# Functional Relationship of Elements of Apron and Terminal Building at the Airport

Igor Poltoracki

*Abstract*— **This paper deals with the problem of determination of the required number of certain elements of airport passenger terminal complex (aircraft parking positions, check-in counters, gate lounges, and baggage claim devices); as well as with determination of the functional relationship between these elements. For each of the abovementioned airport passenger terminal complex elements, an adequate simulation model for determination of the required number of these elements is developed, and several experiments - numerical examples, based on different input data (traffic scenarios), are carried out, showing that models reflect well the ideas they are based on. A set of analyses of results from numerical examples for particular scenarios, as well as comparative analysis of results obtained for different traffic structures in different models of airport passenger terminal complex elements are subsequently performed.**

***Index Terms*—Airport, Apron, Gate, Passenger Terminal, Capacity, Modelling**

## I. Introduction

There are many papers addressing the problem of the capacity of existing or planned facilities at the airport. One particularly important and interesting problem related to modern airports is determination of the capacity of certain elements of a passenger terminal complex (e.g. aircraft parking stands). Namely, most of the large airports are faced with such a demand during peak hours that it exceeds the available number of aircraft stands (positions) adjacent to the terminal building.

However, this problem could be viewed from another perspective, in the sense that the scope is to determine required number of certain elements of airport passenger terminal complex. The motivation for this research comes from the fact that there are very few studies related to this problem, even though it is a very significant aspect in airport passenger terminal complex planning and management.

Within this research, only aircraft parking (gate) positions, and those elements (facilities) of an airport passenger terminal that are by its function connected to aircraft stands, and have direct impact on them, such as check-in counters, gate lounges, and baggage claim devices, were taken into consideration. The other elements (facilities) of an airport passenger terminal that may or may not appear in an arrival or departure flow, such as passport control, customs, security checks, etc., were disregarded.

The basic parameters that have influence on required number of previously mentioned elements of airport passenger terminal complex, are comprised in, or influenced by traffic schedule, e.g. aircraft arrival rate at the apron, fleet structure, gate (stand) occupancy time, passenger arrival rate at the airport, number of passengers and baggage per flight (both arriving and departing), etc.

The aim of this research was to develop several models for determination of the required number of previously mentioned elements of airport passenger terminal complex.

## II. Relationship of Operation of Gate Position and Other Facilities

The relationship of operation of single gate position and other facilities (resources) that are related to it, and obligatory in departure and arrival flow (check-in counters, gate lounge, and baggage claim devices), is depicted in Fig. 1.

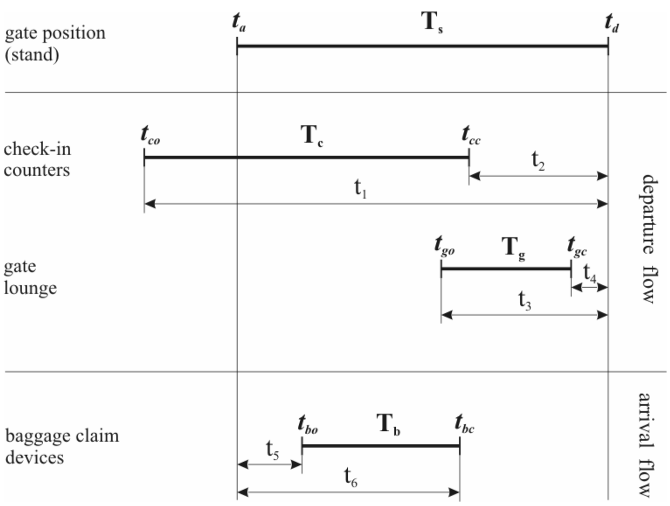


Fig. 1. Relationship of operation of single gate position and other facilities related to it

Where:
$T_s$ - gate position (stand) occupancy time,
$T_c$ - check-in counters occupancy time,
$T_g$ - gate lounge occupancy time,
$T_b$ - baggage claim devices occupancy time,

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## III. Model Definition

### A. Gate (Parking) Positions

For the purpose of determination of gate (parking) position requirements, a couple of simple models were developed: one analytical, and one computer-based.

Several assumptions were introduced which were valid for both models:

- all aircraft are grouped in three classes: class 1 (e.g. ATR 72), class 2 (e.g. A320), class 3 (e.g. B767),
- aircraft of a certain size can only use gates that are specifically designed for these aircraft. However, a gate for a large aircraft can be used by all smaller-size aircraft,
- all aircraft will be served without delay or rejection.

#### 1) Analytical Model

The analytical model is based on Horonjeff's [2] deterministic model for computing the required number of gate positions (G), based on volume of arrivals in aircraft per hour (A), and mean gate occupancy time in hours (T):

$$G = AT$$

This formulation does not account for the time separation required for manoeuvring aircraft between departure from a gate position and the next arrival, thus it underestimates the gate position requirement.

This lower-bound estimation of gate number can be increased either by introducing a "utilization" factor (U), as suggested by Horonjeff [2]:

$$G = AT/U,$$

or by adding a time period that represents the aircraft separation (buffer) time at a gate (S) to the gate occupancy time, as suggested by Bandara and Wirasinghe [3]:

$$G = A\ (T + S).$$

This separation time consists of push-out or power-out time, the time required by departing aircraft to clear the apron area, and the time required by arriving aircraft to move in from the apron entrance to the gate position.

The previous formulation was used in the analytical model for computing gate position requirements for certain size (class) of aircraft (i), as:

$$G_i = A_i\ (T_i + S),$$

as well as for total gate position requirements:

$$G = \Sigma G_i = \Sigma A_i\ (T_i + S),$$

where:

$T_i$ is standard (average) gate position occupancy time for certain size (i) of aircraft. Adopted values were 40, 50, and 80 minutes, for aircraft class 1, 2, and 3, respectively,

$A_i$ is the volume of arrivals of certain size aircraft (i) during the design hour, and $A = \Sigma A_i$. It should be emphasized that design hour doesn't have to be the same for different types (size) of aircraft, e.g. it is possible that there are several peak periods during the day with different distributions by type (size) of aircraft, so that the design hour is derived as some sort of "envelope" of those peak periods.

The adopted value for gate separation time (S) in the model was 10 minutes, regardless of the size of aircraft.

#### 2) Computer-based (Simulation) Model

As was mentioned earlier, the previous analytical model is deterministic. In order to allow (introduce) stochastic, i.e. variation in time of arrivals at the gate position, as well as in gate (stand) position occupancy time, a simple computer-based (simulation) model was developed.

