The New Flight Efficiency Performance Approach

9 th SESAR Innovation Days

Partitioned Efficiency Indicator

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“If you can’t measure it,
you can’t improve it.”

– Peter Drucker

Background

“The consequences of the air traffic growth on the environment have been recognized as a key challenge in aviation today.”

-The WPG on the Future of the Single European Sky

Inventing new approaches for measuring environment impact requires to identify **abnormal behaviour** and **concealed influences**

The Single European Sky Performance Framework

EU Regulation no. 549/2004 defining the framework for Single European Sky (SES), with a goal to enhance Air Traffic Management (ATM) performance related to: safety, environment , cost-efficiency and capacity in the EU

- Followed by:

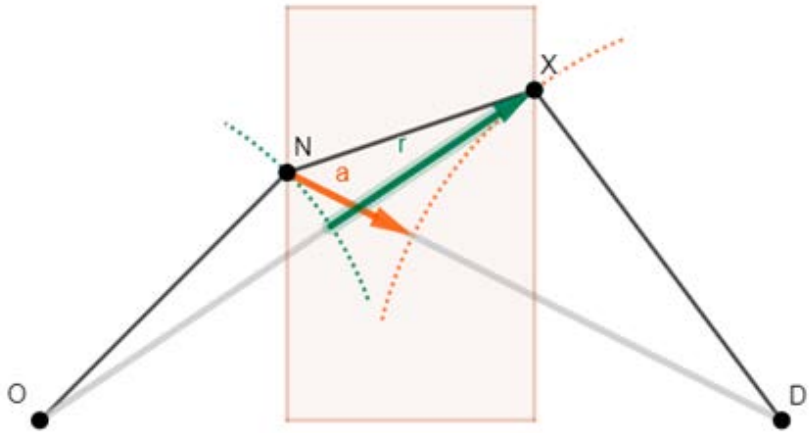
  Implementing Regulation no. 691/2010

  Implementing Regulation no. 390/2013

  Implementing Regulation no. 317/2019

Current environment KPI

Established KPI for environmental performance in the horizontal plane is the En-route Horizontal Flight Efficiency, defined as: **“comparison between the length of a trajectory and the shortest distance between its endpoints”**



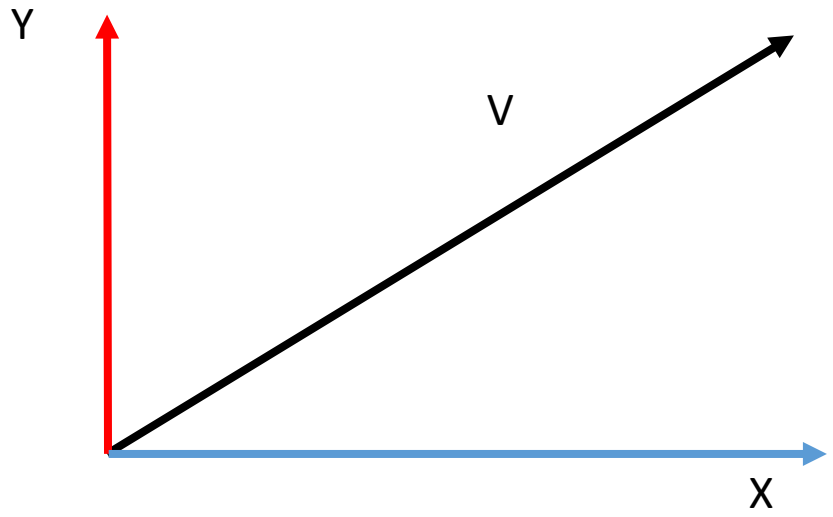
$$HFE = \left(1 - \left(\frac{\overline{NX}}{\frac{1}{2} * (a + r)} - 1\right)\right) * 100\%$$

HFE – horizontal flight efficiency
NX – flight segment
a - achieved approach
r – achieved remoteness
O – origin
D - destination

