Conception of logistic support model for the functioning of a ground handling agent at the airport

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Abstract: This article presents the concept of a model of logistical support for the functioning of a ground handling agent. The developed concept of a model will enable the analysis and optimization of logistical processes associated with ground handling of an aircraft. In particular, the model will enable the multi-criteria analysis of aspects determining the effectiveness of the executed processes, such as the analysis of the functioning of the ground handling agent for the projected traffic flows - flight timetable, which will be executed in the next flight season - distant time horizon, the analysis of the functioning of the airport for the projected traffic flows - flight timetable, which is executed in the current season - a given day when there are more known premises regarding the projected (few hour) period - short-term horizon. In addition, the projected results will include the impact of the aspects of reliability of the operational equipment - on the basis of operational data, functions characterizing the reliability (probability density function of time between damages and probability density function of the time of restoration of operating capability) will be developed.

Keywords: simulation model, airport, reliability, ground handling

1. INTRODUCTION

The functioning of the ground handling agent has a very significant impact on the timely execution of the flight network by the air carrier. The main tasks of the ground handling agent include the handling of the aircraft before and after the flight, and in particular: handling passengers, handling baggage, handling the aircraft.

The developed model allows for the analysis and optimization of logistical processes associated with ground handling of the aircraft, in particular it enables a graphical representation of the utilization of individual operating objects (luggage carts, luggage conveyors, etc.). The developed model also enables the dynamic allocation of operating equipment for the particular aircraft (including the compatibility of the equipment and the aircraft type). It also takes into account the necessity of using it at the moment (for example, refueling does not have to be carried out between each flight).

2. GROUND HANDLING OF AN AIRCRAFT

The main legal act determining the management of civil air transport within the Republic of Polish is the Aviation Law Act of 3 July 2002 [12] implementing the directives of the European Communities. These are binding rules unless ratified international agreements provide otherwise. The international rules contained in the Chicago Convention [5], which replaced the Paris Convention and is still the basic act regulating the international air traffic, also apply within the Polish Republic.

Ground handling in an airport includes a number of activities in the range of [11]:
1. Ground Administration And Supervision,
2. Passenger Handling,
3. Baggage Handling,
4. Cargo And Mail Handling,
5. Ramp Handling,
6. Aircraft Cleaning And Servicing,
7. Fuel And Oil Handling Services,

8.   Aircraft Maintenance Services,
9.   Flight Operations And Crew Administration Services,
10. Ground Transport Services,
11. Aircraft Catering Services.

Ground handling at the airport is run by ground handling agents (GHA) who have the mandate to perform activities from the above mentioned service categories (Airport Handling Agent Certificate). Activities carried out by GHA are based on a set of procedures contained in the Ground Handling Manual, introduced in a given company and approved by the President of the Civil Aviation Authority. The main task of the GHA is, among others, conducting his business in a way that ensures the proper functioning and elimination of disruptions at the airport, as well as ensuring the continuity in the performance of the ground handling services within the scope of the held certificate (§ 38, [11]). In order to achieve the main legal objectives it is essential to forecast the possibility of the occurrence of disruptions associated with the reliability of technical objects, forecast the intensity of flights, the stream of passengers and baggage owned by them. Also important is the cooperation in the scope of planning the flight schedule with the authority of the airport, in regards to the ability to provide the appropriate amount of technical and human resources in order to execute the task on time, taking into account the possibilities of disruptions at the input to the system (aircrafts arriving with a delay).

In accordance with GHM the ground handling agent performs activities related to ground handling of an aircraft. Ground handling of a selected aircraft (for example Boeing 737-800) for two airlines can vary considerably. The ground handling process is dependent on the standards and policy of the airline. Some airlines (especially low budget airlines), allow the performance of certain activities independently of each other (for example, refueling and boarding of passengers, boarding of passengers and catering service). Figure 1 shows an example of the process of ground handling of the Boeing 737-800 aircraft.

