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OPTIMIZATION OF THE AIRCRAFT GROUND HANDLING PROCESS

Aircraft ground handling is a process that includes all the operations that must be performed on an aircraft when parking on a stand. The aim of the article is to discuss the optimization possibilities of the aircraft ground handling process. The core of the contribution consists of a description of the activities carried out during the aircraft ground handling process, their timing and order. In the aircraft ground handling process, it is also important to determine the factors that affect the performance of these processes. Finally, the problem solution is outlined using a network analysis method and changing the constraints to optimize the aircraft ground handling process for the Boeing 737-300 aircraft and creating a timetable of activities with their timing and exact order.

Keywords*: optimization, aircraft, ground handling, process, in-block, off-block*

INTRODUCTION

The issue of optimization of the aircraft ground handling system is currently the subject of interest to several airlines, handling providers and, last but not least, the airports themselves. Airports as the main providers of these services are dealing with it on a daily base. The diversity of aviation technology and equipment of airlines, the rapid development of technologies, the reduction of waiting hours, the high occupancy of airports are one of several factors influencing the effectiveness of aircraft handling process at the airport. It is about designing procedures to optimize the use of available resources to increase the efficiency of the aircraft ground handling system. Network analysis methods allow, in particular, an analysis of the continuity of activities and the time reserves that occur in them. On the basis of such an analysis, it is possible to find the optimal distribution of the available resources to ensure the timely follow-up of the activities in order to avoid unjustified delays and to achieve the objectives set in the shortest possible time with the given resources and means. We chose one of the most widespread used types of Boeing 737-300 aircraft to optimize the ground handling process. We will focus on factors influencing the aircraft operating system and their likelihood of occurrence.

ACTIVITIES CARRIED OUT DURING THE AIRCRAFT GROUND HANDLING PROCESS

Aircraft ground handling is a process that includes all the operations that must be performed on an aircraft when parking on a stand. These actions must be performed from in-block time to off-block time. Figure no. 1 shows an overview of all services and corresponding equipment involved in the aircraft ground handling process [4].

The following vehicles and equipment are located around the aircraft on a stand:

- ✈ Push-back vehicle;
- ✈ Vehicles for catering;
- ✈ Vehicles for unloading and loading cargo and mail;

- Luggage trailer;
- Fuel Tank;
- Maintenance vehicle (cabin cleaning);
- Vehicle with drinking water and toilet vehicle;
- Entry/boarding pass for passengers/Staircases for passengers' departure/arrival;
- Electricity Source – power unit [4].

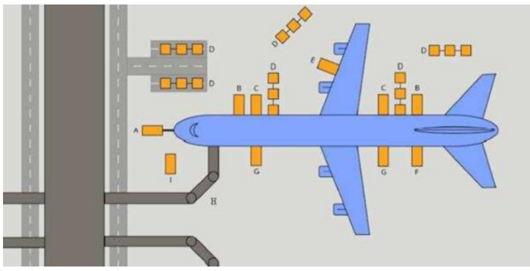

Figure 1. The deployment of ground handling equipment

The exact number and location of these vehicles and equipment depends on the type of aircraft and aircraft stand (remote stand, stand at the entrance). Next, we will deal only with one type of aircraft, namely the Boeing 737-300, which is one of the most frequent types used by aircraft by air carriers. It is clear that planning processes are used to ensure that these activities are carried out at the right time and without interfering with each other.

Figure no. 2 shows an overview of the ground handling service flow between the moment of arrival to the stand and the departure of the stand. In this process, ground handling services were divided into four different parallel flows:

- luggage and cargo;
- passengers and cabin;
- fueling;
- technical aircraft services.

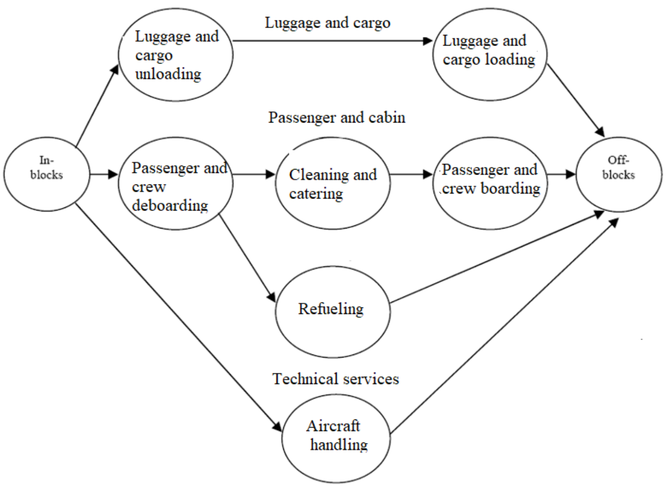

Figure 2. Division of ground handling services

Most of these activities can be performed at the same time. Importantly, these processes need to be further subdivided into one or more partial processes. The arrows in Figure no. 2 show the required order and continuity of activities.