The elementary building block of PEI

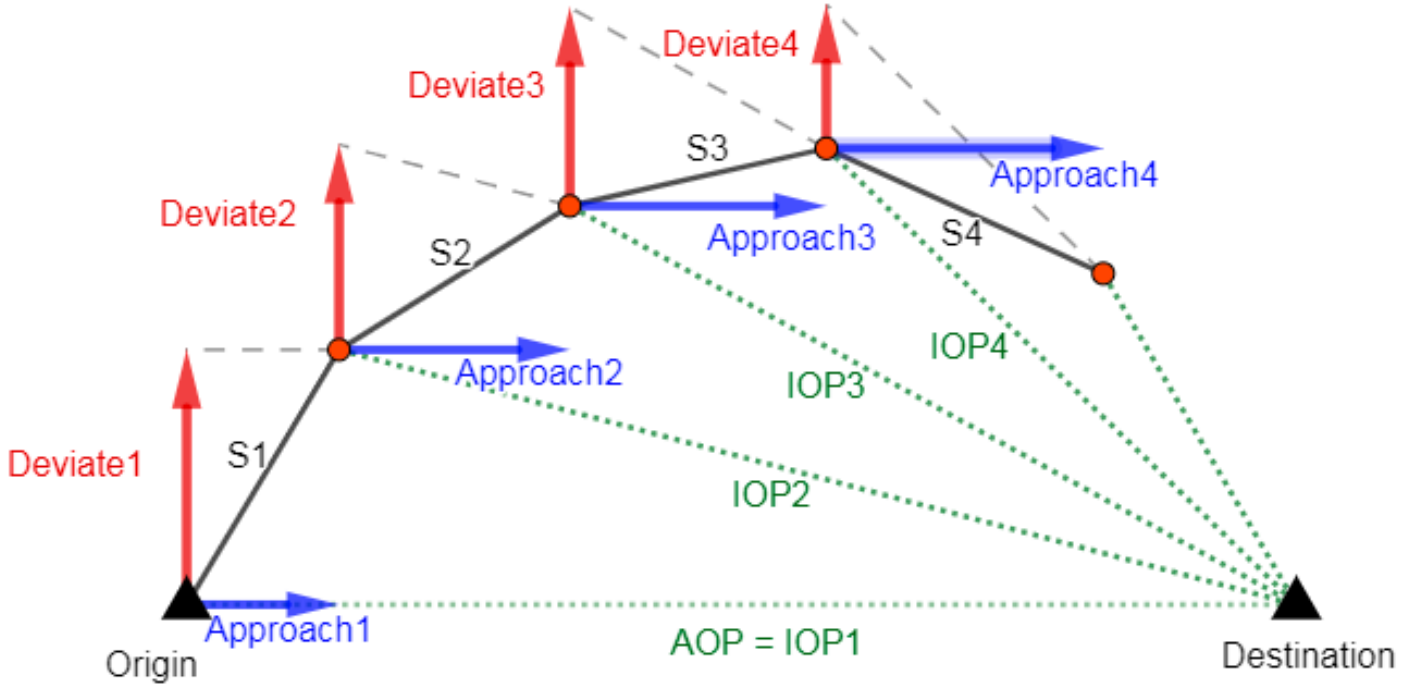
- Normal decomposition of a vector

Vector decomposition is the general process of breaking one **vector** into two or more **vectors** that add up to the original **vector**.