Fig. 1. The process of ground handling of the Boeing 737-800 aircraft
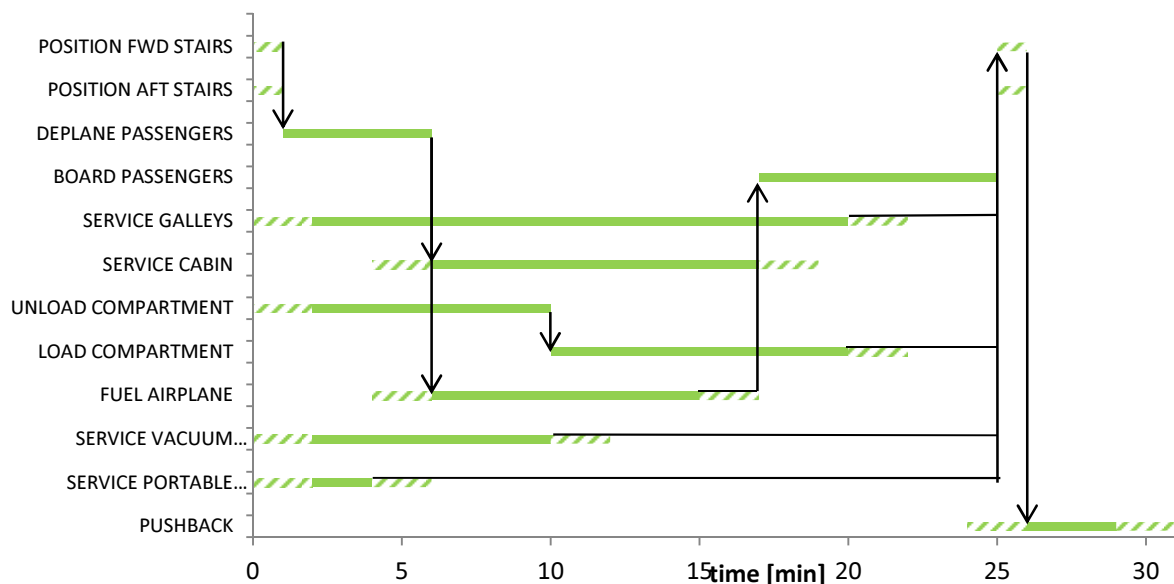
In Figure 1 the relationships between various processes were indicated by arrows. Number of the ground handling equipment is also dependent on the aircraft equipment. Some aircrafts of the Boeing 737-800 type have automatically folded front stairs under the deck. When planning the ground handling the agent functioning at the airport has to ensure only one pair of stairs for this type of aircraft. Figure 2 shows an example of the ground handling process for the ATR72 aircraft. The total ground handling time of the ATR72 aircraft is much shorter than that of the Boeing 727-800. In addition, the ATR72 aircraft ground handling does not require using airport stairs. Figure 3 shows the

process of ground handling of the Embraer 190 aircraft - at least one stairs or the use of a sleeve with a bridge to conduct boarding.

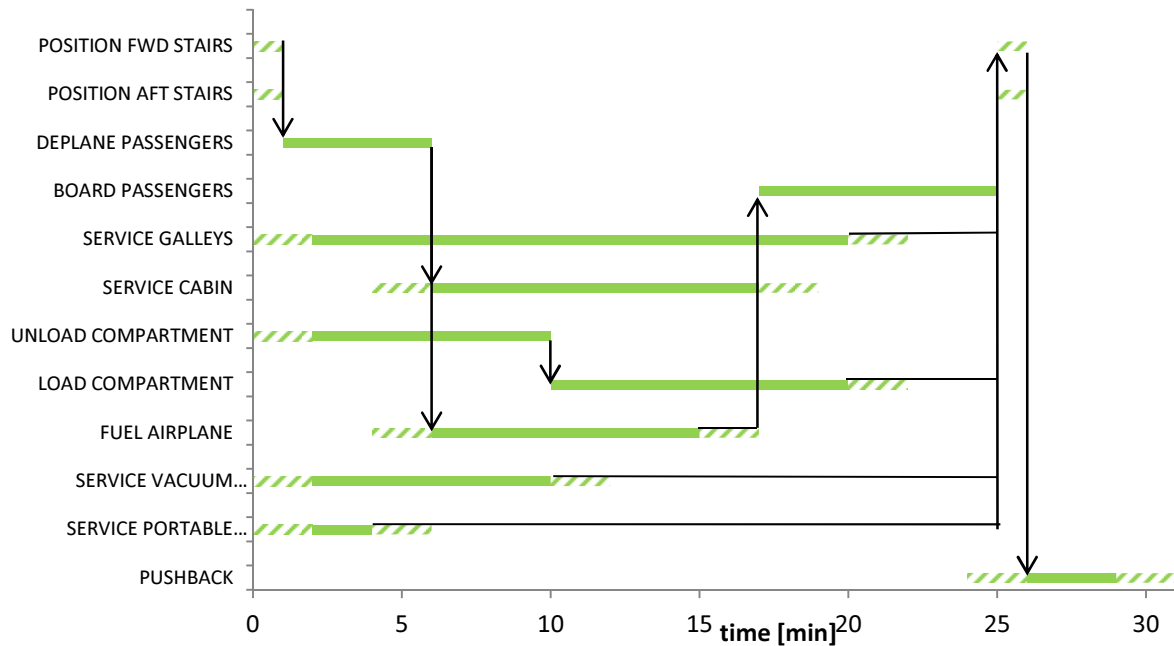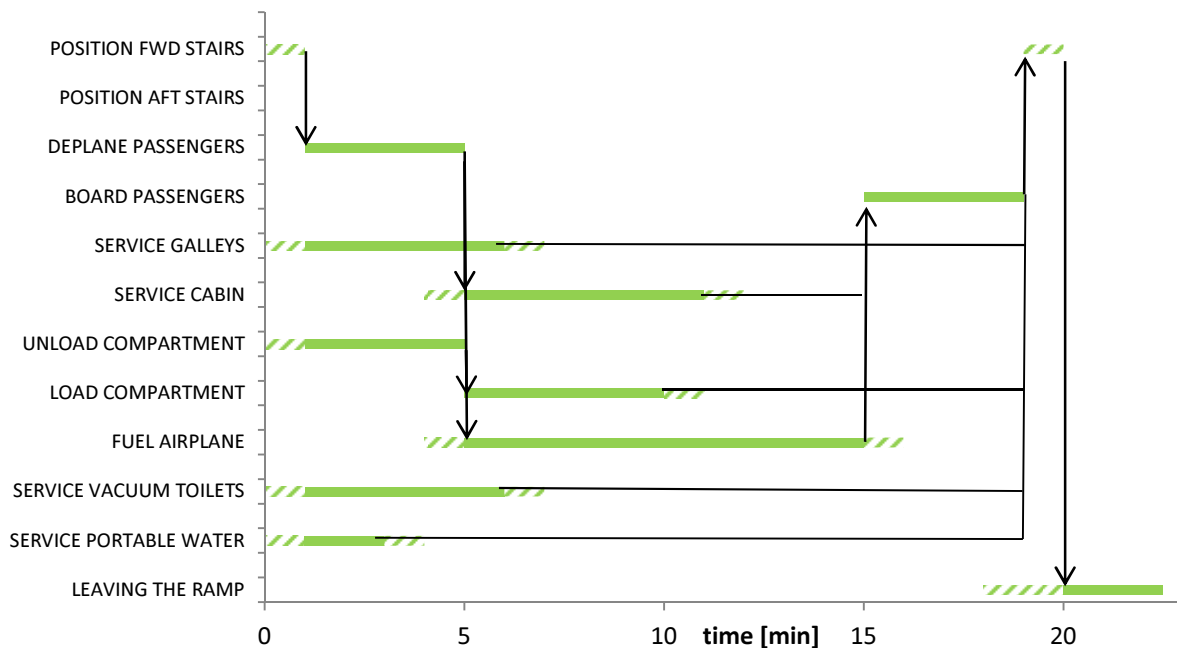Fig. 2. The process of ground handling of the ATR 72 aircraft

