Increasing trajectory prediction accuracy under bad weather conditions

Norbert Fuerstenau (DLR)

&

Guglielmo Lulli (University of Lancaster)

DLR

Sub-challenge 1: approaches for uncertainty management in trajectory prediction

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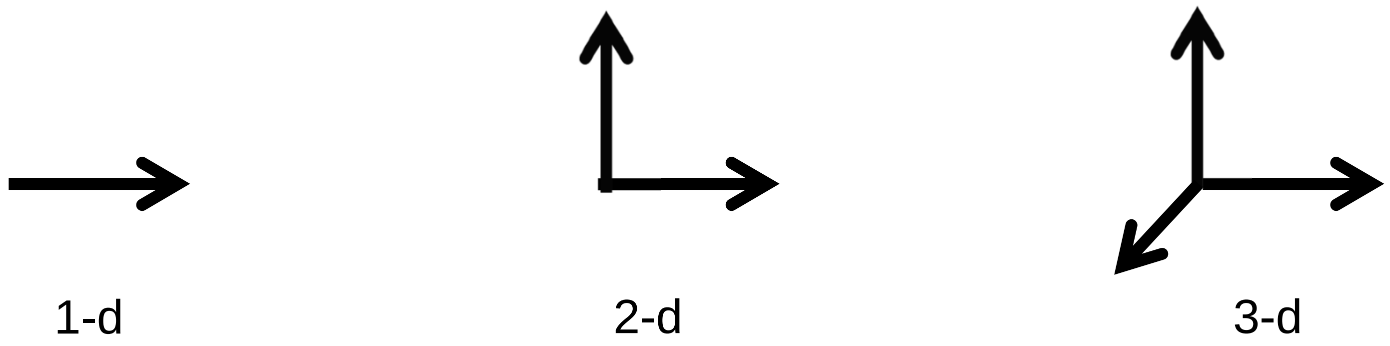
- Characterization of uncertainty



- Large-Disruptive (weather phenomenon, other disruption, etc.)
- Normal Traffic uncertainty (inherent stochasticity of the system)

“Macro” uncertainty

- Optimization under uncertainty, e.g., stochastic programming, robust optimization, etc.
- RO’94,VBO’94, AEO’00, HM’07, BHM’10, ADL’11, AAEP’12, BS15, CLNV’16, BC’16

$$\underset{x_1 \in X_1}{Min}\; c_1(x_1) + E[\, f_2(x_1,\, \overline{\omega}_1)\,]$$

Computational challenges:

- Multi-dimensional integration
- Integer Requirement
- Large volume of data

$$\underset{x \in X}{Min}\left\{ f(x) : g(x,u) \le b \;\; \forall u \in U \right\}$$

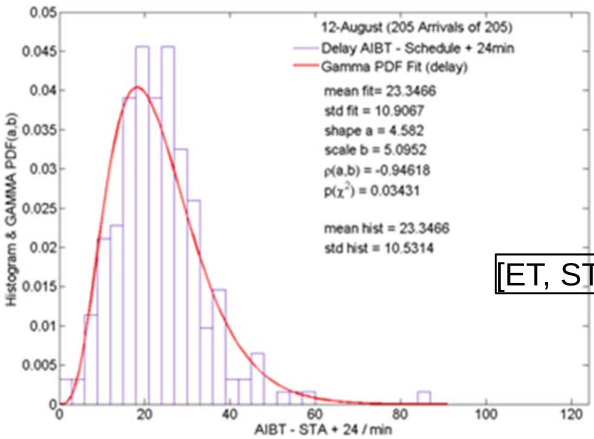
“Micro” uncertainty

- Methods to measure and forecast congestion at airports
- K’76, M’95,PBO’95, WFM’04, H *et al*.’09, GNS’11, NH’12

Optimized Approach Sequencing (WP-E Robust-ATM, FAU-DLR, 2013-16)

Empirical Airport /A-SMGCSTraffic Data :
Arrival / Departure Delays with Γ-PDF Model