The elementary building block of PEI

- Normal decomposition of a vector



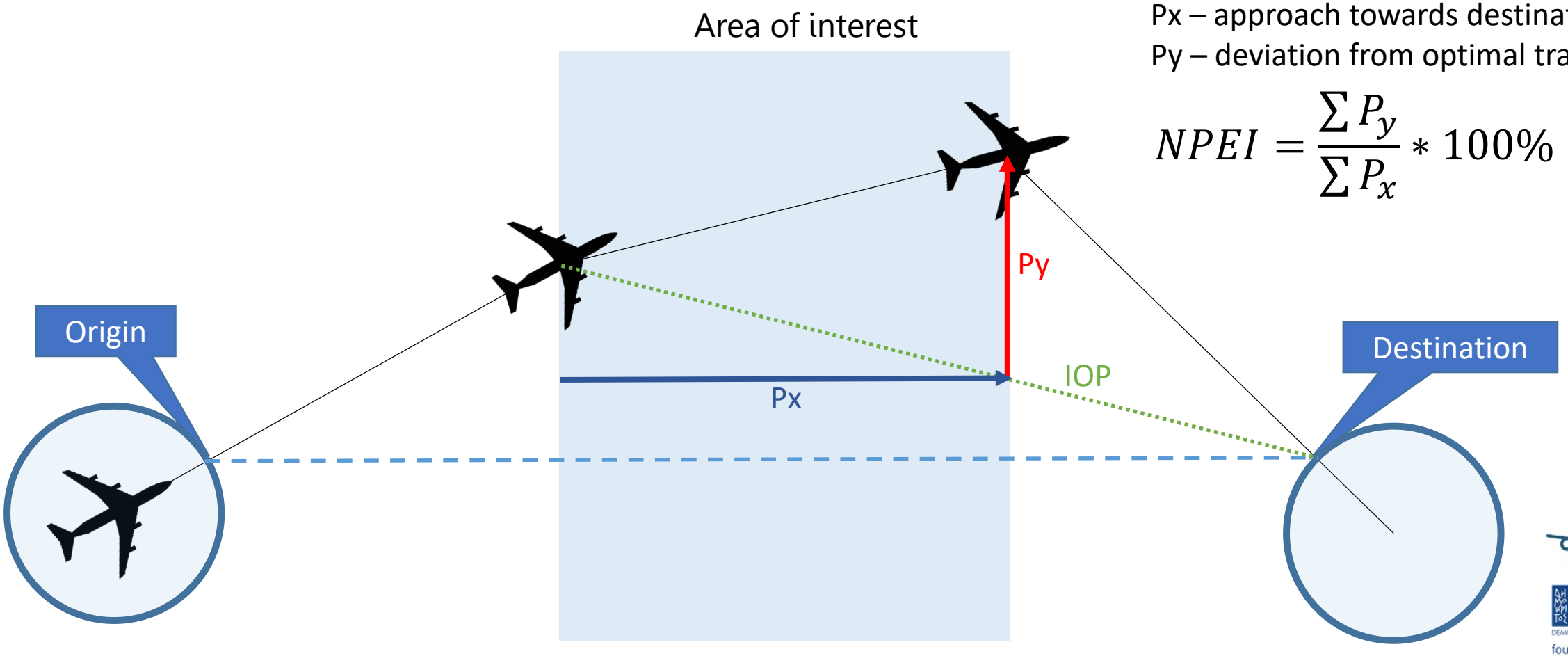
Origin – *position that we consider the beginning of a flight*
Destination – *position that we consider the end of a flight*
Absolute Optimal Path (AOP) *– the great circle line connecting your origin and destination*
Instant Optimal Path (IOP) *– the great circle line connecting your current position and your final destination*

Approach *– moving towards your final destination along the AOP (further denoted as "Px")*
Deviation *– moving away from the IOP along axis perpendicular to AOP (further denoted as "Py")*

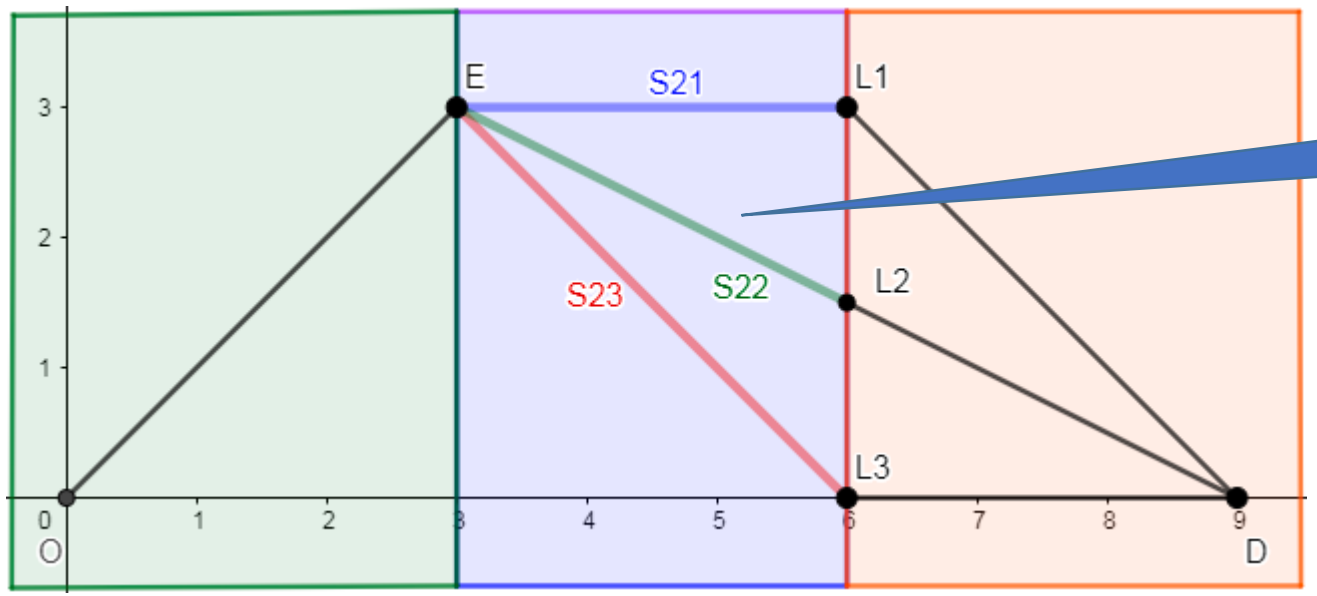
PEI Methodology Network Partitioned Efficiency Indicator