Fig. 3. The process of ground handling of the EMBRAER 190 aircraft

3. CONCEPT OF A MODEL OF LOGISTICAL SUPPORT FOR THE FUNCTIONING OF A GROUND HANDLING AGENT

The constant development of computer software supporting process modeling, contributed to the increasingly frequent attempts at programming simulation models of processes in the field of aviation, such as [1, 2, 3, 8, 9]. The majority of them are models concerning the movement of passenger flows in the airport terminals. [10] The presented simulation model was developed with the use of the FlexSim simulation software. This software can be used for

the planning and management of ground handling services at the airport. The simulation model includes the basic activities from the scope of categories (V, VII, XI) of ground handling services in the operational part of the airport. The model assumes the deterministic durations of individual activities, selected based on [4, 5, 6]. The possibility of starting consecutive activities of ground handling was assumed in accordance with the handling schedule designated in Figure 4 The handling of aircrafts without crew exchange and without the assistance of the fire brigade was assumed.

Fig. 4. The structure of relationships of the activities in the process of ground handling
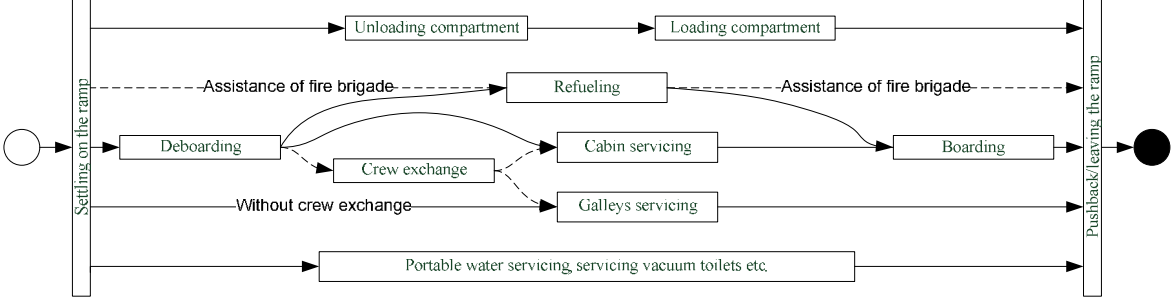
One overnight flight schedule in accordance with Table 1 was adopted. The table contains information concerning the flight number and the estimated time of arrival as well as the possible delay of the aircraft at the input to the system. The departure time is dependent on the time of completion of the ground handling services.