This model was made in MS Excel. Input for this model could be any traffic data (e.g. schedule) for one day (24h). Namely, model regards period between 00:00 and 23:59, whereas the changes of state are tracked down with an increment of one minute.

Input data (inserted manually) are times of aircraft arrival and departure at gate positions, i.e. appropriate schedule, modified so that it takes into account separation time at a gate (S), as in [3]. As in the analytical model, the adopted value for (S) was 10 minutes, regardless of the size of aircraft.

The logic of the model is actually based on a graphical method of superimposing the number of certain resources (facilities) that are occupied at the observed moment.

Besides determination of the total gate position requirement, which is determined based on peak traffic period (as in analytical model), this model provides information about the change in number of simultaneously occupied gate positions during the day. Since this model was made in Excel, it was very easy to produce appropriate charts and graphically represent output results.

### B. Check-in Counters

In the case of check-in counters, only the computer-based (simulation) model was developed. As for the previous model, it was made in MS Excel, and the logic is based on the graphical method of superimposing the number of certain resources (facilities) that are occupied at the observed moment.

The following assumptions were introduced for this model:

- check-in counters are operated as dedicated, i.e. per-flight check-in, whereas the number of counters that are opened for a particular flight depends on the size of aircraft (1, 2, and 3 counters for aircraft class 1, 2, and 3, respectively),
- opening and closing times of the counters for certain flight are linked to aircraft departure time from the gate, regardless of the size of the aircraft. The adopted values were 90 and 20 minutes prior to aircraft departure time, for opening and closure of the counters, respectively.

The outputs from the model are also appropriate charts, which graphically represent the change in number of simultaneously operated check-in counters during the day (24h), with an increment of one minute.

### *C. Gate Lounges*

The following assumptions were introduced for the gate lounge model:

- there are only gate (parking) positions adjacent to the terminal building (no "open" positions on distant apron),
- each flight uses a separate gate lounge, but it is possible (allowed) that in certain situations a single gate lounge, in a short time period, "handles" sequentially several aircraft parked on different stands (positions) adjacent to the terminal building. This is possible due to passengers being able to come from the gate lounge to certain aircraft in two different ways:
  a) directly through the air-bridge (if the aircraft is parked on a stand right in front of the observed gate lounge), or
  b) walking across the apron (in the case of the aircraft being parked at a nearby position adjacent to the terminal building). This case is feasible only if the aircraft is of the same or smaller size (class) than the size (class) of the observed gate lounge.
- opening and closing times of a gate lounge for certain flight are linked to aircraft departure time from the gate, whereas the period it is in use depends on the size of the aircraft. The adopted values for gate lounge usage time per flight were 15, 25, and 30 minutes for aircraft class 1, 2, and 3, respectively, whereas the closure time of the lounges was set to 5 minutes prior to aircraft departure time.

The model for gate lounges had also been developed in MS Excel, using the logic of the graphical method of superimposing the number of certain resources (facilities) that are occupied at the observed moment.

The outputs of this model are also appropriate charts, which graphically represent the change in the number of simultaneously used (occupied) gate lounges during the day (24h), with an increment of one minute.

### *D. Baggage Claim Devices*

The following assumptions were introduced for the baggage claim devices model:

- all baggage claim devices are of the same size (capacity) and are sufficient for the largest aircraft (class 3),
- based on the previous assumption, the baggage from each flight performed by aircraft class 2 or 3 are placed on a separate baggage claim device; whereas it is possible, if there is a need, to use one baggage claim device to simultaneously deliver baggage from two flights performed by smallest (class 1) size aircraft (based on assumed size of such aircraft, compared with class 3 aircraft),
- beginning and final times for using a baggage claim device for certain flight are linked to the aircraft arrival time at the gate, whereas the period it is in use depends on the size of aircraft. The adopted values for baggage claim device usage time per flight were 15, 20, and 30 minutes for aircraft class 1, 2, and 3, respectively, whereas the starting time for usage of these devices was set at 10 minutes after the aircraft arrival time.

The model for baggage claim devices is also computer-based, and developed in Excel, using the logic of the graphical method of superimposing the number of certain resources (facilities) that are occupied at the observed moment.

As in previous models, the outputs are appropriate charts, which graphically represent the change in number of simultaneously used baggage claim devices during the day (24h), with an increment of one minute.

## IV. NUMERICAL EXAMPLES - SCENARIOS

For the purpose of validating the logic of the abovementioned models, several numerical examples - scenarios were performed.

Traffic data (scheduled and realized traffic for three peak days) obtained from Tivat Airport (a small seaside airport in Montenegro with a high seasonal peak in the summer) had served as a basis for these numerical examples. Fig. 2 depicts the apron at Tivat Airport (source: AIP Serbia and Montenegro). Beside traffic data, the data about usage of check-in counters for the same days was available.

In order to be implemented in the models, the above mentioned traffic data for three peak days had to be modified in a sense that cancelled, special and general aviation flights were excluded from the sample.

From those three peak days, the one with the largest total number of aircraft was chosen to be introduced into the models. After the previously cited modifications were made, a total of 24 aircraft during the above mentioned day remained, whereas the distribution by classes was: 4, 17, and 3 aircraft of class 1, 2, and 3, respectively.

Four different scenarios were considered within these numerical examples, out of which the first three scenarios are deterministic and fourth one is stochastic, where:

1) Scenario 1 represents scheduled traffic for a selected day, modified in a sense that average gate occupancy times for different size (class) of aircraft (calculated based on traffic data for all three days) are used. The adopted (average) values were 40, 50, and 80 minutes, for aircraft of class 1, 2, and 3, respectively,
2) Scenario 2 (basic scenario) represents original scheduled traffic for the same day, and is shown in Fig. 3,
3) Scenario 3 represents realized traffic for the same day as in Scenarios 1 and 2,
4) Scenario 4 represents a random variation of Scenario 2 in respect of aircraft arrival times at the gate positions, and gate occupancy times. These variations were generated using the Monte-Carlo simulation, based on appropriate distributions and cumulative frequencies of aircraft arrival lateness at the gate position, and deviation of realized gate occupancy time compared to the one planned by schedule, respectively.

