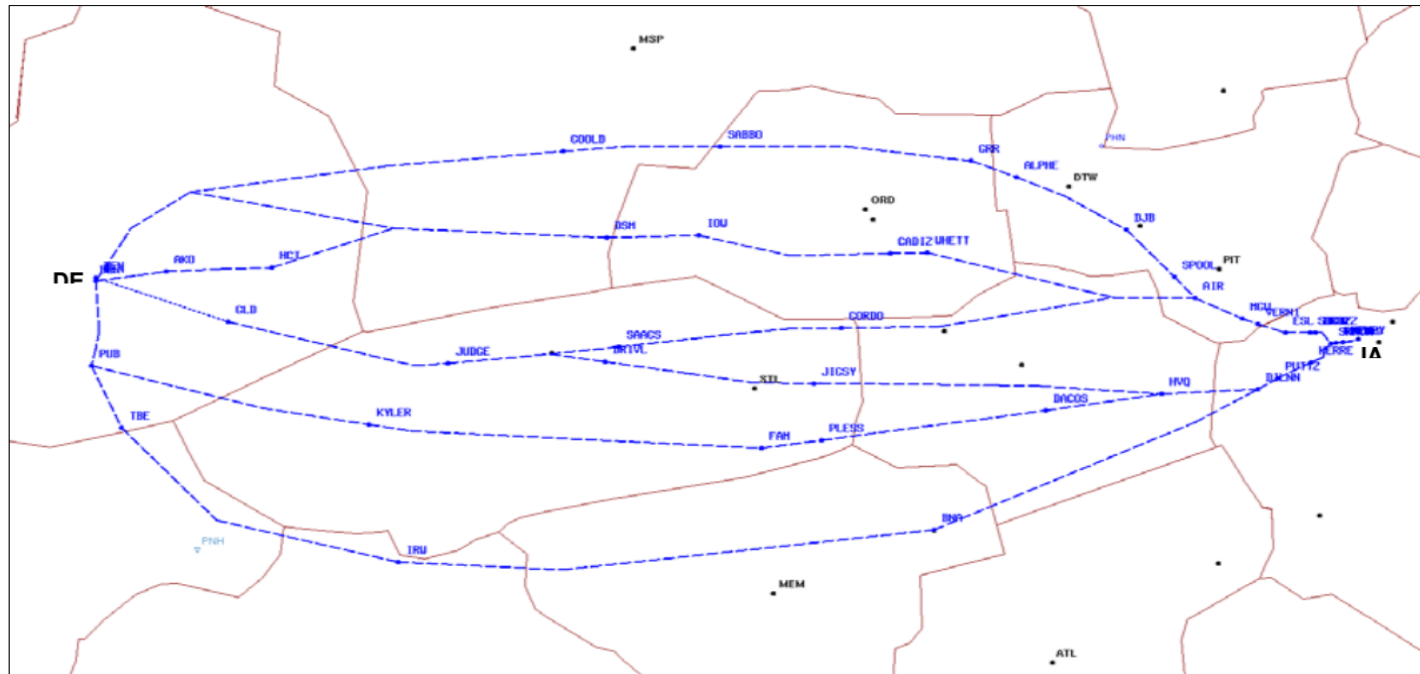
Delay Reduction in CTOP by TOS

- Optimization in TOS planning by airlines in CTOP when it happens multiples Flow Constrained Areas (FCA).

- Expected Results
  - Dynamic decision support model to plan airlines' TOS, considering how many trajectories option might be sent for every flight in each CTOP demand and strictly known information by each airline.

Challenges in the approach

- Optimize the TOS planning process with limited knowledge about each CTOP demand environment.
  - Flights, airlines and strategies

- Develop models that work satisfactorily in most of cases, considering there is no information about competitors' CTOP captured flights and strategies.