Tab. 1. Input data

input data FLIGHT PLAN					
Flight no.	arrival	delay	Flight no.	arrival	delay
01-E190	5:55 AM	00:00	14-B737	1:10 PM	00:00
02-B737	6:05 AM	00:00	15-ATR72	1:15 PM	00:00
03-B737	6:50 AM	00:00	16-E190	2:35 PM	00:00
04-E190	7:10 AM	00:00	17-E190	3:25 PM	00:00
05-E190	8:25 AM	00:00	18-E190	5:05 PM	00:00
06-ATR72	8:25 AM	00:00	19-E190	5:30 PM	00:00
07-ATR72	9:10 AM	00:00	20-B737	5:40 PM	00:00
08-ATR72	10:35 AM	00:00	21-E190	6:10 PM	00:00
09-B737	11:55 AM	00:00	22-B737	6:25 PM	00:00
10-B737	12:00 PM	00:00	23-E190	9:00 PM	00:00
11-B737	12:20 PM	00:00	24-B737	9:20 AM	00:00
12-ATR72	1:00 PM	00:00	25-B737	9:25 AM	00:00
13-ATR72	1:05 PM	00:00			

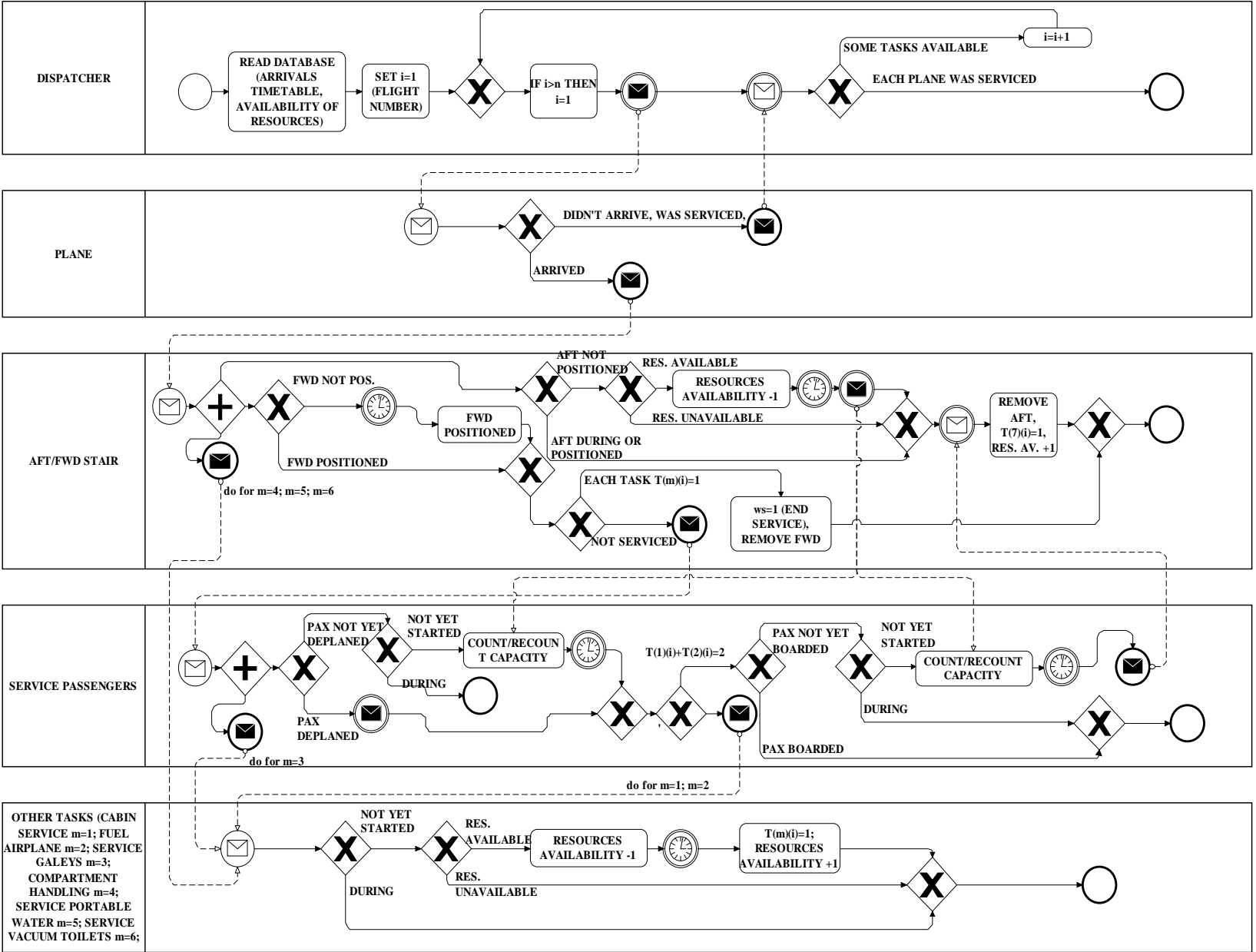The algorithm of the process is carried out in accordance with figure no. 5.

