Supporting European Aviation

EUROCONTROL

Prediction of propagation and evolution of delays with machine learning (ML)

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Engage

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NETWORK MANAGER

Outline

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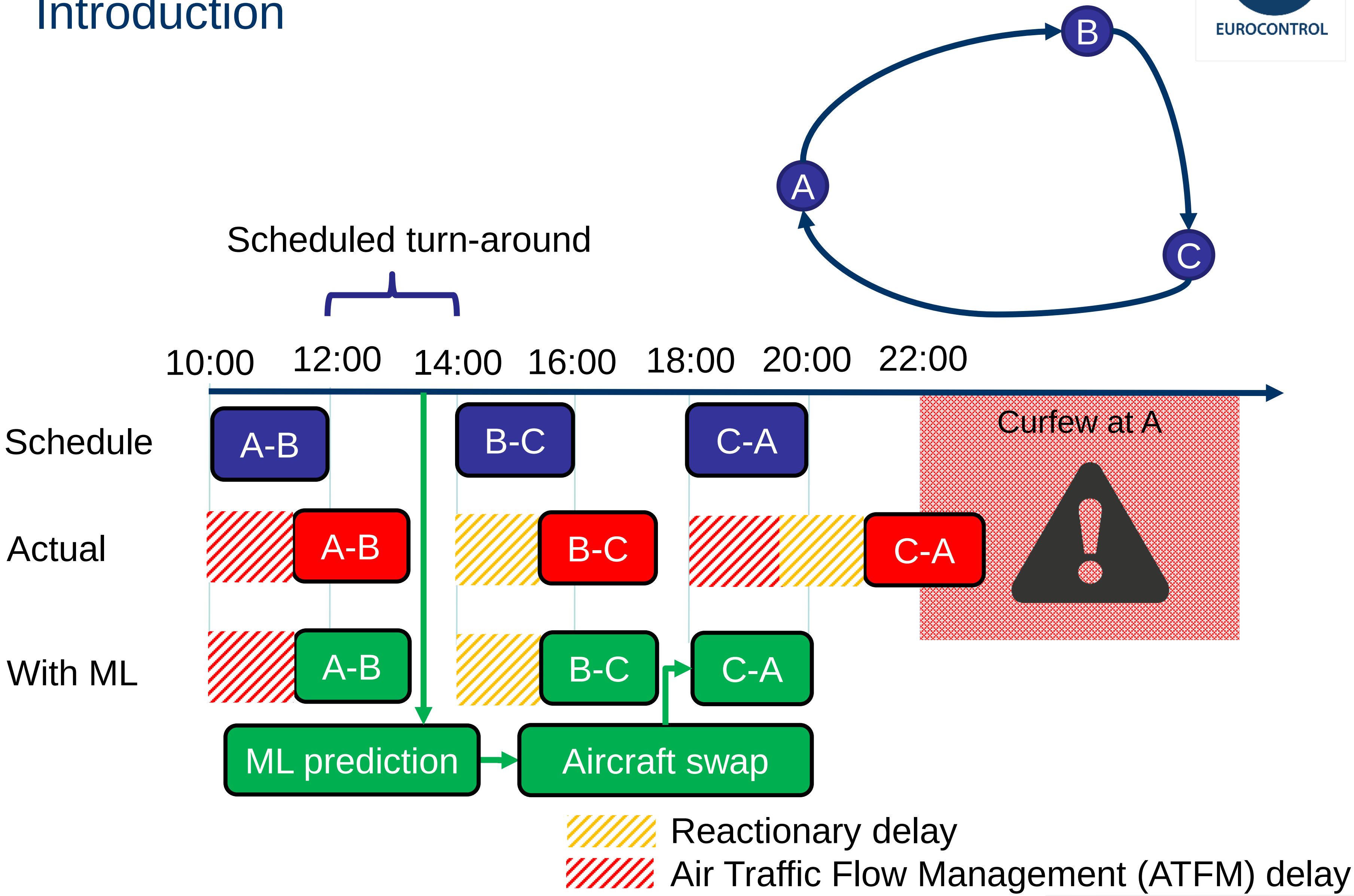
- Demo