Px – approach towards destination
Py – deviation from optimal trajectory

$$NPEI = \frac{\sum P_y}{\sum P_x} * 100\%$$



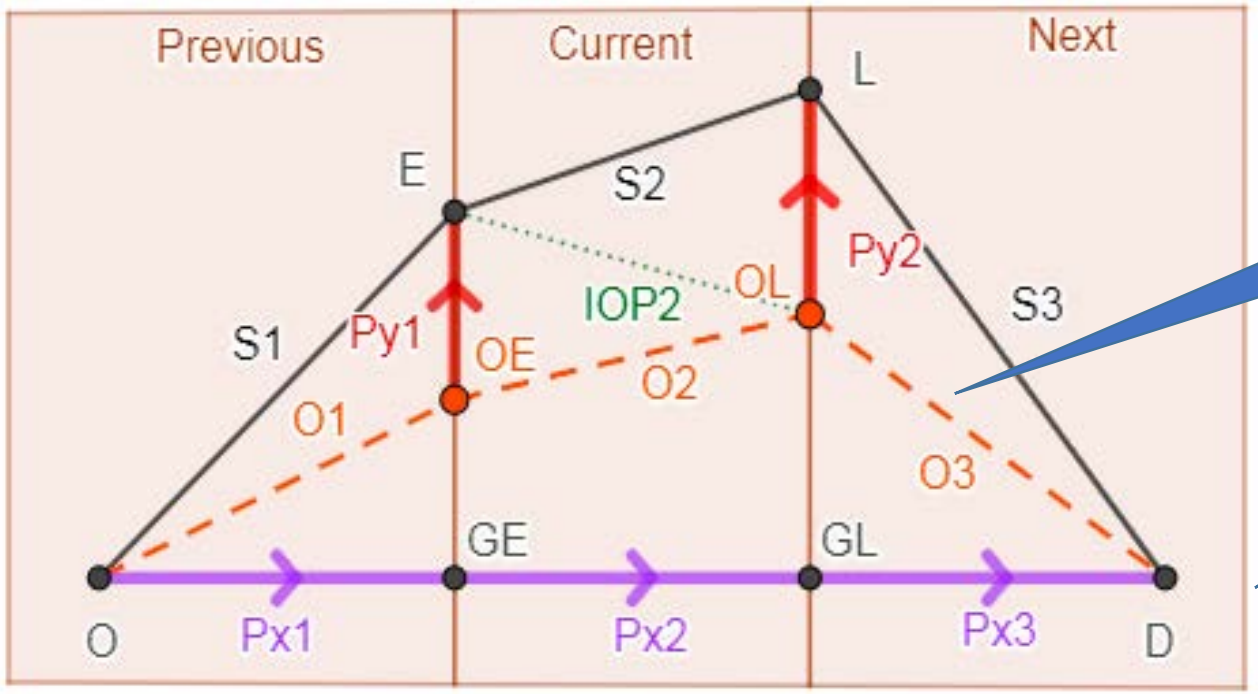
Comparison of the old and new approaches



What is the best way to go ??