Current methods in CTOP

- Greedy Method
- Greedy Game Theory methods with knowledge. These two methods need to obtain detail flight information of every airline which is impossible. This research proposed
- Single Game CTOP model (SG-CTOP), which is a non-cooperative, non-repeated game with incomplete information.
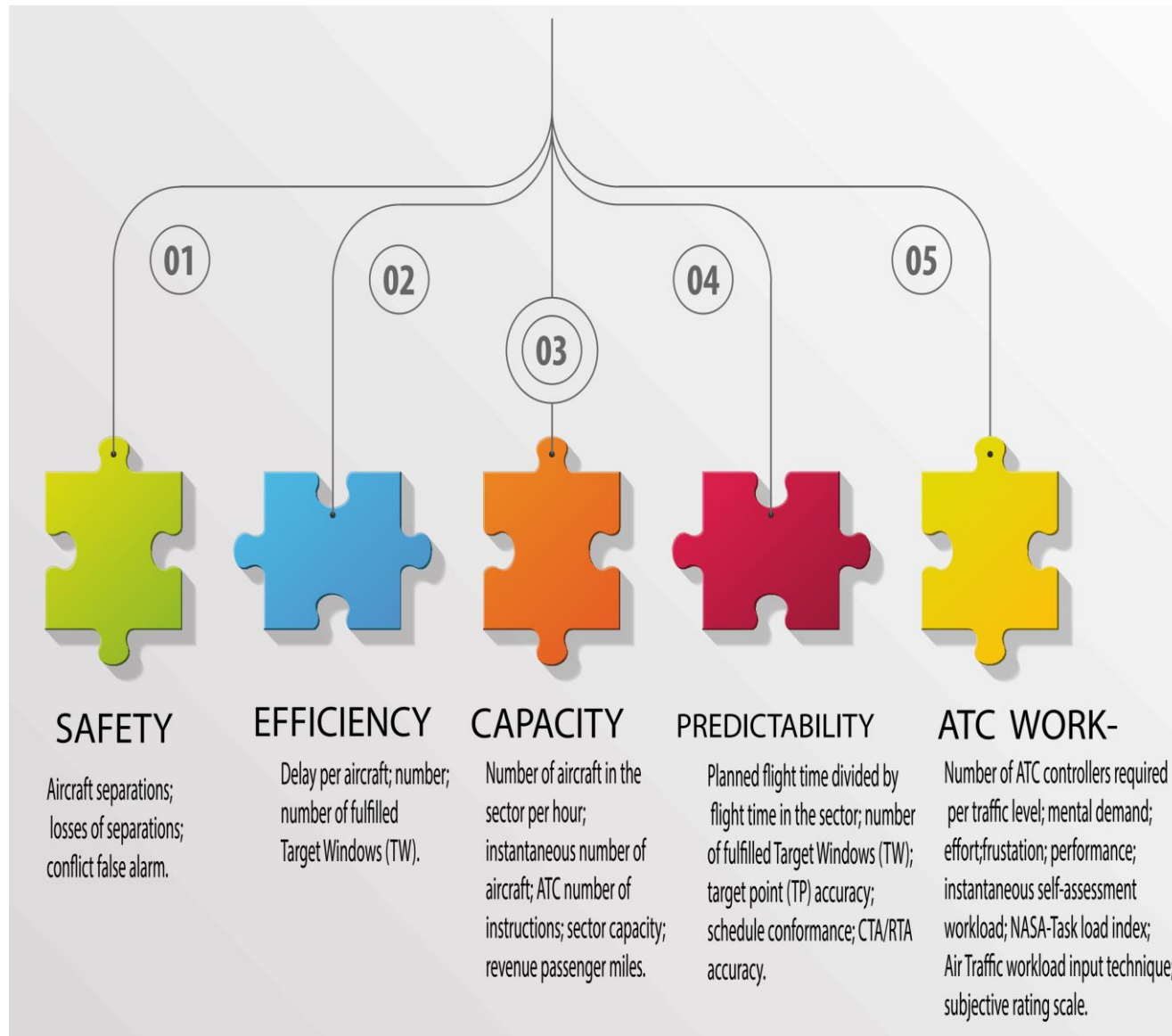
System Wide Information Management (SWIM)

- All the detailed trajectory information will be shared between all the stakeholders through a System Wide Information Management (SWIM) platform;

- It is a network where all the information are shared amongst authorized users;

