Paradigm SHIFT

EEC Innovative Research
Dec, 2004

Laurent GUICHARD (Project Leader, ATM)
Sandrine GUIBERT (ATC)
Horst HERING (Engineering)

Khaled BELAHcene (Math Mod., Airspace)
Didier DOHY (ATM, System)
Jean-Yves GRAU (HF)
Jean NOBEL (ATM, ATC)
Julie LABORDE dit BOURIAT (Law Student)
Time Focus: 2020

En-route optimization through its integration in the global air transport.

Global objectives:
- Answer to the capacity need
- Maintain the safety level
- Better punctuality
- Performance, cost --> efficiency
Background & Scope

Operational Concepts (Top/Down)

Support Tools (Bottom/Up)

Recommendations (user preferences)

ACARE
DataLink
EUROCONTROL OCD
AFAS/MAFAS
C-ATM
 Paradigm SHIFT
SWIM
SESAME
Airline view
CDM
ASAS
G2G
LEONARDO

Operational Concepts (Top/Down)
Support Tools (Bottom/Up)
Recommendations (user preferences)
Paradigm SHIFT: Analyse

From the analysis, three main axis have to be investigated:

- Consistency
- Flexibility
- Robustness
From the analysis, three main axes have to be investigate:

- **Consistency**
- **Flexibility**
- **Robustness**

**Functional and operational continuity:**
- Actors are linked together through the aircraft lifecycle.
- Same object but:
  - different constraints (Airlines, ANSPs, Airports, ...)
  - different time scale (1 year, 1 month, 10 mn ...)
  - different granularity
  - ex: ATC / ATFM
From the analysis, three main axis have to be investigated:

- **Consistency**

- **Flexibility**
  - The traffic is non homogeneous
    - nature: cruise, servicing airports ...
    - operations: standard route, direct routing, free flight
    - fluctuation: morning /evening, summer/winter, ...

- **Robustness**

Managing traffic is a domain of expertise at the local level.

Flexibility => allow best use of resources = efficiency
From the analysis, three main axis have to be investigate:

- **Consistency**
- **Flexibility**
- **Robustness**

Uncertainty is part of Air Navigation System: build the system with and **not against**.

- Management of disruption
- Containing residual uncertainty inside windows
- Integrate windows to planing:
  - to optimise resources (constraint only when necessary)
  - to define transparent and achievable objectives for ATC
  - (improve stability and confidence)
Paradigm SHIFT: Concepts

From the analysis, three main axis have to be investigate:

- Consistency
- Flexibility
- Robustness

Paradigm SHIFT

- Operational plan
- Dual Airspace
- Decentralised Design
- Target windows
- Contract of Objective
Paradigm SHIFT: Concepts

Today

- **ATFM**
  - Best use predefined resources with constraints
  - Global optimisation on local resources

- **Flight Plan (OBT)**

- **ATC**
  - Manage a/c separation

Punctuality is lost
No link planning / execution

Paradigm SHIFT

- **Operational Plan**
  - Process to obtain consensus on reachable objectives
  - Local resources optimisation to match global constraints

- **Contract of Objective**
  - ATC object representing punctuality and efficiency for a flight: Flight plan with target windows

- **ATC**
  - Manage a/c separation and Objectives

Objectives are shared and transparent

Airspace Decentralised optimisation

Full Air/Ground integration

Actors collaboration

Airspace Decentralised optimisation

Actors collaboration

Objectives are shared and transparent
Operational contract associated to a flight:

- punctuality at destination airport
- integrated efficiency: linking planning and execution
- common objectives: operational continuity linking actors
- marked out by target windows

Say what you do
Do what you say

1 flight = 1 CoO
4D intervals to constrain traffic in order to ensure planning is respected

Downstream issues reflected at actor level:

- **Efficiency**
  - Destination punctuality
  - Technical capability (flight envelope, ...)
  - Congested en-route area (bottleneck)

- **Resilience**
  - Residual uncertainty (disruptions management)
  - Open room of adaptation to operation to ensure resilience to disruptions
  - Limits chain reactions
Operational Plan

- **Strategic level**
  - Macroscopic approach rather than a temporal reference
  - Defines collaboration between actors allowing them to coordinate (i.e. agreed interfaces) called Operational Agreement
  - Operational Agreement: traffic resulting from the expressed & agreed constraints of involved actors (initial source of contracts of objectives)

- **Collaborative & transparent mechanism involving all actors**
  - Airlines, Airports & ANSPs (civil & military providers)

- **Conciliate demand with scarce resources**
  - Demand vs. Resources

- **Refinement & enhancement process**
  - Iterative evaluation of demand versus resources
  - Adaptive granularity description regarding disruptions
Operational Plan

Airports

Airport capacity

Rotations

AirLines

OA_{r1}

Actor preparation phase

Actor publication phase

time
MANAGING SCARCE RESOURCES
Considering first, highly constrained resources: Runways

- Conciliate initial demand & airport capacity
  - Large granularity
    - Initial demand
      - Rotations described as successive airborne segments linked by airport operations on ground
        - Airborne segment defined by a city pair & an average flight duration
        - On ground segment defined by an average «airport operation» time
    - Airport capacity
      - An average number of landing & taking off aircraft for a given time frame (mitigate by on ground operations)

- Come to a first Operational Agreement (OAr1)
Operational Plan

RESOURCE MANAGEMENT

Airports

Control capacity

Rotations

AirLines

ANS Providers

Disruptions

Disruption forecast (e.g. meteo forecast)

