Agent-Based Pilot Model for Alternative Primary Airport Slot Allocation with Price-setting Auctions

Preliminary results of the ACCESS project

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***Abstract*—ACCESS (www.access-sesar.eu) is a SESAR WPE project aimed at designing, analysing and assessing alternative slot allocation mechanisms for primary and secondary allocation at congested airports. Compared to the current system, mainly based on administrative regulation and historic rights, ACCESS is focused on the study of market mechanisms. Market mechanisms are expected to provide the right incentives for a more efficient use of the available capacity, but they also raise a number of concerns. To evaluate the impact of different mechanisms in terms of a comprehensive set of Key Performance Indicators, ACCESS applies a scientific approach based on Auction Engineering to design the Auction Markets, Experiment Design to structure their analysis, and Agent-Based Modelling (ABM) and Simulation as the tool to perform Experimental Economics and test these mechanisms in realistic scenarios. This paper shows how these methodologies are applied in ACCESS, using a specific Combinatorial Auction Market as an example.**

Keywords-Slot allocation; primary allocation; secondary allocation; multi-airport; combinatorial auction markets; agent-based modelling; ABM; simulation; auction engineering; experimental economics.

I. INTRODUCTION

Currently, the primary allocation of slots in European airports is an administrative process governed by the EU Regulation 95/93 [1], based on the global principles defined by the IATA Worldwide Slot Guidelines [2], [3]. According to these regulations, primary allocation applies a series of criteria mainly based on historical precedence (the so called "grandfather rights"). New entrant airlines are only able to access freely to part of the remaining capacity. Secondary allocation takes place later, enabling airlines to trade or exchange some of the obtained slots on a one-for-one basis, so they can better accommodate their needs. The European regulation about this is not clear, and depending on the Member states, monetary exchanges can be allowed or not [4].

Despite its advantages, the current system does not guarantee that slots end up in the hands of the airlines that value them the most [5]. Besides, it has to be borne in mind that slot allocation is a problem of at least two airports: origin (take-off slots) and destination (landing slots). In some cases (especially for network carriers with a hub & spoke network) it can be an even more complicated problem involving more than two airports (i.e. flights feeding the hub, connections, etc.).

Many studies recommend open markets and auction markets for the acquisition of airport slots both in the EU and the US [6], [7], [8], [9], [10], [11]. Works such as [12] propose mechanisms that try to overcome the shortcomings of the typical auctioning procedures by incorporating the concept of social welfare. Another auction system aimed at progressively introducing auctions to replace administrative allocation is presented in [13], but it could involve different prices for slots in the same coordination time interval. ACCESS will provide two main advances beyond the state of the art: i) it will tackle slot allocation at multiple airports at the same time and ii) it will deliver a tool to test and assess different market mechanisms for primary and secondary allocation.

This paper presents the ACCESS methodology to study airport slot allocation mechanisms, and a Pilot Model to illustrate the application of combinatorial price-setting auctions to solve the primary allocation in a simple scenario. For this purpose, section II presents alternative primary and secondary slot allocation mechanisms, section III explains the scientific methodology applied in ACCESS, section IV describes the framework and characterisation of a combinatorial price-setting auction for the primary allocation, section V presents the simulation of a simple scenario to illustrate its implementation, and section VI summarises the main conclusions of the study.

II. ALTERNATIVE AIRPORT SLOT ALLOCATION MECHANISMS

ACCESS addresses primary and secondary slot allocation. The alternative mechanisms for primary allocation are classified in two major branches: mathematical optimisation techniques and market mechanisms. For the secondary allocation, two major approaches are distinguished: centralised markets with monetary exchanges, and decentralised markets with monetary or non-monetary exchanges. This paper is focused on the preliminary results of a simple Pilot Model for primary allocation.

Mathematical optimisation techniques use exact and heuristic algorithms that provide the best (or close to best) solution achievable for a pre-established problem definition, scope and constraints [14], [15], [16]. The need for a complete specification of the problem makes them hard to apply in the real world since: i) airlines may not be in favour of disclosing strategic information associated to the revenues and costs of operating certain flights at certain slots; and ii) even if they accepted to provide this information, they might not be able to express it correctly and precisely in mathematical terms.

As an alternative, market mechanisms, especially those based on auctions, should provide similar, or even the same results [8] without the need for any participant to disclose private information. Markets are based on supply and demand, which are ultimately based on economic factors, so they can provide information about how valuable a slot is in economic terms, therefore making explicit any implicit economic aspect. Besides, a market where the participants maximise their surplus is usually associated with a maximisation of the social welfare [17].

Airport slot allocation is a multi-airport dependent problem: to fly between two coordinated airports, airlines will always need at least two slots at different airports. These slots are interrelated, imposing restrictions over their requests (flight times, connections, etc.). Due to these dependencies between items, airport slot allocation is a combinatorial allocation problem (CAP). The mathematical analogy between CAPs and auction markets allows the use of auctions to solve CAPs [18].