Fig. 5. Algorithm of the simulation model of support for the functioning of a ground handling agent.

The first activity executed by the algorithm is downloading the data of the arrival times of the aircrafts, the number of available technical objects and human resources for the performance of the individual tasks. The algorithm allocates adequate resources to carry out tasks for aircrafts located at the ramp of the airport on the basis of the FIFO strategy. In accordance with the assumption, the Boeing 737-800, embraer 190 and atr 72 aircrafts are handled. It is possible to expand the model to other aircrafts conducting flight operations at the airport.

Available resources are allocated to the tasks with deterministic duration of the handling operations, which will be ultimately replaced with random characteristics on the basis of the conducted research. In the case where the algorithm determines that an activity is already initiated, in progress, has been completed or does not have the appropriate resources, in a given step the equipment allocation is omitted. After the completion of a given activity, the technical objects are again assigned as available.

After unfolding the front stairs, the deboarding of passengers procedure begins. The time necessary for the completion of the procedure is calculated on the basis of the available number of stairs (front and rear). At the time of deploying the rear stairs the throughput of passengers and the time for the completion of the process is updated. Catering service can be performed in parallel with other activities. After deboarding of passengers the algorithm checks the possibility of executing the process of refueling the aircraft and the cabin services in a manner analogous to the allocation of other technical objects. The completion of these two processes enables the entry of passengers on board. After the completion of boarding of passengers, the rear stairs are released (if they were deployed until that moment). The front stairs are folded in the step of the algorithm, when all handling operations have been completed and after the folding of the front stairs and starting of the taxiing procedure, the algorithm designates the aircraft as handled.

The developed simulation model allows checking the possibility of executing the assumed flight plan in terms of the availability of ground handling equipment. For a set flight schedule (Table 1) the availability of resources as in table no. 2 was assumed.

Tab. 2. Number of resources available for performing the tasks of ground handling of an aircraft

resource/task	amount
Stairs	6
Service galleys	3
Service cabin	2
Conveyors	4
Service baggage	6
pushback	2
Fuel airplane	2
Service vacuum toilets	1
Service portable water	1

The results for the conducted simulation are presented in Figure no. 6. It should be noted that, in accordance with the previously adopted assumptions, with the timely arrival of the aircraft, the ground handling is performed in accordance with the plan.

The detailed process of ground handling of a selected flight operation (01-E190) is presented in figure no. 7. The verification of the results in comparison to the assumed times for the completion of individual tasks indicates the proper functioning of the simulation model with respect to the previously adopted assumptions.