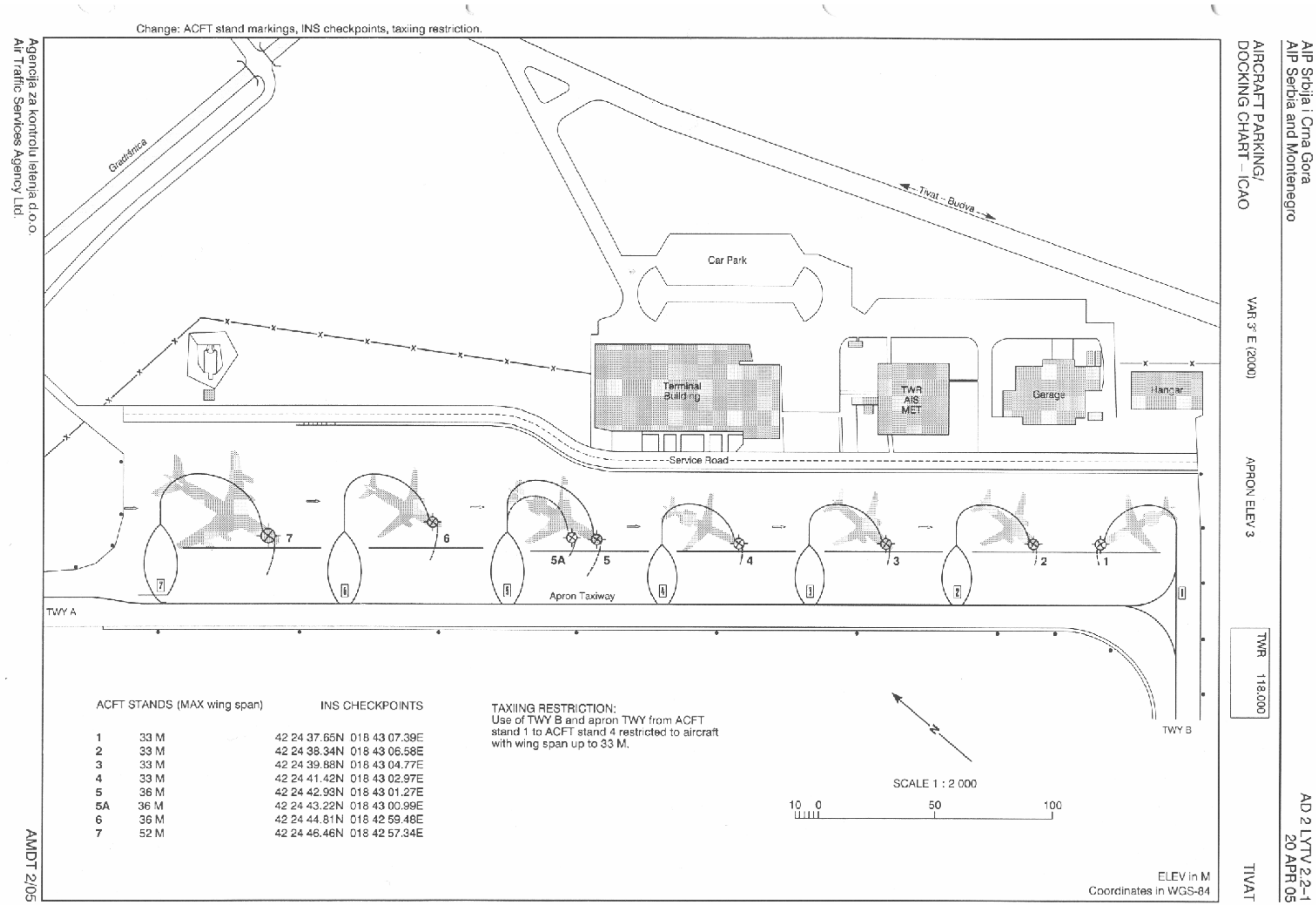


Fig. 2. Apron at Tivat Airport with the gate (parking) positions disposition (source: AIP Serbia and Montenegro)

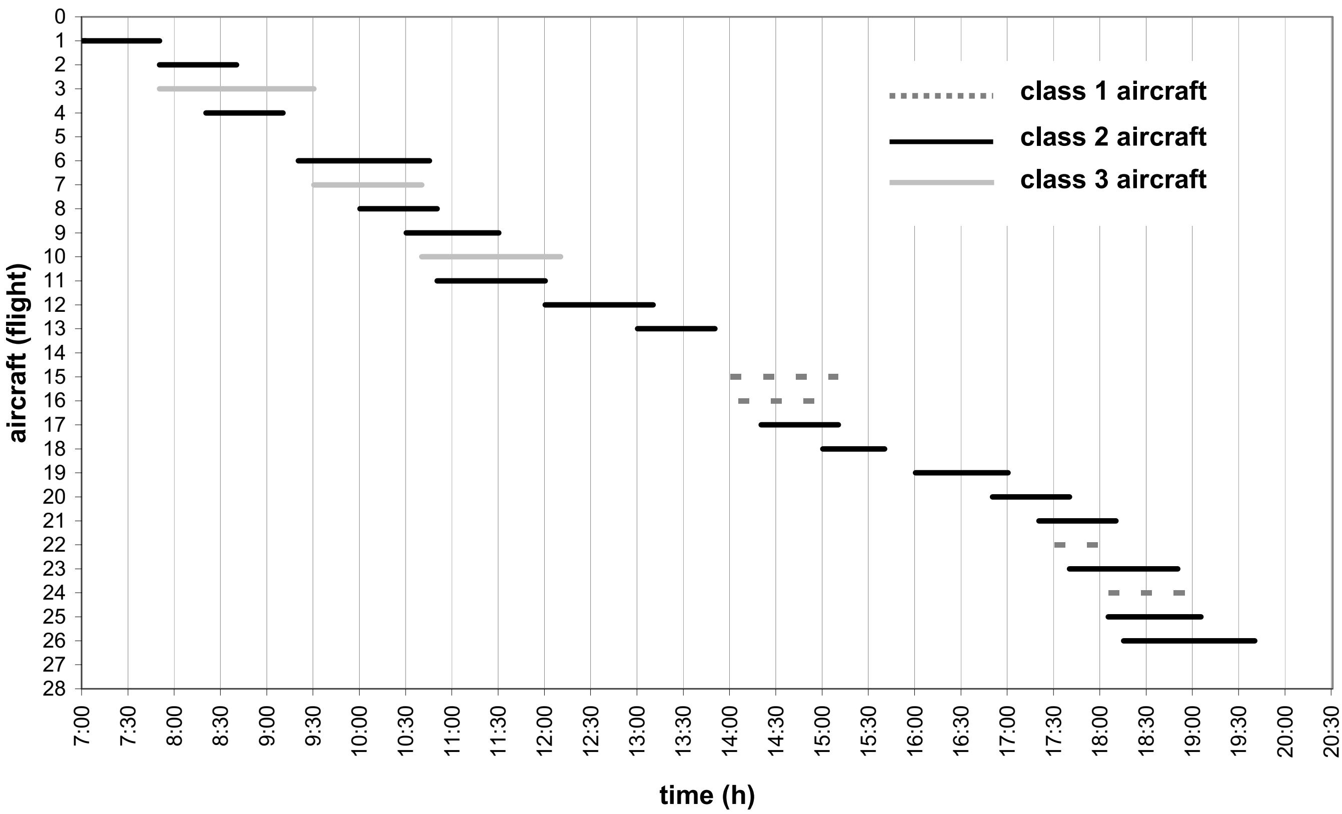


Fig. 3. Time distribution of requests for the gate (parking) positions (traffic data for Scenario 2)