The above processes may be further subdivided according to whether they refer to the arrival or departure of the aircraft from the stand. In this way ground services can be divided into:

- Arrival:
  - parking;
  - passengers and crew deboarding;
  - luggage and cargo unloading;
  - safety;
- Departure:
  - cleaning;
  - refuelling;
  - catering;
  - luggage and cargo loading;
  - passengers boarding;
  - safety and security;
  - aircraft control;
  - push-back from the stand.

Each type of aircraft has a defined minimum time required to ensure complete ground handling. The time depends on the number and complexity of the processes that need to be done. Operations time will be longer for larger aircraft or airlines providing additional passenger services (eg magazines, newspapers, catering, etc.). Before we get into the details between ground handling and other airport operations, it must be emphasized that ground handling does not have the space to perform its own resource planning. The ground handling of the aircraft should take place throughout the aircraft handling process, which means that all ground services should be planned from the time of leaving the stand to arriving at the stand (within the on - and off - block time of the aircraft). Ground handling must stick to these times. It is advantageous for ground handling to be involved in decision-making on the allocation of aircraft stands. It means that they can best evaluate the situation in ground handling. Planning of aircraft handling is the main process in airport planning. Ground handling of aircraft is considered to be the most common and important reason for delays in aviation.

The efficiency of the handling process has a strong impact on the punctuality of aviation activities. Punctuality strongly influences passengers when selecting a particular airline and thus plays an important role in the success of airlines. By improving ground handling activities we hope to increase the accuracy of the entire aviation system. This will certainly have a positive impact on the operation of the airport and all the partners involved.

When optimizing aircraft handling at the airport we will focus on handling luggage, cargo and mail. The unloading and loading of luggage, cargo and mail is one of the most time consuming tasks, given the large volume of cargo that has to be unloaded and loaded over a short period of time. The ways of solution are taken in two parallel ways. One of them is the development of powerful mechanical means for horizontal and vertical cargo transportation. Simplifying material (cargo) handling goes through palletization and containerization, which are re-adapting means of mechanization.

Another important element of optimization in the contribution will be filling with aviation fuels. Fuel filling is carried out from mobile tanks or the hydrant system of the airport by means of pumping vehicles (dispensers). The actual filling of fuel (refueling) into aircraft tanks can be performed in larger aircraft in two ways:

- gradient from the top of the wing (top filling);
- pressure by means of a pressure filling connection (lower filling).

Before refueling the aircraft, it is necessary to check the grounding of the aircraft, the fuel tank and the filling quick coupler. Refueling must not be started when there are no fire-fighting equipment on the stand. When refueling the aircraft only performing workers may be present. In the case of a storm refueling of aircraft is banned.

PROPOSAL FOR THE OPTIMIZATION OF THE AIRCRAFT GROUND HANDLING PROCESS

In this part of the contribution, there is a simple example that serves to demonstrate how simple the ground handling process can be streamlined. The example is a step-by-step approach and includes a set of variables, available resources, and time constraints. Next, the network is constructed from nodes that represent variables, and the edges between the nodes represent limitations (constraints).

Let's imagine the following simplified part of the aircraft stand deployment plan:

- Aircraft: KLM 310, type B737-300, stand 1, in-block 12:00, off-block 13:15.

We also have technical information about the required aircraft handling time and the corresponding ground handling activities times for a specific aircraft type. This information can be divided into two groups. In the first group, there are information and times defined by the airport (as the check-in time and the duration of the individual ground handling services). This is the so-called "standard times, which are the same for most airports and for most airlines and include minor service delays that may occur in the operating phase. In the second group there are the minimum times of handling services provided by the aircraft manufacturer.

