



# Trajectories through the Clouds

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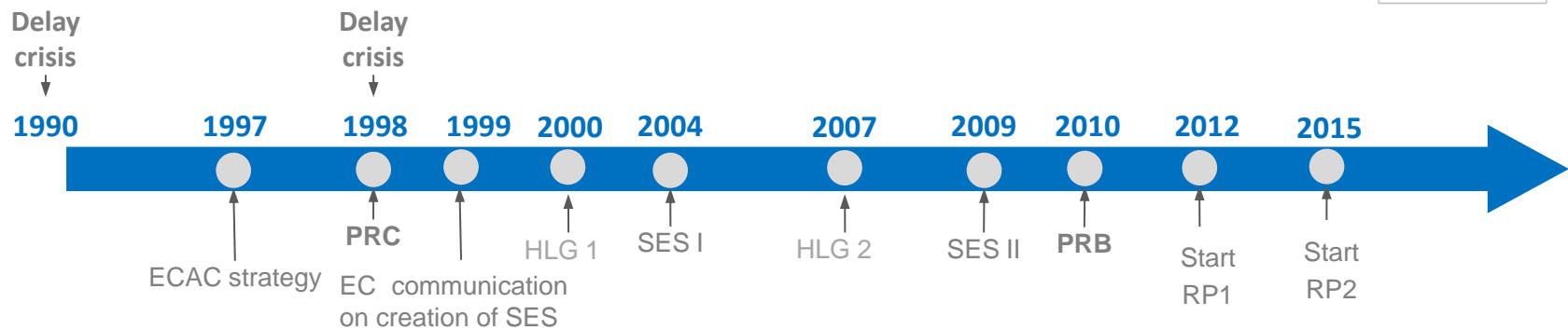
# SUMMARY

- Background
  - History
  - Performance schemes
  - Rationale
  - Europe and beyond
- Trajectories for PI's
  - Current status
  - Rationale for change
- Project setup and status
- Future

# HISTORICAL PERSPECTIVE

“Historia Magistra Vitæ”, Cicero, De Oratore, II, 36

# Performance-oriented approach in ANS (1/2)



## ECAC Strategy (1997)

- One objective “to introduce strong, transparent and independent performance review and target setting to facilitate more effective management of the European ATM system, encourage mutual accountability for system performance [...]”

## EUROCONTROL Performance Review System (1998)

- PRC (and supporting unit PRU) totally independent of all parties, including EUROCONTROL
- Focus on 4 of the 11 KPAs defined in ICAO “Global Air Traffic Management Operational Concept”: Safety, Capacity (en-route, airports), Environment and Cost-efficiency.
- PRC provides objective advice, information and recommendations
- International reputation for excellence:
  - IATA Special Recognition Award 2006
  - ATC Maastricht Award for Contribution to European ATM 2006

# Performance-oriented approach in ANS (2/2)

## Performance Scheme of the Single European Sky (2012)

- Performance Review Body (PRB) assists the European Commission to implement the performance scheme.
- Focus on 4 of the 11 KPAs defined in ICAO “Global Air Traffic Management Operational Concept”: Safety, Capacity (en-route, airports), Environment and Cost-efficiency.

# RATIONALE

# The problem.....

***Air Traffic Management was based on historical national structures***

**Fragmentation**

- Organisations
- Route network
- Military zones
- Systems

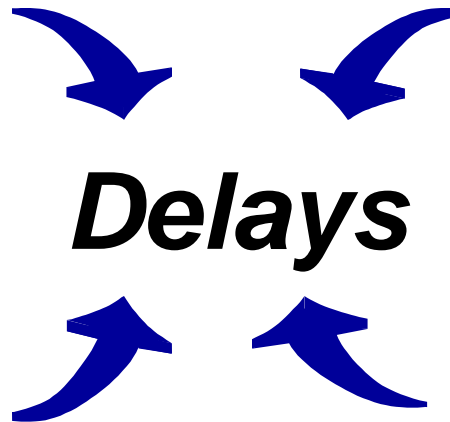
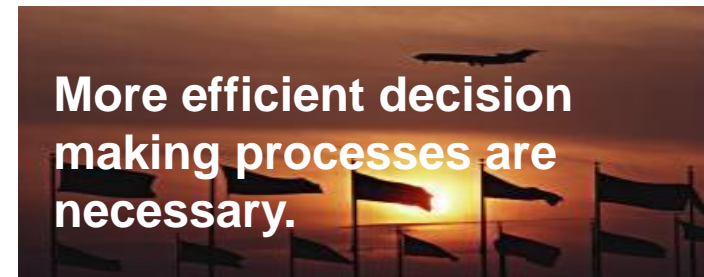
***Supply-driven service provision***



***Staff shortage***




***Limited international coordination***



# The solution....

## **More efficient airspace structure**

- 
- Organisations
  - Route network
  - Military areas
  - Systems

## **Demand-driven Service provision**



All stakeholders  
interact and commit

# Single European Sky

- Optimise safety
- Restructure airspace by traffic flow (i.e. by national borders)
- Increase capacity
- Increase ATM efficiency