Both of these distributions and appropriate cumulative frequencies were determined from traffic data for all three days. The distributions of arrival lateness and deviation from gate occupancy time, used for generating the variations in Scenario 4 are shown in Fig. 4, and Fig. 5, respectively. Within this scenario, 10 simulation runs (i.e. 10 iterations) have been performed for each of four defined simulation models of elements of airport passenger terminal complex.

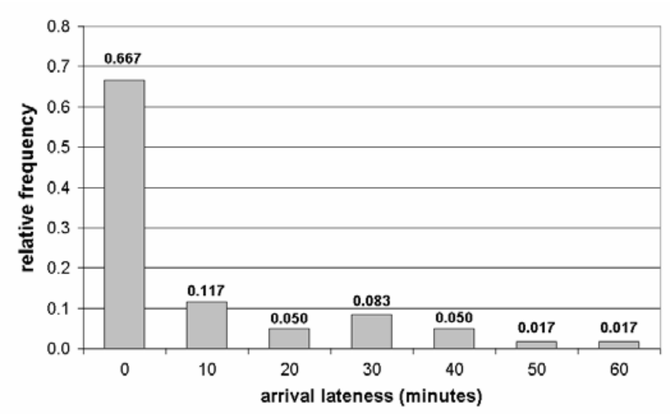


Fig. 4. Distribution of arrival lateness at the gate (parking) position

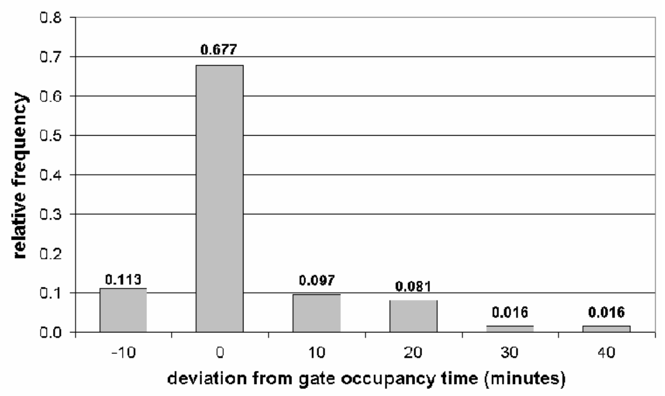


Fig. 5. Distribution of deviation from gate occupancy time

Within each of aforementioned scenarios, output results for each of the four simulation models (gate positions, check-in counters, gate lounges, and baggage claim devices) were obtained and analysed.

## V. Output Results

For the purpose of illustration, the results obtained for the first three (deterministic) scenarios, for each of the models, are presented combined; whereas the results of the fourth (stochastic) scenario are shown separately, compared with the basic (second) scenario.

### *A. Gate (Parking) Positions*

As it was mentioned in Section III-A, for the purpose of determining the gate (parking) position requirements, a couple of models were developed: one analytical, and one computer-based. With the goal of comparing and validating the logic of computer-based model, both models were first tested using Scenario 1 traffic.

The input values for the analytical model were two peak periods during a selected day with a different aircraft mix, as shown in Table I. This shows that design hour is not the same for aircraft of different sizes (as it was emphasized in Section III-A-1).

TABLE I
PEAK PERIODS USED AS INPUT DATA FOR ANALYTICAL MODEL

| peak period | total number of arrivals | number of arrivals by the size of aircraft | | |
|---|---|---|---|---|
| | | $A_1$ | $A_2$ | $A_3$ |
| 10:00 - 11:00 | 4 | 0 | 3 | 1 |
| 17:20 - 18:20 | 6 | 2 | 4 | 0 |

The output results of the analytical model, rounded up to a first larger whole number are shown in Table II. It can be seen that results differ between the two observed periods, hence the ultimate values were obtained as a sort of envelope of values for those two periods, having in mind the adopted principle that smaller-size aircraft can park at gate positions for larger aircraft, whereas the opposite is not permitted.

TABLE II
ADOPTED VALUES OF OUTPUT RESULTS FOR ANALYTICAL MODEL

| peak period | required number of gate positions by classes | | | total |
|---|---|---|---|---|
| | $G_1$ | $G_2$ | $G_3$ | $\Sigma G_i$ |
| 10:00 - 11:00 | 0 | 3 | 2 | 5 |
| 17:20 - 18:20 | 2 | 4 | 0 | 6 |
| **envelope** | **1** | **3** | **2** | **6** |

The output results for the computer-based (simulation) model are shown in Fig. 6. From this figure it is easy to perceive two peak periods used for calculation in the analytical model. But beside that, the information about the change in number of simultaneously occupied gate positions during the day (total and by classes) is provided.

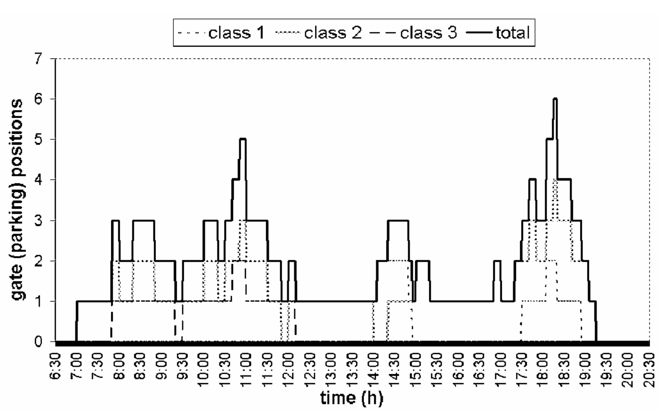


Fig. 6. Output results for simulation model of gate positions for Scenario 1

It can be seen that the values (both total and by classes) obtained using the simulation model for two previously mentioned peak periods are identical to the ones from the analytical model. This verifies that simulation model could be used for calculation of required number of gate positions. Having in mind the above mentioned advantages of this model (e.g. more information that it provides), it was decided that only the simulation model will be used for subsequent scenarios.

