COmbining Probable TRAjectories — COPTRA

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Founding Members
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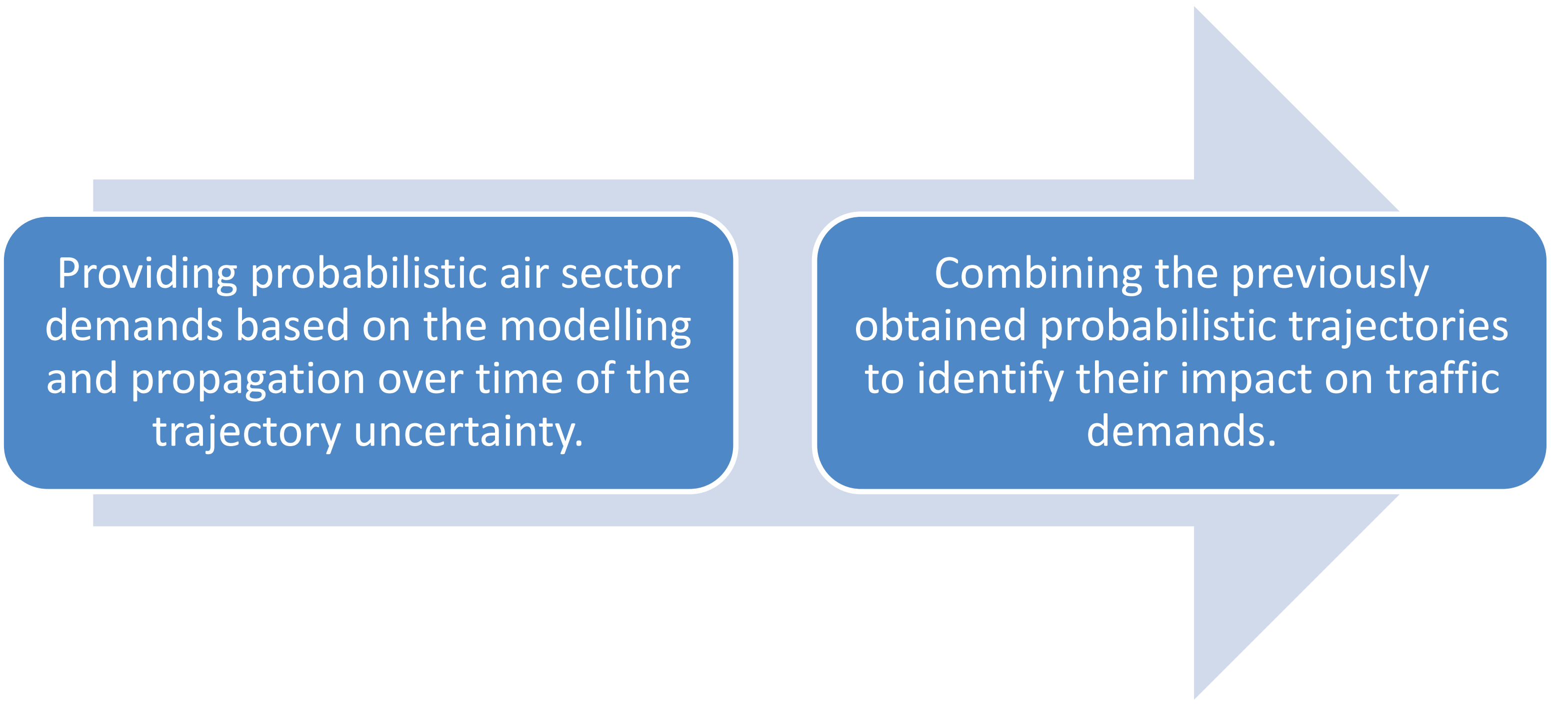
Introduction

COPTRA addresses a very specific aspect of TBO related with the ability to help efficient, **long-term capacity and complexity management** as well as **planning through the identification and management of uncertainty** (both at trajectory and traffic levels) as expressed in the S2020 advanced DCB concept.