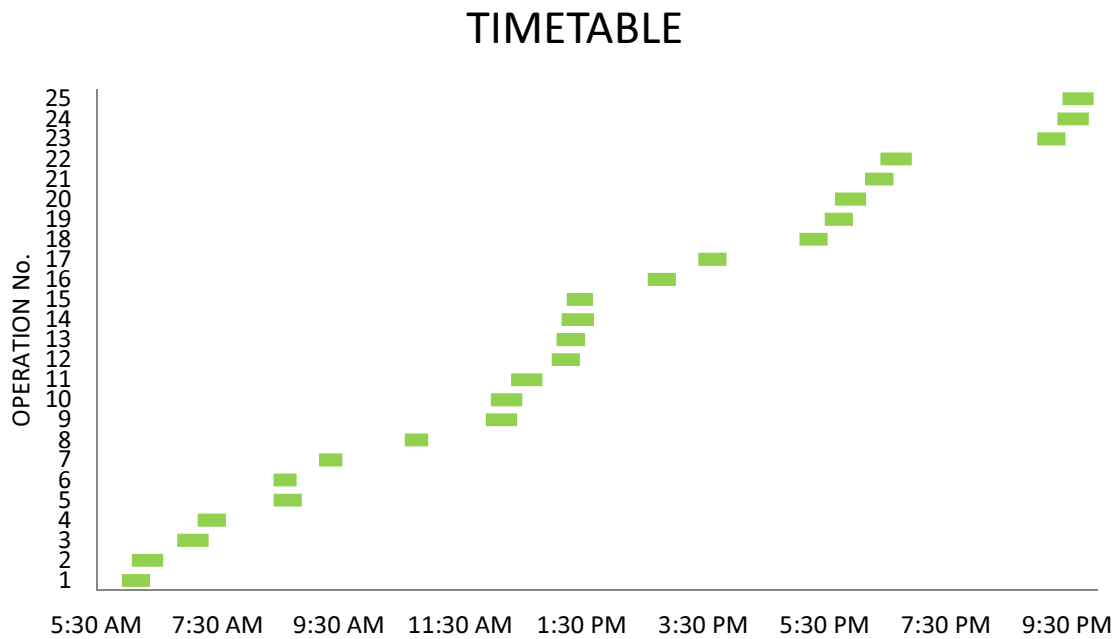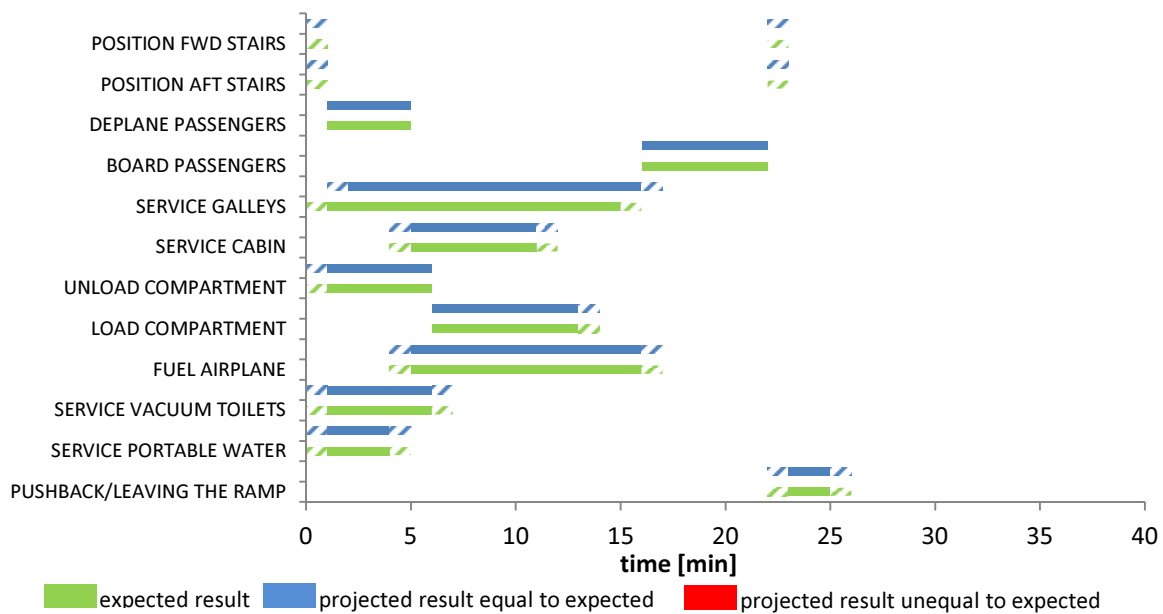Fig. 6. Resulting flight schedule

TIMETABLE

Fig. 7. Detailed characteristics of operation 01-E190

The computer simulation also enables the introduction of disruptions resulting from the propagation of errors from previous steps of the performed operational cycles of aircrafts. Insufficient time buffers between successive flights of aircrafts can transfer delays resulting from, for example the ground handling of the aircraft at prior airports. In addition, airports with high intensity of flight operations, close to the assumed maximum capacity, are struggling with the availability of slots for landing and takeoff of aircrafts. Weather conditions can also play an important role in additional delays affecting the aircraft landing time for the considered airport. All these factors may influence the landing time delay of the aircraft in relation to the scheduled time.

Using the presented simulation model, for the flight schedule (Table 1) the delay of the aircraft in accordance to Table No. 3 was assumed.

Tab. 3. Assumed delay of the selected flight

| Flight no.	Scheduled arrival	Delay
10-B737	12:00 PM	01:20

In accordance with the previously adopted assumptions, the ground handling with the assumptions for flight no. 10-B737, causes an additional delay of aircrafts 14-B737 and 15-ATR72. The results for the given plan, including the expected delay are shown in figure no. 8