III. ACCESS Project Methodology

ACCESS is aimed to analyse how alternative allocation mechanisms would perform to allocate slots of several airports at the same time, with particular focus on auction markets.

ACCESS is developing a simulation environment that will facilitate the assessment of a set of auction types and market configurations proposed for both primary and secondary allocation. Regarding primary allocation, auctions will be compared both with optimisation mechanisms and the current administrative allocation in terms of a set of Key Performance Indicators (KPIs) related to economic efficiency, equity, market competition, resilience, interoperability, capacity and delay [19].

For the sake of a rigorous scientific analysis, the use of this simulation environment is embedded in a methodology based on the design of scientific experiments [20], whose general scheme is shown in **Figure 1**, where:

- The inputs of the simulation environment are the particular combinations of primary and secondary slot allocation mechanisms to be studied and their configurations: they are the policies under testing, and it is in the hand of the regulator to modify them.
- The core of the simulation is composed by all the models (most of them agent-based models) that are going to be specified and coded, such as the airlines, airports, slot coordinators, passengers, the logic of the allocation mechanisms, etc.

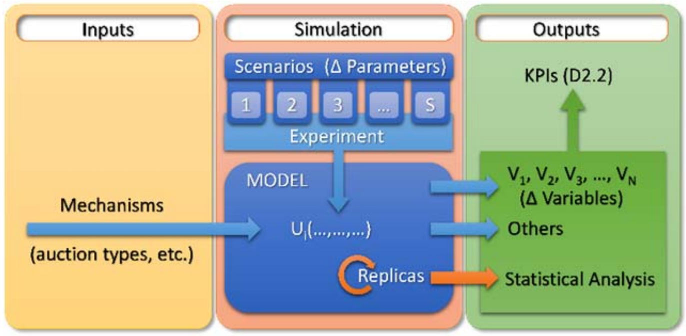


Figure 1. General structure of the ACCESS simulation process.

- Different combinations of the inputs shall be simulated using the models across a set of pre-established scenarios representing a variety of situations involving aspects not under the control of the regulator/policy maker, such as the passengers demand, the fuel price, the number of airlines in the market, the number of airports, etc. Scenarios will be arranged in experiments, where each experiment has a particular scientific aim that shall be achieved by means of a set of interrelated simulation scenarios.
- Simulations where randomness may be present will be replicated (executed) several times to allow a statistical analysis of the results.
- The output data are a set of variables influenced by the slot allocation mechanisms. These output data will be combined and/or aggregated to translate the results into the predefined set of KPIs to facilitate the elaboration of useful and understandable policy assessments.

A more detailed scheme of the experiment design process is shown in **Figure 2**. The different allocation mechanisms will be run through a combination of scenarios composed by sets of variables. Different replicas of each simulation will produce a huge amount of output data that will be post-processed to assess the performance of the different proposed mechanisms.

To design and configure the auction mechanisms under test we will apply Auction Engineering, a bottom-up approach where we are given a description of the outcome and the aim is to design the rules for the auction experiment that will reach it. Lots of aspects can be distinguished and parameterised in an auction (especially regarding the price update mechanism) and slight changes may lead to totally different outcomes. Experimental Economics with Agent-Based Modelling (ABM) and Simulation will be applied to test, refine and validate these auction designs. ABM enables a bottom-up approach which allows the interaction of different individual models that represent different parts of an overall problem. Each sub-problem can be formulated separately and emergent effects due to interactions can be identified. [21], [22], [23].

Following [21] and other Experimental Economics research, we consider three essential dimensions to design any market experiment: i) the Institution (I), comprising the exchange rules, the way to close contracts and the information network; ii) the Environment (E), comprising agent endowments and values, resources, etc.; and iii) the Agents' behaviour (A), including their objective functions, decision parameters, actions, etc.

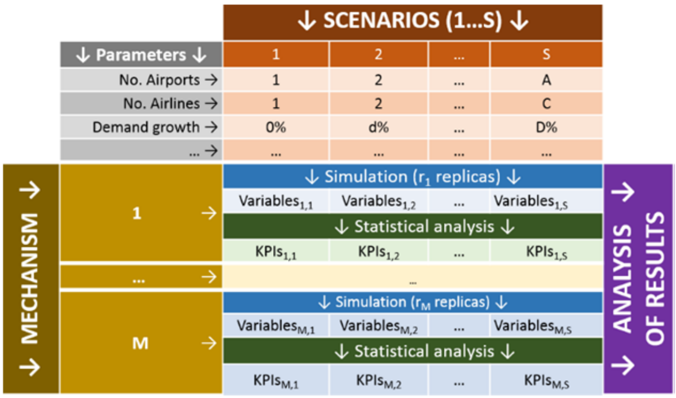


Figure 2. ACCESS experiment design.