- SWIN will provides the infrastructure and services to deliver network-enabled information access to a multitude of ATM system users.
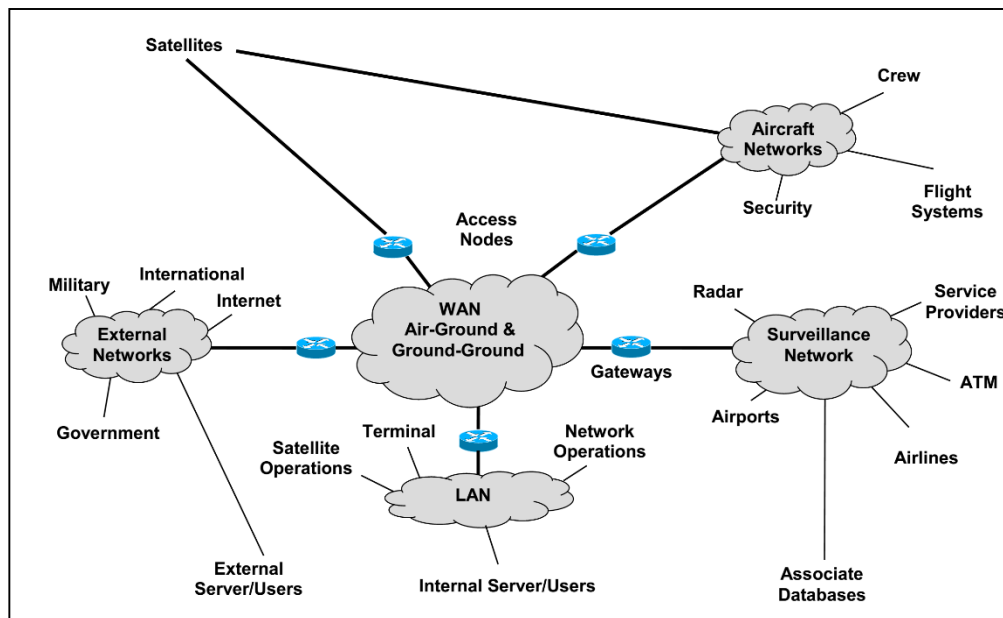
Future Scope – Comparative Metrics

- in order to achieve the TBO environment, the following technologies are considered necessary:
  - **Advanced Flight Management System (FMS) capabilities**: 4DTcan only exist with accurate Controlled Time of Arrival (CTA) capabilities. These CTA capabilities will need that the FMS presents features that are more advanced.
  - **Data communication**: the voice communication channel between ATC and cockpit will not be sufficient to handle the amount of traffic. It will be necessary to introduce Data communication, and it will decrease the controller´s workload.
  - **ADS-B**: this technology will replace the RADAR as surveillance instrument. The implementation of ADS-B out (on the ground) and ADS-B in (on board of the aircraft).
  - **Air Traffic Control Decision Support Tools**: necessity to implement Decision Support Tools (DST) for air traffic controllers. DST will be necessary to provide air traffic controllers with acceptable levels of workload.

Future Scope – Comparative Metrics

01 **SAFETY**
Aircraft separations; losses of separations; conflict false alarm.

02 **EFFICIENCY**
Delay per aircraft; number; number of fulfilled Target Windows (TW).

03 **CAPACITY**
Number of aircraft in the sector per hour; instantaneous number of aircraft; ATC number of instructions; sector capacity; revenue passenger miles.

04 **PREDICTABILITY**
Planned flight time divided by flight time in the sector; number of fulfilled Target Windows (TW); target point (TP) accuracy; schedule conformance; CTA/RTA accuracy.

05 **ATC WORK-**
Number of ATC controllers required per traffic level; mental demand; effort; frustation; performance; instantaneous self-assessment workload; NASA-Task load index; Air Traffic workload input technique; subjective rating scale.

Source: Adapted from ENEA; PORRETA, 2012)

POSSIBLE IMPLEMENTATIONS IN BRAZIL

Constrained area – capacity
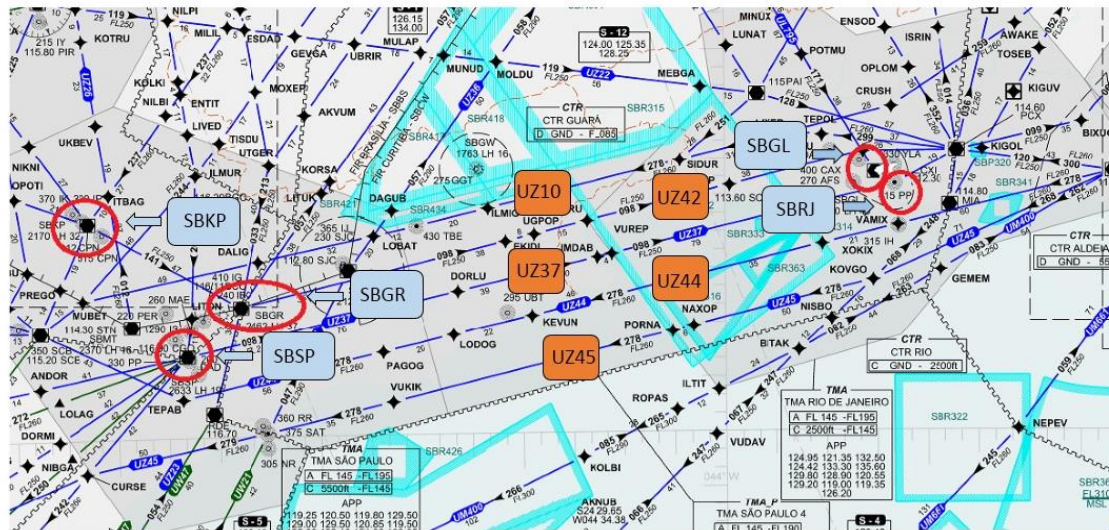
Campinas Airport
Total pax: 9.8 million