COPTRA will pursue this goal using a two pronged strategy:



Our Operational Objectives

Increase the use of residual capacity

- Avoid unnecessary capacity reductions
- Identify accurate capacity limits

Improve Decision Making

- Include Uncertainty information
- Accurate prediction of imbalances
- Confidence Index

Integrate in TBO environment

Our Scientific Objectives

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Mathematical model of probabilistic trajectory for use in Traffic Prediction

Quantify uncertainty in the prediction of mechanical models

Determine benefits of TBO to Trajectory Prediction

Determine Probabilistic Traffic Prediction Requirements

Define the content of probabilistic traffic prediction in terms of traffic distribution and flight dependencies

Apply recent and innovative (computational) methods from robust control to the combination of probabilistic trajectories

Apply recent and innovative data mining (in particular graph mining) cutting edge techniques to traffic situations

Propose a probabilistic traffic prediction method

Our Process

Define and assess the concept of probabilistic trajectory in a TBO environment

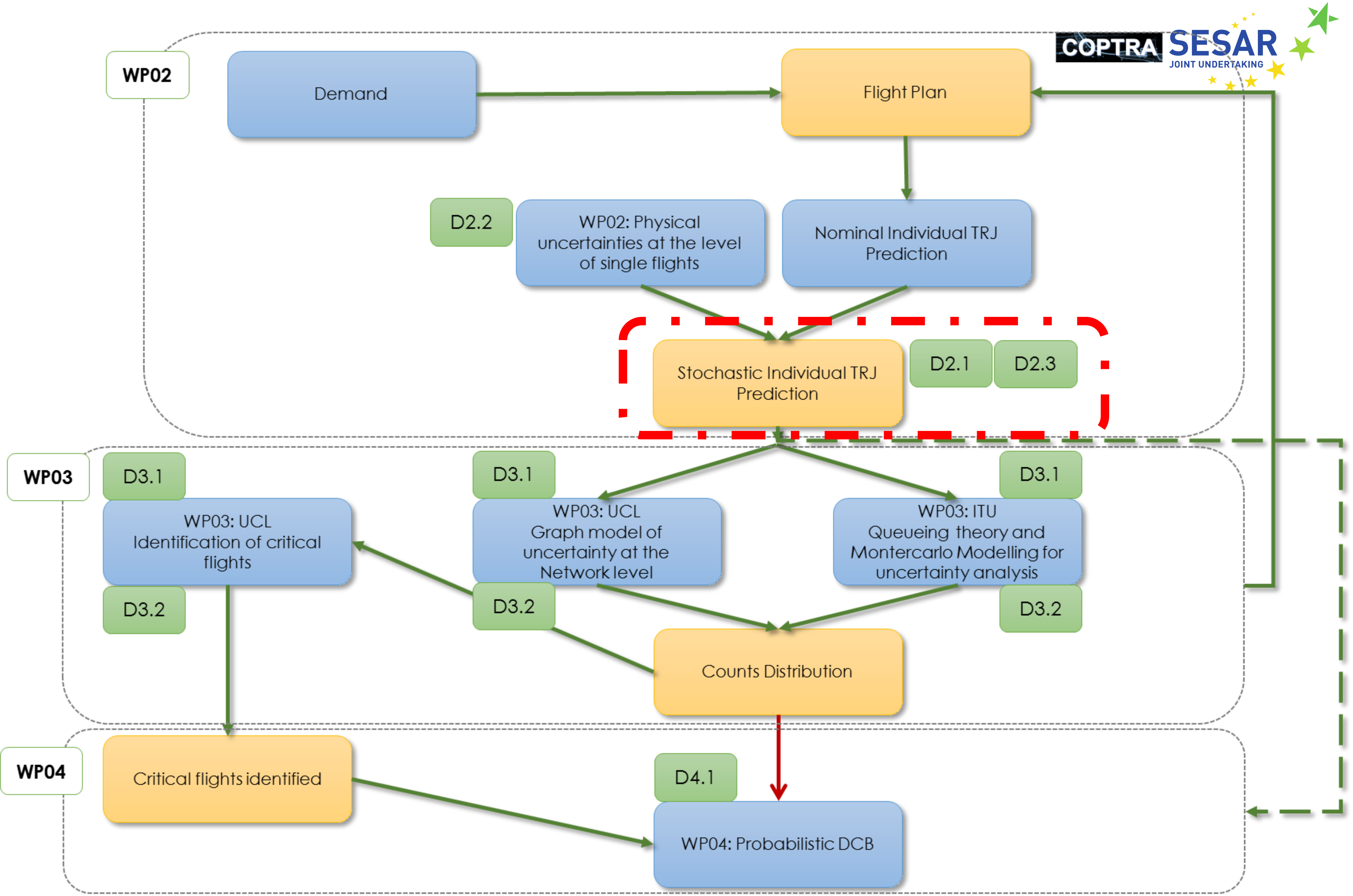
Mathematical model of probabilistic trajectory for use in Traffic Prediction	Determine benefits of TBO to Trajectory Prediction	Determine requirements from Probabilistic Traffic Prediction