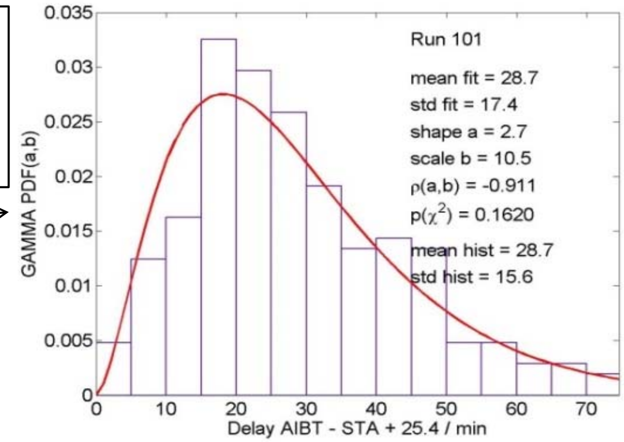
Monte-Carlo Simulation of pre-tactical Arrival Scheduling with Random Departure-Delays

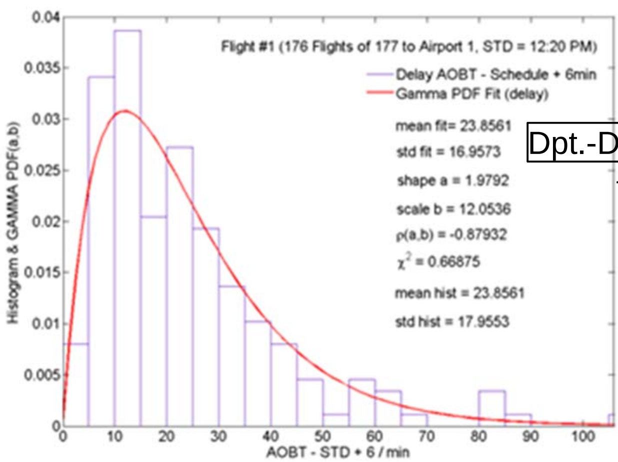


Single 17h-Day: 209 Arrivals a_i μ = 0 min

[ET, STA, LT, Ltmax]

Baseline: FCFS, Arrival Delays

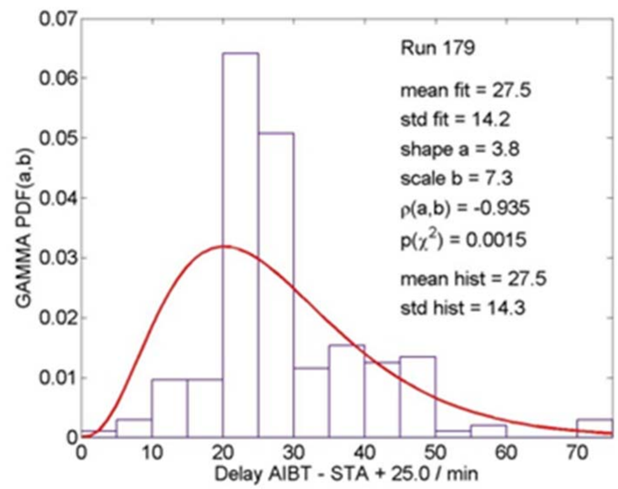




Dpt.-Delay Γ-PDF(a,τ)

Single Flight 176 Departures: 7-12/2013 μ = 18 min

FAU Optimizer (discrete, Gurobi-nominal)

