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BEACON

BEHAVIOURAL ECONOMICS FOR ATM CONCEPTS

This Technical Report is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 893100 under European Union's Horizon 2020 research and innovation programme.

Abstract

This technical deliverable describes the database used in BEACON, including the data structure adopted, data sources, and data elaborations that were needed for the data analyses in other WPs. All data have been used to set up and run the simulations defined by tasks 4.1 and 5.2. The deliverable includes a diagram of the relational database and the full table of the data considered with a description of their usage. Furthermore, human-in-the-loop simulations were performed to collect the data for calibration of behavioural parameters to be included in the final simulation. The data collected in the human-in-the-loop is described.

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1 Introduction

1.1 Scope and objectives

BEACON aims to develop and test several mechanisms that will be modelled to create the different case studies. The detailed description of the mechanisms developed and studied during the project is given in D3.1 [1]. In BEACON three simulation stages have been planned and data have been collected, stored and elaborated accordingly. In task 4.1 several small scale simulations have been performed using a small subset of data as a source to generate all the synthetic data required. For task 5.2 instead, consisting of several human-in-the loop simulations, a considerable amount of data was required in order to produce the most realistic scenarios possible, as described in detail in D2.1 [2], section 2, section 3 and summarised in table 1 of section 3.7. The data for the latter two simulation stages come from different sources and were originally stored in different format. For these reasons, after the collection phase, they had to be reorganised and gathered in a single source, guaranteeing confidentiality as well as controlled and secure access for all partners of the consortium.

1.2 Structure of the document

The document is structured as follows

- Section 1 introduces the document explaining its aim and scope and describes the structure of the report;
- Section 2 describes the data used for task 4.1, small scale simulation for mechanism assessment.
- Section 3 describes the data sources, acquisition and elaboration.
- Section 4 describes the database structure for data used in simulations. It contains the full list of the data tables used.
- Section 5 describes the data collected in the human in the loop simulation and their storage.

2 Task 4.1 simulation data

Task 4.1, performed by NOMMON, had the specific goal of testing the selected mechanisms, described in D3.1 [1], on a small scale scenario (5 airports, situated in simulated airspace network, see Figure 1). These initial tests, described in detail in D4.2 [3], aimed to study the performance and the effects of the mechanisms on a subset of airports and the corresponding connecting network. As the goal of this preliminary test phase was to provide an initial assessment of the mechanisms, all scenarios have been synthetically generated based on a sample of the real data, extracted from the **AIRAC 2019** and considering:

- traffic data of May the 23rd,
- only the most congested airports in Europe (EGLL, EHAM, LFPG, EDDF, LTFM),
- only flights departing from 9:00 to 23:00.

Starting from the above-mentioned items, the synthetic data for the small-scale simulations has been generated (see D4.2 [3] for details), and summarised below.

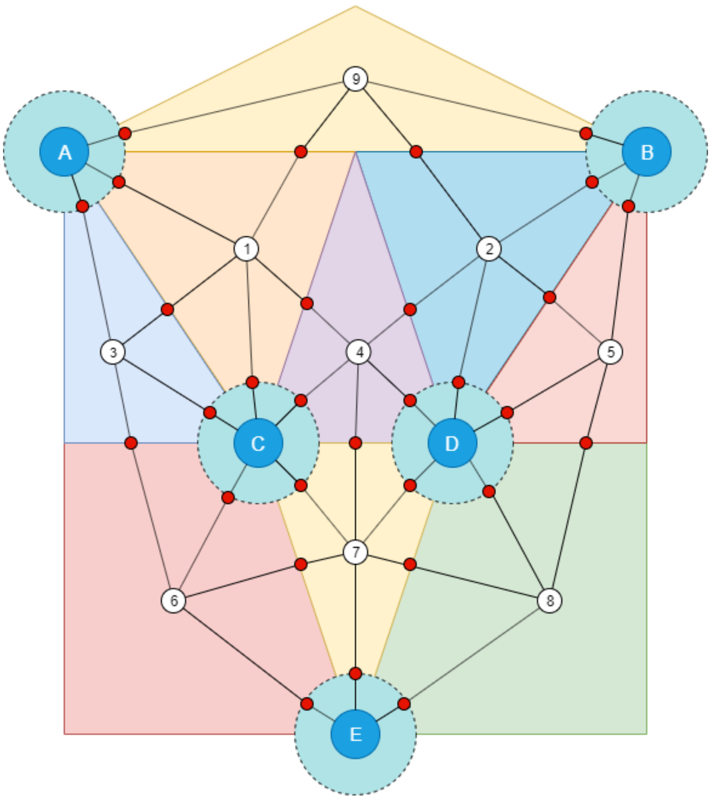

Figure 1. Simulated network configuration.

2.1 Extraction and cleaning of the real data

The real traffic data of 23rd May 2019, from EGLL, EHAM, LFPG, EDDF, LTFM, with departure times 09:00-23:00 was sources from AIRAC. The information of thusly sourced flights is then adjusted to the simulated network shown in Figure 1.

Each sourced flight had a series of data fields associated with it. The list of data fields and the short description of the adjustments can be found below:

- origin, replaced by pseudo code of one of the 5 airports,
- destination, replaced by pseudo code of one of the 5 airports,
- departure time, retained,
- arrival time, calculated based on the destination pseudo airport and the simulated airspace network.
- airline id, assigned to the airline alliance.
- aircraft type, assigned to be narrow-body or wide-body
- aircraft id, assigned in the rotation generation process (see D4.2 [3]for detailed explanation)
- and synthetic flight id, composed of alliance code and flight id.

2.2 Creation of point-to-point schedules

The schedule generated in this manner, does not yet meet the desired requirements for the simulation. Almost every airline that was captured in the file corresponds to one of the legacy airlines, which use well-known hub-and-spoke system[1]. However, the point-to-point strategy characteristic of low-cost airlines is still missing. To include this strategy new flights are included in the schedule. This process is explained below:

- New “low cost” airlines are defined and a dummy schedule with point-to-point flights between two predefined airports is generated. The method creates a first flight going from one airport to the other and calculates the flight duration between these two airports. Then, a return flight is generated at the destination airport. The definition of the schedule departure time of the new fight is calculated from the addition of a defined waiting time (turnaround time plus buffer time) to the scheduled arrival time of the first flight.

2.3 Passenger connectivity

To measure the impact that different prioritisation mechanisms have on passengers, it is necessary to include passenger connectivity in the model. For this, the following assumptions were set:

- Only legacy airlines have connections.
- The passengers can only have a maximum of one connection in their journey.
- The waiting time for passengers connecting flights lies between 45 and 120 minutes.
- The connections are only between flights operated by the same airline.
- All flights departing from 18:00 onwards are direct flights.
- The number of total passengers inside a particular flight and aircraft is randomised between the following percentages:
    - 80-85% of aircraft capacity for flag carriers

[1] Hub-and-spoke is the system where an airline routes the flights from end point airports into its hub (hub is airline’s main airport/airports), where the passengers can switch to other flights to reach their final destinations. Hub is the main airport, while the spokes are the routes coming into and going out of the hub.

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    - 85-90% of aircraft capacity for charter airlines
- The total number of connecting passengers, inside a particular flight, which will take a second flight later, is computed by applying a 20% to the total number of passengers on the actual flight who have not made a connection yet.
- In the event that the connecting passengers on a flight could take different second flights, the number of passengers going to each one of these next flights is randomised from the total number of connecting passengers inside the actual flight.

The generated file consists of several rows corresponding to each of the flights included in the simulation. Each row contains the following flight information:

- Flight id: the id of the flight.
- Pax at origin: number of passengers at the origin airport. These are the passengers that come originate at the airport.
- Pax from connections: number of passengers coming from another flight/s.
- Pax total: total number of passengers inside the flight.
- Connection info: list of flight ids and number of connecting passengers boarding future flights.

2.4 Data storage

These data have been created by NOMMON and are kept in their database, as no other partner needed this information in their work within BEACON.