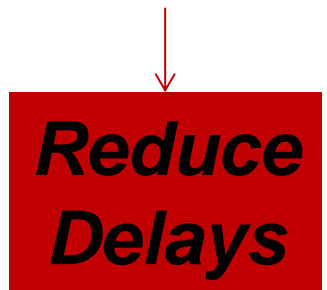
## **More staff**



## **Improved international cooperation**



New decision  
making  
processes



**Reduce  
Delays**

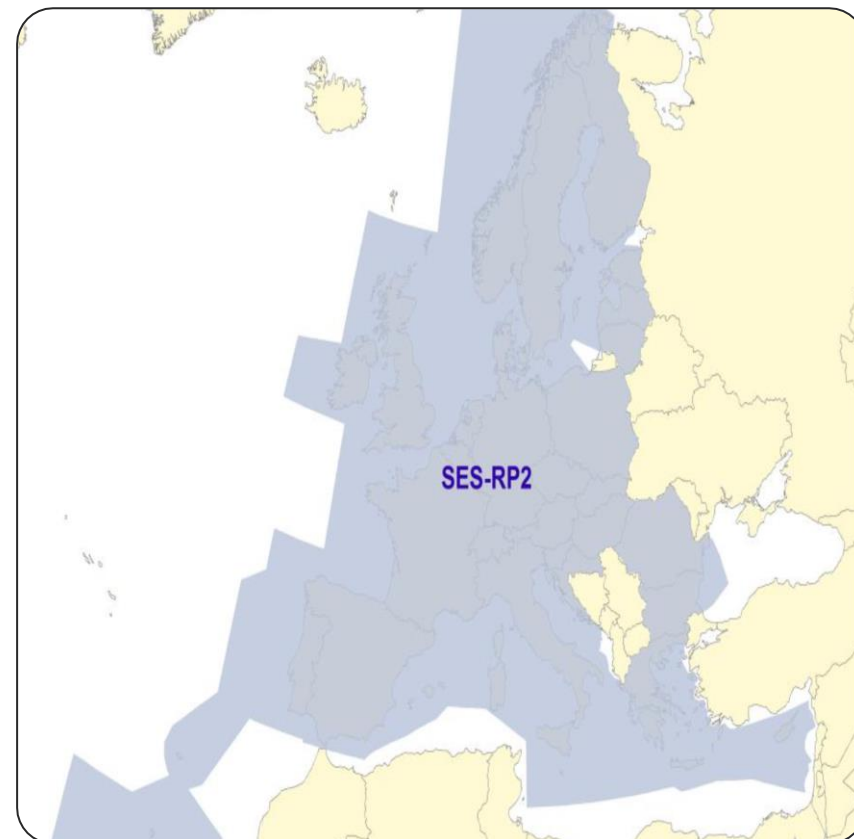


# Geographical Scope of SES RP2 (2015-2019)

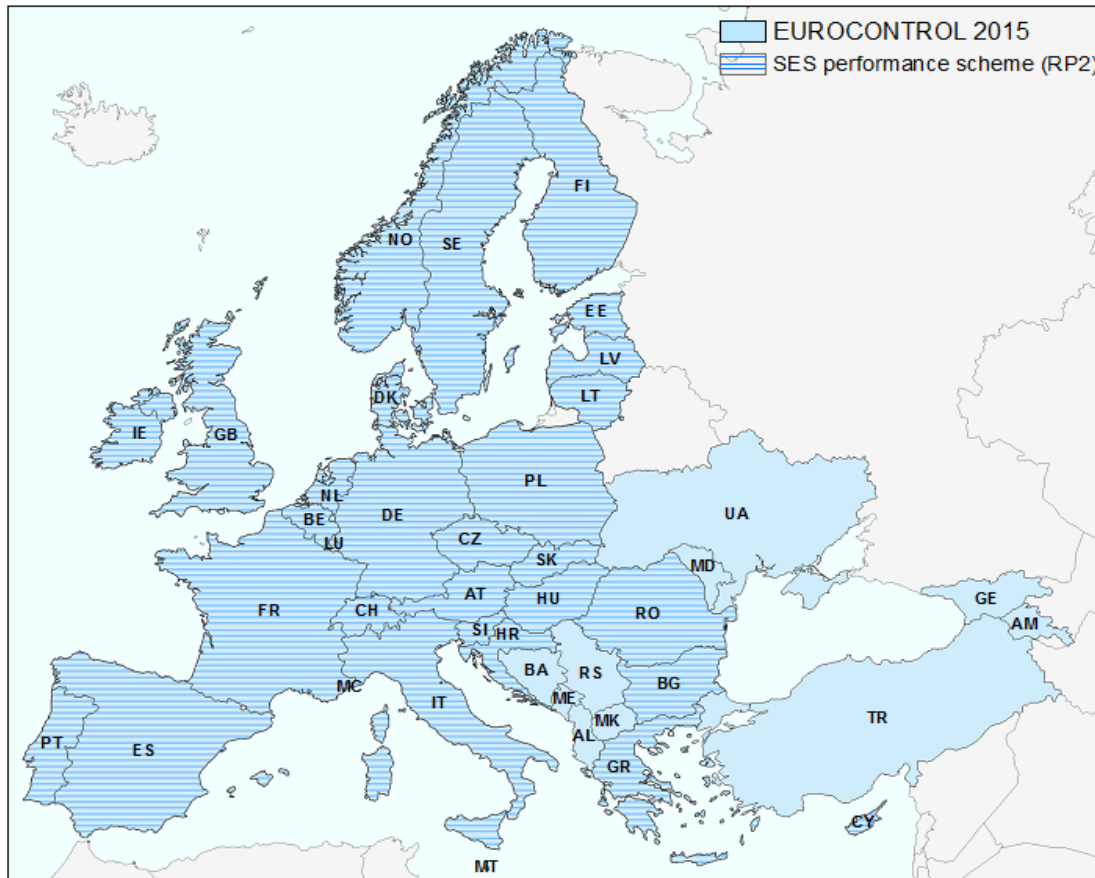
RP2 covers :

- the airspace of the 9 FABs controlled by the 28 EU Member States,
- the airspace controlled by Norway and Switzerland in the ICAO EUR region,
- Canaries FIR (Spain),
- Bodø FIR (Norway) and
- NOTA/SOTA (UK/IRL).

