START

a Stable and resilienT ATM by integrAting Robust airline operations into the neTwork

START Project
a Stable and resilient ATM by integrating Robust airline operations into the network

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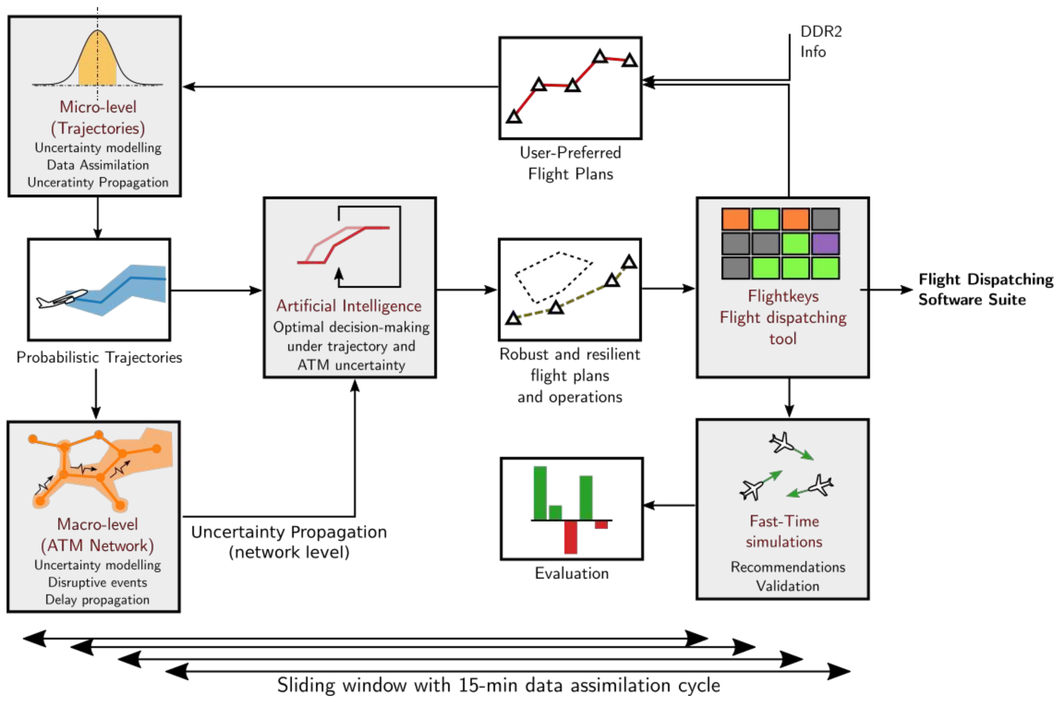
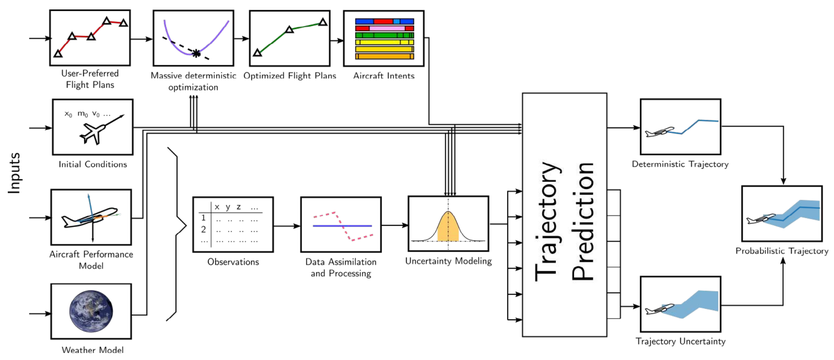


The **overall goal** of **START is to develop, implement, and validate optimisation algorithms for robust airline operations that result in stable and resilient ATM performance even in disturbed scenarios.**