Fig. 8. The impact of delay of flight 10-B737 on other cruises in the given flight schedule
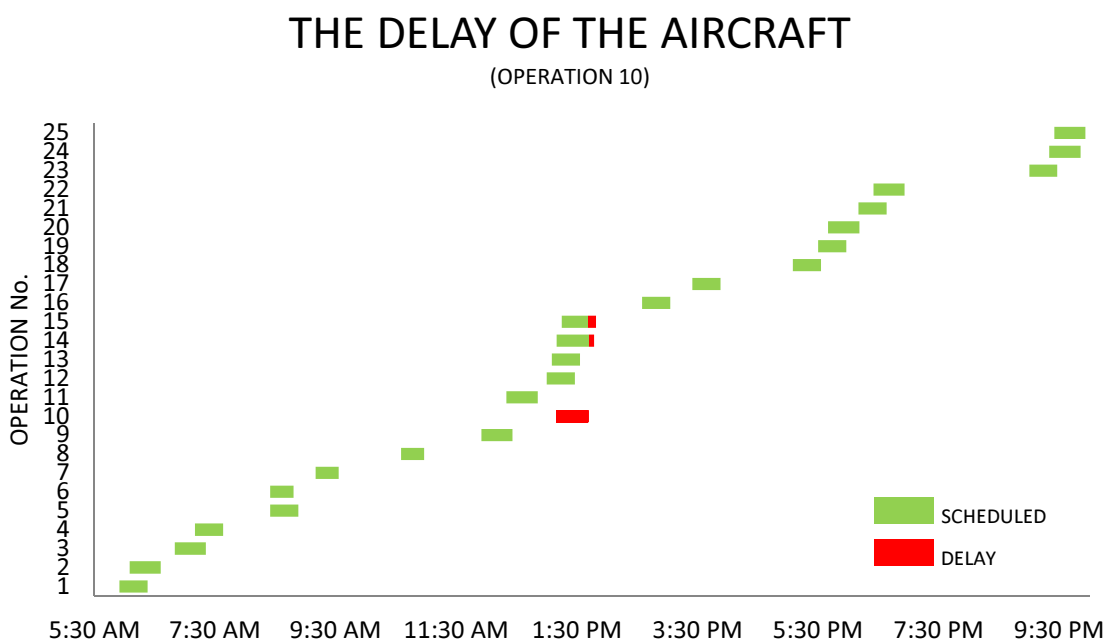
In conducting a detailed analysis of the delayed flights (for example, Figure no. 9), it is possible to obtain information on which of the particular tasks of ground handling has been delayed as a result of insufficient number of technical equipment held or the inappropriate selection of the human resources allocated to the execution of the tasks in the analyzed period of time.

Fig. 9. Detailed analysis of the ground handling of cruise 15-ATR72
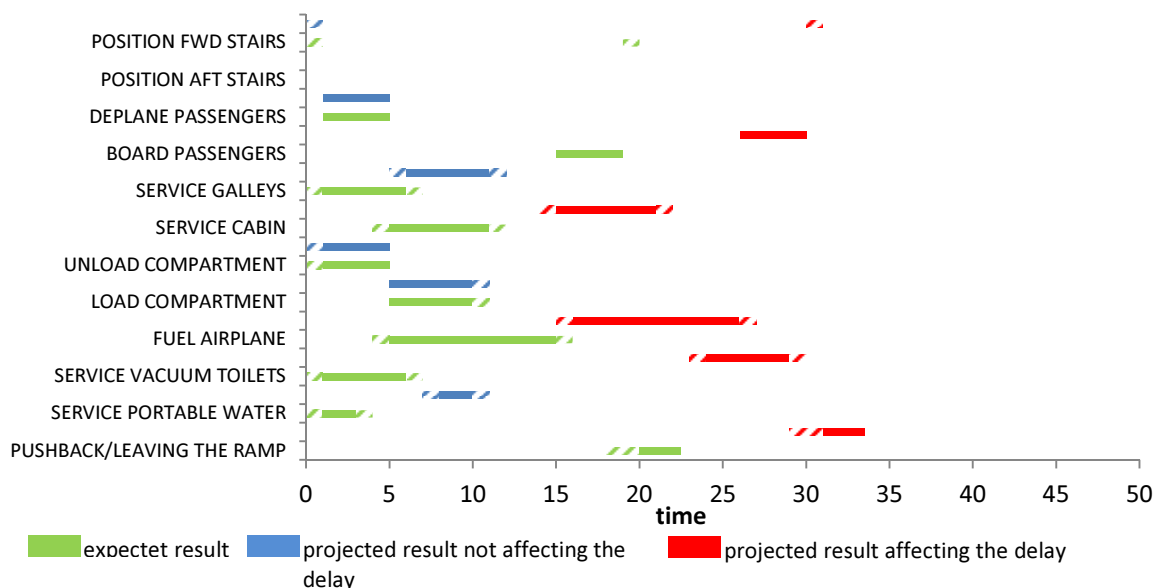
Another factor significantly influencing the efficiency of the executed ground handling activities is the reliability of the technical equipment for the handling services. At the current stage of development of the simulation model it is possible to assume errors caused by equipment damages in a deterministic manner. Ultimately, functions characterizing the random nature of the damages will be introduced, in order to conduct the analysis of the likelihood of disruptions of handling in terms of the reliability aspects of the system.

In order to perform an exemplary analysis for the flight schedule (Table no. 1) a deterministic transition to the state of unfitness of the airport fuel tank was assumed. Time for the restoration of the fitness of the fuel tank was assumed to be longer than the duration of the simulation. The impact of the damage on the handling process is shown in figure no. 10