*Note that on 01 July 2013, Croatia became the 28th EU Member State. As it joined the performance scheme during RP1, no performance plan was established. Therefore, Croatia was not part of the SES monitoring process for RP1.*

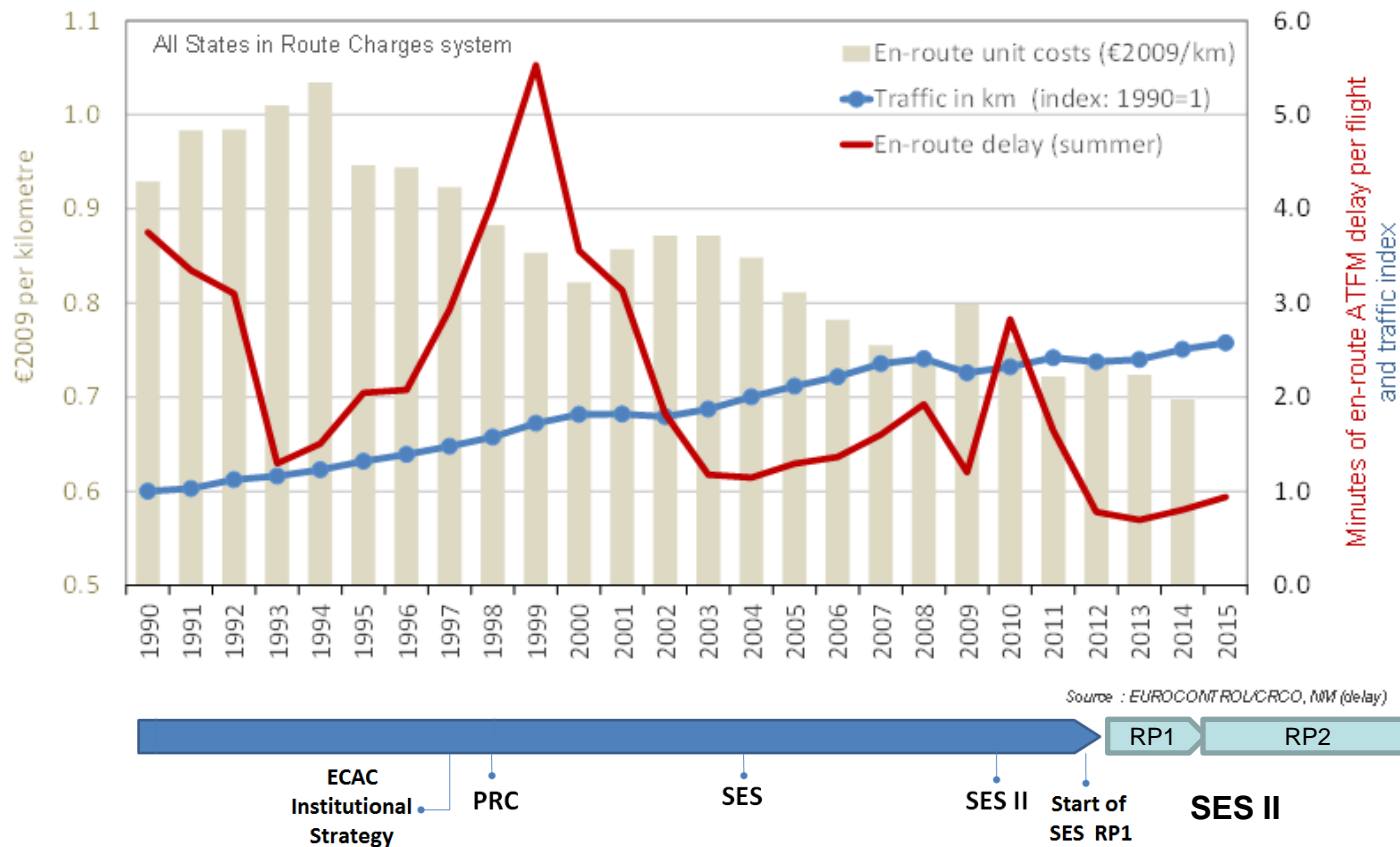


# EUROCONTROL's role (2/2)



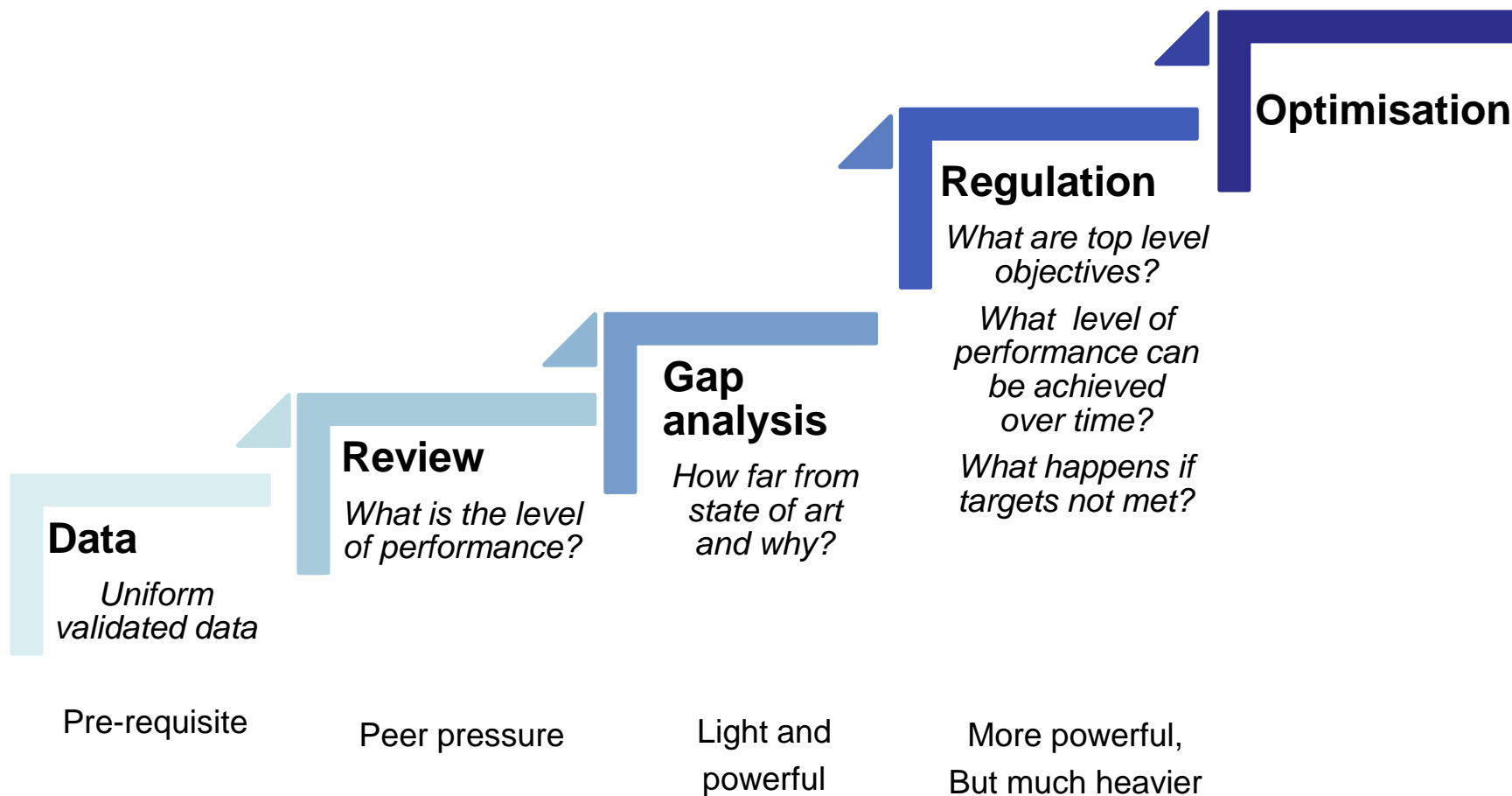
EUROCONTROL pan-European Performance Review System (41 States) and the Performance Scheme of the SES (30 States) jointly contribute towards improving the overall performance of air navigation services and network functions.

# Unit costs and delays since 1990



- Reactive policy in the 90's: delays go up while costs go down, and vice versa
- Performance-oriented approach as of 1998
  - Reduction of both delays and unit costs
- Enforceable Single European Sky performance targets as of 2012

# From observing to regulating ANS Performance



# INTERNATIONAL BENCHMARKING

# International ANS benchmarking

- EUROCONTROL has 18-years' experience in benchmarking
- Benchmarking reveals best practices, weaknesses
  - Relatively low cost, high impact of performance review
  - International benchmarking useful to ensure own performance
- Requires comparable data, harmonised indicators
- EUROCONTROL international projects  
are using and feeding into ICAO performance frameworks
  - GANP (Doc 9750), Manual on ANS economics (Doc 9161)
  - supporting ICAO Paris office for EUR region
- PRC's publications are on its website: <http://www.eurocontrol.int/european-ans-performance-review>

# ICAO GANP KPIs in Benchmarking projects

## US-Europe

OPS: 13/16 ICAO GANP KPIs  
ECO: ICAO Doc framework

## China-Europe

OPS:  
KPI01/KPI14: arrival/dep. punctuality  
KPI02/KPI13: additional taxi-in/-out time  
KPI10: peak arrival throughput