	HFE[%]	NPEI[%]
S21	78	50
S22	73	100
S23	44	50

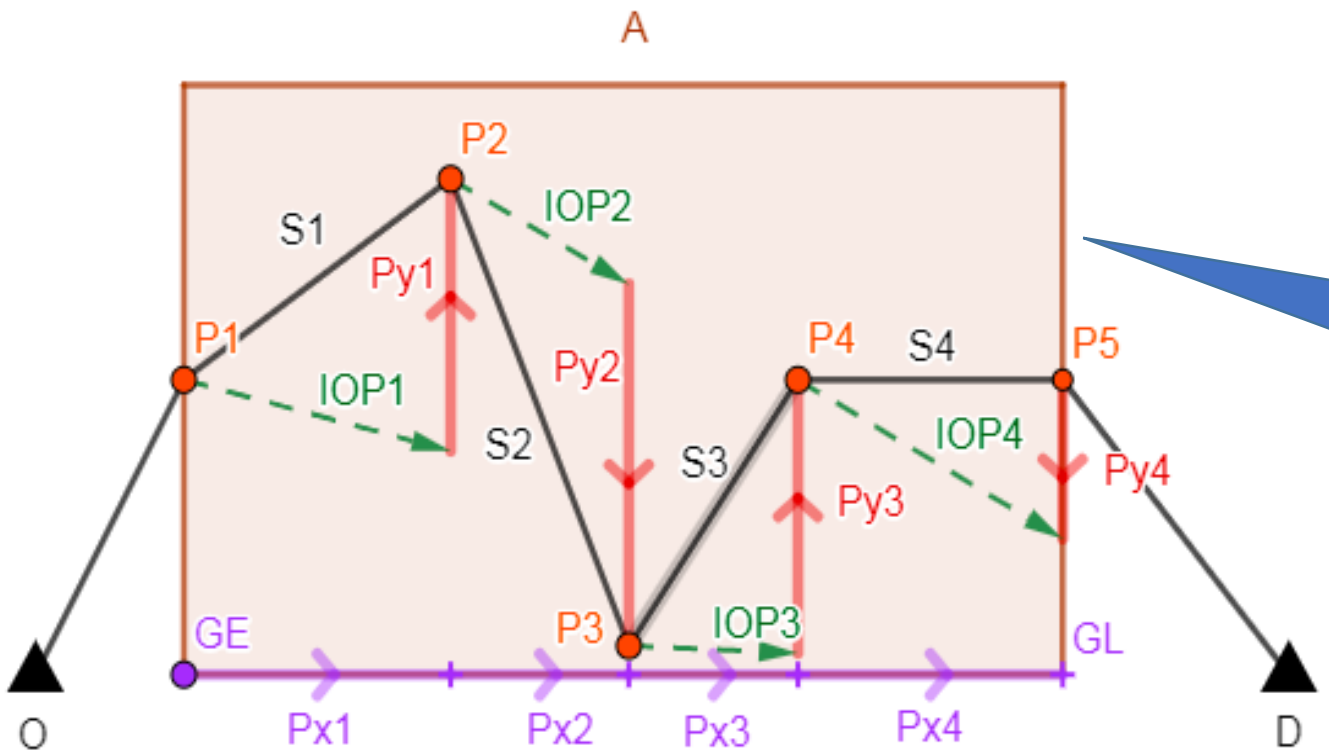
PEI application Using a user preferred reference



Define your optimal trajectory based on fuel consumption, distance, time or other parameters

calculate the partitioned efficiency of your flight using the reference you established

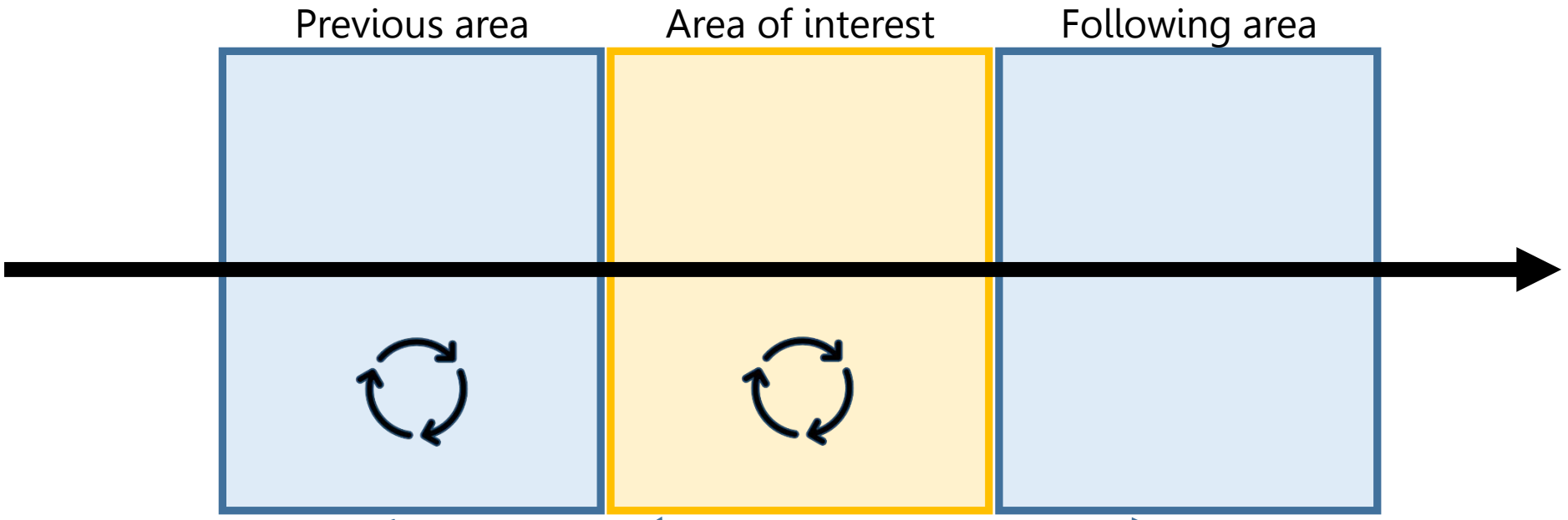
PEI application on measuring local efficiency