The above mentioned advantages of the simulation model for gate positions provided, as well, argument for usage of other simulation models (for check-in counters, gate lounges, and baggage claim devices), since the logic used in them is very similar.

As indicated at the beginning of this Section, the output results for the first three (deterministic) scenarios (total values only) are presented as combined results in Fig. 7, for better illustration and comparison.

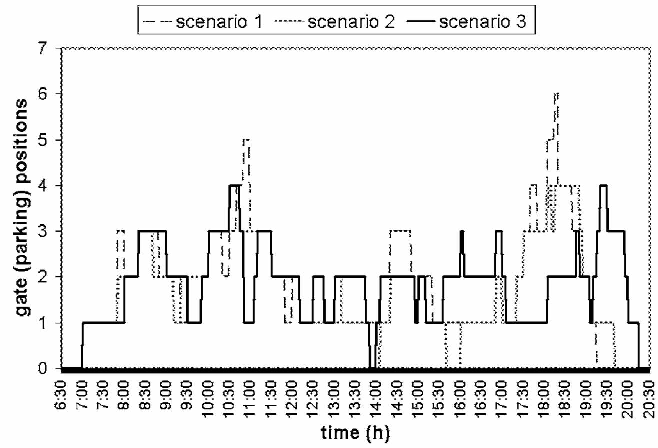


Fig. 7. Comparison of output results for model of gate (parking) positions for Scenarios 1, 2, and 3

Fig. 7 shows that only in Scenario 1 the required number of gate positions exceeds 4 (in two aforementioned peak periods).

The previous graph can be presented in another way, so that the total duration of states with a certain number of simultaneously used gate positions is shown, as in Fig. 8.

This type of graph is very useful for comparison when there are several sets of similar data that change over time.

From Fig. 8 it can more easily be seen that situations (states) when there are more than 4 simultaneously used gate (parking) positions have a very short total duration, which leads to very low utilization of some of the gate positions. This poses a question as to whether the adopted assumptions should be changed so that it is allowed that some aircraft will have to wait for the gate position to become free and experience some delay; whereas in turn, costs for the airport (both infrastructure and operational – stuff and equipment-vise) will be reduced.

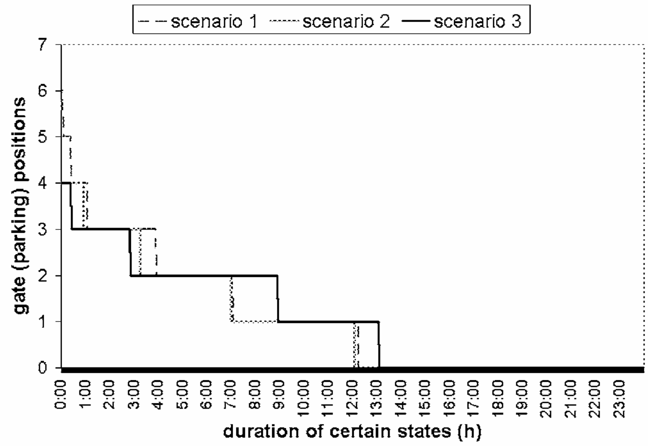


Fig. 8. Comparison of duration of states with certain number of simultaneously used gate (parking) positions for Scenarios 1, 2, and 3

The output results for Scenario 4 (stochastic one) are shown in Fig. 9. This graph depicts results from each of 10 iterations (total values only), combined with appropriate results from the basic (second) scenario, for better illustration and comparison.

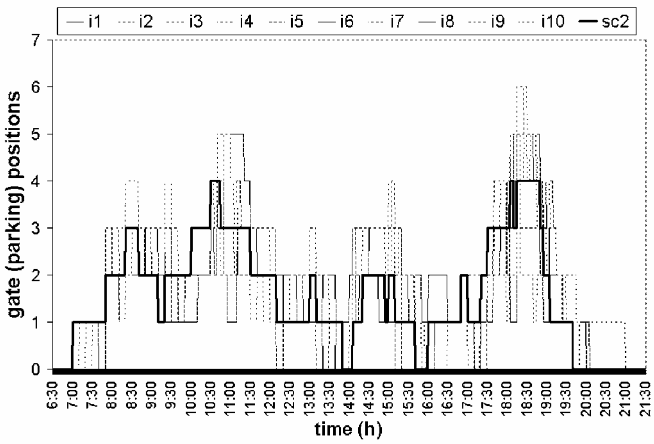


Fig. 9. Comparison of output results for model of gate (parking) positions for Scenario 4 (all 10 iterations) and Scenario 2 (basic scenario)

This figure shows that the results from 10 iterations are spread around the values from the basic (second) scenario, and follow the trend in change of those, which was expected. It can also be observed that for couple of iterations, the number of simultaneously used gate positions reaches the value of 6 during peak periods, whereas in the basic scenario the maximum value is 4.

The previous graph can also be presented in another way, so that the total duration of states with certain number of simultaneously used gate positions for each of 10 iterations from Scenario 4 are shown, compared with corresponding values from Scenario 2, in Fig. 10.

From this graph, it can be seen that in most iterations duration of certain states are longer, and that there are some iterations in which the maximum value of 4 simultaneously used gate positions from the basic scenario is exceeded. This is due to the fact that the share of positive values of distributions used for generating the variations in Scenario 4 is by far greater than of those with negative values (see Section IV, Fig. 4 and Fig. 5).