Fig. 10. The impact of the fuel tank damage on the executed ground handling process
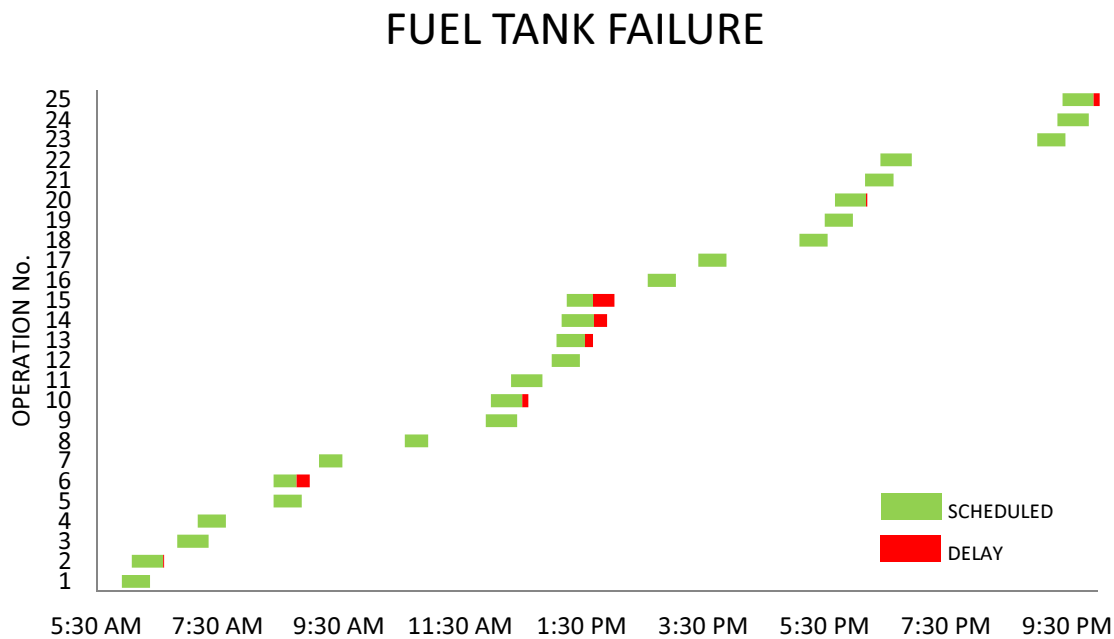
The analyzed damage caused a delay in 24% of flight operations. The simulation model enables the analysis of the average utilization of airport equipment in ten minute intervals. The results for the technical objects intended for refueling the aircraft are presented in figure no 11, which shows that the operational load of the fuel tanks repeatedly reached the level of 100%, which was the reason for the delay of individual flight operations.

Fig. 11 The operational load of the airport fuel tanks in 10 minute intervals
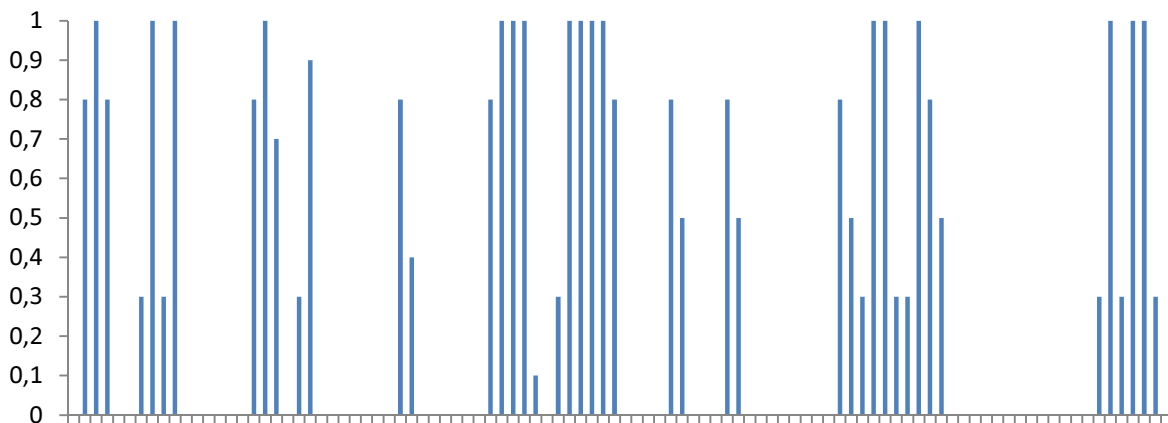
4. CONCLUSION

In the article we presented the concept of a model of logistical support for the functioning of a ground handling agent. We indicated the possibilities of its utilization and the advantages resulting from it. The developed software enables:

- the analysis of the functioning of the ground handling agent for the projected traffic flows - flight network, which will be executed in the next flight season - distant time horizon;
- the analysis of the functioning of the ground handling agent for the projected traffic flows - flight network, which is executed in the current season - a given day when there are more known premises regarding the projected (few hour) period - short-term horizon.
- the analysis of operational parameters of the ground handling agent's equipment,
- the analysis of the process of operating of the ground handling agent's equipment.

Further work will be conducted towards the introduction of random variables of the execution of individual activities of ground handling or the dependence of the duration of activities on, for example, the number of passengers. The model will be enriched with variables characterizing the operation of technical objects of the ground handling agent (probability density distributions of time between any damages and time of restoration of operating capability).

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