Calculate the local efficiency of an area by taking into account all segments within

$$LPEI_A = \frac{\sum Py}{\sum Px} * 100\%$$

PEI Methodology efficiency transfer (chain of events)

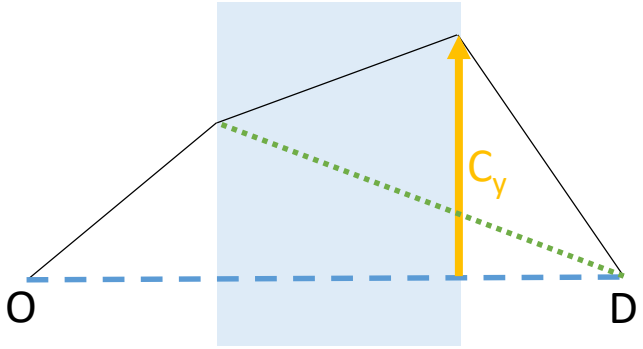


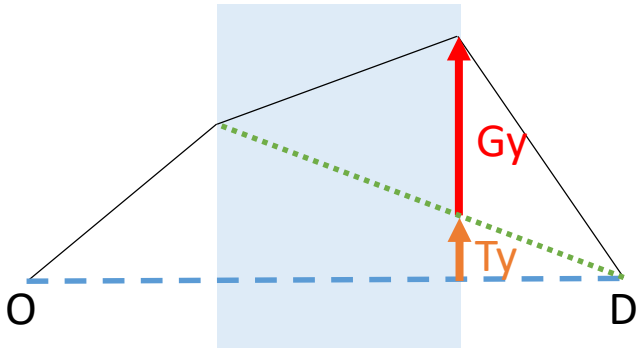
Something happened ?

Could the occurrence in the previous area affect operations here ?

Could the occurrence in the area of interest and in the previous area affect operations here ?

PEI application measuring efficiency transfer (chain of events)



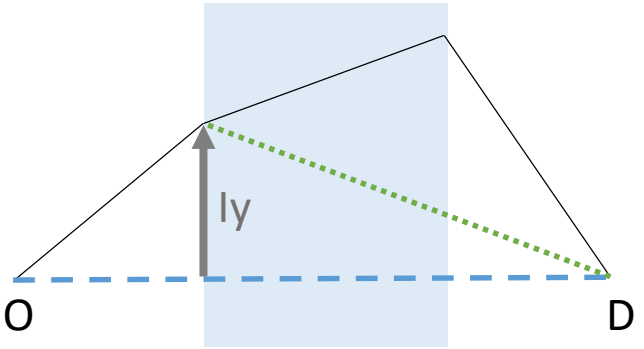


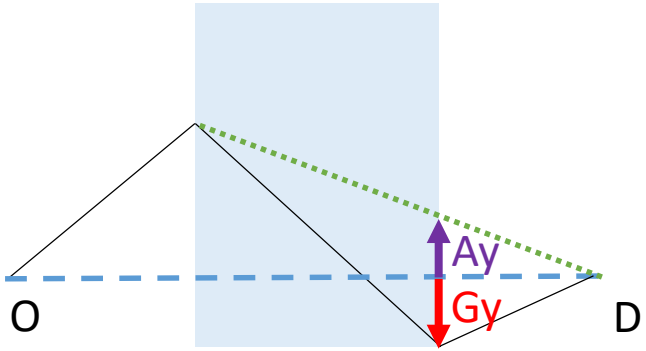
Gy – the deviation the current area created and sent to next area
Ty – deviation from previous area that is transferred to next area
Ay – deviation from previous area that is absorbed in the current area and not sent to the next area
Cy – deviation from AOP to real trajectory point
Iy – deviation that comes from the previous area to the current area