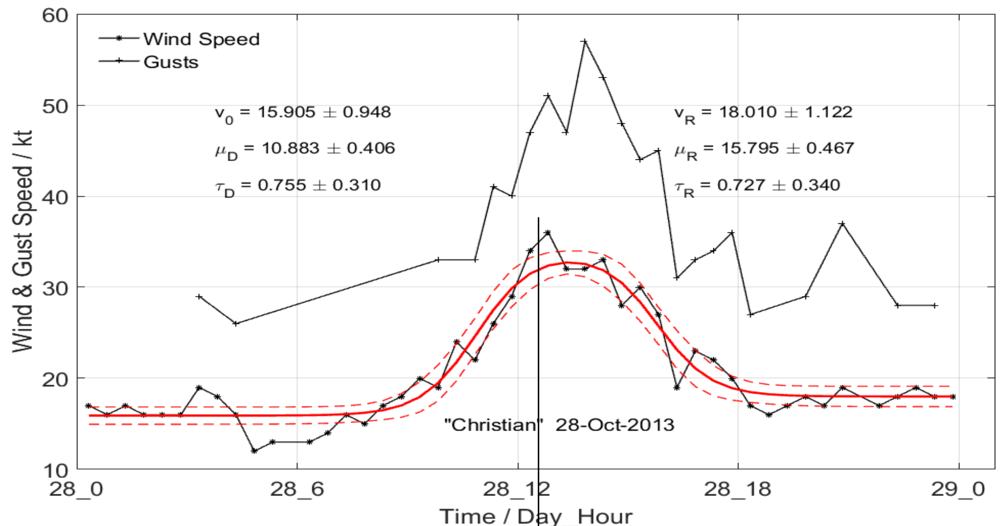


Combining Optimized Sequencing with **Dynamic Performance Prediction under Disruptive Weather. Example Low Pressure Event „Christian“**

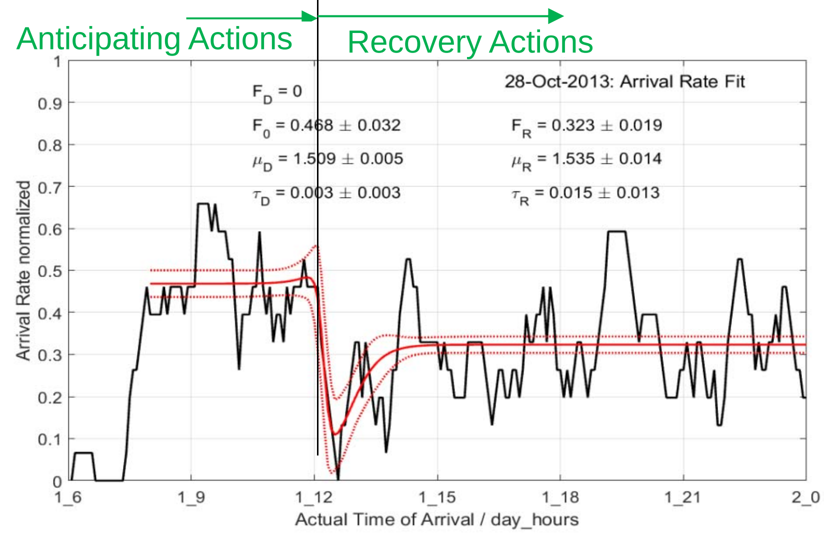
Wind speed & Gust data (METAR)

Fit with Dynamical Systems

Disturbance Model: Speed v(t)



Arrival Rate Data & Fit with Dynamical Systems Model for **Performance-Disruption and Recovery**