Combine probabilistic trajectories to build probabilistic traffic prediction

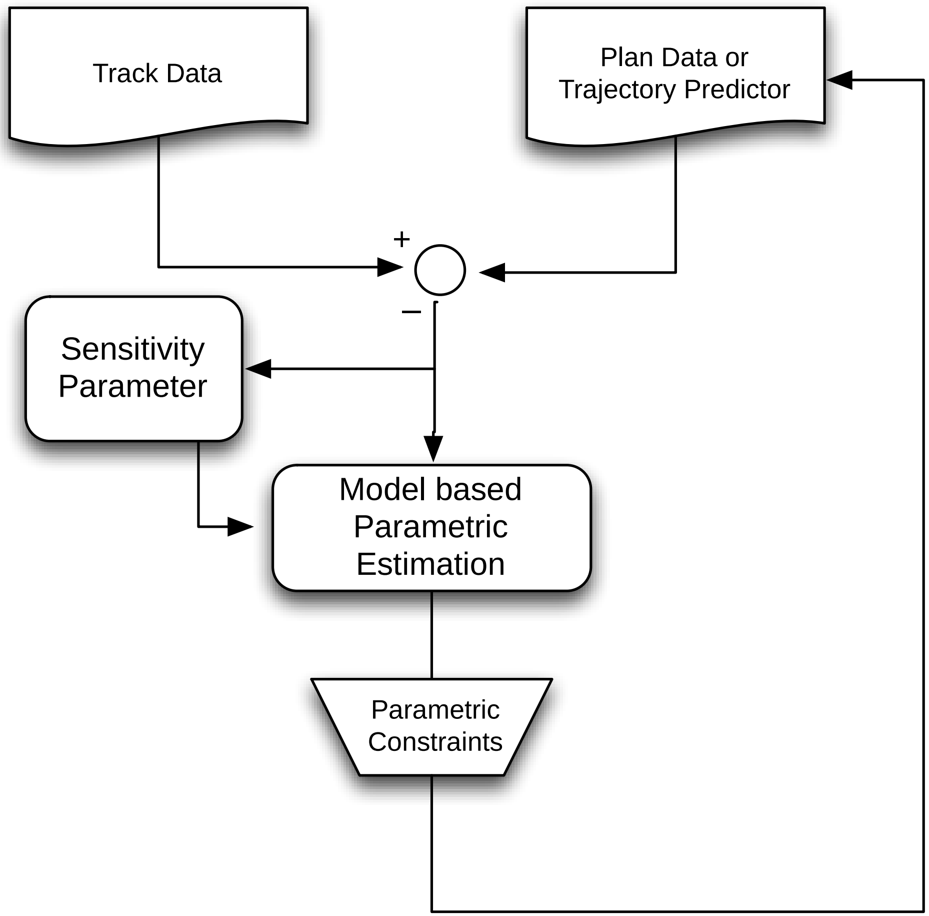
Define the content of a probabilistic traffic prediction in terms of traffic distribution and flight dependencies	Apply computational methods from stochastic queuing theory to the combination of probabilistic trajectories	Apply data mining to traffic situations	Propose efficient methods to build probabilistic traffic prediction • Estimate performance • Id possible constraints

Apply Probabilistic Traffic Prediction to ATC Planning

Inject probabilistic traffic predictions into DCB prototype tools • Demonstrate the benefit	Measure the improvements in term of traffic prediction accuracy • Compare occupancy predicted vs today’s


WP02
Demand
Flight Plan
D2.2
WP02: Physical uncertainties at the level of single flights
Nominal Individual TRJ Prediction
Stochastic Individual TRJ Prediction
D2.1
D2.3
WP03
D3.1
WP03: UCL Identification of critical flights
D3.2
D3.1
WP03: UCL Graph model of uncertainty at the Network level
D3.2
D3.1
WP03: ITU Queueing theory and Montercarlo Modelling for uncertainty analysis
D3.2
Counts Distribution
WP04
Critical flights identified
D4.1
WP04: Probabilistic DCB