$$ADEV = \frac{\sum Ay}{\sum Cy} * 100\%$$

$$GDEV = \frac{\sum G_y}{\sum Cy} * 100\%$$

$$TDEV = \frac{\sum T_y}{\sum Cy} * 100\%$$





Case study parameters

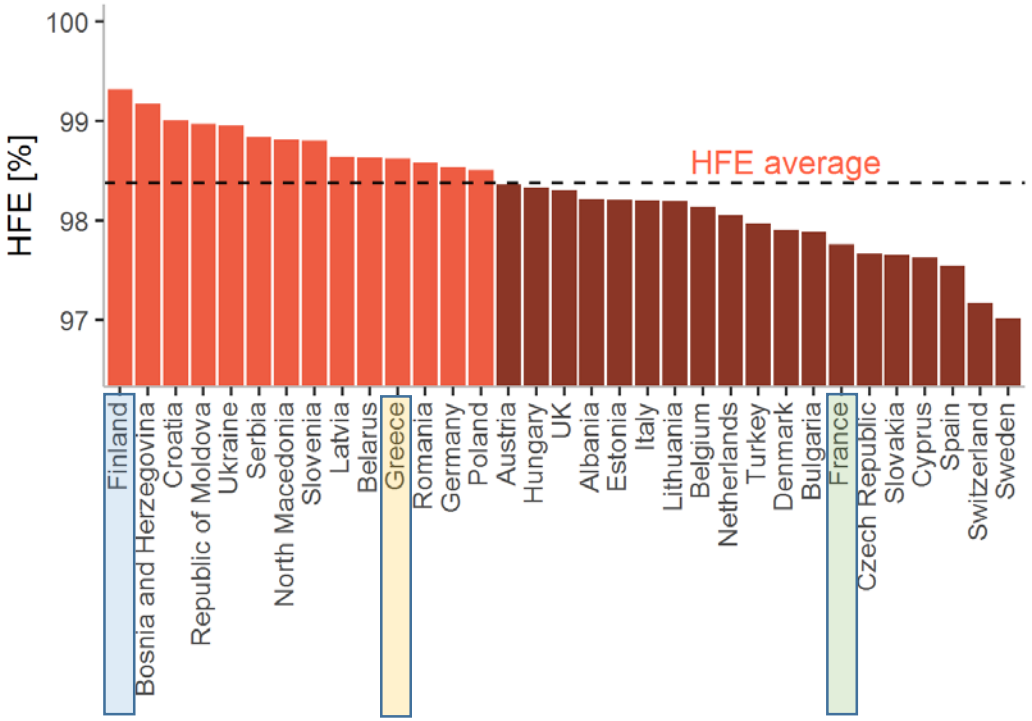
Data sources

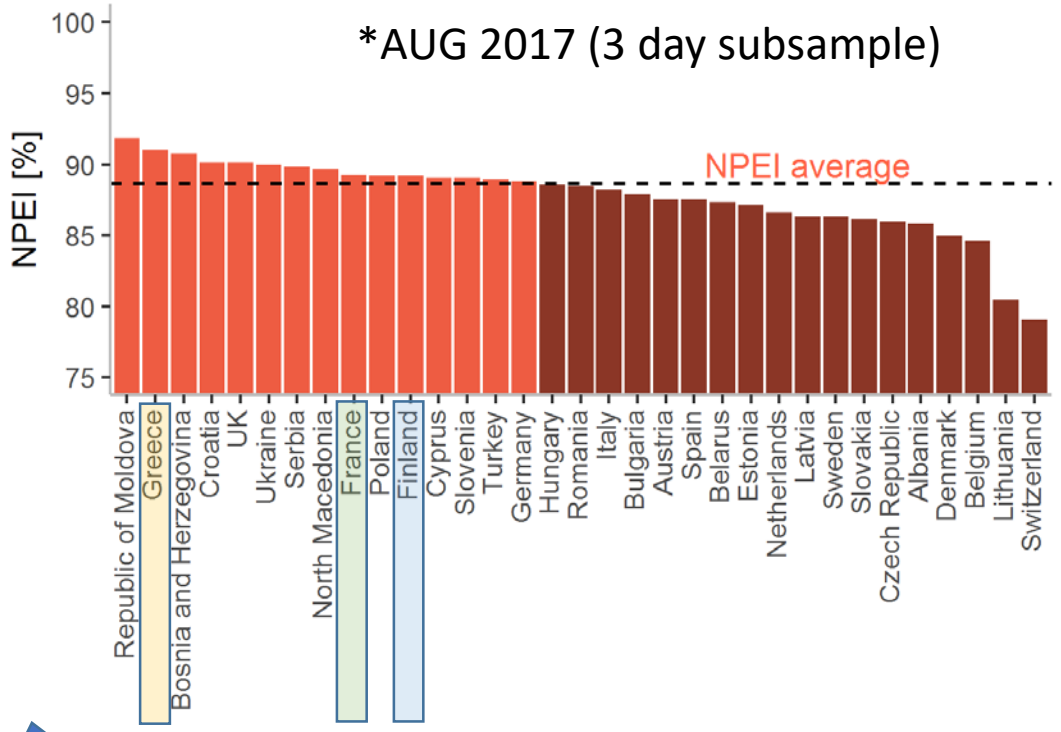
- PRUs Github portal for Reference trajectory
  - 3 days of trajectories freely available (from 2017-08-01 to 2017-08-03)
- ICAO API
  - worldwide airports (over 1485)
  - countries spatial information