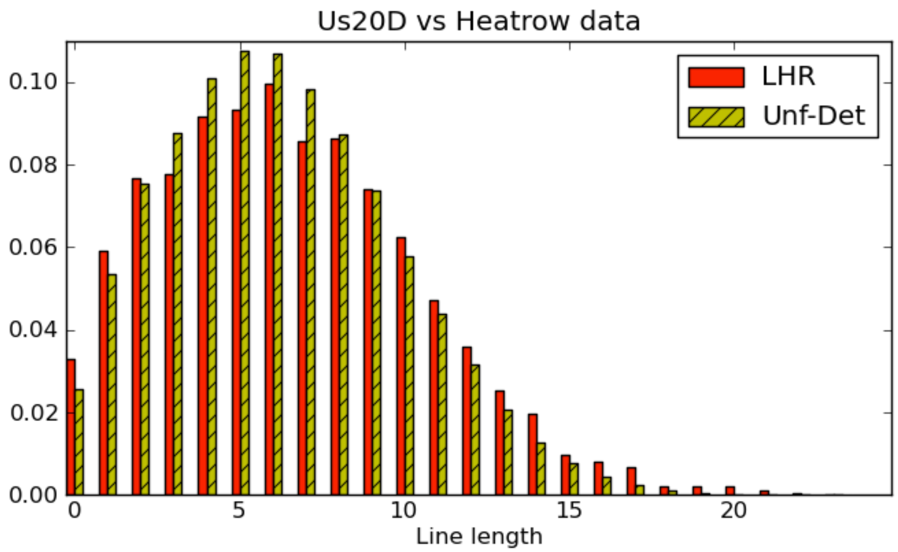


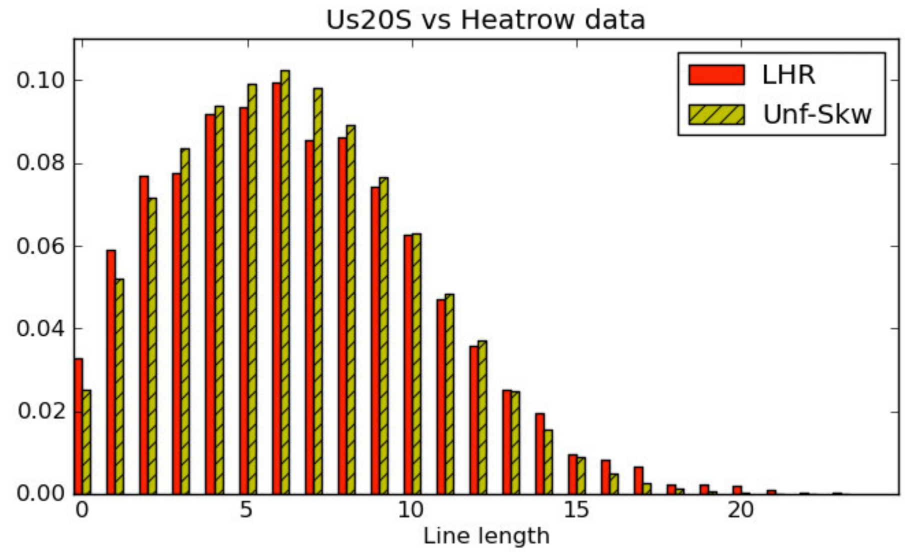
Dynamical Systems Model for **Disturbance & Performance prediction**