Guarulhos Airport
Total pax: 36.7 million

Congonhas Airport
Total pax: 18.1 million

Total distance 215 NM

Galeão Airport
Total pax: 17.3 million
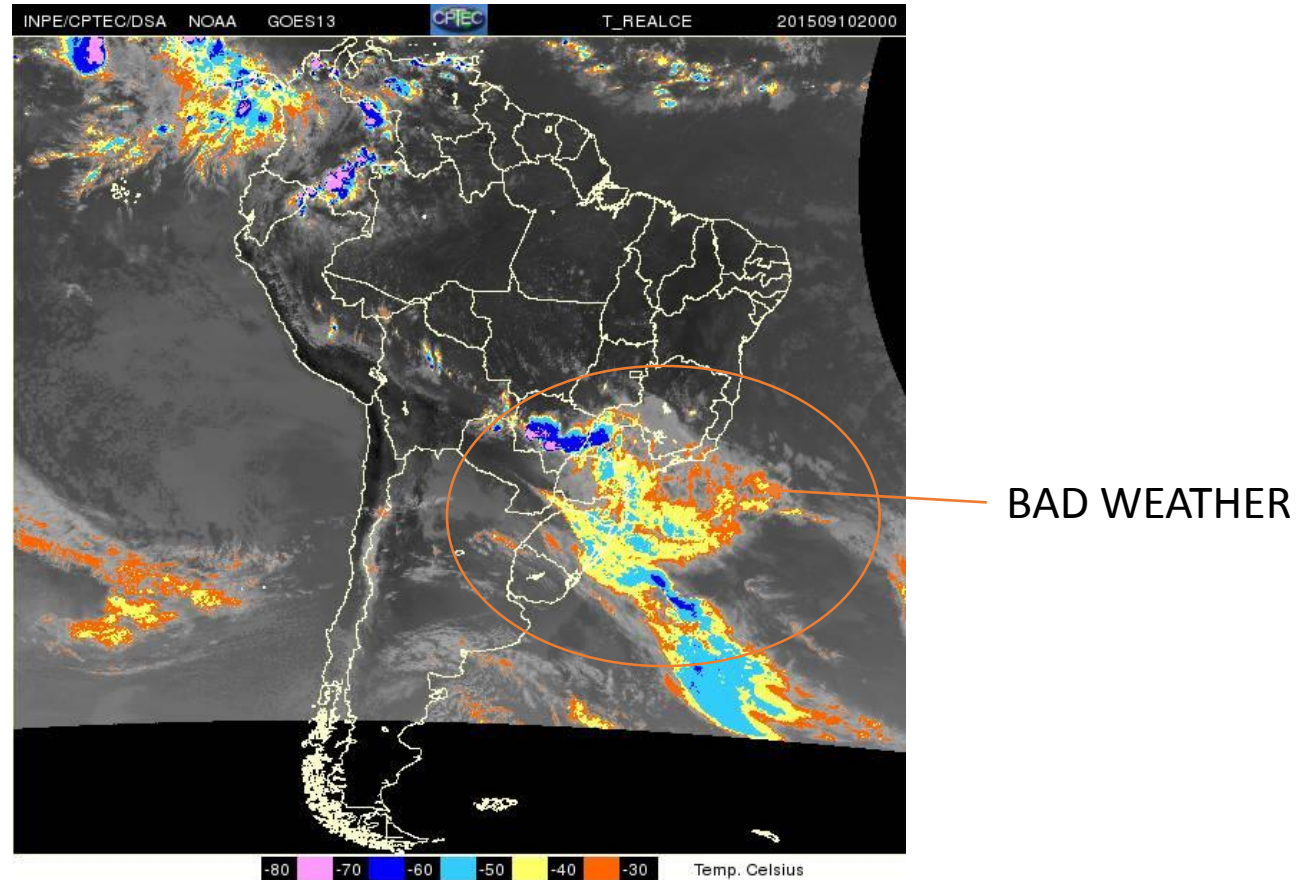
Santos Dumont Airport
Total pax: 9.9 million

Demand generation · **Majority destinations in Brazil** · **Capacity Problem**

POSSIBLE IMPLEMENTATIONS IN BRAZIL

Constrained area – Weather

POSSIBLE IMPLEMENTATIONS IN BRAZIL

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