Introduction



Raw data

- Enhanced Traffic Flow Management System (ETFMS) – **per flight and timestamp**. *Several events may trigger an update*
  - Departure airport ICAO code (e.g., LEBL)
  - Destination airport ICAO code (e.g., LEMD)
  - Airline (e.g., VLG)
  - Event that triggered the ETFMS update (e.g., Initial Flight Plan - IFP)
  - Flight state (e.g., Airborne – AA)
  - Air Traffic Flow Management (ATFM) delay (if any)
  - Off-block time - Estimated, targeted, calculated or actual
  - Landing time: Estimated, calculated and/or actual
  - Taxi-time
- Flight schedules – **per flight**
  - Scheduled off-block time (SOBT)
  - Scheduled in-block time (SIBT)

Features (per flight and timestamp)

Legend:
Embedded features
One-hot encoded features
Periodic features (cos, sin)
Other features

- Departure airport ICAO code
- Destination airport ICAO code
- Aircraft type
- Airline
- Event that triggers the ETFMS update
- Flight state
- Hour of the day
- Day of the week
- Month of the year
- ATFM delay (if any)
- Taxi-in and Taxi-out times
- Time to SOBT
- Time to SIBT
- Scheduled block-time
- Estimated/calculated/actual (depending on flight state) block-time
- Scheduled turn-around
- Estimated/calculated/actual (depending on flight state) turn-around
- Departure delay (w.r.t to SOBT)
- Arrival delay (w.r.t to SIBT)
- Time from last update
- Time from Initial Flight Plan (IFP)
- Traffic volume of most penalising regulation (if any)
- Reason of the most penalising regulation (if any)
- …

Model

Legend: Input; Embedding; Concatenate; Feed-Forward Neural Network (FFNN); Recurrent Neural Network (RNN); Output

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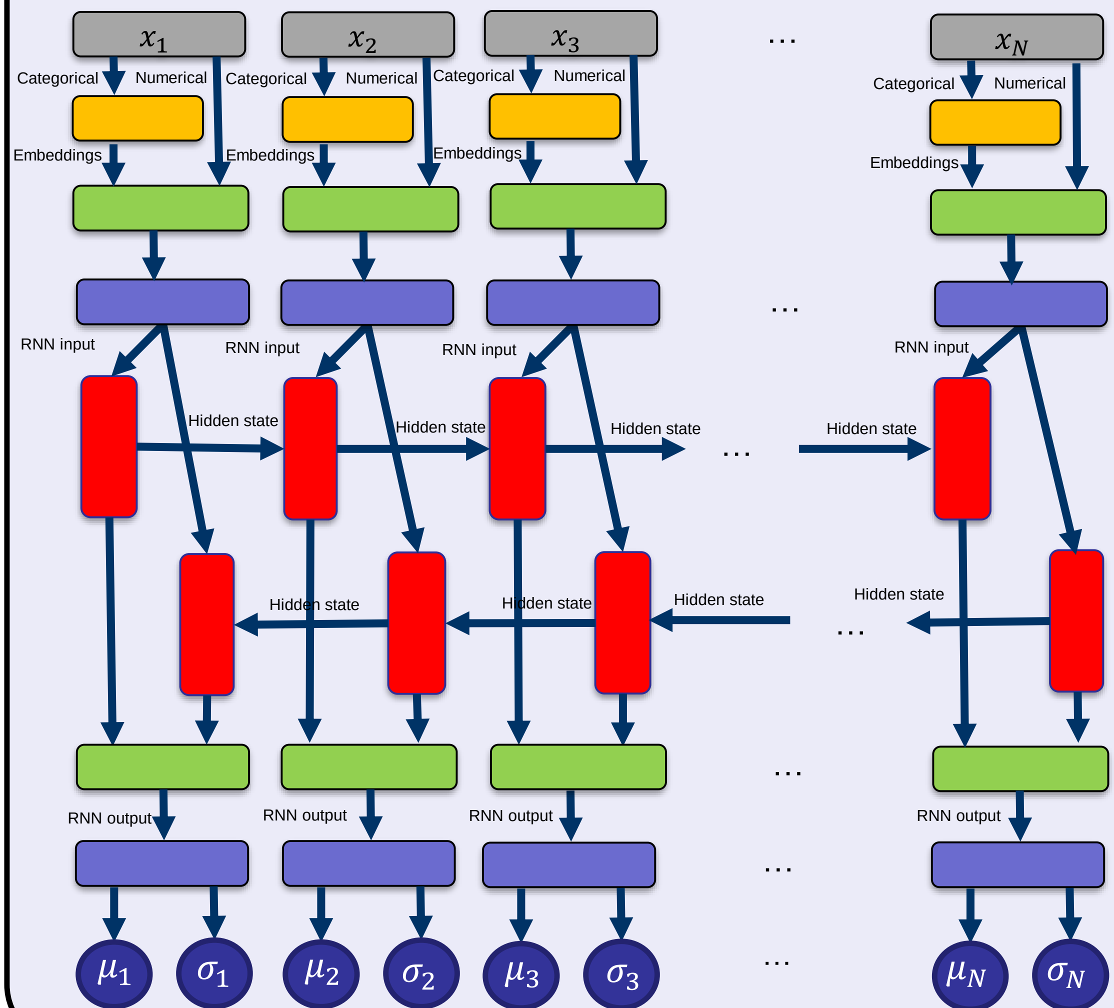
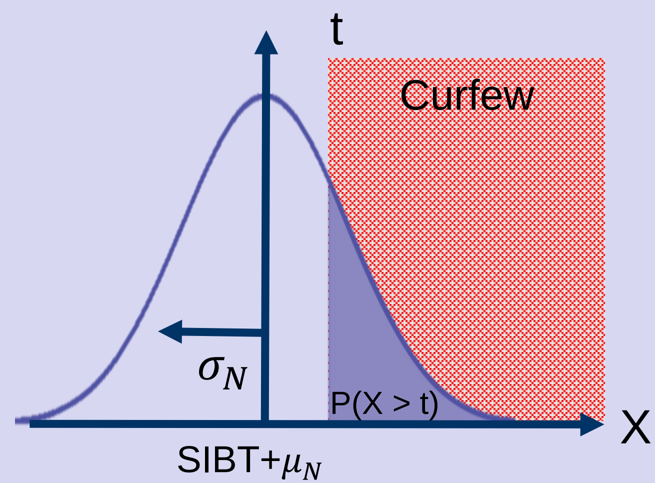
1. Delay prediction and propagation with ML