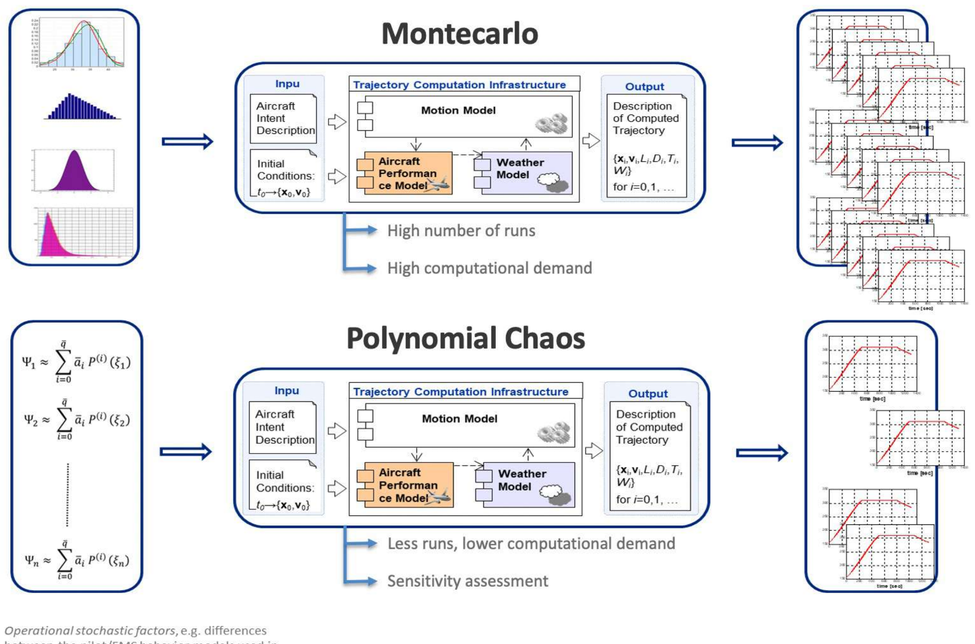
Objectives

1. To **model uncertainties at the micro (trajectory) level**, **assimilate observations** (via ADSB/Radar) every 15 min. using advanced data science methods, and **propagate trajectory uncertainties** using assimilated models and a stochastic trajectory predictor.
2. To **model uncertainties at the macro (ATM network) level**, **assimilate observations** (satellite data for storm, and network status) every 15 min. using advanced data science methods, and **propagate ATM network uncertainties** using the assimilated models.
3. To **develop an Artificial Intelligence (AI) algorithm** capable of generating a set of pan-European (i.e., considering the whole traffic over Europe) robust trajectories that make the European ATM system resilient when facing these relevant uncertainties.
4. To **implement** those algorithms as an **advanced flight dispatching demo functionality** for airspace users to obtain robust trajectories.
5. To **validate these concepts** through system-wide simulation procedures in order to evaluate their stability, **assessing the benefits for both the airspace users and the network manager**. Recommendations for the derivation of resilient TBO networks will be derived.

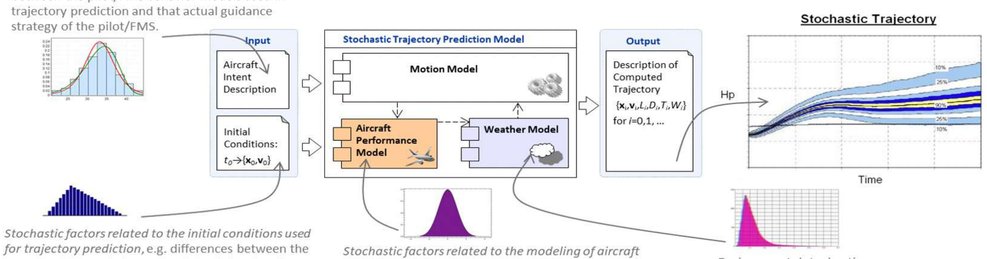
Micro-Level: Trajectory level: Uncertainty modelling, data assimilation and uncertainty propagation.



GOALS: Develop uncertainty propagation models at trajectory level; identify and characterize potential sources of trajectory level uncertainty following a data-driven approach.; build and develop methods for the cyclic ingestion of data inputs that will feed the uncertainty propagation models at the trajectory level.



Operational stochastic factors, e.g. differences between the pilot/FMS behavior models used in trajectory prediction and that actual guidance strategy of the pilot/FMS.



Stochastic factors related to the initial conditions used for trajectory prediction, e.g. differences between the actual position, velocity and weight of the aircraft at a given time and the values of those variables used as initial conditions for trajectory prediction from that time onwards.

Stochastic factors related to the modeling of aircraft performance, e.g. random differences between real aircraft performance characteristics such as thrust, drag or fuel consumption and the aircraft performance models used for trajectory prediction.

Environmental stochastic factors, e.g. wind and temperature modeling or forecast errors.

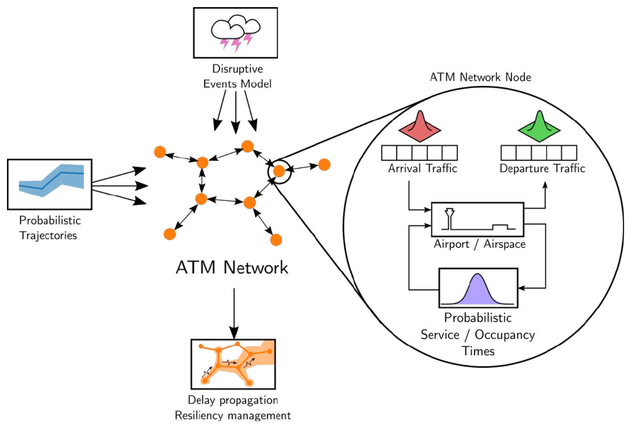
Initial Conditions:
- Initial time
- Initial mass
- Initial position
- Initial altitude

Aircraft Intent:
- Climb speed (CAS & M)
- TOC altitude
- Cruise (speed & altitude)
- TOD altitude
- Descent speed (CAS & M)

Aircraft Performance:
- Fuel
- Drag

Weather:
- Temperature
- Pressure
- Wind speed
- Wind direction

Macro-Level: ATM Network level: network modelling, uncertainty propagation with disruptive events