For example, for the aircraft Boeing 737-300 the normative times for the performance of activities are determined by the airport for 3 types of services for which it will be set:

- Total check-in time: 55 min.
    1. Refueling: 25 min. (plus added time of 12 minutes for possible delay), this activity starts at 8 min. after the in-block time of the aircraft;
    2. Cargo: 46 min, starts at 4 min. after the in-block time of the aircraft;
    3. Boarding: 15 min. (plus added time 3 min for eventual delay) starts at 32 min. after the in-block time of the aircraft.

On the contrary, Boeing states the following times for the aircraft type B737-300:

- Total check-in time: 38 min.
    1. Refueling: 10 min;
    2. Cargo: 30 min;
    3. Boarding: 5 min [6].

For the flight of KLM310, we take the following steps:

We create variables for each sub-activity that will indicate its start and end (e.g., variable x2 will indicate the start of the KL310 refueling). We specify for each variable that indicates either the start or end time of the activity according to given time limits:

- the start or end time of an activity that corresponds to the normative time specified by the airport for a given activity;
- the start or end of the activity time, which corresponds to the minimum time set by the aircraft manufacturer.

Variable	**Aircraft type**	**Aicraft stand**	**In/off - block time**	**T_{start} (Norm)**	**T_{end} (Norm)**	**T_{start} (Min)**	**T_{end} (Min)**
X_1 (in-block)	B737-300	No. 1	12:00				
X_2 (start of refuelling)	B737-300	No. 1		12:08		12:08	
X_3 (end of refuelling)	B737-300	No.1			12:45		12:18
X_4 (start of loading)	B737-300	No.1		12:04		12:04	
X_5 (end of loading)	B737-300	No.1			12:50		12:34
X_6 (passenger boarding)	B737-300	No.1		12:32		12:32	
X_7 (end of passenger boarding)	B737-300	No.1			12:50		12:37
X_8 (off-block)	B737-300	No.1	13:15				

Table 1 Catalog of ground handling activities

Table no. 1 is constructed in the following manner. Flight KLM310 is operated by Boeing 737-300 aircraft. In the corresponding Boeing service manual, it is stated that the fuel can first be refuelled 8 minutes after the in-block time, which is 12:00. The refuelling takes at least 10 minutes (according to the Boeing Manual), so the first end of refuelling under this document is 18 minutes after the in-block time of the aircraft. Since the in-block time is 12:00, then T_{start} (min) will be 12:08 and T_{end} (min) will be 12:18. We can do the same for the standard times given for this type of aircraft and for all other flights. It is important to note the time difference between the minimum end time of refuelling given by the airport (T_{end} (Norm)) and Aircraft Manufacturer (T_{end} (Min)). (T_{end} (Norm): 12:45 and T_{end} (min.): 12:18) [6].

In determining the minimum time of completion of activities we have to realize that it is not always appropriate to carry out all activities as soon as possible and as quickly as possible. When we finish the handling of the aircraft and all passengers are on board half an hour before the off-block time, the passengers are becoming impatient. Therefore, it is necessary to set restrictions for certain activities, such as the boarding and deboarding of passengers. Passenger deboarding should start as soon as possible after the in-block time and the boarding of passengers should start not too soon before the off-block time of the aircraft. In our example, we assume that passengers will not wait more than 15 minutes before the off-block time of the aircraft [6].

Unlike limited time limits that determine when, before or after which time the activity is performed, there are also limitations on the order of the tasks performed. These restrictions create a procedure for the provision of services at the airport. We can include such limitations as:

- in-block occurs before all other activities;
- deboarding of passengers must be completed before boarding, catering, cleaning;
- placing the entrance / exit bridge must be done before performing any other activities;

- the cabin must be cleaned only after the passengers deboarding or before the passengers boarding;
- for several types of aircraft, airports, airlines, fuel refueling should not be performed during boarding / deboarding of passengers if there is no presence of firefighters;
- aircraft off-block is only performed after all other activities have been completed [4].