Actor preparation phase
Actor publication phase

OAr

OAf

OAf
MANAGING SCARCE RESOURCES
Integrating ANSPs constraints & resources

◆ Refine Operational Agreement by inserting control capacity
  ➔ Medium granularity
      ➢ Conciliate control resources to demand, build first strategic traffic
      ➢ Refine airport capacity by taking into account control constraints (reduce time frame window size)
      ➢ Enhance departure & arrival time windows for initial demand

◆ Come to the second Operational Agreement (OAr2)

◆ Anticipation of disruptions (survey process)
  ➔ Integrate disruption forecast to align iteratively strategic traffic & interfaces

◆ Come to the final Operational Agreement (OAf)
INNOVATIVE RESEARCH

Operational Plan

RESOURCE MANAGEMENT

AIRPORTS

Airport capacity

control capacity

ANS PROVIDERS

AIRLINES

Rotations

Disruptions

Disruption forecast (e.g. meteo forecast)

Actor preparation phase

Actor publication phase

time

OA_{r1}

OA_{r2}

OA_{f}

EUROCONTROL Experimental Centre
MANAGING DISRUPTIONS
Real Time adaptation of the traffic scheme

- Integrate disruptions to continuously enhance rotation schemes
  - Small granularity
    - Amend strategic traffic induced by disruptions detection
    - Refine & adapt airport capacity to departure time window (define slot lists)

- Come to most accurate flight description (iterative drafting of Contract of Objectives)
Operational Plan

**RESOURCE MANAGEMENT**

**DISRUPTION MANAGEMENT**

**Airports**

**Airlines**

**ANS Providers**

**Anticipate Disruption**

**Disruption Forecast** (e.g. meteo forecast)

**Actor Preparation Phase**

**Actor Publication Phase**

**Rotations**

**Capacity**

**Renegotiate**

**Disruptions**

**Time**
A strategic level involvement

- Specific situations induce that contract of objectives cannot be assumed
- Exit of target windows is a disruption
  - Need early detection
  - Continuous tracking of the flight progress
  - Need solving process with a strategic view
    - Evaluate induced “chain reaction” mechanism
    - Allow best alternatives at a global level
    - Ensure overall consistency regarding planned/reorganized operations
- Number of occurrences is a performance indicator
- Corrective post analysis
  - Tune target windows from operational plan to minimize occurrences
Set of 4D constraints imposed to each flight prior to operations

→ Alleviates operator’s Workload
→ Creates a Safety layer
→ Affects Trajectory efficiency
**Design of the Air Navigation Services**

**Organization of En-Route resources by the ANSP**

- **Tactical balance**
  - Traffic
  - Airspace
  - ATC working methods and tools
  → Local homogeneity

- **Decentralized Black Box model**
  - Macroscopic strategic planning
    - Contractual specification of interfaces
  - Local responsibility of tactical planning
    - Autonomous design process
  → Operational diversity

- **Reaching an agreement**
  - Iterations refining strategic Traffic description
  - Coordination scheme ensuring traffic continuity
  - Early involvement of Military users
  → Flight consistency
**Dual Airspace**

**Highway**
- Long haul, Cruise traffic
- Parallel Tracks

Features:
- Easy Trajectories
- Difficult Input

Challenges:
- Capacity
- Punctuality

Airspace & ATC:
- New Paradigm
- Parallel lanes
- Delegation
- ECAC-wide continuity

**District**
- Airport Service, short hauls
- Diverging / Converging traffic patterns

Features:
- Difficult Trajectories
- Stable Input / Output

Challenges:
- Separation
- Sequencing

Airspace & ATC:
- As usual, with better specialization

**Cohabitation**
- Independent operations
  - Opacity
  - No Intrusion
  - Minimal Hindrance
  - Transition via Airlocks
- Resilience to Disruptions

**High Density Operational Concept**
Traffic split according to ATC issues (a/c phase of flight)
Highway Features

- **Districts**
- **Highways**
- **Continental Major Flows**
- **Parallel Lanes**
- **Vertical Layers**
Aeronautical Airlock

- District ATC responsible for horizontal manoeuvre
- Highway ATC responsible for vertical manoeuvre
- Personal airlock guarantees Safety for aircraft
Change in working methods, airspace structure ...
=> impact on operators juridical responsibilities

The task sharing between:
- Human/Human
- Human/Machine
  - Certification
- Ground/Board

Juridical implications: - responsibilities ?
- delegations ? …

For the project:
- Completing multidisciplinary team by juridical approach
- Leading some choice of design

For the Law:
- Avoiding legal deadlock
- Technical evolution => Regulation evolution
A concrete application: the dual airspace

- "Intercontinental Highways"
  - States sovereignty (International Law)
  - Route Charges (Public Law, Aviation Law)
  - ATCOs’ status (International, Public, Civil Law and why not an ATM Law?)

- Design issues:
  - Should the 2 sub-systems visualize the other’s traffic?
    - yes = possibility to be responsible of these aircraft
    - no = no possible responsibility
  - Establish clear connection between the 2 sub-systems
    - To avoid responsibilities problems
    - To create confidence in the juridical system for ATCOs

Conflict between Safety and Responsibility

French Law
Article 121-3 du code pénal
1 Impact of Highway on District
Exploration | Experimentation
Data

2 Contract of Objective for ATCO
Exploration + Prototyping | Experimentation
Data | Data

3 Connexion District & Autoroute
Exploration + Prototyping
Data