$$\dot{f}(t) = G(t)k(v(t))f(t)(1 - f(t))$$

→**optimized Management Actions G(t)**

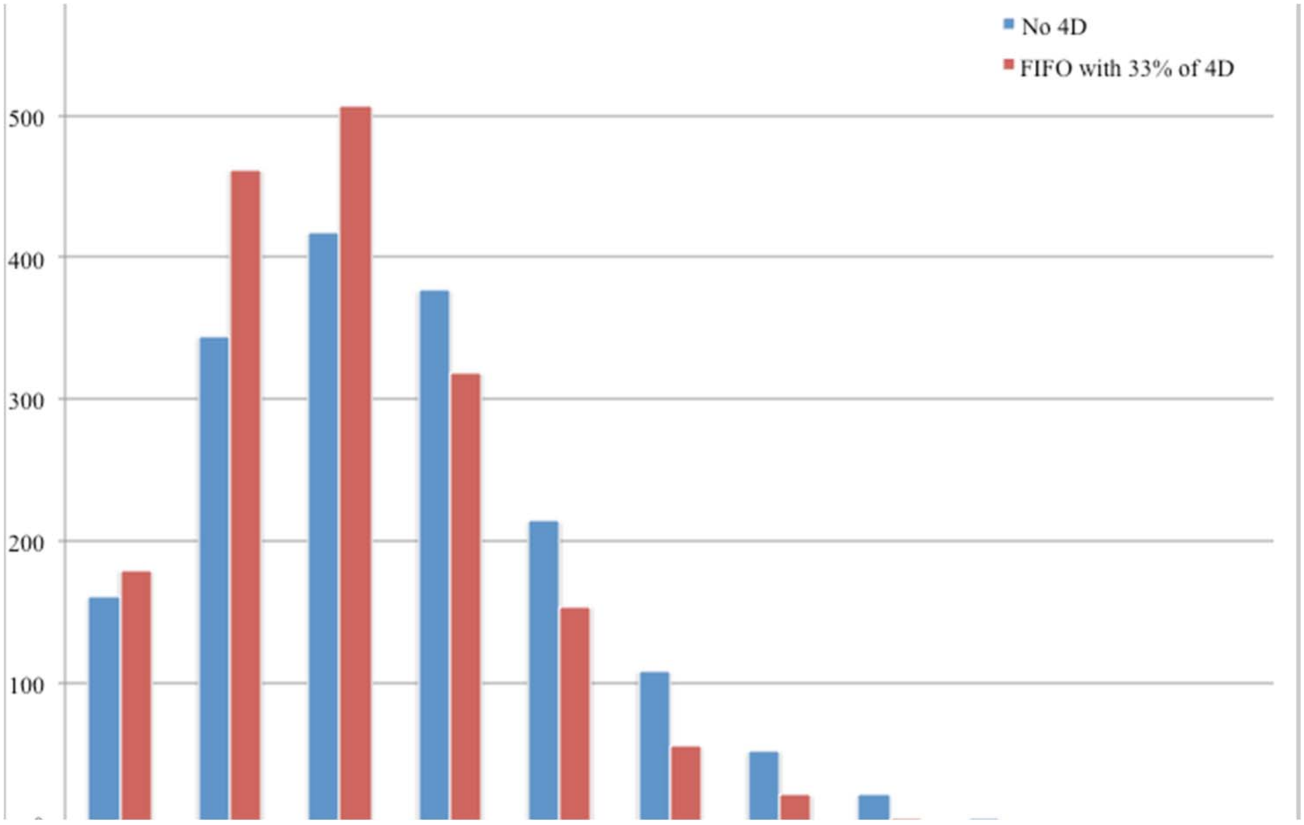
Case of Heathrow airport*





* Caccavale, M.V., Iovanella, A., Lancia, C., Lulli, G., Scoppola, B. 2014. A model of inbound air traffic: the application to Heathrow airport. Journal of Air Transport Management 34, p. 116-122.

Sub-challenge 2: identifying the need for prediction accuracy and defining the required level of certainty.



- Iovanella, Scoppola, Pozzi, Tedeschi: The Impact of 4D Trajectories on Arrival Delays in Mixed Traffic Scenarios, SID 2011.

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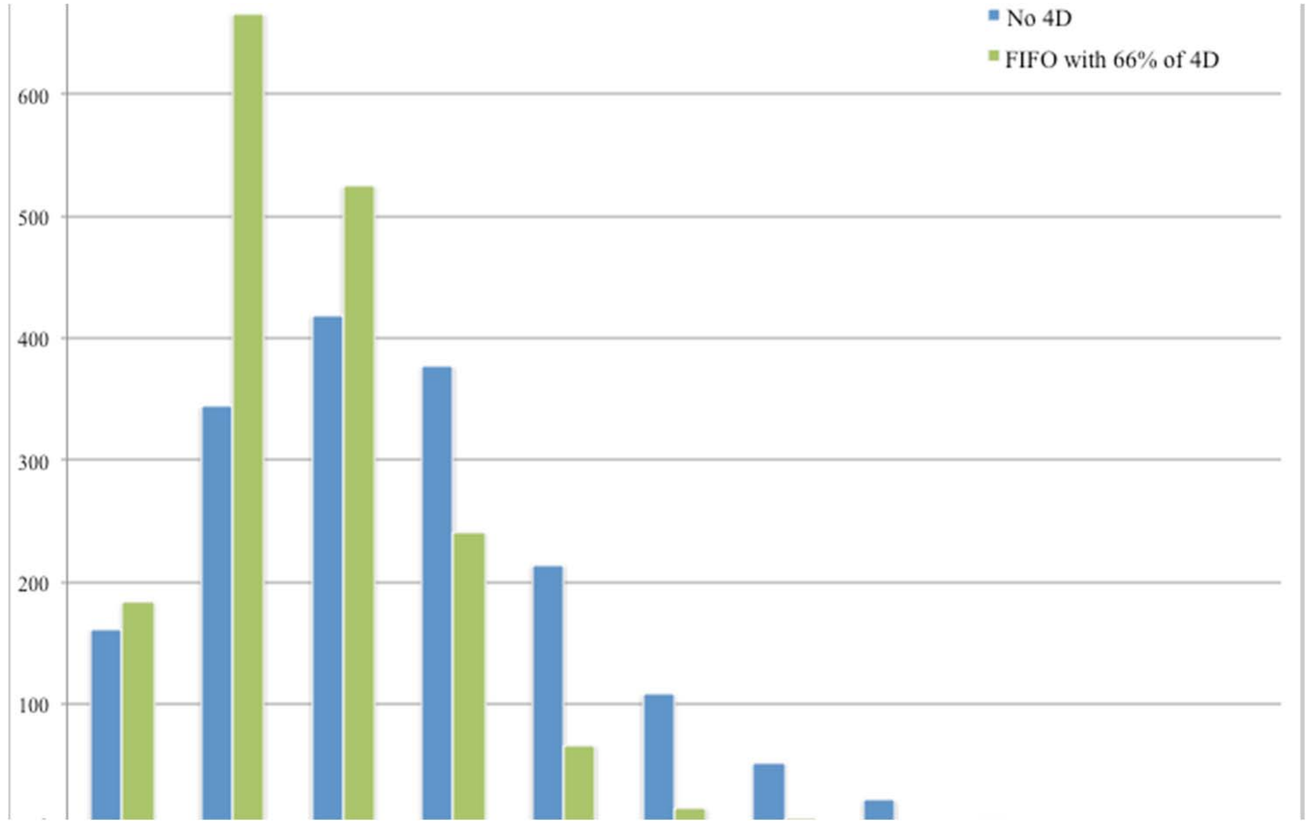