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3 Data sources, acquisition and elaboration

Based on the data requirements and chosen test day (14 September 2018) described in D2.1 Data management and sources [2], the consortium acquired flight plan and trajectory data from EUROCONTROL's databases, schedule data from Cirium and passenger itinerary data from IATA, for September 2018. Next sections describe shortly the elaboration of data in the following categories:

1. Traffic and delay;
2. Aircraft performance data;
3. Airspace environment;
4. Passengers;
5. Other.

3.1 Traffic and delay

Different sources were used and consulted in order to prepare the traffic data for BEACON's models:

- EUROCONTROL'S R&D data archive: R&D archive offers filed and actual flight trajectories, more specifically flight points, sequence of national regions and sequence of airspace blocks. The data from September 2018 are available and are used for everything concerning the trajectories, or more generally, the traffic. The data on flight trajectory, origin, destination, airline type, departure and arrival times, and aircraft type are used.
- EUROCONTROL's DDR2: DDR2 also contains trajectory data. Older data from a number of other AIRACs (Aeronautical Information Regulation and Control) are available to consortium members, so these will be used to perform statistical analyses when required (these analyses cannot be done with R&D because data of only 4 months per year are available).
- Daily ATFCM summary data: contain detailed information on the regulations that were applied on the day of study. These are obtained from Network Manager (NM) ATFCM statistics.
- CODA summary delay data: are used to analyse delay and enable realistic delay generation (for all the delays not caused by the ATFM actions).
- CODA taxi times: standard taxi times, published by CODA, are useful to model the time between gate and runway and from the runway to the stand as these values are required to accurately estimate the arrival and departure delay, and passenger connections.
- Commercial data sources: BEACON purchase schedule data for the month of September of 2018. The data on scheduled departure and arrival times is merged with the trajectory data from EUROCONTROL (see above), to be able to calculate delays against schedule, not only against the flight plan.

3.2 Aircraft performance data

- BADA performance models: BEACON uses BADA 4.2 performances from EUROCONTROL especially with regard to aircraft performance. Some consortium members have access to BADA 4.2.

3.3 Airspace environment

- R&D archive: it contains data for both filed and actual trajectories, and information about Flight Information Regions (FIR) and Air Traffic Control unit Airspace (AUA) crossed. More specifically: minimum and maximum vertical boundary of the airspace volume, FIR's shapes expressed as a set of points (latitude, longitude).
- EUROCONTROL's DDR2: the DDR2 repository also contains information regarding the airspace environment in terms of sector shapes, sector activations, sector and airport capacities, and basic ATFM regulations.

3.4 Passengers

3.4.1 Passenger itineraries:

Passenger itineraries in use are based on previous datasets developed by the University of Westminster for 2010 and 2014. As the consortium obtained the passenger itinerary data from IATA, these are currently under elaboration to divide passenger flows across the flights in use on 14 September 2018. The obtained data consists of the list of itineraries aggregated on the monthly level. Each itinerary contains:

- Dominant airline
- Segment airline
- Origin,
- Destination,
- Stops,
- Number of passengers
- Class
- Average fare

The elaboration of this data consists of disaggregating the monthly flows on flights that were operated on 14 September 2018.

3.4.2 Other passenger related items

- Airline load factors: passenger load factors reported by airlines.
- Airport connectivity information: airport reports on passenger connectivity from ACI EUROPE and individual airports.

3.5 Other

- Cost of delay: cost of delay models developed in-house by the University of Westminster (Cook & Tanner, 2015) have been revised for 2019 (see D3.2 Industry briefing on updates to the European cost of delay [4]. The cost tables in the database have been updated (see next section).
- CRCO unit rates: unit rates in effect on the selected test day for every Member State are required to properly assess the operational costs of modelled flights.

4 Database infrastructure

Large amounts of input and output data are used (and generated) by the project. Initial Data management plan [2] described potentially suitable platforms for storing data that the consortium was evaluating. The choice of the consortium is to continue exploiting the University of Westminster's database facilities. The database hosted at UoW has proven efficient and reliable during previous projects, guaranteed secure and flexible access, and did not require additional financial investment. Therefore, the majority of data used in the BEACON simulations are currently centralised in a single, secure database hosted at the University of Westminster. More in detail, data are stored in a MySQL server, as relational database, consisting of a virtual machine located at the University of Westminster's cluster.

4.1 Database access

Security is guaranteed via password-protected access, encrypted with an SSL (secure sockets layer) certificate. Partners have permissions to use the database resources for testing and production. These permissions are managed by the University of Westminster and limited to the partners considering their data requirements and subject to having adequate licencing agreements. The control of data access ensures that possible data corruption is minimised. For instance, UNITS has full writing and reading access to the data, since they are managing the content of the database in BEACON, while other partners involved in the modelling have read-only access or can create new tables but not erase any.

4.2 Database structure

Table 1. BEACON's beacon_*environment* tables summary

Used in BEACON execution	Used in preparing pre-computed data

• **Scenario**
  ○ scenario
  ○ eaman_definition_old1409
• **Demand**
  ○ flight_schedule_old1409
  ○ flight_subset
  ○ pax_itineraries_old1409
• **Aircraft performance**
  ○ ac_eq_badacomputed_static_old1409
• **Airport related**
  ○ airport_curfew_old1409
  ○ airport_info_static_old1409
  ○ airport_modif_cap_old1409
  ○ airports_curfews_ectl_old1409
  ○ airports_extra_time_curfews_ectl_old1409
  ○ airports_with_curfews_old1409
  ○ curfew_cost_estimated_old1409
  ○ curfew_non_pax_cost_old1409
  ○ mtt_static_old1409
	• **Routes/Trajectories**
	  ○ airspace_static_old1409
	  ○ route_pool_old1409
	  ○ route_pool_has_airspace_static_old1409
	  ○ trajectory_pool_old1409
	  ○ trajectory_segment_old1409

- taxi_in_static_old1409
- taxi_out_static_old1409
- **Costs**
  - non_pax_delay_fit_static_old1409
  - non_pax_delay_static_old1409
  - passenger_compensation_static_old1409
  - soft_cost_delay_static_old1409
  - duty_of_care_static_old1409
- **Delay/uncertainty**
  - delay_parameters
  - flight_uncertainties_static_old1409
  - iedf_atfm_static_old1409
  - prob_atfm_static_old1409
  - regulation_at_airport_days_static_old1409
  - regulation_at_airport_manual
  - regulation_at_airport_static_old1409
- **Flight plans/Routes**
  - fp_pool_m_old1409
  - fp_pool_point_m_old1409
- **Other**
  - airline_static_old1409
  - increment_cruise_dci_static_old1409

Table 1 presents the 39 tables present in the *beacon_environment schema*:

- 34 as direct input for the model;
- 5 as part of the pre-computation of data.

The diagram of the database is presented in Section 4.3 and a description of each of the tables with its different fields in Section 4.4.

4.3 Database structure diagrams

Figure 2 presents the full database structure. Due to the small size of the image, Figure 3, Figure 4 and Figure 5 show the page-size sections of the diagram, respectively left, central and right parts of the full diagram.