IV. Combinatorial Price-Setting Auctions for Multi-Airport Slot Allocation

This section presents the specification of the auction mechanisms proposed by ACCESS, a combinatorial price-setting auction, in terms of the triplet I×E×A.

A. The Institution: Combinatorial Price-setting Auction

The proposed combinatorial price-setting auction has the following characteristics and rules [23], [24]:

- As a price-setting auction, the auctioneer varies the prices depending on the difference between supply and demand. The supply is determined by the capacity of the airports involved in the auction, which can be several at the same time. The capacity profile of an airport allows also the definition of rolling capacity constraints.
- Several slots can be combined in one request, therefore allowing an airline to bid at the same time for all its preferred slots and preventing the risk of inefficiencies due to the inability to achieve a correspondent slot pair in another airport for a certain slot already obtained before.
- It follows an iterative process, represented in **Figure 3**:
    1. Initial slot prices are communicated to the participants for individual arrival and departure slots separately. These prices can be related to certain default values, economic studies associated to operational costs, or other type of estimations.
    2. At each iteration, the airlines make their requests for their preferred slots depending on the current prices and their internal objective functions. They can displace the slots they request at each airport to different coordination time intervals.
    3. The auctioneer compares the requests with the capacity constraints and modifies the prices of every slot (arrival and departure separately) according to the gradient between them.
    4. These new prices are announced and used to repeat the process in the next iteration.
    5. The process is repeated until the stop criterion is met (maximum number of iterations, an equilibrium situation is reached, etc.).
- The auctioneer analyses the allocation produced by the auction. If there are situations where capacity constraints are still violated, the auctioneer applies a predefined tie-break mechanism and proposes alternative allocations that airlines are allowed to accept or reject. In any other case, airlines shall accept the slots they have requested.
- Finally, the auctioneer communicates: i) to each airline, the slots it has been allocated at every airport; ii) to each airport, its slots allocated to each airline.

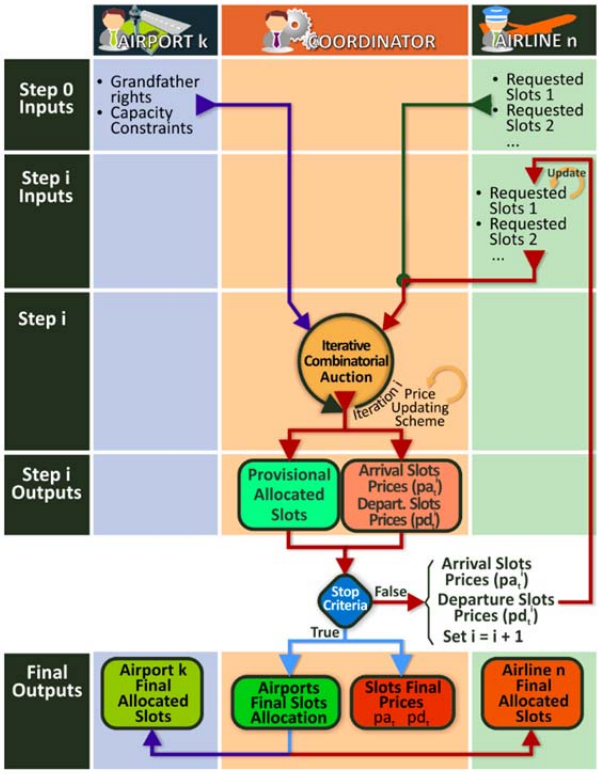


Figure 3. ACCESS combinatorial auction scheme.

B. The Environment

The environment comprises the airports acting as sellers, the airlines acting as buyers, and therefore bidders, and the slot allocation coordinator as the auctioneer.

Airports are endowed with a finite number of slots distributed in coordination time intervals, expressed as a set of capacity constraints profiles. Airports can be characterised by a set of marginal costs per slot or coordination interval, which will influence their minimum slot prices for the auction. Airlines are also endowed with certain baseline preferences and an objective function, which in the end is translated into a finite set of slot requests. Airline cost functions can become very complex as it is explained in Section IV.C.3).

The environment for a particular scenario is restricted in terms of number of traders (number of airlines and airports) and number of items (slots), but the economic values and slot prices are not restricted. Generally, total supply and demand may not be equal: as part of the experiment design, besides balanced scenarios, auctions will be tested in situations where the total demand is higher than the supply (airlines request more slots than the available capacity auctioned at the airports involved) and vice versa.

C. The Agents' Behaviour

Agents' behaviour has been implemented by means of agent-based modelling. ACCESS is defining complex agents' models involving a wide set of aspects, nevertheless at this stage of the project only few of them have been incorporated to the Pilot Model to facilitate the analysis of simpler and more understandable results. This first analysis will generate a deeper knowledge that will enable further analysis with more complex mechanisms and agents.

The following agents are included in this Pilot Model:

1) The coordinator

So far, the coordinator's only role is to act as auctioneer and apply the auction's rules to produce a feasible allocation. It shall communicate with airports to know their capacity constraints and with airlines to inform them about the slot prices and receive their corresponding requests. The coordinator shall not require or disclose any other private information of other agents.