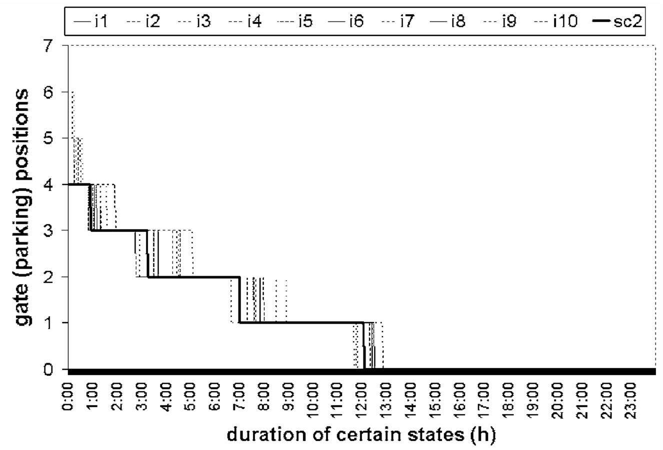


Fig. 10. Comparison of duration of states with certain number of simultaneously used gate (parking) positions for Scenario 4 (all 10 iterations) and Scenario 2 (basic scenario)

*B. Check-in Counters*

The output results for the simulation model of check-in counters for the first three (deterministic) scenarios (total values only) are presented combined in Fig. 11, for better illustration and comparison.

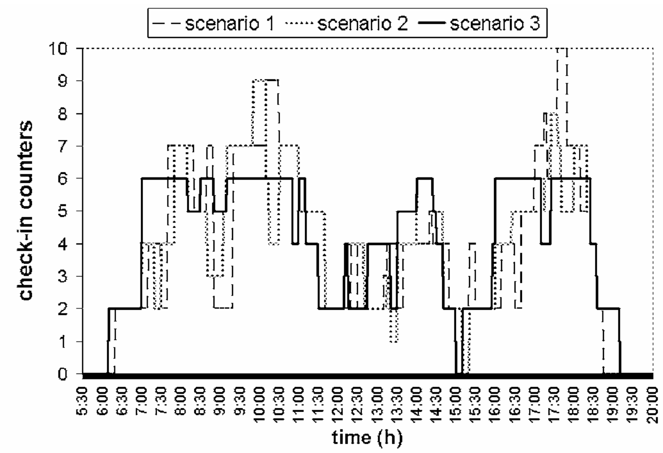


Fig. 11. Comparison of output results for model of check-in counters for Scenarios 1, 2, and 3

It can be seen that the results for scenarios 1 and 2 are almost matching, and show two peak periods which are linked to (precede) the previously indicated peak periods in the gate position requirements. The only greater difference between the results for the first two scenarios appears during the second peak period, where in Scenario 1 there is a request for 10 simultaneously opened counters, compared to request for 8 counters in Scenario 2. The peak periods in Scenario 3 are matching to a great extent the ones in the first two scenarios. The difference in the maximum number of simultaneously opened counters comes from the fact that input data for Scenario 3 (realisation) represents real data about usage of check-in counters obtained from Tivat Airport, and that there are only 6 counters installed and used at that airport. The tactic which is used to meet the requirements at peak periods is that not all of the check-in counters dedicated to a certain flight are used for the same period, i.e. some of them are opened later or closed earlier in order to switch between the overlapping requirements of different flights at peak periods.

As in the previous model, the data from the previous graph can be presented in another way, so that the total duration of states with a certain number of simultaneously opened check-in counters is shown, as in Fig. 12.

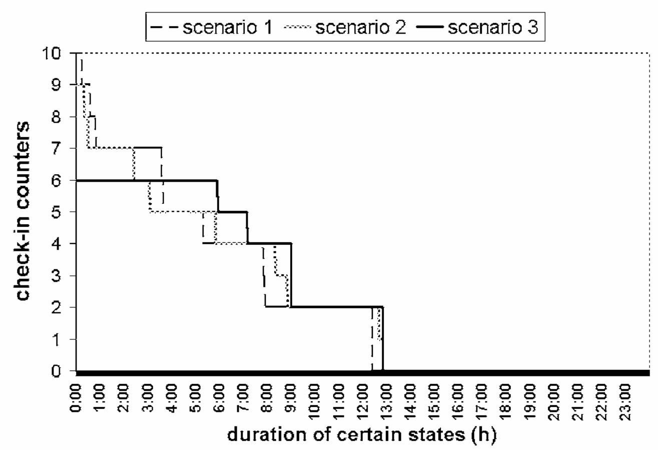


Fig. 12. Comparison of duration of states with certain number of simultaneously opened check-in counters for Scenarios 1, 2, and 3

From this graph it can be noticed even more easily that the previously explained corrections in length of period that some counters are dedicated to certain flights, can contribute to the reduction of investment in procurement of check-in counters, and avoid low utilization of some of the counters that appear in scenarios 1 and 2. Naturally, due to these corrections, the total duration of situations (states) with 5 or 6 simultaneously opened check-in counters in Scenario 3 is quite longer than in scenarios 1 and 2.

The model of check-in counters was not used with Scenario 4 (stochastic one). Namely, there was no point in varying opening and closing times of the counters, since the nature of the check-in process is such that the counters have to be opened during the scheduled period (regardless of eventual lateness in arrival or departure of a flight), as the passengers will come to the airport to perform their check-in according to the flight schedule.

*C. Gate Lounges*

Fig. 13 shows the combined output results for the simulation model of gate lounges for the first three (deterministic) scenarios (total values only). It can be seen that maximum required number of simultaneously used gate lounges is 3 for all three deterministic scenarios, whereas these maximum requirements appear in different periods during the day.

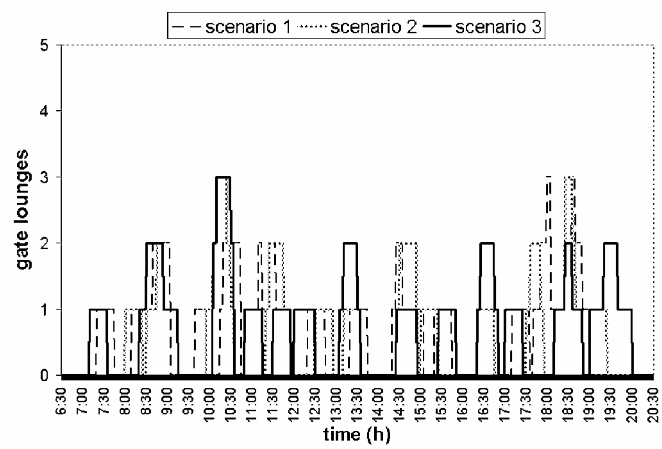


Fig. 13. Comparison of output results for model of gate lounges for Scenarios 1, 2, and 3

The data from the previous graph can, similarly to preceding models, be presented in another way. Therefore, a comparison of the total duration of states with a certain number of simultaneously used gate lounges for the first three (deterministic) scenarios is shown in Fig. 14. This figure shows that the maximum required number of 3 simultaneously used gate lounges appears in a very short period during the day in all three deterministic scenarios. Hence, it would be wise to perform small corrections in the planed length of usage of gate lounges for certain flights, and in turn reduce infrastructure or operational costs for the airport (depending on the planning level), and increase utilization of the remaining gate lounges at the same time.