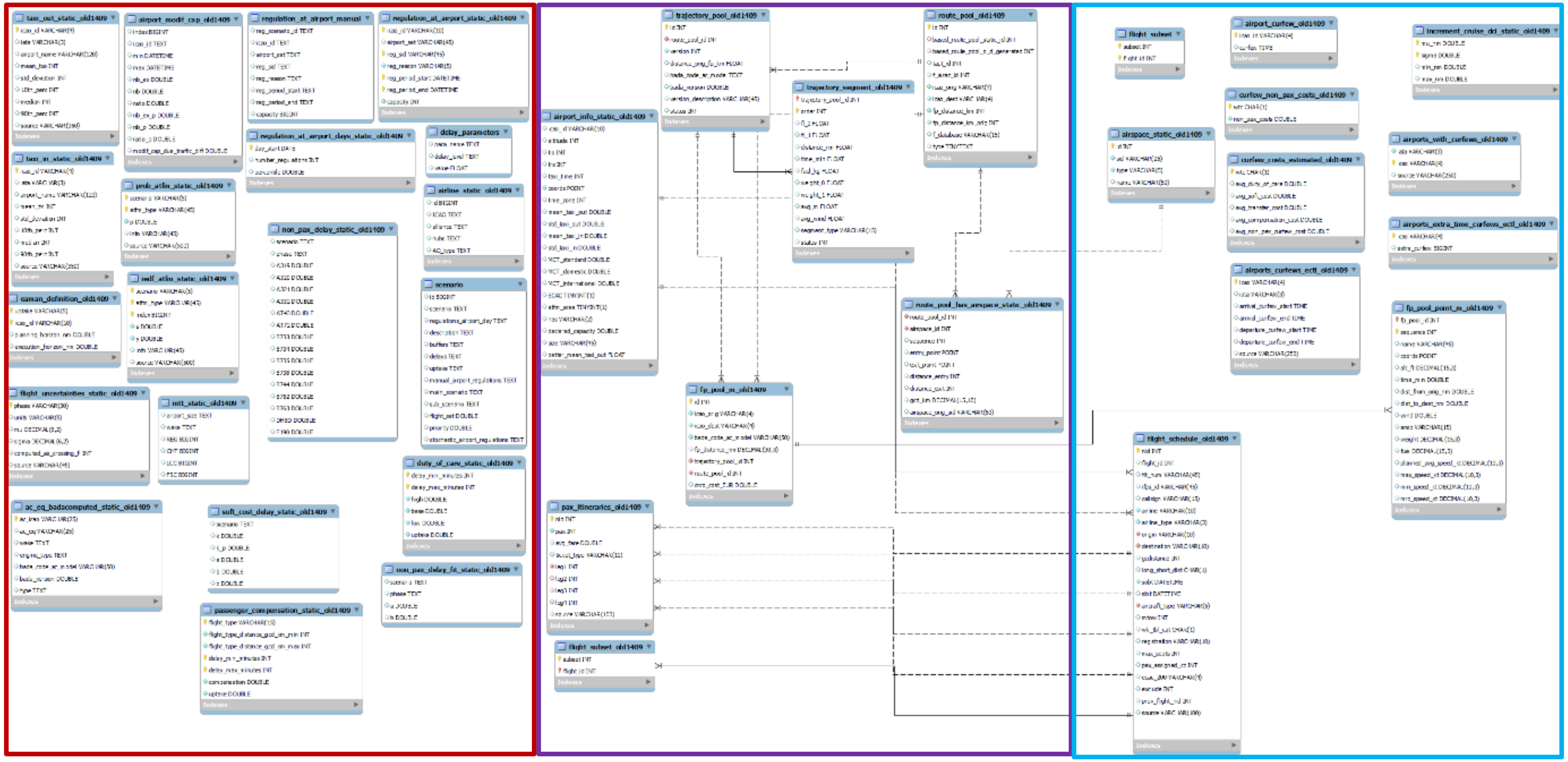

Figure 2. Full database diagram

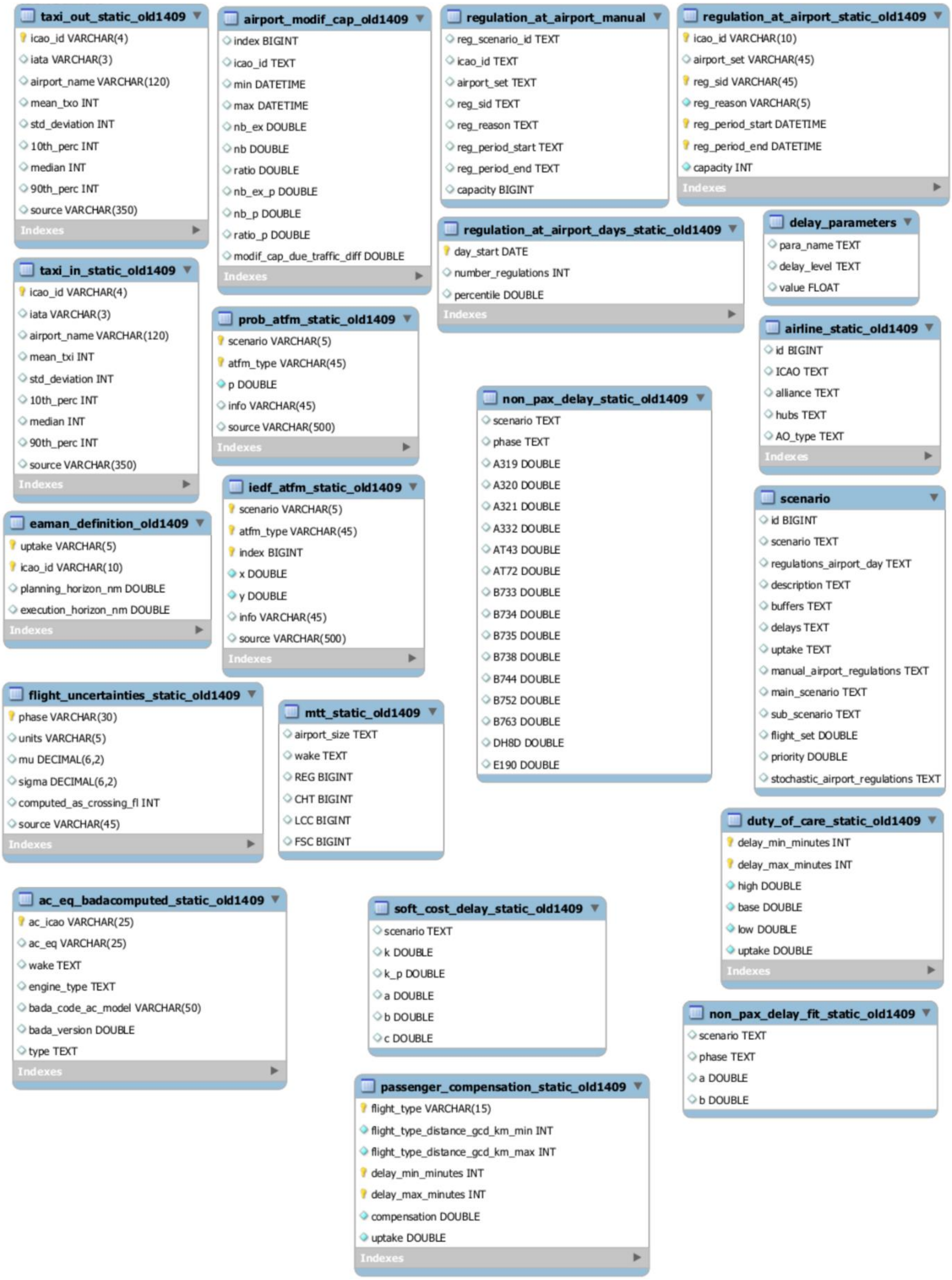

Figure 3. Part 1/3 database diagram (left part – red rectangle in Figure 2)

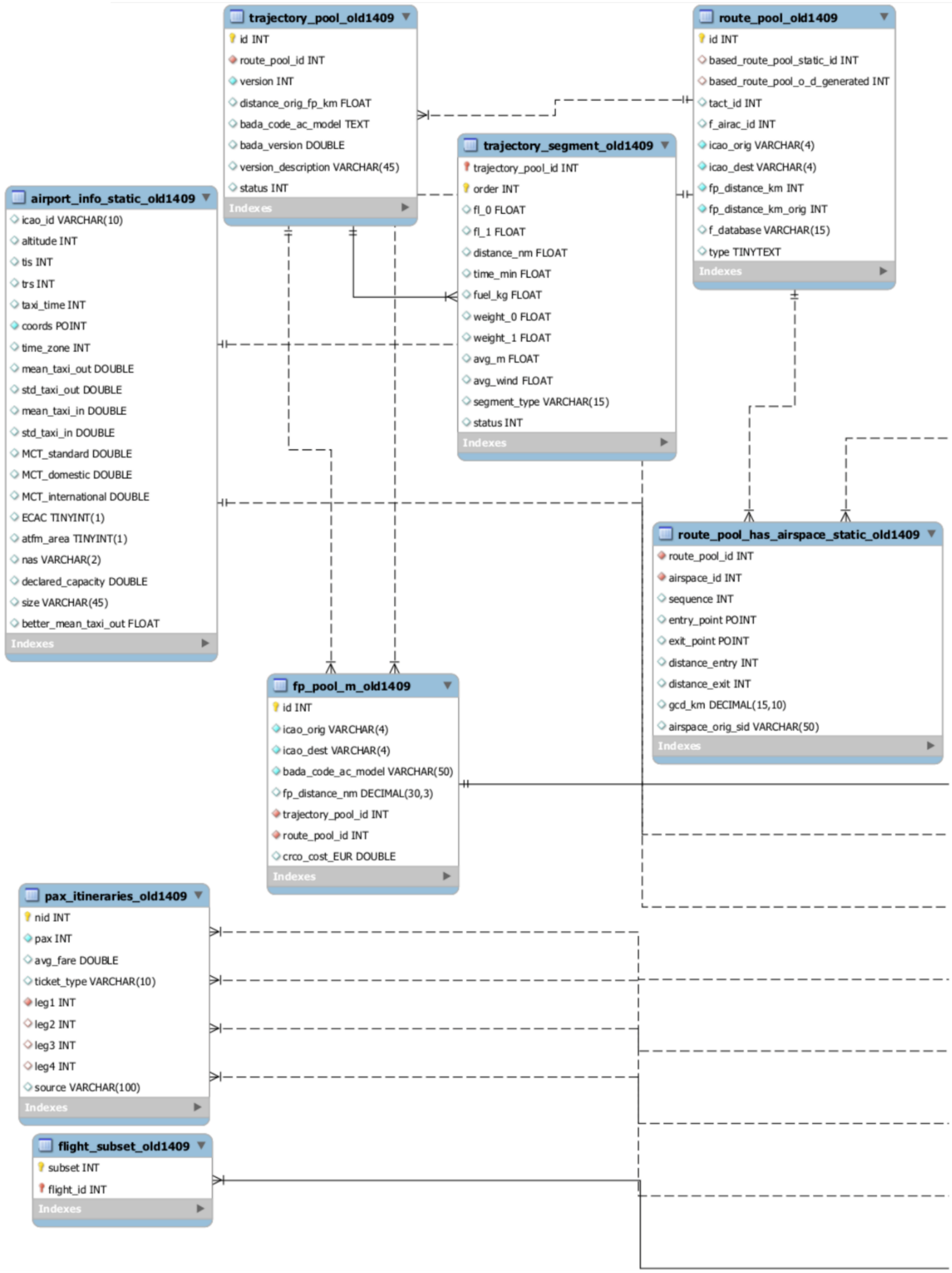

Figure 4. Part 2/3 database diagram (central part – purple rectangle in figure 2)