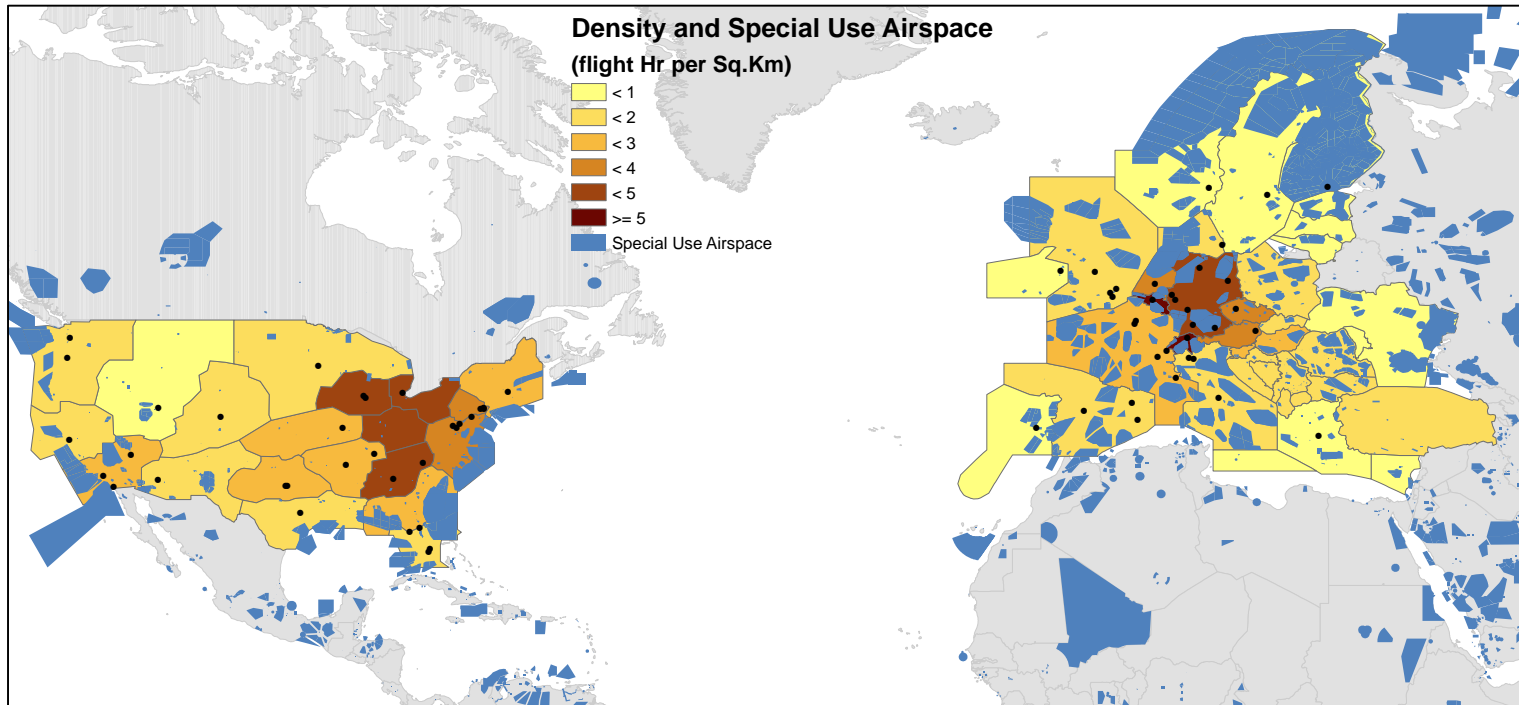
## Brazil-Europe

OPS:  
KPI06 en-route airspace capacity  
KPI09: airport peak arrival cap.  
KPI10: airport peak arrival throughput  
KPI11: airport arrival cap. Utilization  
... others tbd / discussion on-going

## Singapore-US-Europe

OPS:  
KPI02: additional taxi-out time;  
KPI08: additional ASMA time

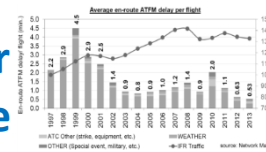
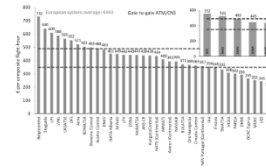
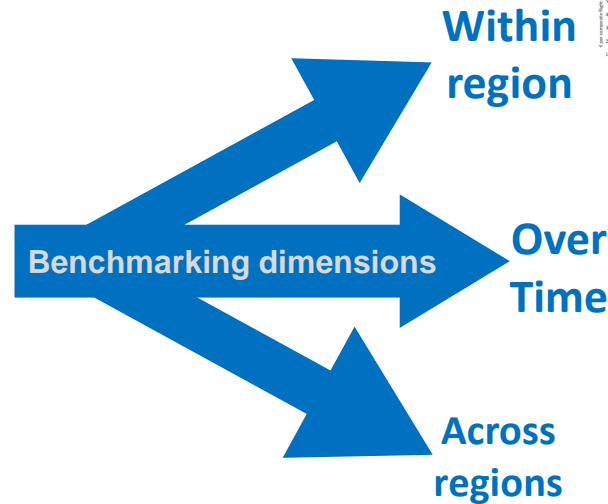
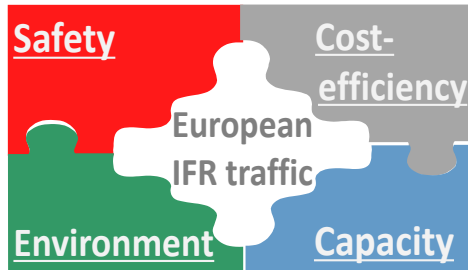
# Airspace structure, density



- Higher average air traffic density in US (x 1.7)
- Fragmented service provision in Europe (37 ANSPs)
- Special Use Airspace (blue areas) more scattered in Europe to meet requirements of each State
- Impact on performance?



# Benchmarking, PRC publications



## Benchmarking enables stakeholders to:

- Understand and position own performance
- Identify best practices, performance gaps, scope for improvement
- Inform target setting