The coordinator shall not favour any airline nor apply any preference; for this purpose airlines may participate anonymously in the auction. It shall establish prices $\left(\overline{P_{at}^{i)}}, \overline{P_{dt}^{i)}}\right)$ for arrivals a and departures d in each coordination interval t depending only on aggregated supply and demand (airlines can be anonymous for this purpose) in auction iteration i.

If the auction ends before achieving a feasible allocation which fulfils the airports' capacity constraints, the coordinator applies a feasibility and tie-breaking mechanism to the auction results in order to modify those allocations that still violate the capacity constraints, proposing alternative allocations. Two possibilities are considered: i) prioritise certain requests depending on economic or allocation criteria, or ii) follow a randomly ordered list of the airlines involved.

2) The airport

At this stage, the airport is represented by a "passive agent", defined only by its attributes and without any capability to initiate a communication process or make any decision.

The airport is defined by two sets of capacity constraints:

- Maximum number of arrival, departure and total slots per coordination time interval along the day.
- Maximum number of arrival, departure and total slots during several consecutive coordination time intervals (rolling capacity), which allow the modulation of the "nominal" capacity.

The airports shall communicate these capacity profiles to the coordinator when asked for them. They will receive their schedule with the allocated slots after the auction process.

3) The airlines

The airline model is expected to become very complex, because the decisions they make on which combinations of slots they request can be based on a wide set of factors such as passengers demand, market alliances, airline operating costs, fuel price, or the airline business model (network carrier, low-cost, etc.), among others. The decisions and behaviour (market strategies) of the bidders may impact any market to the point of producing completely different outcomes, where some of them may represent undesired situations (monopoly, collusion, etc.).

However, the principles of the airline agent applied in our initial Pilot Model are quite simple: the airline will try to maximise its surplus $S^{i)}\left(f^{i)}\right)$ in each auction iteration i according to its objective function, represented by a certain "utility" value, associated to being able to operate a flight $f^{i)}$ at certain coordination intervals $f^{i)} \to \left(\overline{t_a^{i)}}, \overline{t_d^{i)}}\right)$ where:

$\overline{t_a^{i)}}$ → vector of requested slots for arrivals at iteration i,

$\overline{t_d^{i)}}$ → vector of requested slots for departures at iteration i.

We have modelled this surplus as a maximum raw utility value $U\left(f^{0)}\right)$ diminished by:

- $SC^{i)}\left(f^{1)} \to f^{i)}\right) = \left|\overline{t_a^{i)}} - \overline{t_a^{1)}}\right| \cdot w_a + \left|\overline{t_d^{i)}} - \overline{t_d^{1)}}\right| \cdot w_d$, a cost due to having to displace the flight from the preferred coordination interval $f^{1)}$ to $f^{i)}$ (w_a and w_d are the unit cost per temporal unit displaced for arrivals and departures).
- The "auction costs", calculated as a payment function $P_m^{i)}\left(f^{i)}\right)$, due to the current slot prices $\left(\overline{P_{at}^{i)}}, \overline{P_{dt}^{i)}}\right)$.

Each airline requests the slots maximising its surplus considering the current prices. Therefore, depending on the prices, each airline may decide to displace its requests to cheaper slots if they help maximise their expected utility. If the price of every slot becomes so high than no positive utility can be achieved from the flight, the airline will not bid for any of them (for the moment, we don't model more complex behaviours related to indebtedness, speculation, etc.).

For the Pilot Model presented in this work, airlines request just a pair of slots at each airport, one for arrival and one for departure. Flight utility and displacement costs are parameterised with sample values in order to focus on how the auction process works. Future evolutions of the airline's model will associate these values to embedded sub-models.

Turnaround times associated to airlines' flights are considered in the model (s_m), so the departure slot requested depends on the arrival slot, the prices, the costs and the minimum turnaround time of the flight, which ensures basic complementarity between slots at a single airport level.

V. Agent-Based Pilot Model

This section presents the scope of the simulation, the environment used for its implementation, the scenario to be run and the analysis of the results obtained after the execution.

A. *Simulation scope*

The scope of the simulation of this Pilot Model is to represent a combinatorial price-setting auction for a single airport. The results will be compared in the future with both optimisation mechanisms based on linear programming and administrative mechanisms. The aim is to assess whether or not several methodologies can be compared, and which of them can produce better outcomes for each particular scenario.

Although this Pilot Model only accomplishes the slot allocation for a single airport, the airlines' requests are combinatorial: they request an arrival and a departure slot, where the departure slot also depends on internal airline parameters associated to certain flight characteristics.

B. *Simulation environment*

The simulation environment used for this work is based on NetLogo, a platform that enables ABM Programming and Simulation. NetLogo is very useful for prototyping and building pilot models with local interaction of agents and grid environments that are not too complex. Lots of scientific works have been published using NetLogo and it has been proven that many models can be implemented using it. It is freely available and it comes with an extensive model library [26], [26].