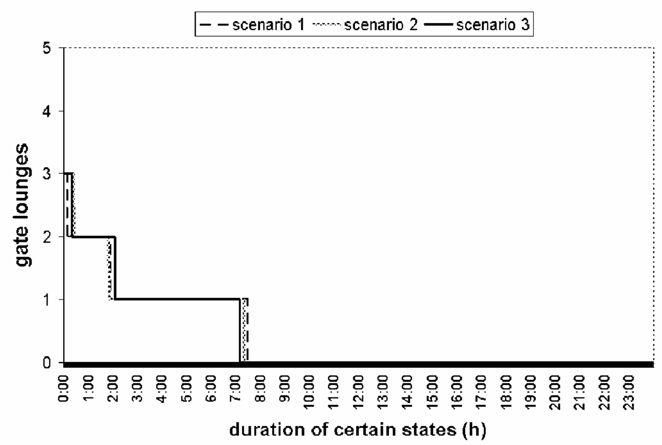


Fig. 14. Comparison of duration of states with certain number of simultaneously used gate lounges for Scenarios 1, 2, and 3

Since the opening and closing times of gate lounge for certain flight are linked to aircraft departure time from the gate, the variations of arrival time and gate position occupancy duration in Scenario 4 resulted only in shifting the planned period of usage of gate lounges for those flights that experienced delay in departure. This means that the passengers will, in case their flight is delayed in departure, stay longer in the central hall (or lounge) after check-in, waiting for a call and the gate to be opened.

The output results for Scenario 4 are shown in Fig. 15. This graph depicts results from each of 10 iterations (total values only), combined with appropriate results from the basic (second) scenario, for better illustration and comparison.

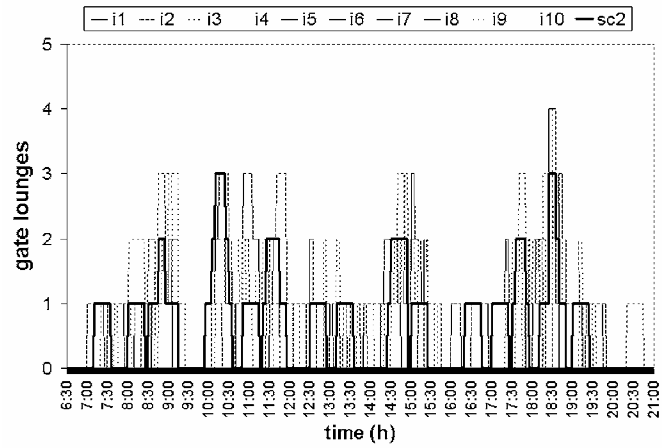


Fig. 15. Comparison of output results for model of gate lounges for Scenario 4 (all 10 iterations) and Scenario 2 (basic scenario)

Fig. 15 shows that results obtained in iterations are very similar to those in the basic scenario. The discrepancies are mostly up to one gate lounge, which was expected since the duration of usage of gate lounges for the flights with departure delay had remained unchanged.

It can be seen that maximum value of simultaneously used gate lounges in a couple of iterations reaches 4, whereas in basic scenario maximum value is 3.

For the sake of easier comparison, the data from the previous graph is presented in another way so that in Fig. 16 the total duration of states with a certain number of simultaneously used gate lounges for each of 10 iterations from Scenario 4 are shown, compared with corresponding values from Scenario 2.

This graph shows even more clearly that the corresponding values in iterations are, due to above mentioned remark, very similar to those in the basic scenario.

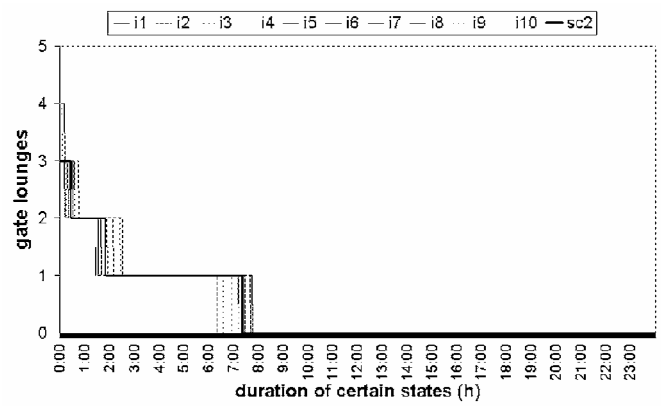


Fig. 16. Comparison of duration of states with certain number of simultaneously used gate lounges for Scenario 4 (all 10 iterations) and Scenario 2 (basic scenario)

### *D. Baggage Claim Devices*

The output results for the simulation model of baggage claim devices for the first three (deterministic) scenarios (total values only) is shown as combined in Fig. 17. It should be emphasized that the results for scenarios 1 and 2 are identical (they are overlapping in the graph).

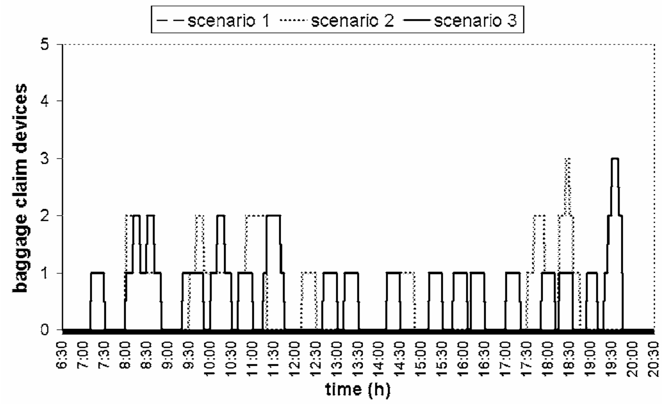


Fig. 17. Comparison of output results for model of baggage claim devices for Scenarios 1, 2, and 3

It can be observed from Fig. 17 that the maximum required number of simultaneously used gate lounges is 3 for all three deterministic scenarios, whereas these maximum requirements appear only once in each of the scenarios, but at different times during the day.

As in previous cases, the data shown in Fig. 17 can be presented in another way, for better comparison between scenarios (Fig. 18). The previous remark about the results from scenarios 1 and 2 being identical is also valid here.