## PRC publications on ANS performance

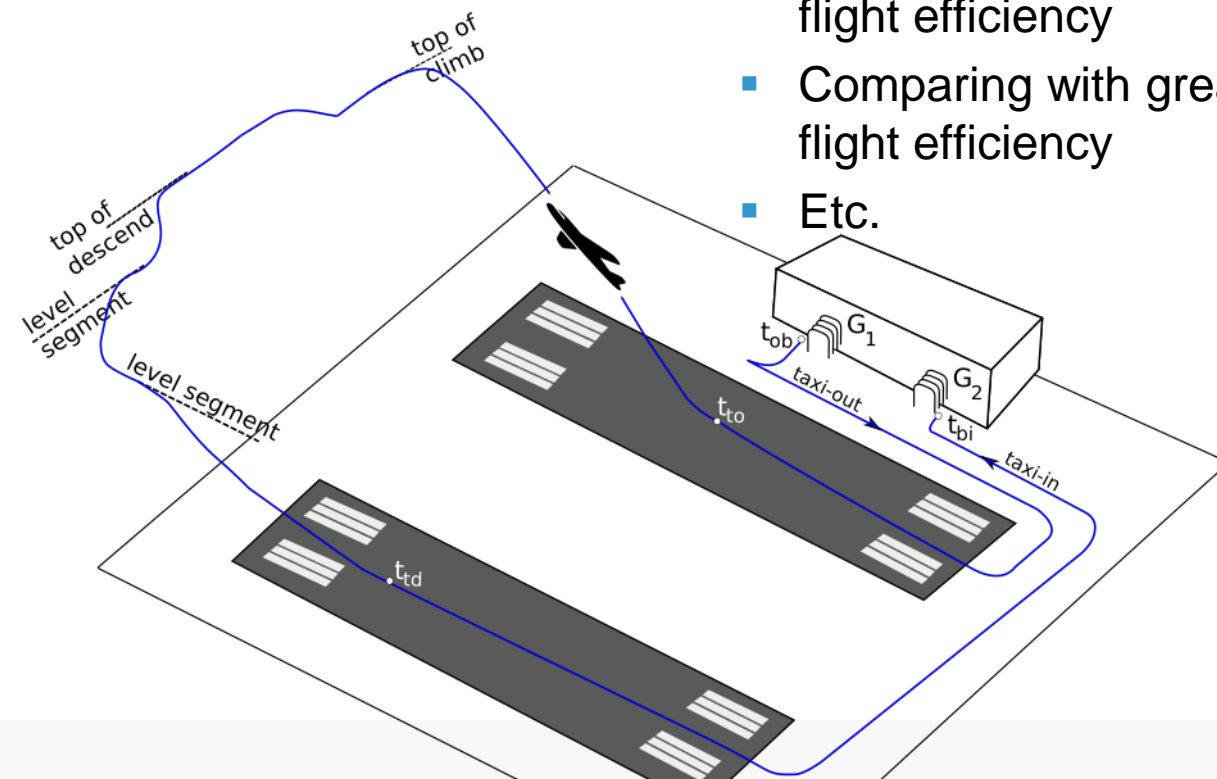
- Annual Performance Review Report (system view, all KPAs)
- ATM Cost Effectiveness Benchmarking (ACE) reports (Economics)
- Ad hoc reports (Civ./Mil. co-operation, Vertical Flight Efficiency, global benchmarking, etc.)

# TRAJECTORIES FOR PI'S

*“Short cuts make long delays, but inns make longer ones.”  
J.R.R. Tolkien, The Fellowship of the Ring*

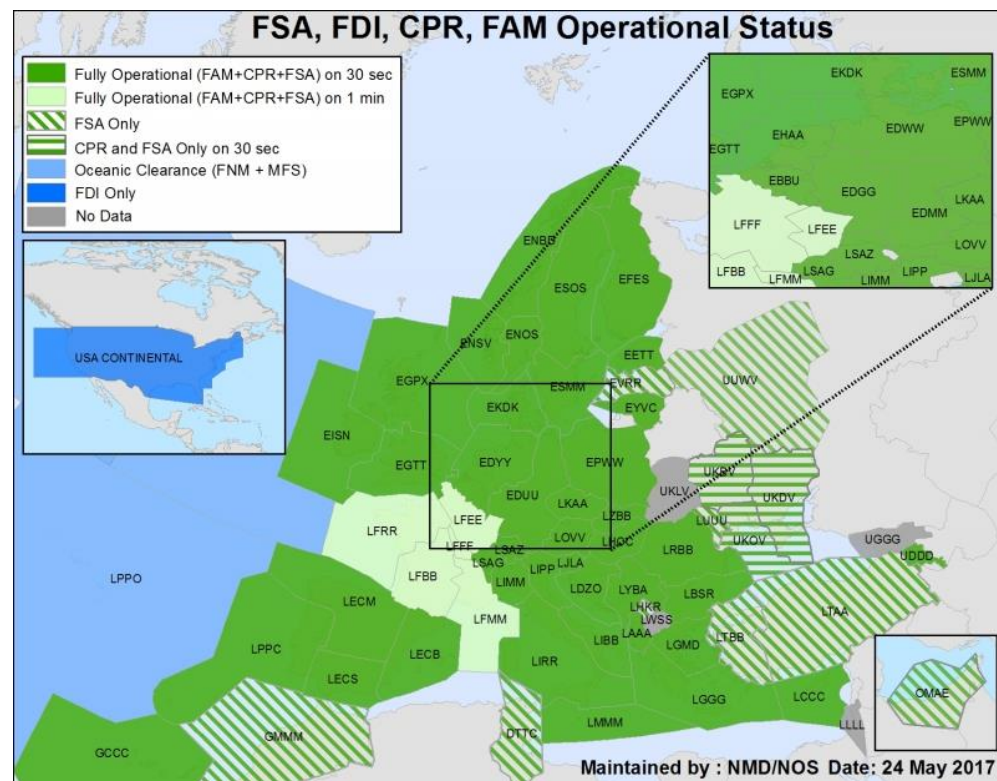
# Trajectories: a Building Block

- Trajectories
  - For (last) filed flight plan
  - For **flown** flight
- 4D intersections with airspaces used for
  - Counting, i.e. # flights per airspace per hours
  - Extracting level flight portions, i.e. used in vertical flight efficiency
  - Comparing with great circle distance, i.e. horizontal flight efficiency
  - Etc.