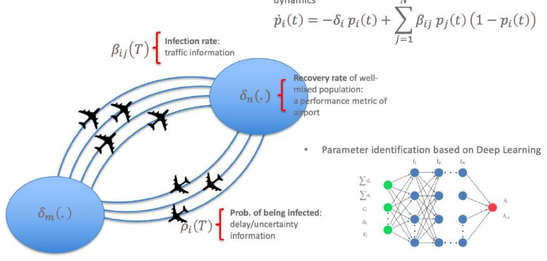
Objectives: Develop an approximate ATM network model from the historical data enabling to simulate and analyse uncertainty and delay propagation; integrate individual trajectory uncertainties into the network model; provide models for disruptive events and integrate them into the network-wide model; validate the model, procedures and provide a simulation environment/tool for use case analyses.

Network Information Diffusion Model

Uses theoretical background of epidemic spreading process to approximate delay and uncertainty propagation dynamics of European ATM network

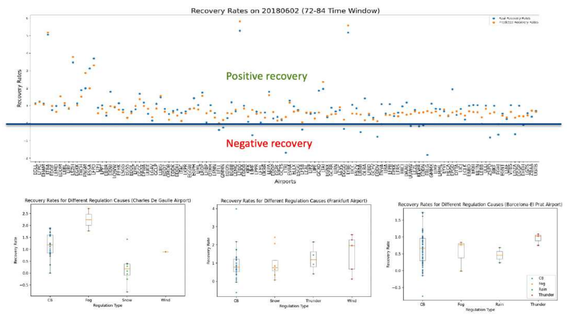
- Continuous time deterministic meta population dynamics

$$\dot{p}_i(t) = -\delta_i\, p_i(t) + \sum_{j=1}^{N} \beta_{ij}\, p_j(t)\,(1 - p_i(t))$$

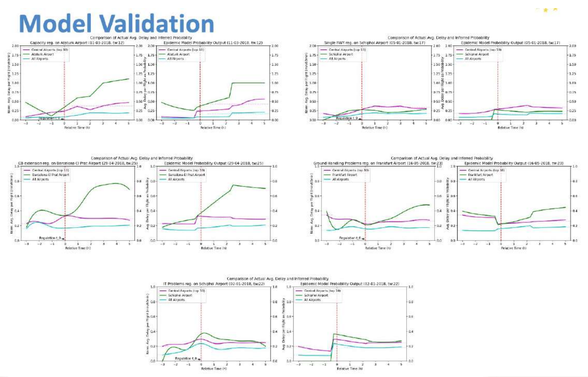


- Parameter identification based on Deep Learning

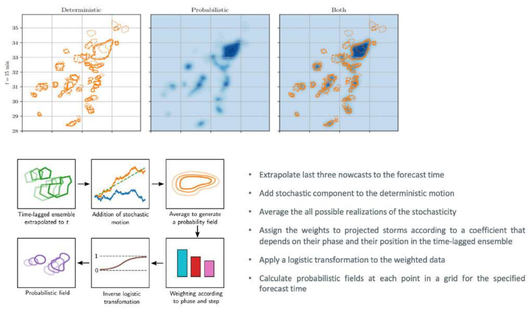
Data/Event Driven Parameterization



Model Validation

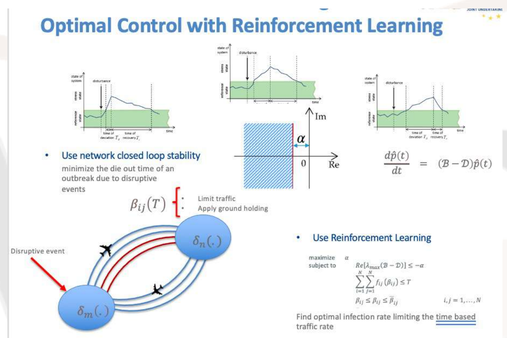


Thunderstorm Case

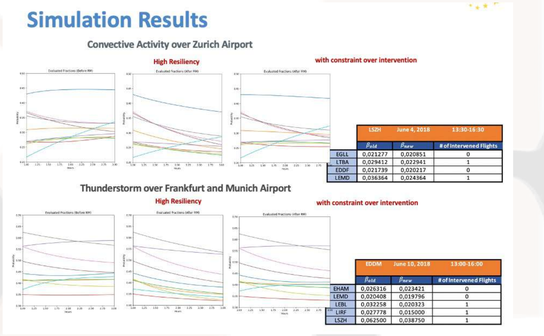


- Extrapolate last three nowcasts to the forecast time
- Add stochastic component to the deterministic motion
- Average the all possible realizations of the stochasticity
- Assign the weights to projected storms according to a coefficient that depends on their phase and their position in the time-lagged ensemble
- Apply a logistic transformation to the weighted data
- Calculate probabilistic fields at each point in a grid for the specified forecast time

Optimal Control with Reinforcement Learning



Simulation Results



Acknowledgments

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