ITU WP02 Approach

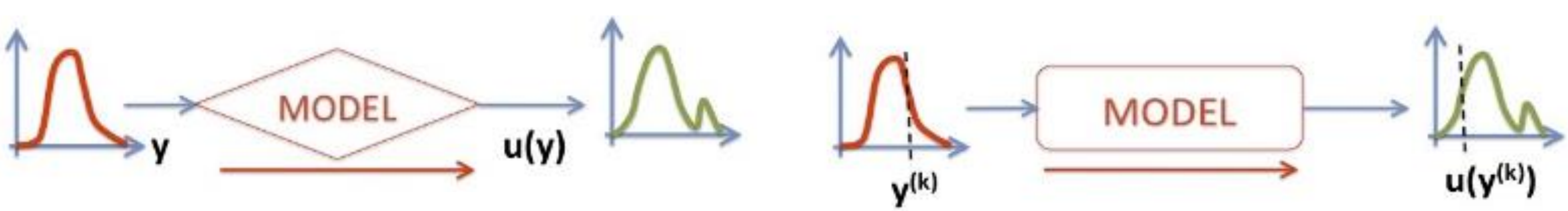


- Estimation of probabilistic definitions (disturbances with their parameters) of uncertainty sources
  - Initial (estimated) mass: major contributing uncertainty source
  - wind speed,
  - climb/descent speed,
  - top-of-descent point
  - etc..
- Uncertainty reduction: model based parametric estimation algorithms

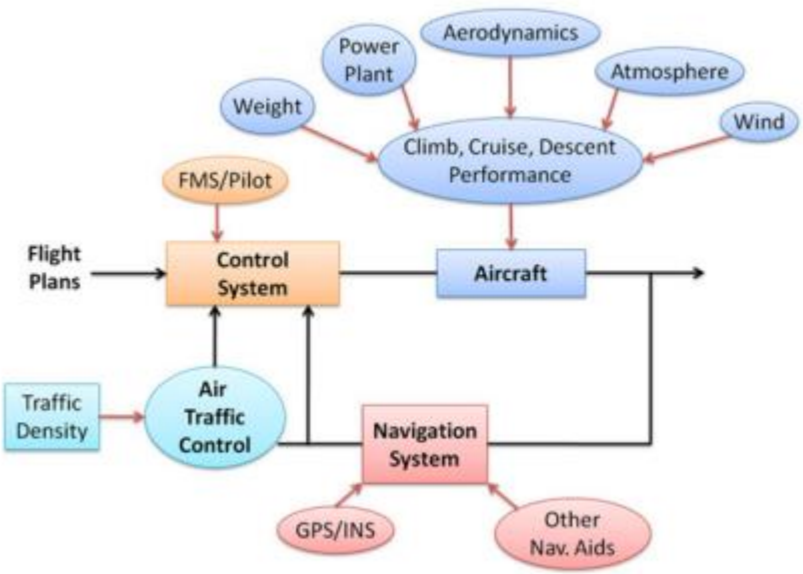
BR-T&E WP02 Approach

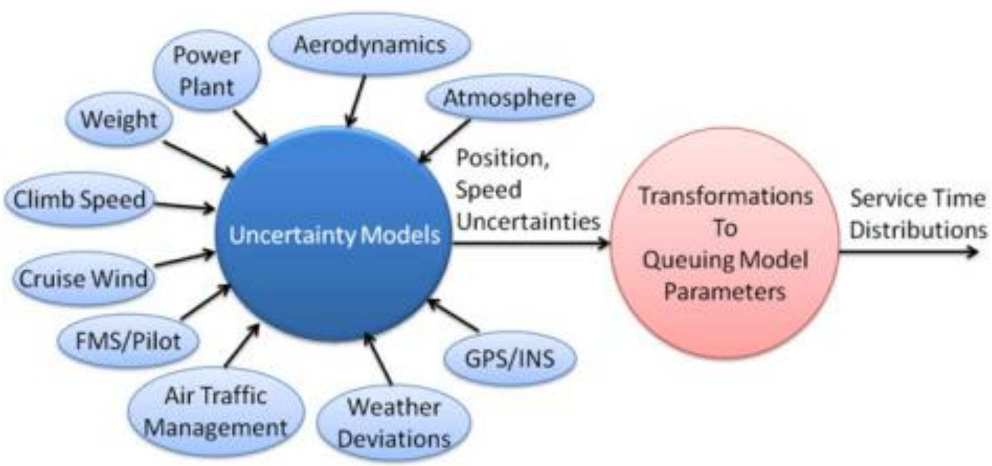
- Application of Polynomial Chaos Expansion (PCE) to quantify the propagation of uncertainty in dynamic systems.
- Technique extensively applied in several fields: aerodynamic design, vehicle dynamics, micro-electromechanical systems, petroleum engineering, nuclear waste disposal, etc.
- The system response (u) can be represented as function of the variability (ξ) of the inputs (x) with the time (t).
- WP02 will explore the applicability of the so-called arbitrary PCE (aPCE) approach, which is a data-driven method that enables the computation of the output variability thanks to the knowledge of inputs variability (determined by analysis historical recorded data).