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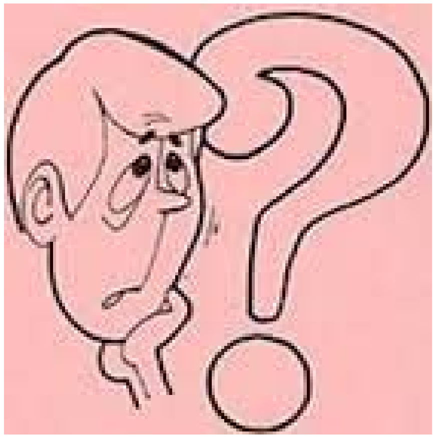
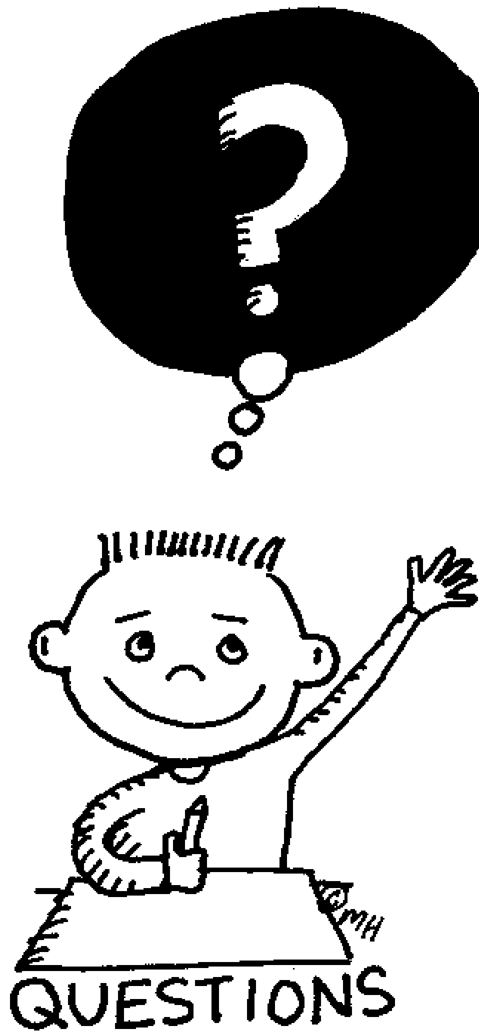
- Is it enough?



Experience

- How to absorb time in a time constrained environment in the most efficient manner is a key issue, e.g., reducing speed in cruise (K. *et al* '11, DP'12).
- Aircraft operators behaviour
    - Gap between system efficiency and individual efficiency
    - Rules / decision mechanisms / incentives to follow the "advised decisions"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QUESTIONS