C. *Simulation scenario*

The simulation scenario is composed by:

- One airport with 10 coordination time intervals and certain number of available slots in them (**TABLE I**).
- 10 airlines that request one pair of slots $(t_a^{1)}, t_d^{1)})$ each, one for arrival and one for departure.
- One coordinator, acting as the auctioneer.

The parameters of the price update mechanism are not fine-tuned (this will be accomplished in future works). Initial arrival and departure slot prices are set to zero: $\left(P_{at}^{1)}, P_{dt}^{1)}\right) = (\bar{0}, \bar{0})$.

TABLE I shows the airport's slot constraints: the number of operations allowed per type (a, d or t) along certain number *(h=1,…,4)* of consecutive coordination intervals ($t_j \rightarrow t_{j+h}$).

TABLE I. AIRPORT SLOT CONSTRAINTS FOR THE SIMULATION SCENARIO.

		Rolling constraint order (h)			
		1	2	3	4
Number of available slots	Arrivals (a)	2	3	5	7
	Departures (d)	2	3	4	5
	Total (t)	3	5	8	10

The parameterisation of the airlines and their preferred flight slot combinations are shown in **TABLE II**. Each airline's request is only known by the coordinator, being confidential for other airlines. Only in the end of the auction the coordinator will announce the winner requests.

TABLE II. AIRLINES' PARAMETERISATION FOR THE SIMULATION SCENARIO.

Airline ID (m)	$t_a^{1)}$	$t_d^{1)}$	w_a	w_d	s_m	$U(t_a^{1)}, t_d^{1)})$
1	2	4	1	1	1	30
2	2	3	1,5	1,8	1	30
3	3	6	1,1	1,2	2	40
4	1	2	0,3	0,5	1	50
5	3	5	0,5	0,9	1	30
6	1	2	2	1,9	1	40
7	3	4	1,4	1,3	1	20
8	4	7	0,2	0,1	2	30
9	2	5	2	1	1	50
10	3	5	1	1,2	2	30

D. *Simulation results*

This section illustrates the development of the iterative combinatorial auction for the scenario presented above, describing the results of several particular iterations.

0) *Initialisation*

The coordinator announces to the airlines the initial slot prices, in this case all equal to zero: $\left(P_{at}^{1)}, P_{dt}^{1)}\right) = (\bar{0}, \bar{0})$.

1) *Iteration i = 1*

Figure 4 shows all the airlines initial slot requests $f^{1)}$, which are the ones established as their preference in **TABLE II**.

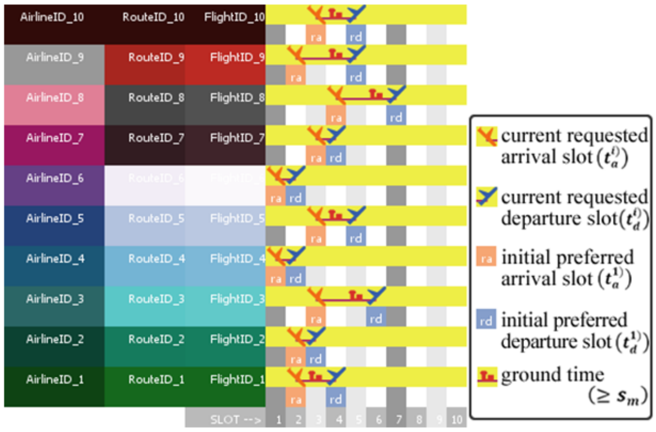


Figure 4. Initial slot requests (iteration *i* = 1).

The coordinator aggregates all the requests $f^{1)} \rightarrow \left(t_a^{1)}, t_d^{1)}\right)$ to obtain the total demand. The initial allocation violates the capacity constraints of the airport, as **Figure 5** shows for the nominal capacity (h = *1*) and three rolling capacity constraints of several orders (h = *2*, *3*, *4*).

The coordinator modifies the prices depending on the difference between supply and aggregated demand: analysing all the capacity constraints at each coordination interval *(h=1,…,4)*, it imposes penalties to increase prices at those coordination intervals affected by constraints violations, and to decrease them otherwise (negative prices are not considered in this model). The new prices obtained are represented in Figure 6 and saved to be used at the next iteration, $\left(P_{at}^{2)}, P_{dt}^{2)}\right)$.

Prices are increased only for those slots *affected* by a capacity constraint violation. It shall be noted that a rolling constraint *affects* as many consecutive coordination intervals as its order. Therefore, although no violation can be directly observed in **Figure 5** at intervals 6 and 7, **Figure 6** shows that their prices have been raised. This is produced by rolling constraints violations at previous intervals which, because of their order, cause that the slot demand at intervals 6 and 7 cannot be satisfied. The coordinator shall take these effects into account when dealing with rolling capacity constraints.