$$u(x,t,\xi) = \sum_{i=0}^{\infty} \underbrace{u_i(x,t)}_{\text{deterministic}} \underbrace{\psi_i(\xi)}_{\text{stochastic}}$$



ITU WP03 Approach



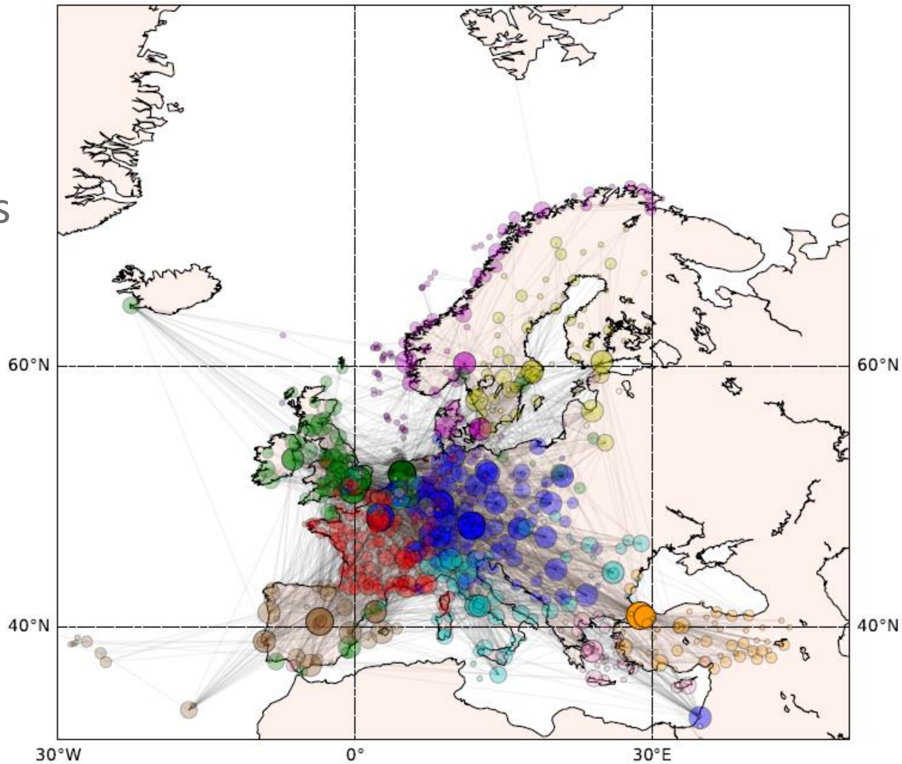


Queueing Network models to identify and integrate parameters contributing to uncertainty based on:

- Probabilistic entry counts and occupancy counts obtained from probabilistic trajectories
- Stochastic queue network models:
  - Airport throughput queues
  - Sector pair queues
- Data driven estimation of demands, capacities and sector delay transition parameters

UCL WP03 Approach

- An algorithm to detect critical flights, as a decision helping tool for better load repartition
- A community detection ad-hoc algorithm for a Divide and Conquer approach
- Proof of concept establishing Game Theoretical mechanisms for fair resource allocation
- TBO methodology: each flight is free to make its own decisions, system maximizes the global welfare
- Simulator for generating occupancy counts



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