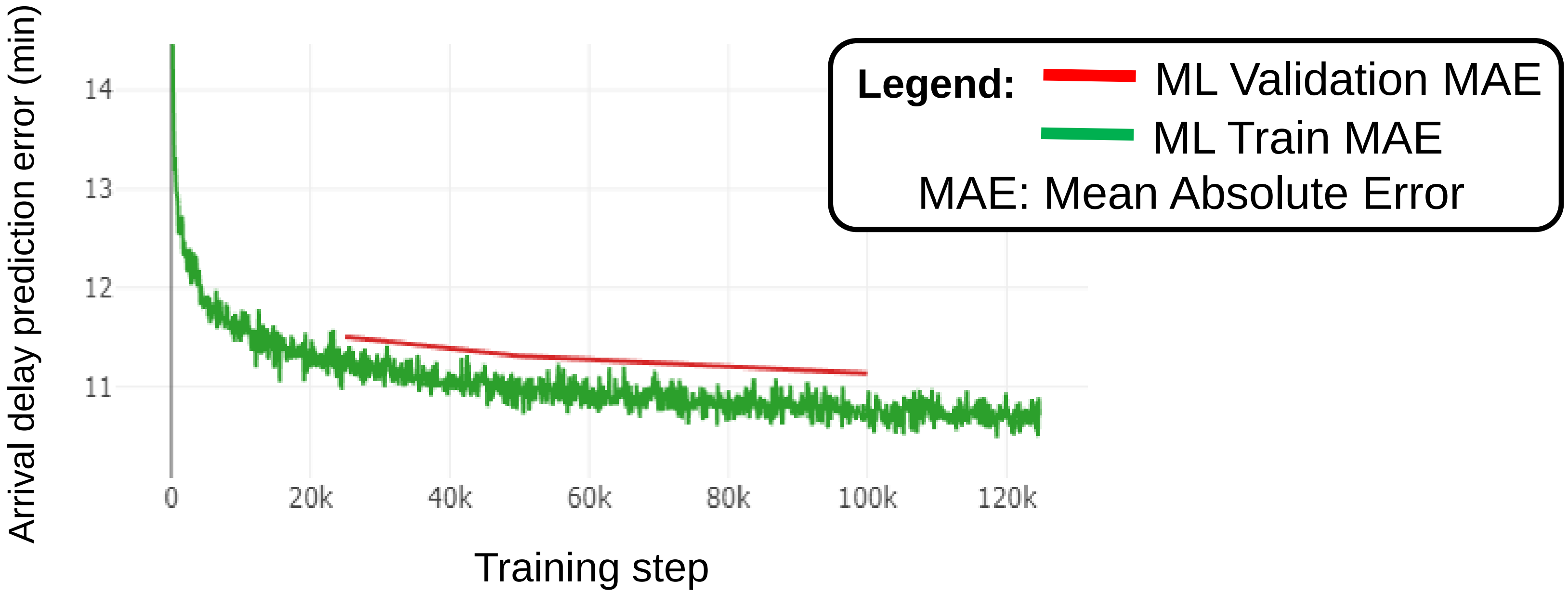


2. Curfew risk assessment

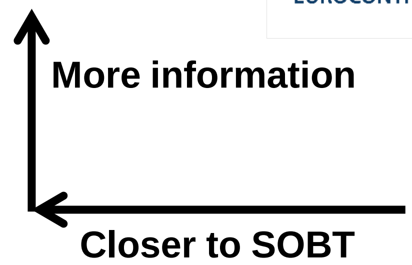


Initial results

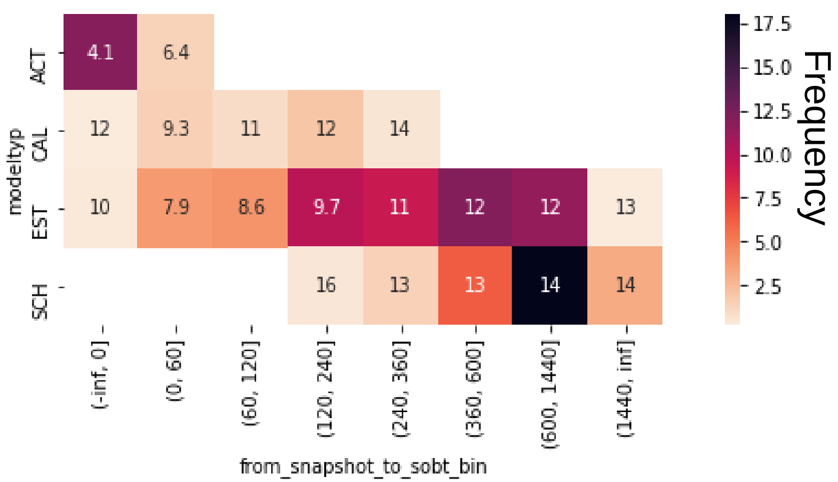
- **2019** flight traffic – all aircraft that landed, at least once, at LFPO (Paris-Orly)
- 270 **random days** for train, 30 for **validation** and 60 for **testing**
- **24M** examples (sequences to train the RNN)
- **3 hours** training for **1 epoch** with a **batch size of 128** and **learning rate 1e-4**
- **Loss function** is the **negative log-likelihood**



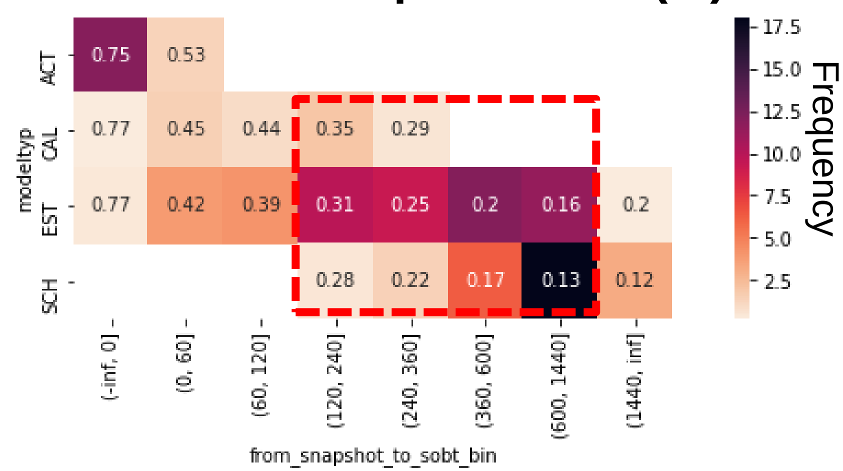
Initial results
Machine Learning



Arrival delay prediction error (min)



Relative improvement (%)



SCH: Only the SOBT and SIBT are available
EST: The EOBT is available, in addition to SOBT and SIBT
CAL: The flight is **regulated**, CTOT is known, in addition to EOBT, SOBT and SIBT
ACT: The flight is supposed to be **airborne**, AOBT is available

Next steps (short-term)

- Weight of each sample (example) **inversely proportional** to its probability. Less frequent examples will have more importance
- **Analyse results** to identify in which situations the model *fails*
- **Deploy the model**

Thank you!