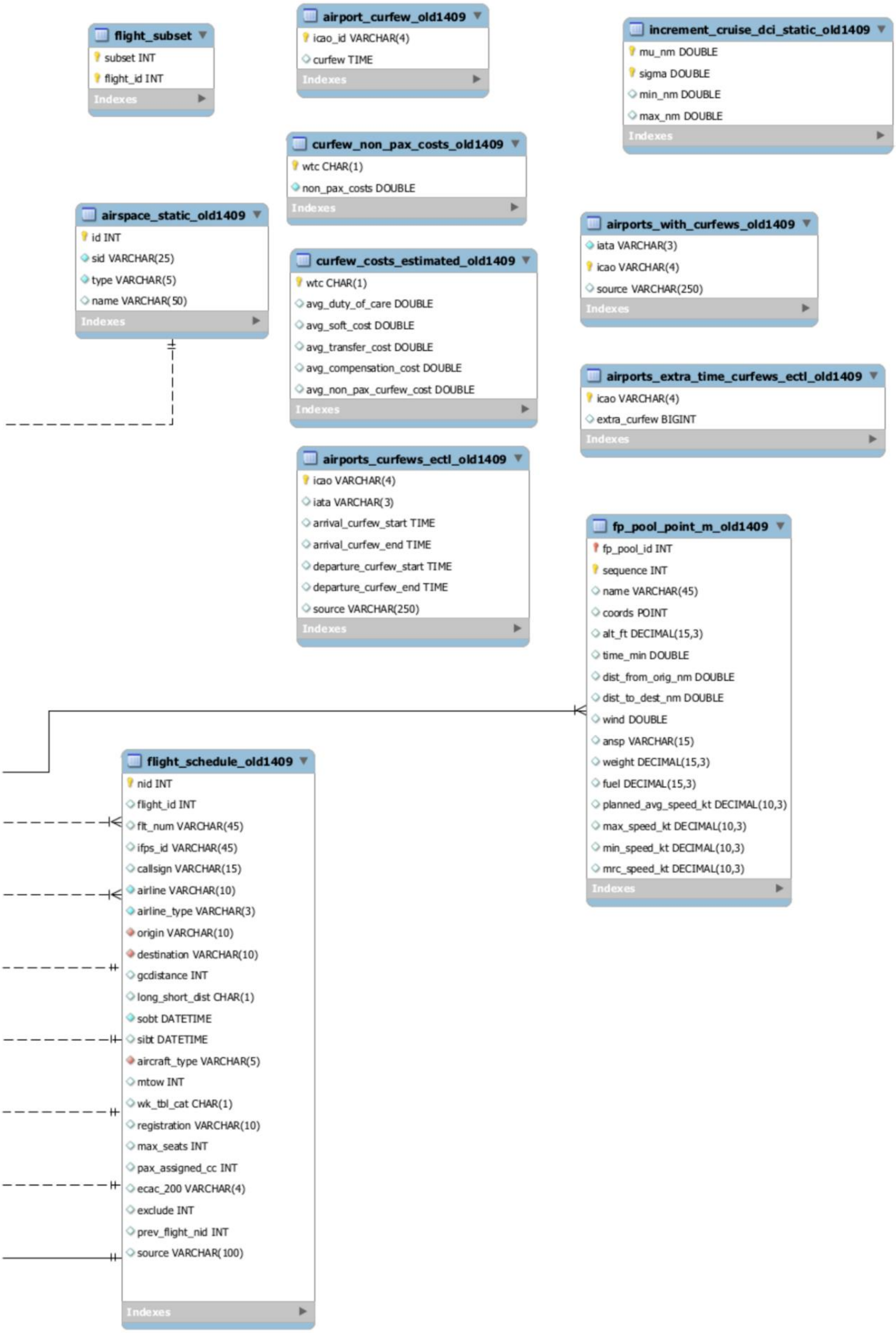

Figure 5. Part 3/3 database diagram (right part – blue rectangle in Figure 2)

4.4 Database tables

4.4.1 Data tables and their description

Table 2. ac_eq_badacomputed_static_old1409

Rationale: Table to link aircraft type with BADA model to be used to compute performances. Each ICAO aircraft type has an equivalent aircraft performance model to be used (it could be the same) and an associated BADA model to be used.

Field	Type	Primary key	Foreign Key	Rationale	Other info
ac_icao	varchar(25)	*		Aircraft ICAO code (e.g., A124)	
ac_eq	varchar(25)			Equivalent aircraft type used in performance (e.g., H_JET, E170)	
wake	text			Wake turbulence (i.e, H, M, J, L)	
engine_type	text			Engine type of aircraft (i.e., JET, PISTON, TURBOPROP)	
bada_code_ac_model	varchar(50)			Code from BADA3 or BADA4 used for the performance (e.g., A340-642)	
bada_version	double			Bada version used (i.e, 3, 4)	
type	text			Source of link between aircraft and bada_code_ac_model (i.e., historic, manually_added)	

Table 3. airline_static_old1409

Rationale: Information on airline type, hubs and alliances. The alliance information is used to build alliance objects within the model, important for the rebooking strategy of the airline. The information on the hubs is not used. The airline type field is used for the post-analysis only.

Field	Type	Primary key	Foreign Key	Rationale	Other info
id	bigint(20)			Incremental index	
ICAO	text			Airline ICAO code (e.g.,RYR)	
alliance	text			Alliance code	
hubs	text			Hub airport used by the airline as hub	
AO_type	text			CHT (charter), FSC (legacy carriers), LCC (low cost), REG (re-gional)	Low = all LCC flights High = FSC flights into a hub; REG flights into a hub Base = all other flights

Table 4. airport_curfew_old1409

Rationale: For airports with curfew the time when the curfew applies. This is only used in the strategy decisions of the airline to compute their cost function. The curfew is not yet enforced on the flights themselves in the current model version.

Field	Type	Primary key	Foreign Key	Rationale	Other info
icao_id	varchar(4)	*		Airport ICAO code (e.g., EDDM)	
curfew	time			Hours of night curfew at the airport in local time	

Table 5. airport_info_static_old1409

Rationale: Static information about the airports. This information collects different 'static' information about the airport. In particular, some statistics on the taxi-in, taxi-out, minimum connecting time etc. have been pre-computed and added to the database to be used in the model.

Field	Type	Primary key	Foreign Key	Rationale	Other info
icao_id	varchar(10)			Airport ICAO code (e.g., EDDM)	
altitude	int			Airport altitude in ft	
tis	int				from DDR2
trs	int				from DDR2
taxi_time	int				
coords	point			Airport coordinates	WKT format
time_zone	int				
mean_taxi_out	double			Average taxi-out time at the airport in minutes	
std_taxi_out	double			Standard deviation of taxi-out time at the airport in minutes	
mean_taxi_in	double			Average taxi-in time at the airport in minutes	
std_taxi_in	double			Standard deviation of taxi-in time at the airport in minutes	
MCT_standard	double			Standard minimum connecting time (min)	
MCT_domestic	double			Domestic minimum connecting time (min)	
MCT_international	double			International minimum connecting time (min)	
ECAC	tinyint(1)			Boolean to indicate if airport is part of ECAC	

atfm_area	tinyint(1)			Boolean to indicate if flights departing from airport could be affected by ATFM	
nas	varchar(2)			ANSP code from where airport is located	
declared_capacity	double			Airport declared capacity	
size	varchar(45)			Size of airport (small, medium, large or blank)	
better_mean_taxi_out	float			Better estimation for the taxi out times (min)	Not used in simulation

Table 6. airport_modif_cap_old1409

Rationale:

Field	Type	Primary key	Foreign Key	Rationale	Other info
index	bigint				
icao_id	text				
min	datetime				
max	datetime				
nb_ex	double				
nb	double				
ratio	double				
nb_ex_p	double				
nb_p	double				
ratio_p	double				
modif_cap_due_traffic_diff	double				

Table 7. airports_curfews_ectl_old1409

Rationale:

Field	Type	Primary key	Foreign Key	Rationale	Other info
icao	varchar(4)	*		Airport ICAO code (e.g., EDDM)	
iata	varchar(3)				
arrival_curfew_start	time				
arrival_curfew_end	time				
departure_curfew_start	time				
departure_curfew_end	time				
source	varchar(250)				

Table 8. airports_extra_time_curfews_ectl_old1409

Rationale:

Field	Type	Primary key	Foreign Key	Rationale	Other info
icao	varchar(4)	*		Airport ICAO code (e.g., EDDM)	
extra_curfew	bigint				

Table 9. airports_with_curfews_old1409

Rationale: For airports with curfew the time when the curfew applies. This is only used in the strategy decisions of the airline to compute their cost function. The curfew is not yet enforced on the flights themselves in the current model version.