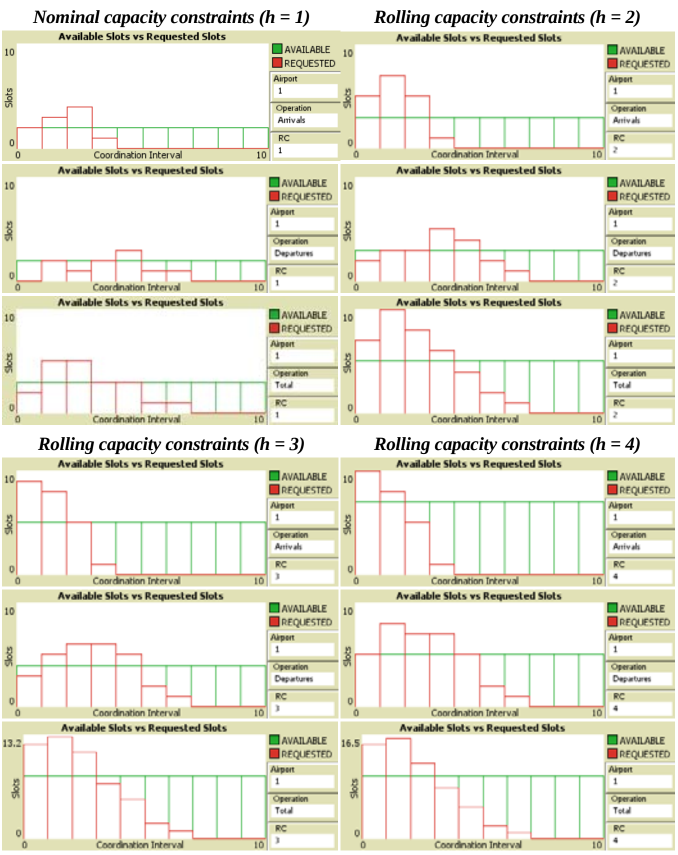


Figure 5. Available slots VS allocated slots at iteration *i* = *1*. Operations *a*, *d*, *t*. Constraints for *h* = *1*, …, *4*.

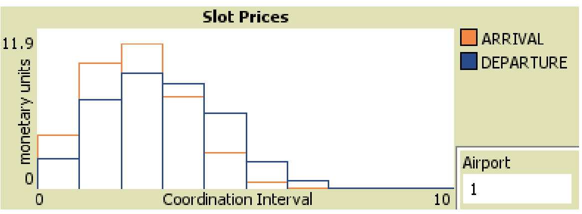


Figure 6. Prices after iteration *1*, to be applied for iteration *2*.

2) Iteration i = 2

The coordinator announces the new prices $\left(P_{at}^{2)}, P_{dt}^{2)}\right)$ and each airline recalculates its new request $f^{2)}$ (**Figure 7**) to maximise its surplus $S^{2)}\left(f^{2)}\right)$ according to these new prices. To achieve this, if necessary, airlines will displace their request to cheaper coordination intervals so that the payment savings $P_m^{2)}\left(f^{2)}\right)$ compensate the utility loss due to this displacement $SC^{2)}\left(f^{1)} \rightarrow f^{2)}\right)$. Figure 8 shows that, although some requests have spread to other coordination intervals, the aggregated demand still violates several slot constraints at the airport. Therefore, the coordinator updates the prices to be used in the following iteration $\left(P_{at}^{3)}, P_{dt}^{3)}\right)$, represented in **Figure 9**.

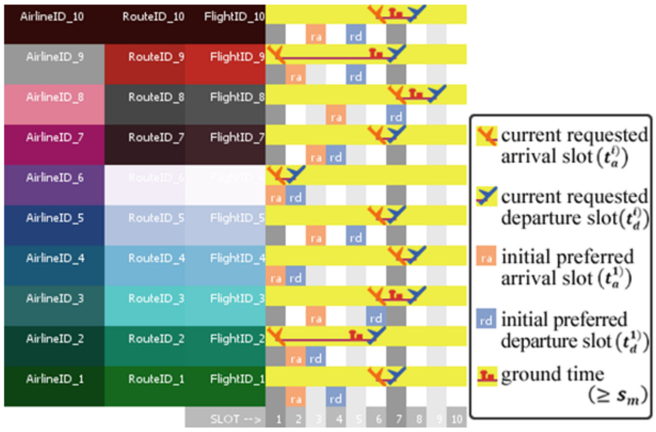
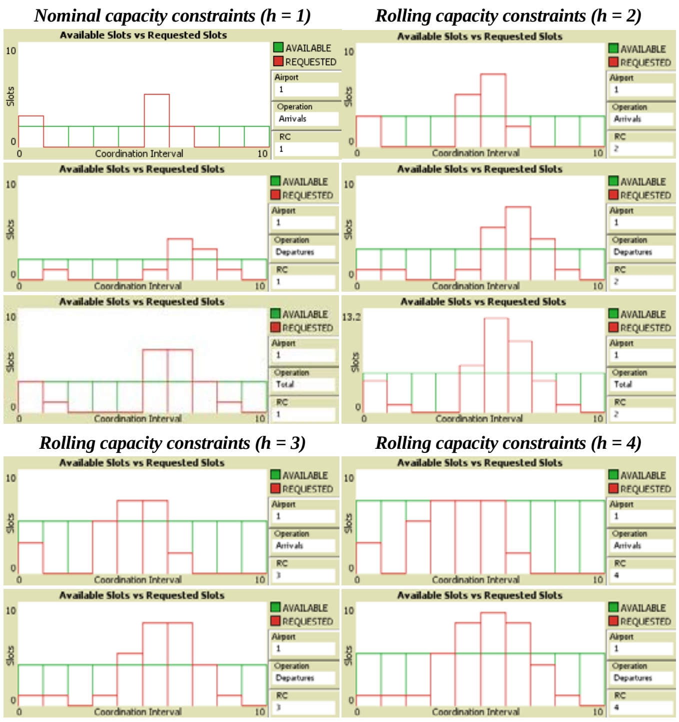