# Flown Trajectories

- Provided by NM
- Built on Flight Plan + BADA + CPR's (Model 3) or CPR-*only* (CPF)
- CPR: one every 30 sec, a problem for analysis around airports
- Some *issues*: diversions, big back-forth



BADA = **B**ase of **A**ircraft **D**ata

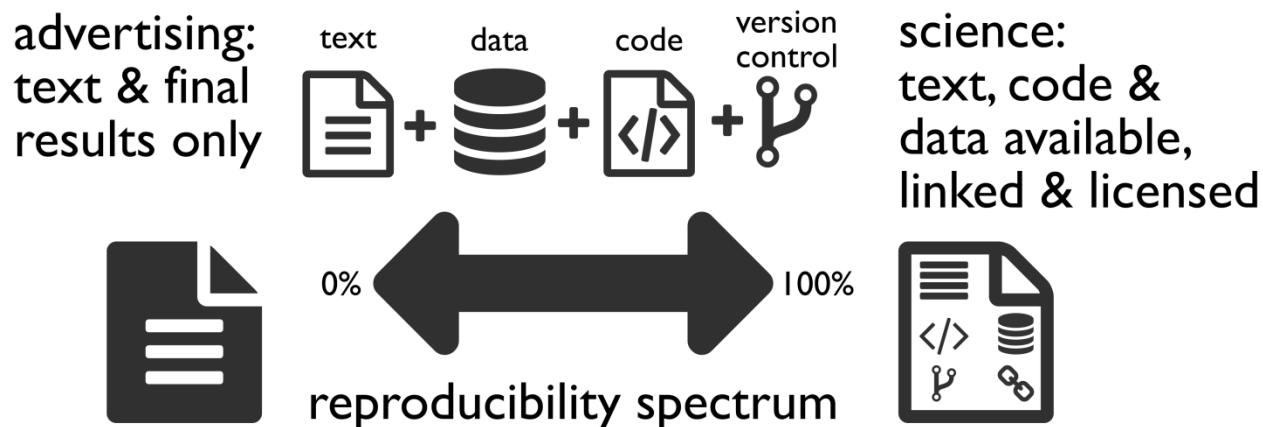
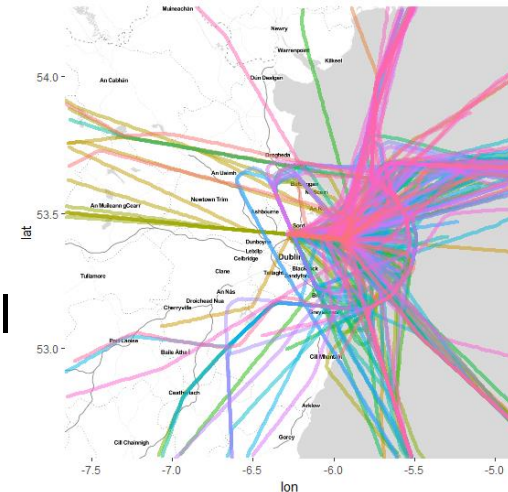
CPR = **C**orrelated **P**osition **R**eport

NM = **N**etwork **M**anager

CPF = **C**orrelated **P**osition report for a **F**light

# Rationale for Change

- Better model departure and approach portions
  - Additional ASMA time
  - Vertical flight efficiency
- Post-ops analysis so no time pressure on (semi real time) computational efficiency.
- Availability (of higher rate) position reports via ADS-B
- **Reproducibility** (& accountability) (Where is aviation?)
- Foster research with European data



Adapted with permission from Rodriguez Sanchez F, Perez Lopez AJ, Bermejo L (2014) Ciencia reproducible: qué, por qué, cómo. *Exscientia*, 20(2):88-93. <http://dx.doi.org/10.7818/EECO.2014.20.2.11>. See also <http://www.elsevier.com/locate/S0169526914000000>. Copyright © 2014. Computational Reproducibility in Archaeological Research: Best Practices and a Case Study of Their Implementation. *Journal of Archaeological Method and Theory* 23(2): 1-27. <http://dx.doi.org/10.1007/s10816-015-9272-8>. This figure is CC-BY.