Field	Type	Primary key	Foreign Key	Rationale	Other info
iata	varchar(3)				
icao	varchar(4)			Airport ICAO code (e.g., EDDM)	
source	varchar(250)				

Table 10. airspace_static_old1409

Rationale: Air Navigation Service Providers' (ANSPs') airspaces linking their id to their name. This table is used to retrieve the name of the ANSP, whereas the model uses an id to identify it.

Field	Type	Primary key	Foreign Key	Rationale	Other info
id	int	*		Incremental index	
sid	varchar(25)			String id of the airspace	e.g., LP
type	varchar(5)			Type 'NAS' for all airspaces	
name	varchar(50)			Airspace name	e.g., PORTUGAL

Table 11. curfew_cost_estimated_old1409

Rationale:

Field	Type	Primary key	Foreign Key	Rationale	Other info
wtc	char(1)	*			
avg_duty_of_care	double				
avg_soft_cost	double				
avg_transfer_cost	double				
avg_compensation_cost	double				
avg_non_pax_curfew_cost	double				

Table 12. curfew_non_pax_cost_old1409

Rationale:

Field	Type	Primary key	Foreign Key	Rationale	Other info
wtc	char(1)	*			
non_pax_costs	double				

Table 13. delay_parameters

Rationale: Table to store parameters linked with delay management in the simulation for different levels of delay. This table is used to set some parameter values depending on the scenario, and also to calibrate the model by adjusting some of the parameters.

Field	Type	Primary key	Foreign Key	Rationale	Other info
para_name	text			Name of the parameter	capacity_modifier to reduce capacity at airports extra_climb_tweak to adjust climb phase lambda_tat to adjust turnaround times non_ATFM_delay_lambda to adjust delay due to non-ATFM reasons perc_day_max percentile maximum used to sample days to select day for ATFM regulations at airport perc_day_min percentile minimum used to sample days to select day for ATFM regulations at airport taxi_time_modifer to adjust taxi times
delay_level	text			Delay level in simula-tion (D, H)	
value	float				

Table 14. duty_of_care_static_old1409

Rationale: Parameters for the duty of care of passengers. This table is used to build the cost function of the airline by setting the different time thresholds and level of care for passengers.

Field	Type	Primary key	Foreign Key	Rationale	Other info
delay_min_minutes	int	*		from which minute of delay the care start	
delay_max_minutes	int	*		up to which minute of delay the care goes	
high	double			Value for high case of care per pax	

base	double	Value for baseline case of care per pax
low	double	Value for low case of care per pax
Uptake	double	Percentage of passengers claiming the care

Table 15. eaman _definition_old1409

Rationale: Definition of E-AMAN scope for different cases. This table is used to fix the planning and execution horizon of the AMAN. The extent of these horizons depends on the scenario simulated.

Field	Type	Primary key	Foreign Key	Rationale	Other info
uptake	varchar(5)	*		Level of uptake (D: default)	
icao_id	varchar(10)	*		Airport ICAO code	
planning_horizon_nm	double			Planning horizon in NM around the airport	
execution_hori-zon_nm	double			Execution horizon in NM around the airport	

Table 16. flight_schedule_old1409

Rationale: Schedules used in BEACON. Includes the origin, destination, schedule off-block time and on-block time. Used to build the Flight object of the model and initialise it.

Field	Type	Pri-mary key	Foreign Key	Rationale	Other info
nid	int	*			
flight_id	int			id of the flight schedule	
fit_num	varchar(45)			unique code per flight joining airline_origindesti-nation	
ifps_id	varchar(45)			Ifps flight id	
callsign	varchar(15)			Callsign of the flight	
airline	varchar(10)			Airline of the flight	
airline_type	varchar(3)			AO type of the airline	
origin	varchar(10)		air-port_info_static_old 1409.icao_id	Origin of the flight	
destination	varchar(10)		air-port_info_static_old 1409.icao_id	Destination of the flight	
gcdistance	int			Great-circle distance from origin to destination	
long_short_dist	char(1)				
sobt	datetime			Scheduled off-block time	

sibt	datetime	Scheduled in-block time
aircraft_type	varchar(5)	Aircraft ICAO code (e.g., A124)
mtow	int	Maximum Take-Off Weight (MTOW) of the aircraft (in metric tones)
wk_tbl_cat	char(1)	Aircraft wake category
registration	varchar(10)	Aircraft registration (tail number)
max_seats	int	Maximum number of seats for this type of air-craft
pax_as-signed_cc	int	Number of passengers as-signed in ComplexityCosts project as reference
ecac_200	varchar(4)	If the airport of arrival (arr), departure (dep) or both (both) are part of the top 200 airports of ECAC
exclude	int	If the flight should be ex-cluded. E.g., cargo flight. In this table all flights are not excluded.
prev_flight_nid	int	Id of the previous rotation of the flight
source	varchar(100)	Source of schedules for traceability

Table 17. flight_subset

Rationale: Table to link subset of flights with their schedules. Different flights are used in different scenarios, mainly for testing purposes (the final scenarios have all the flights). This table allows to se-lect a subset of flights easily, with a single subset id.

Field	Type	Primary key	Foreign Key	Rationale	Other info
subset	int	*		subset of flight schedules id	
flight_id	int	*		id of the flight schedule that is part of the subset	

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Table 18. flight_uncertainties_static_old1409

Rationale: Statistics used in the model for the uncertainty on the different flight phases modelled as Normal distributions.

Field	Type	Primary key	Foreign Key	Rationale	Other info
phase	varchar(30)	*		Phase to where the uncertainty applies (i.e., climb, cruise)	
units	varchar(5)			Units of the Normal distribution (min for climb, NM for cruise)	
mu	decimal(6,2)			µ of Normal distribution used to model the uncertainty	
sigma	decimal(6,2)			σ of Normal distribution used to model the uncertainty	
computed_as_crossing_fl	int			Threshold to differentiate between climb/cruise used	
source	varchar(45)			Source from these uncertainties for traceability.	

Table 19. fp_pool_m_old1409

Rationale: Pool of flight plans (with pre-computed speed (i.e., Mach) and CRCO charges). This can be used in the model allowing changes of speed, winds and CRCO charges (e.g., unit rates), but since those computations are done in the execution of the simulation, it requires more computational time.

Field	Type	Primary key	Foreign Key	Rationale	Other info
id	int	*		Incremental index	
icao_orig	varchar(4)			ICAO code of the origin airport of the flight	
icao_dest	varchar(4)			ICAO code of the destination airport of the flight	
bada_code_ac_model	varchar(50)			Code from BADA3 or BADA4 used for the performance (e.g., A340-642)	
fp_distance_nm	decimal(30,3)			Flight length in NM	
trajectory_pool_id	int		trajectory_pool_old1409.id	Id of trajectory_pool table	Which trajectory (4D profile is used to generate this flight plan)
route_pool_id	int		route_pool_old1409.id	Id of route_pool table	Which route (2D profile is used to generate this flight plan)
crco_cost_EUR	double			CRCO cost of flight plan (EUR)	

Table 20. fp_pool_point_m_old1409

Rationale: Same as fp_pool_point_old1409 but with information on speed: wind, planned speed, minimum and maximum speed (considering the aircraft type, flight level and weight), MRC speed.