Figure 7. Slot requests at iteration *i* = *2*.



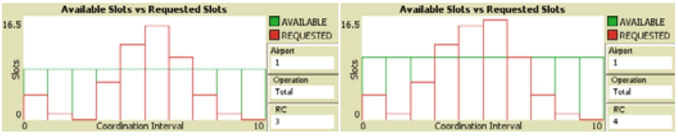


Figure 8. Available slots VS allocated slots at iteration $i = 2$. Operations a, d, t. Constraints for $h = 1, \ldots, 4$.

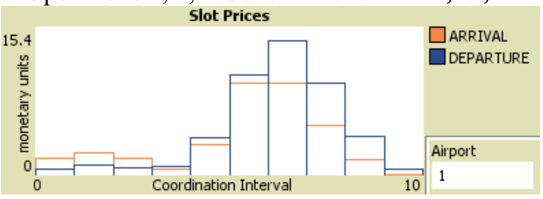


Figure 9. Prices after iteration $i = 2$, to be applied at iteration $i = 3$.

3) *Iteration i = 175*

The process continues and we jump to $i = 175$. The slot prices announced for this iteration are the ones calculated and established after iteration $i = 174$: $\left(\overline{P_{at}^{175)}}, \overline{P_{dt}^{175)}}\right)$ (**Figure 10**).

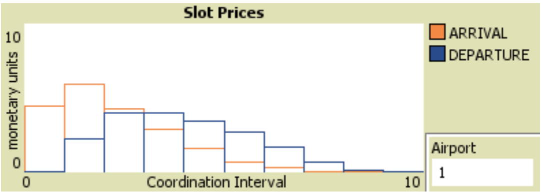


Figure 10. Prices after iteration *174*, to be applied at iteration *175*.

The requests $f^{175)}$ at this iteration are shown in **Figure 11**. In this case, as it can be seen in **Figure 12**, the aggregated demand fulfils all the capacity constraints. Therefore, the current requests are a feasible solution for the slot allocation problem.

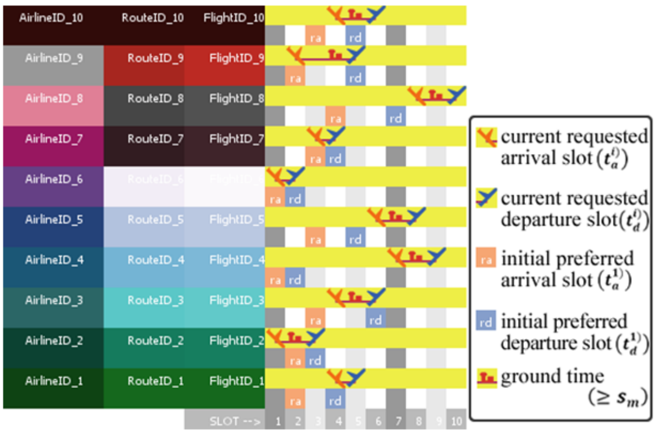


Figure 11. Slot requests at iteration $i = 175$.

The prices that allowed this solution are the ones that led to this set of requests: $\left(\overline{P_{at}^{175)}}, \overline{P_{dt}^{175)}}\right)$, detailed in **TABLE III.** Although these prices have cleared the market, there may still be better solutions that we can only observe running more iterations of the auction [24], [27].

TABLE III. PRICES PRODUCING A FEASIBLE ALLOCATION AT ITERATION *I = 175*

Coordination Interval t	***Arrival slot price*** $P_{at}^{175)}$	***Departure slot price*** $P_{at}^{175)}$
1	4.4398	0
2	5.9745	2.2756
3	4.2881	3.9178
4	2.7839	3.9017
5	1.6361	3.3918
6	0.7232	2.6674
7	0.3511	1.8105
8	0.0625	0.7469
9	0	0.1395
10	0	0.0125

4) *Following iterations and auction results*

During the model runs we have also observed that the slot prices were approximately stabilised (with little variations) since the iteration $i = 90$; subsequent iterations only provided slight or no changes in the slot allocation.