Geographical scope: EUROCONTROL Member States*

*only flights crossing at least 10 countries

Case study HFE and NPEI per country

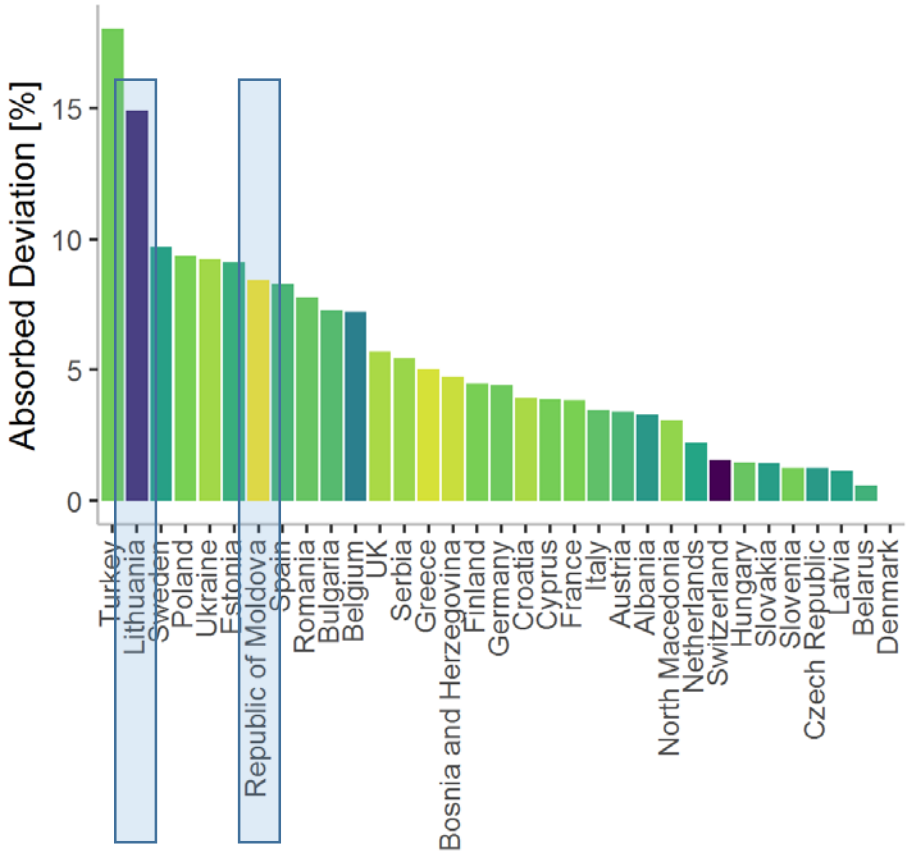


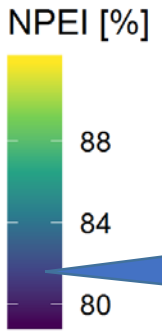


*AUG 2017 (3 day subsample)

Differences in rank appear for almost all countries

Case Study Transfer of inefficiencies





Do I perform well and also absorb the deviation that I receive from other areas before me ?

Benefits summary of the new PEI approach

- PEI can measure performance considering multiple user requirements
- PEI can help us understand how inefficiency is transferred from one area to another
- PEI addresses both the currently measurable (e.g. HFE) and overlooked parts of the current ANS performance framework
- PEI offers possibilities of measuring efficiency in terms of distance, emissions or time
- PEI can measure at sector, country, FAB, ICAO region or any other user defined region, taking into account local or network components

Next steps

Further research:

- applying PEI on a larger set of data (preferably with an operational partner such as the Network Manager, ANSP, FAB …)
- application of PEI:
  a) to develop PEI functionality to measure the units of CO2
  b) to assess vertical efficiency
  c) to merge horizontal and vertical into a 3D efficiency indicator
  d) to specific user defined baseline (wind or price optimal route..)

Thank you!

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