Field	Type	Primary key	Foreign Key	Rationale	Other info
fp_pool_id	int	*	fp_pool_old1409.id	Id of fp_pool_old1409 table	
sequence	int	*			
name	varchar(45)			Name associated with the point indicating the type or coordinates	
coords	point			Point coordinates	
alt_ft	decimal(15,3)				
time_min	double			Minute in which the point will be reached from departure	
dist_from_orig_nm	double			Distance between the point and the origin in NM	
dist_to_orig_nm	double			Distance between the point and the destination in NM	
wind	double				
ansp	varchar(15)			NAS ICAO code (e.g., EG) where the point is located.	
weight	decimal(15,3)			Aircraft weight at the point (kg)	
fuel	decimal(15,3)			Fuel consumed to reach the point from departure	
planned_avg_speed_kt	decimal(10,3)			Average planned flight speed at that point in Kt	
max_speed_kt	decimal(10,3)			Maximum speed that can be used at that point by the flight	
min_speed_kt	decimal(10,3)			Minimum speed that can be used at that point by the flight	
mrc_speed_kt	decimal(10,3)			Maximum Range Cruise speed at that point	

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Table 21. iedf_atfm_static_old1409

Rationale: Inverse empirical cumulative function for ATFM delay. Used to build the empirical distribution from which ATFM delays are sampled.

Field	Type	Primary key	Foreign Key	Rationale	Other info
scenario	varchar(5)	*			
atfm_type	varchar(45)	*		Type of ATFM regulation providing the delay: all_vista, weather_all, non_weather_all, all, weather_excluding_airports, non_weather_excluding_airports, all_excluding_airports	
index	bigint	*		Incremental index. A different one for each atfm_type	
x	double				
y	double				
info	varchar(45)				
source	varchar(500)				

Table 22. increment_cruise_dci_static_old1409

Rationale:

Field	Type	Primary key	Foreign Key	Rationale	Other info
mu_nm	double	*			
sigma	double	*			
min_nm	double				
man_nm	double				

Table 23. mtt_static_old1409

Rationale: Minimum turnaround time (MTT) for different aircraft types (considering wake turbulence), for different airports (small, medium and large) and for different types of airlines. Used as base statistic (quantile) for the turnaround time sampling.

Field	Type	Primary key	Foreign Key	Rationale	Other info
airport_size	text			Size of airport (small, medium, large)	
wake	text			Wake turbulence category (i.e, H-heavy, M - medium, J - super, L - light)	
REG	bigint			Regional airline MTT	
CHT	bigint			Charter airline MTT	
LCC	bigint			Low cost airline MTT	
FSC	bigint			Legacy carrier or scheduled carrier MTT	

Table 24. non_pax_delay_fit_static_old1409

Rationale: Table summarising a regression of non-passenger related costs as a function of time. This is used to build a function for quick cost of delay computations.

Field	Type	Primary key	Foreign Key	Rationale	Other info
scenario	text			Low, base, high	
phase	text			airborne, at_gate, taxi	
a	double			1st coefficient fitting	
b	double			2nd coefficient fitting	

Table 25. non_pax_delay_static_old1409

Rationale: Non-passenger delay cost for different phases, scenarios and aircraft types. This is used to build the detailed cost function for the airlines in the model.

Field	Type	Primary key	Foreign Key	Rationale	Other info
scenario	text			low, base, high	
phase	text			airborne, at gate, taxi	
A319	double				
A320	double				
A321	double				
A332	double				
AT43	double				
AT72	double				
B733	double				
B734	double				
B735	double				
B738	double				
B744	double				
B752	double				
B763	double				
DH8D	double				
E190	double				

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Table 26. passenger_compensation_static_old1409

Rationale: Information on Regulation 261 rules [5] and uptake, used in the detailed cost of delay function for the airlines. This table represents the actual rule; the uptake ratio is estimated.

Field	Type	Primary key	Foreign Key	Rationale	Other info
flight_type	varchar(15)	*		Long, medium or short	
flight_type_distance_gcd_km_min	int			Minimum distance in GCD for which this compensation applies	
flight_type_distance_gcd_km_max	int			Maximum distance in CGD up to which this compensation applies	
delay_min_minutes	int	*		Minimum delay experienced by passenger at arrival from which this compensation applies	
delay_max_minutes	int	*		Maximum delay experienced by passenger at arrival from which this compensation applies	
compensation	double			Amount of compensation according to Reg 261 (EU)	
uptake	double			Percentage of passengers claiming compensation	

Table 27. pax_itineraries_old1409

Rationale: Input passenger itineraries, used to build the passenger objects and initialise them.

Field	Type	Primary key	Foreign Key	Rationale	Other info
nid	int	*		Incremental index	
pax	int			number of passengers in group	
avg_fare	double			Average fare of the passengers in the group	
ticket_type	varchar(10)			Type of fare: flex or economy	
leg1	int		flight_schedule_old1409.nid	Index of flight_schedule_old1409 table of the 1st flight leg	
leg2	int		flight_schedule_old1409.nid	Index of flight_schedule_old1409 table of the 2nd flight leg or NULL	
leg3	int		flight_schedule_old1409.nid	Index of flight_schedule_old1409 table of the 3rd flight leg or NULL	
leg4	int		flight_schedule_old1409.nid	Index of flight_schedule_old1409 table of the 4th flight leg or NULL	
source	varchar(100)			source of data for traceability	

Table 28. prob_atfm_static_old1409

Rationale: Probability of being delayed due to ATFM for different reasons. These probabilities were computed from historical data.

Field	Type	Primary key	Foreign Key	Rationale	Other info
scenario	varchar(5)	*			
atfm_type	varchar(45)	*		all_vista, weather_all, non_weather_all, all, weather_excluding_airports, non_weather_excluding_airports, all_excluding_airports	
p	double				
Info	varchar(50)				
source	varchar(500)				

Table 29. regulation_at_airport_days_static_old1409

Rationale: Number of regulations at airports for historical days with their percentiles. This table allows the model to select random days for regulations, but controls their impact based on the number of regulations. High delay scenarios are built by selecting higher quantiles.

Field	Type	Primary key	Foreign Key	Rationale	Other info
day_start	date	*		Day to which regulations are associated	
number_regulations	int			Number of regulations at airport which were issued on that day	
percentile	double			Percentile according to number of regulations	

Table 30. regulation_at_airport_manual

Rationale:

Field	Type	Primary key	Foreign Key	Rationale	Other info
reg_scenario_id	text				
Icao_id	text				
airport_set	text				
reg_sid	text				
reg_reason	text				
reg_period_start	text				
reg_period_end	text				
capacity	bigint				

Table 31. regulation_at_airport_static_old1409

Rationale: Definition of regulations for each historical day at airports, used as references to model ATFM regulations. This includes the starting time of the regulation, its ending time, and the new capacity of the airport.

Field	Type	Primary key	Foreign Key	Rationale	Other info
icao_id	varchar(10)	*		Airport ICAO code (e.g., EDDM)	
airport_set	varchar(45)			If regulation is applied to an airport set (e.g., EBBR/MB)	
reg_sid	varchar(45)	*		Id of regulation	
reg_reason	varchar(5)			V, E, N, U, S, C, G, T, W, O	
reg_period_start	datetime	*		Date and time of start of the regulation	
reg_period_end	datetime	*		Date and time of end of the regulation	
capacity	int			Capacity associated with the airport	

Table 32. route_pool_old1409

Rationale: Routes possible between origin and destination pairs. These are based either on a route_pool_static (i.e., computed from a given historical flight plan) or a route_pool_o_d_generated when the origin-destination did not exist in the historical data and an estimation has been made.

Field	Type	Primary key	Foreign Key	Rationale	Other info
id	int	*		Incremental index	
based_route_pool_static_id	int			Index of route_pool_static_id table	
based_route_pool_o_d_generated	int			Index of route_pool_o_d_generated table	
tact_id	int			Id of the historical source	
f_airac_id	int			Id of the historical source	
icao_orig	varchar(4)			Airport ICAO code (e.g., EDDM)	
icao_dest	varchar(4)			Airport ICAO code (e.g., EDDM)	
fp_distance_km	int			Flight length in km	
fp_distance_km_orig	int			Distance in km from origin	
f_database	varchar(15)			Source database for traceability	ddr_1409 for all entries

type	tinytext	Type of data source: historic, based historic with intermediate, based_historic

Table 33. route_pool_has_airspace_static_old1409

Rationale: Table to link the route_pool_old1409 with the airspace information. This is used to compute CRCO charges for individual flight plans.

Field	Type	Primary key	Foreign Key	Rationale	Other info
route_pool_id	int		route_pool_old1409.id	Index of route_pool table	
airspace_id	int		airspace_static_old1409.id	Index of airspace_static table	
sequence	int			Order in the sequence of airspaces crossed by the route	
entry_point	point			Coordinates of entry point in the airspace	
exit_point	point			Coordinates of exit point in the airspace	
distance_entry	int			Distance between the entry point and the origin	
distance_exit	int			Distance between the exit point and the origin	
gcd_km	decimal(15,10)			Great circle distance travelled to go from the entry point to the exit point	
airspace_orig_sid	varchar(50)			Airport ICAO code (e.g., EDDM)	

Table 34. scenario

Rationale: Information on the scenario to be modelled in BEACON.