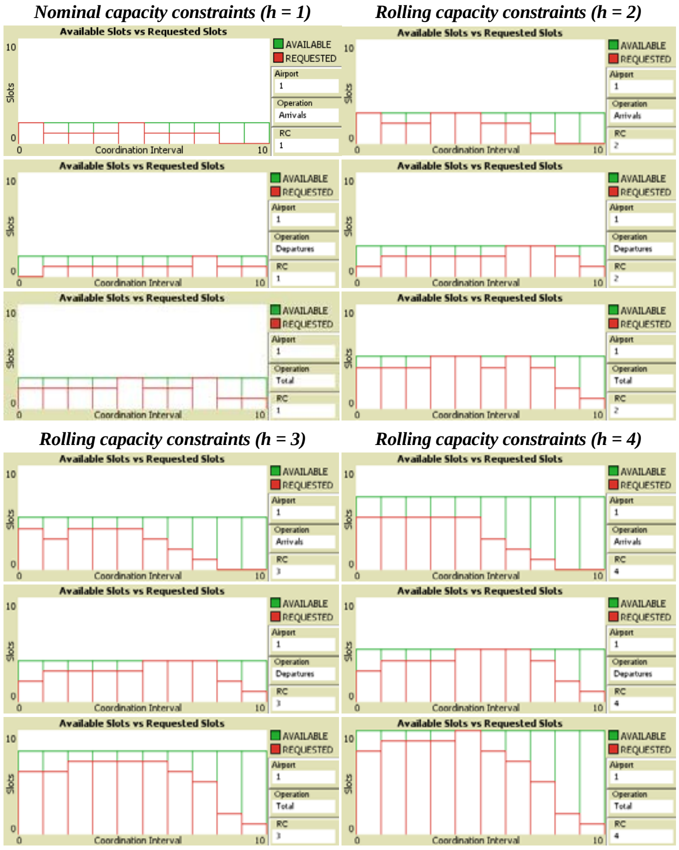


Figure 12. Available slots VS allocated slots at iteration $i = 175$. Operations a, d, t. Constraints for $h = 1, \ldots, 4$.

Preliminary tests showed that the convergence speed to equilibrium prices strongly depends on the initial prices, the price update mechanism and its parameterisation. By optimising these factors the auction process will require to run less iterations to achieve similar results.

ACCESS will study this optimisation in future research. In the simulated scenario, equilibrium prices also provided a feasible allocation, so the coordinator does not need to apply the feasibility mechanism. The slots requested in the last iteration are taken as winner bids and established as the final allocation.

VI. Conclusions

In this paper we have studied primary auctioning of all airport capacity in a simplified scenario. More sophisticated primary and secondary mechanisms will be studied in future research, e.g. combining the current grandfather rights with auctioning of the slot pool and/or with the use of combinatorial price-setting auctions for the secondary market.

Combinatorial auction markets can be valid mechanisms for primary airport slot allocation. Depending on the scenario, auctions lead to equilibrium situations where, without violating any airport capacity constraint, airlines are allocated slots while the overall surplus is maximised. They provide a way to solve the problem where the only information exchanged between coordinator and airlines are slot prices and slot requests: participants do not disclose private information such as costs, strategies, etc. When the process is completed, the economic value of each slot is obtained. Different prices are obtained for arrival and departure slots, but the price of every arrival or departure slot in the same coordination interval is the same.

A simulation environment based on Agent-Based Modelling allows the application of Experimental Economics (a bottom-up approach) to assess and validate Auction Market designs for slot allocation. The proposed methodology, based on Experiment Design, facilitates the definition of particular scenarios that will be used to compare the outcome of auction markets with mathematical optimisation and administrative mechanisms.

The triplet Institution, Environment and Agents' behaviour (I×E×A), provides a complete specification of the market design. Given the scope of the ACCESS project, the Institution and the Agents' Behaviours will be so far the main point of study. Basic agents' implementation in a first stage facilitates the understanding of the auction mechanisms. Preliminary tests have shown that the speed of the convergence to equilibrium prices strongly depends on the initial prices, the price update mechanism and its parameterisation. These optimisations are currently under study as part of the Project's scope and they are expected to significantly decrease the number of iterations that the auction process needs to achieve similar results.

ACCESS is extending this Pilot Model in several ways. On the one hand, it is extending the auction mechanisms to allocate slots at several airports at the same time. Issues related to market protection against undesired effects (monopolistic behaviours, etc.) will also be addressed. On the other hand, it is including more complex and realistic agent characterisations to study the impact of more complex behaviours over the allocation mechanisms. (Project partners will publish the results of these studies in future papers.

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