It is noticeable that the values from Scenario 3 are very similar to those from the first two scenarios, and that the maximum required number of 3 simultaneously used baggage claim devices appears in a very short period during the day in all three deterministic scenarios. So, it would be reasonable to make small corrections in the planned length of usage of baggage claim devices for certain flights, in order to avoid engagement of a third device with its very low utilization.

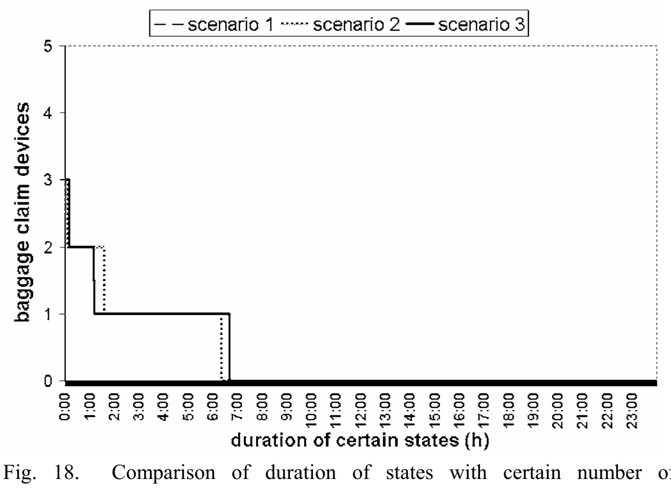


Fig. 18. Comparison of duration of states with certain number of simultaneously used baggage claim devices for Scenarios 1, 2, and 3

As the beginning and final times for usage of baggage claim device for certain flight are linked to aircraft arrival time at the gate, the variations of arrival time and gate position occupancy duration in Scenario 4, resulted only in shifting the planned period of usage of baggage claim devices for those flights that experienced arrival delay; whereas the duration of their usage remained unchanged.

The output results for Scenario 4 are shown in Fig. 19. This graph depicts results from each of 10 iterations (total values only), combined with appropriate results from the basic (second) scenario, for better illustration and comparison.

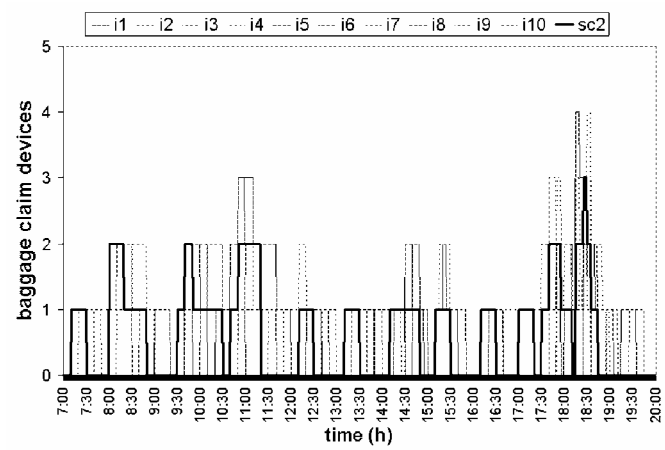


Fig. 19. Comparison of output results for model of baggage claim devices for Scenario 4 (all 10 iterations) and Scenario 2 (basic scenario)

The previous figure shows that results obtained in iterations are very similar to those in the basic scenario, and that differences are mostly up to one baggage claim device, which was expected in accordance with the remark about unchanged duration of usage of gate lounges for the flights with an arrival delay.

It can be seen that the maximum value of simultaneously used baggage claim devices in a couple of iterations reaches 4, whereas in the basic scenario the maximum value is 3.

For the sake of easier comparison, the data from the previous graph is presented in another way so that Fig. 20 depicts the total duration of states with a certain number of simultaneously used baggage claim devices for each of 10 iterations from Scenario 4, compared with corresponding values from Scenario 2.

This graph shows in an even clearer way that the corresponding values in iterations are very similar to those in the basic scenario, due to the above mentioned remark about unchanged duration of usage of baggage claim devices for flights with an arrival delay.

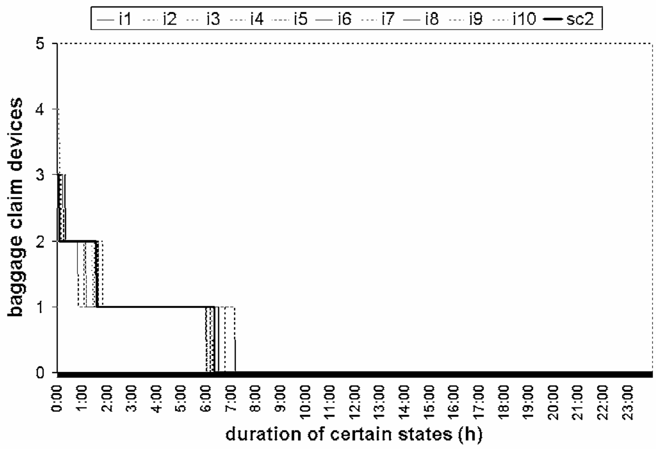


Fig. 20. Comparison of duration of states with certain number of simultaneously used baggage claim devices for Scenario 4 (all 10 iterations) and Scenario 2 (basic scenario)

## VI. Conclusion

The research presented here considers the problem of determination of the required number of certain elements of an airport passenger terminal complex (aircraft parking positions, check-in counters, gates, and baggage claim devices)

For the purpose of determination of gate (parking) position requirements, a couple of models were developed: one analytical, and one computer-based. With the goal of comparison and validation of the computer-based (simulation) model, both models were tested using Scenario 1 traffic, showing that the logic of the simulation model is correct. Having in mind the advantages of this simulation model (e.g. more information that it provides), it was decided that only this model will be used for subsequent scenarios.

These advantages of the simulation model for gate positions provided, as well, argument for development and usage of other simulation models (for check-in counters, gate lounges, and baggage claim devices), since the logic used in them is very similar.

Several experiments - numerical examples, based on different input data (traffic scenarios), were performed, using each of previously mentioned simulation models. Namely, four different scenarios were considered within the cited numerical examples, out of which the first three scenarios were deterministic, whereas the fourth one was stochastic

A set of analysis of results from numerical examples for particular scenarios, as well as comparative analysis of results obtained for different traffic structures in different models of airport passenger terminal complex elements were performed afterwards.

The methodology developed and presented here could be used in the process of planning (dimensioning) the required resources (capacities) of airport passenger terminal complex (on tactical and strategic level).

Possible further research could be to introduce costs (take them into consideration), as well as to determine the cancellation probability.

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