Field	Type	Primary key	Foreign Key	Rationale	Other info
id	int			Incremental id	
scenario	varchar(255)			Test, baseline, tactical_adjustments, pretactical_tactical_synergy, unitary_4DTA, unitary_FP, unitary_FAC or full_TBO	
regulations_airport_day	text			Date use as reference to generate explicit ATFM regulations at aiports from table regulation_at_airport_static_old1409	

description	text	Textual description of scenario
buffers	text	Buffers in scenario (D, L)
delays	text	Delay level in scenario (D,H)
uptake	text	Uptake level of mechanism (D, L)
manual_airport_regulations	text	
main_scenario	text	
sub_scenario	text	Sub-scenario within the main scenario
flight_set	double	
priority	double	Scenario priority: -1 (test), 0, 1, 2, 3, 4, 5
stochastic_airport_regulations	text	

Table 35. soft_cost_delay_static_old1409

Rationale: Passenger soft cost parameters for different scenarios. This table is used to estimate the impact of delay on the airline. This is based on the disutility of the passengers, using a logit rule, assuming that a decrease in passenger utility translates partly into a loss of market share for the airline.

Field	Type	Primary key	Foreign Key	Rationale	Other info
scenario	text			Low scenario, Base scenario, High scenario	
k	double				
k_p	double				
a	double				
b	double				
c	double				

Table 36. taxi_in_static_old1409

Rationale: Taxi-in information from CODA (from IATA Summer Season 2010). Distributions are built from the statistics included in this table, from which the taxi times are sampled.

Field	Type	Primary key	Foreign Key	Rationale	Other info
icao_id	varchar(4)	*		Airport ICAO code (e.g., EDDM)	
iata	varchar(3)			Airport IATA code (e.g., MUC)	
airport_name	varchar(120)			Name of the airport	
mean_txi	int			Mean taxi-in time	
std_deviation	int			Std deviation	
10th_perc	int			10th percentile	
median	int			Median	
90th_perc	int			90th percentile	
source	varchar(350)			source of the data for traceability	IATA Summer

Season 2010

Table 37. taxi_out_static_old1409

Rationale: Taxi-out information from CODA (from IATA Summer Season 2010).

Field	Type	Primary key	Foreign Key	Rationale	Other info
icao_id	varchar(4)	*		Airport ICAO code (e.g., EDDM)	
iata	varchar(3)			Airport IATA code (e.g., MUC)	
airport_name	varchar(120)			Name of the airport	
mean_txo	int			Mean taxi-out time	
std_deviation	int			Std deviation	
10th_perc	int			10th percentile	
median	int			Median	
90th_perc	int			90th percentile	
source	varchar(350)			source of the data for traceability	IATA Summer Season 2010

Table 38. trajectory_pool_old1409

Rationale: A 4D trajectory for a given route (2D). These trajectories have been generated using the BADA model and are used to initialise the planned trajectory in the model.

Field	Type	Primary key	Foreign Key	Rationale	Other info
id	int	*			
route_pool_id	int		route_pool_old1409.id	Index of route_pool_old1409 table to which this trajectory applies	
version	int			version used to generate the trajectory	
distance_orig_fp_km	float			Flight length in km	
bada_code_ac_model	text			Code from BADA3 or BADA4 used for the performance (e.g., A340-642)	
bada_version	double			Bada version used (i.e., 3, 4)	
version_description	varchar(45)			Test - no wind, Test - speed in info, Nominal - avg wind cruise - 0.7 payload or blank	
status	int			Status of the trajectory computation: 0 – all computation ok	0 for all entries

Table 39. trajectory_segment_old1409

Rationale: Segments of the trajectory. This table is used during the iterative cycle when the flight follows its trajectory in the simulation. It allows quick access to the distance, time needed, and weight of the aircraft at different points.

Field	Type	Primary key	Foreign Key	Rationale	Other info
trajectory_pool_id	int	*	trajectory_pool_old1409 .id	Index of trajectory_pool_old1409 table	
order	int	*		Order in which this segment is used in the trajectory	
fl_0	float			flight level of first point	
fl_1	float			Flight level of second point	
distance_nm	float			Distance between the points	
time_min	float			Time to go from first point to second point	
fuel_kg	float			Fuel consumed in segment (kg)	
weight_0	float			weight of the plane in the first point	
weight_1	float			weight of the plane in the second point	
avg_m	float			Average Mach speed	
avg_wind	float			Average wind (kt) in segment	
segment_type	varchar(15)			Climb, cruise or descent	
status	int			Status of segment computation	

5 Behavioural economics data collection

BEACON's general goal is to design new procedures for airspace users (AUs) to better allocate their resources (aircraft, pilots, crew, and others) in case of disruptions and evaluate the proposed procedures through new methods and tools able to take into account AUs' complex behaviours. To do so, the project aims to integrate the insights gained from behavioural economics into an agent-based microsimulation model of the full ECAC network able to capture network effects.

To the best of our knowledge, the behavioural economics literature does not cover aviation stakeholders and their decision-making processes. The BEACON project thus prepared two experiments to collect the data needed to assess behavioural economics parameters for decision-making in resource allocation by AUs: questionnaire and human-in-the-loop simulations.

5.1 Questionnaire

The questionnaire was planned in order to get data to calibrate behavioural effects in the subsequent models. Indeed, the behavioural frameworks we use in BEACON, prospect theory and hyperbolic discounting, use several parameters that need to be chosen. The questionnaire was designed by using typical situations in which behavioural effects captured by hyperbolic discounting and prospect can appear, with the goal to collect the parameters from the target population – airline dispatchers. The questionnaire can be found in the appendix of D4.1 [6].

Even though the survey was largely advertised, using different channels, only few responses were collected. The sample was too small to allow for statistical analyses and parameter estimation. Instead, the project used parameter values found in a literature review, as summarised in Table 40 from D4.1.

Table 40: Behavioural parameters from literature review.

	Suggested Model Formulation	Suggested Model Parameters
Prospect Theory Value Function	$v(x) = \begin{cases} x^{\alpha} & for\ \ x \geq 0 \\ -\lambda(-x)^{\beta} & for\ \ x < 0. \end{cases}$	*x* denotes the loss or gain relative to the reference point with *α = β = 0.88* and *λ = 2.25*
Prospect Theory Weighting Function	$\omega_{\pm}(p) = \frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{1/\gamma}}$	p denotes the probability of the outcome with $\gamma^{+} = 0.61$ and $\gamma^{-} = 0.69$
Hyperbolic Discounting	$V = \frac{A}{1 + kD}$	A denotes the value of the delayed reward, D the time delay length and *k* the discount rate with *ln(k) = 0.77*

We had two major pushes with the survey, over a long period of time. In the first attempt, the survey went online on 30th April 2021, and was shared with European Federation of Airline Dispatchers Association (EUFALDA), as the EUFALDA president agreed to share the link to the survey with their members. The survey was further publicised through BEACON website and BEACON Linked-in account and shared directly via consortium and advisory board members. Five months later we had one response.

The second attempt was agreed with IATA. The consortium members met with IATA representatives to discuss how they could help with the survey. The consortium proposed to organise a short workshop with dispatchers to explain the reasons for collecting the data and why the survey does not really touch on aviation questions, and then to ask the participants to fill in the survey. We were advised to share the survey link with IATA, as due to the high uncertainty under which the airlines were operating, it was close to impossible to get even an hour or two from dispatchers that are not linked directly to their work. Thus, IATA agreed to send the survey to their members, suggesting to fill it in. This second push started on 3rd December 2021. In March 2022 we obtained two additional responses.

In addition to these two major pushes, ECTL also contacted the advisory board and UDPP contacts in three separate occasions (15/07/21, 31/08/21 and 15/12/21) to push them to take the survey.

While it is difficult to estimate the required number ex-ante to be able to calibrate the behavioural parameters successfully, we estimated a minimum of 20 responses to be required as outlined in D4.1 [6]. In summary, the survey was online for almost a year, publicised through Advisory Board, EUFALDA, EUROCONTROL's UDPP contacts, IATA, SJU newsletter, shared through BEACON website, Linked-in, personal Linked-in accounts of BEACON team members, but we still did not manage to obtain the minimum responses needed despite multiple reminders and follow up requests.