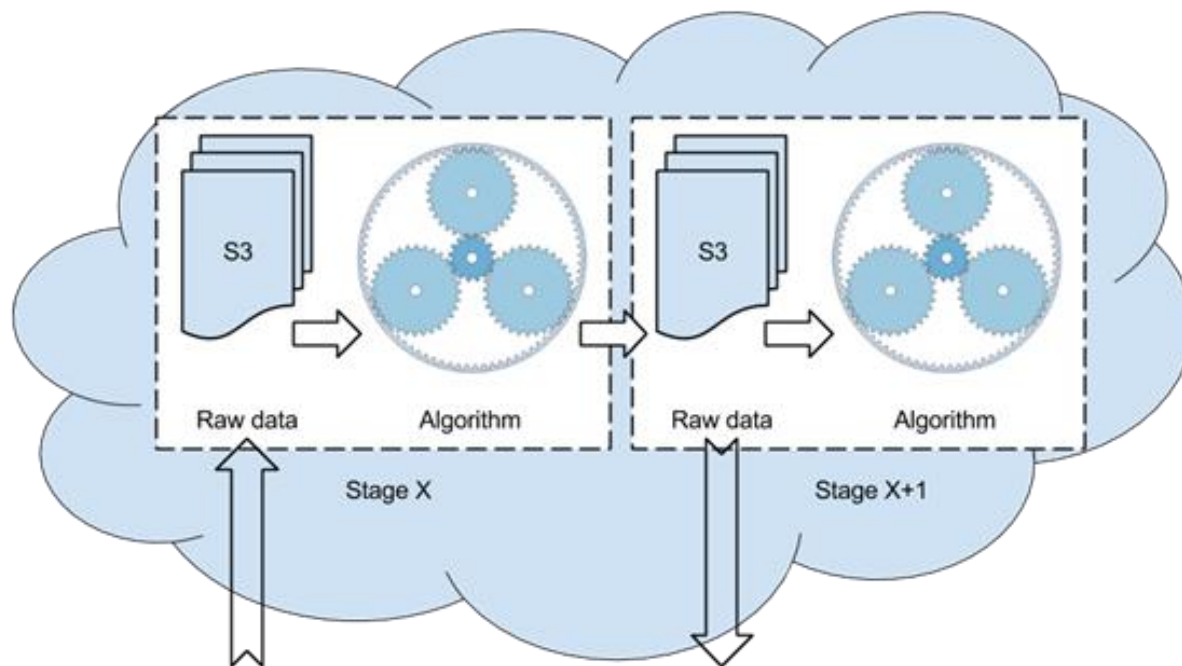
# PROJECT SETUP & STATUS

# Cloud infrastructure

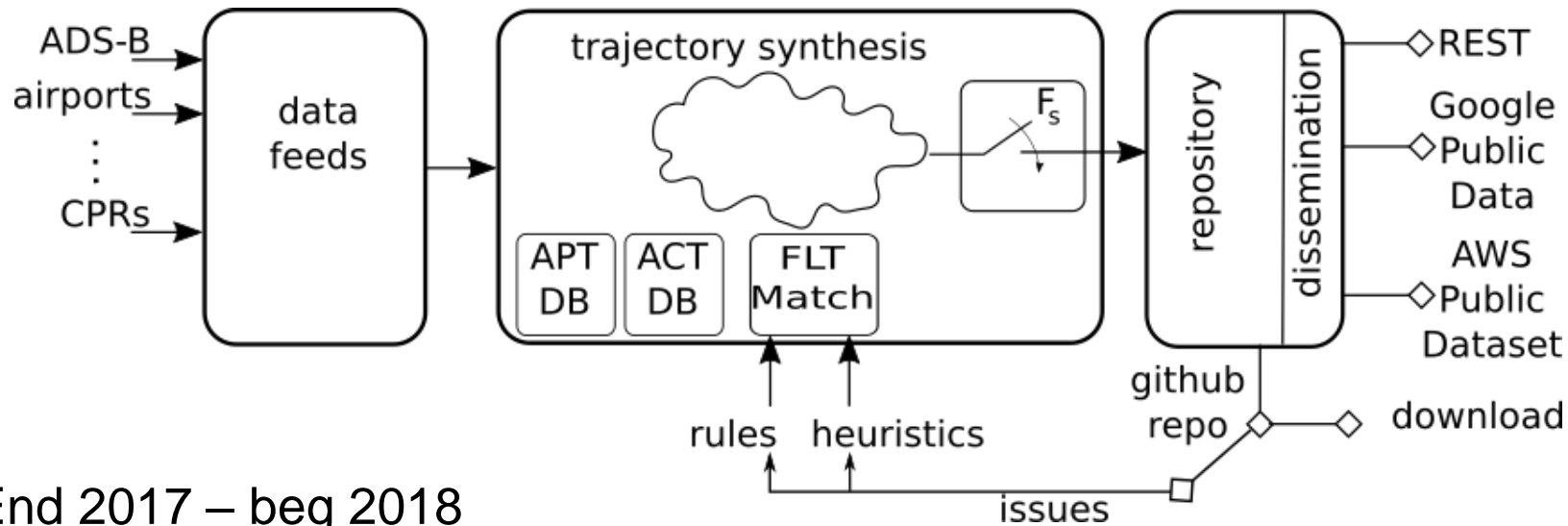
End 2016 – beg 2017

Investigated

- Pipeline setup via AWS & scaling opportunities
- Sharing of resources
- First implementation of trajectory and airspace intersections



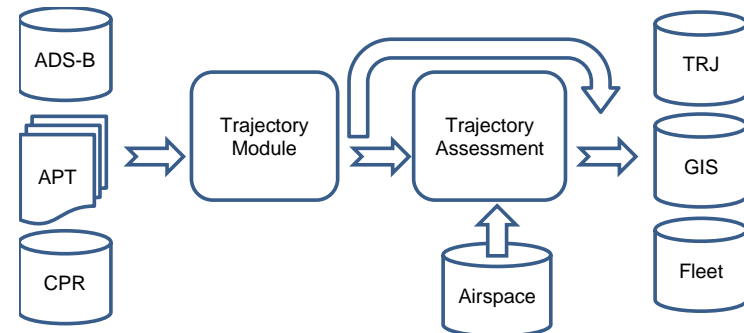
# Trajectories



End 2017 – beg 2018

Production:

- Fuse ADS-B, CPRs, Airport movements
- Reference Trajectory Dataset:
  - Curated
  - Open (algorithms, datasets)
- Derived/supporting datasets: fleet, airspaces, etc.





# FUTURE

# Future: Learn from the Past!

- Use the new trjs for PI's (and compare w/ currently used trjs)
  
- Expand / complement raw data feeders:
  - [OpenSky Network](#)
  - [ADS-B Exchange](#)
  - [airframe.org](#) (?)
  
- Exploit predictive models to “fill the gaps” in the data
  - [DART](#): SESAR project
  - [APACHE](#) (?)
  
- Build a community to openly support RTD