5.2 Human-in-the-loop simulations

The goal of the human-in-the-loop (HITL) simulations was to get feedback on the mechanisms from participants and, if possible, compare the previous calibration (taken from literature, as explained above) to these new data. On top of that, the simulations will allow to assess the efficiency (as well as other metrics) of the mechanisms themselves when compared to real decision-making processes, i.e. from humans, as opposed to artificial agents. The HITL setup will be described in detail in D5.2 Final tactical model and results (pending).

In the HITL simulations the human participants to interacted with the Mercury simulator, through the interface designed for this purpose (see Figure 6 below for a screen snapshot). During the HITL simulations, we enabled data exchange between the simulator and participant, both as input (source simulator) and output (both simulator and participant are sources). The consortium collected ***both input and output data***, to be used in further calibration of behavioural economics parameters.

In the HITL simulations, the fast-time simulation model (Mercury) was starting a simulation of flights and passengers moving through Europe, until an air traffic flow management (ATFM) regulation hit the airport used in the simulation. The Mercury model uses as input the data from the database described in the previous section (see section Database tables4.4). When the ATFM regulations starts, information on the flights the participant was "managing" were sent to the interface. The participant had to prioritise the flights in the regulation, by inserting two pieces of information through the interface – margin and jump. This information were sent back to the model, which used them together with the decisions of artificial airline agents to solve the regulation. The final slot allocation was then sent back to the player, along with other relevant information, serving as feedback for their decisions.

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The participants interacted with two mechanisms: credit and ISTOP mechanisms (see deliverable D3.1 for description). The majority of information exchanged was the same in both mechanisms, details are described in the following text.

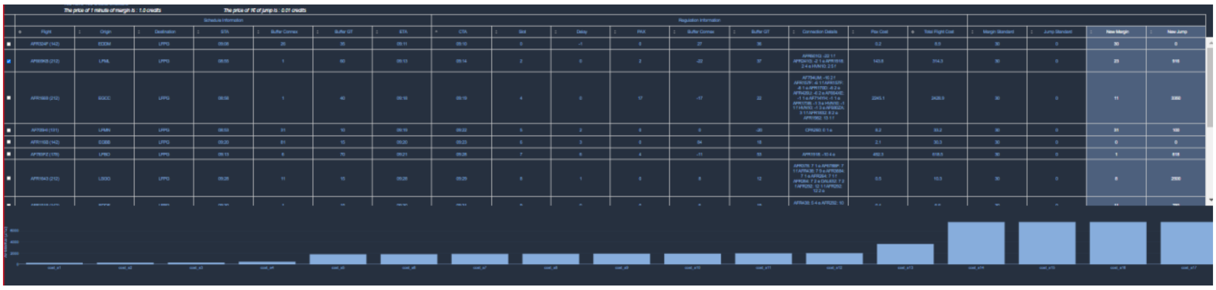

Figure 6. BEACON interface for HITL simulations.

5.2.1 HITL input data

The following data are sent from the simulator to the interface (and thus to the participant):

1. Slots in regulation. The slots are represented as times in seconds in the simulator, but were given as numbered slots in the interface.
2. Flights involved in the regulation, given as the flight ID number:
    a. Schedule information:
        i. Origin,
        ii. Destination,
        iii. Scheduled time of arrival,
        iv. Estimated times of arrival of regulated flights,
        v. Buffer connection – the time, in minutes over the guaranteed minimum connecting time for the passengers that have the least time between their arriving and departing flights,
        vi. Buffer GT – buffer ground time for the flight, which is expressed as the time over the minimum turn-around time, that captures the time between the arrival at the gate and the next scheduled arrival of the same airframe.
    b. Regulation information:
        i. Controlled time of arrival – as assigned with First Planned First Served algorithm,
        ii. Slot number – the slot in the queue that corresponds to the controlled time of arrival,
        iii. Delay in minutes,

iv. PAX – number of passengers loosing connection with the assigned delay,

v. Buffer connection – same as above, but taking into account the controlled time of arrival and not the estimated time of arrival,

vi. Buffer GT - same as above, but taking into account the controlled time of arrival and not the estimated time of arrival,

vii. Connection details – lists the connecting flights, number of passengers, per class, and the buffer the connecting passengers have (the number below zero indicates the lost connection),

viii. Passenger cost – the costs related to passengers missing connection if staying in the assigned slot,

ix. Total flight cost - the total flight costs if staying in the assigned slot.

3. Cost vectors of the flights. For each flight the costs were calculated for each slot in regulation (see the graph on the bottom of Figure 6). The costs take into account the operating costs and costs of delay. The costs of delay include passenger compensation and rebooking in case the delay causes the passengers to miss their connections. The costs include the reactionary and curfew delay, if applicable.
4. Margin standard – the 'free' value margin for this flight, based on which credits are paid or earned.
5. Jump standard – the 'free' value jump for this flight, based on which credits are paid or earned.
6. Amount of credits participant has to use in the regulation. Note this applies only to the credit mechanism.

5.2.2 HITL output data

The output data consists of data collected from the participant via interface, and the regulation resolution by the Mercury simulator.

The participant data consists of:

1. Margin – the minutes of delay at which the cost of delay for a particular flight has the value specified in jump.
2. Jump – the cost of delay.
3. Time it took to prioritise the flights in the regulation, i.e. the time that passed between the information appearing in the interface and the submittal of the prioritisation.

The simulation data:

1. Parameters for all flights in the regulation, as assigned by artificial airline agents,
2. Final slot allocation for all flights,

3. Final flight costs for all flights.
4. Credits each airline had at the beginning and at the end of regulation resolution. Note: only for credit mechanism.

5.2.3 HITL data storage

The data collected in the HITL simulation consists of simulation data and the data collected from participants. Deliverables D8.1, D8.2 and D8.3 describe ethical implications and actions to be undertaken by the consortium to inform the participants, obtain the consent and anonymise the data collected in the HITL simulations.

Based on the processed described in the above-mentioned deliverables, the data collected in the HITL are kept on the UoW's OneDrive. The data is anonymised, i.e. it is not known to the researchers who was the participant that produced certain output.

The data will be assessed and reported on in deliverable D5.2.

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6 Conclusions

The details of the database used in BEACON, including the data structure adopted, data sources, and data elaborations that were needed for the data analyses within a project are described.

The data elaborated for the database and the data synthesised for toy-model in WP4 are described in sections 2and 3, respectively. The detailed description of the relational database is presented, together with description of their usage.

Furthermore, one of the BEACON project aims was to calibrate behavioural economics parameters relating to airline dispatchers. To that end two instruments were applied: the questionnaire and the human-in-the-loop simulations. The survey was online for almost a year, publicised through Advisory Board, EUFALDA, IATA, SJU newsletter, shared through BEACON website, Linked-in, personal Linked-in accounts of BEACON team members, but we still did not manage to obtain the minimum responses needed (20) to be able to calibrate the parameters. Unfortunately, last year seems to have been quite a challenging one for airlines, which influenced this part of the project as well.

The goal of the human-in-the-loop (HITL) simulations was to get feedback on the mechanisms from participants and, if possible, compare the previous calibration (taken from literature, as explained above) to these new data. On top of that, the simulations will allow to assess the efficiency (as well as other metrics) of the mechanisms themselves when compared to real decision-making processes, i.e. from humans, as opposed to artificial agents. The HITL setup will be described in detail in D5.2 Final tactical model and results (pending).

7 References

[1] BEACON consortium, «D3.1 High-level modelling requirements,» 2021.

[2] BEACON consortium, «D2.1 Data Management Plan,» 3 February 2021.

[3] BEACON consortium, «D4.2 Final model results,» 2022 (forthcoming).

[4] BEACON consortium , «D3.2 Industry briefing on updates to the European cost of delay,» 2021.

[5] European Parliament, «Regulation No 261/2004 of the European Parliament and of the Council. Establishing common rules on compensation and assistance to passengers in the event of denied boarding and of cancellation or long delay of flights, and repealing Regulation No 295/91,» 2004.

[6] BEACON consortium, «D4.1 First model version and behavioural calibration,» 2021.

8 Acronyms

Acronym	Definition
AU	airspace user
ATFM	air traffic flow management
BADA	Base of aircraft data
CHT	charter
CRCO	Central Route Charges Office
ECAC	European Civil Aviation Conference
EUFALDA	European Federation of Airline Dispatchers Association
FSC	legacy carrier
H	heavy
HITL	human in the loop
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
J	et
L	light
LCC	low-cost carrier
M	medium
MCT	minimum connecting time
MRC	maximum range cruise
MTOW	maximum take-off weight
MTT	minimum turnaround time
REG	regional
SSL	secure socket layer

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