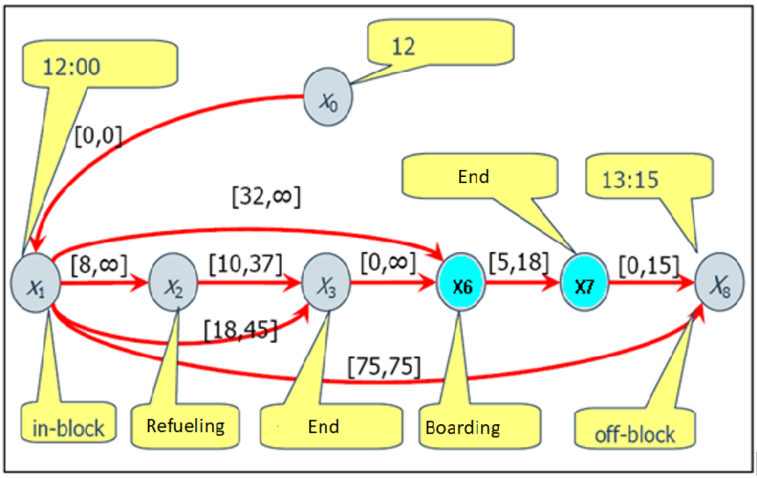

Figure 3 Aircraft ground handling activities

In figure 3, we used 6 variables from table no. 1: X_1, X_2, X_3, X_6, X_7, X_8. Note that restrictions on the order of performance of activities determine the precise sequence according to which variables are deployed. In addition, we added a reference variable X_0 for which we set time 12:00. The minimum and maximum time between variables X_0 and X_1 is [0.0]. The next activity X_2 is refueling. The time limit [8, ∞] between variables X_1 and X_2 indicates that refuelling can begin earliest 8 minutes after the in-block time and there is no upper limit for this activity.

The refueling may take up to 10 minutes (time determined by the manufacturer) up to (25 minutes + 12 minutes time reserve = 37) 37 minutes (normative time determined by the airport). Therefore, the transition between refueling X_2 with the end of refueling X_3 is limited by times [10, 37]. The transition between the in-block time X_1 and the end of the refueling X_3 should be somewhere between T_{end} (Min) and the later T_{end} (Norm) or [18, 45]. Another limit [32, ∞] means that the boarding of passengers X_6 cannot begin earlier than 32 minutes after the in-block time of aircraft designated by X_1.

The boarding of passengers may take at least 5 minutes (T_{end} (Min)) and maximum 18 minutes (T_{end} (Norm)), thus creating a limit [5, 18]. After the passengers boarding, there should be time for other services that we have not included in our example. That's why we've added the variable X_7 (indicating that the boarding is over). As we said that passengers should not wait more than 15 minutes before the off-block time of the aircraft between variables X_6 and X_7, we added a limit of [0.15]. The off-block of the aircraft should be executed exactly at 13:15, therefore we added a [75.75] limit between the in-block time of the aircraft $X_1$and the off-block time of the aircraft X_8. The variable X_8 eventually marks the end of the handling process. We can still add the process cargo loading/unloading to the overall process.

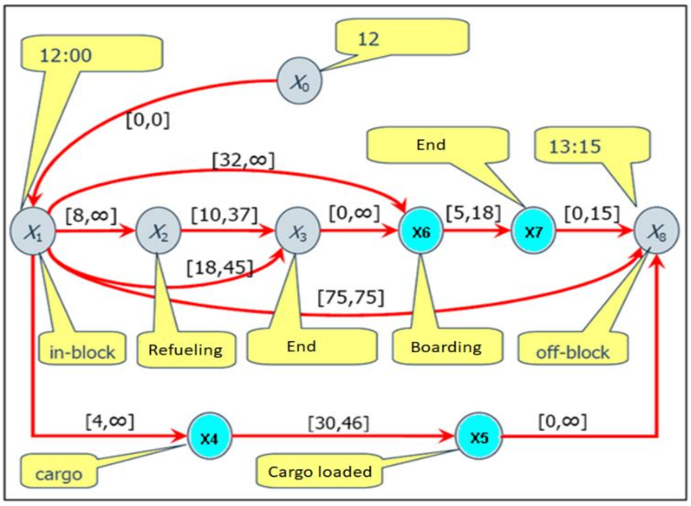

Figure 4 Aircraft ground handling activities

In Figure 4, the X_4 and X_5 variables were added for the beginning and end of cargo loading/unloading. From Figure 6, we can see that cargo loading and unloading can first begin 4 minutes after the in-block time of the aircraft, and the whole activity requires at least 30 and at most 46 minutes. This procedure illustrates the ideal course of ground handling of the Boeing 737-300 aircraft.

CONCLUSION

The contribution addresses the broad issues of optimization of the aircraft ground handling system at the airport. Before optimization is started, it is always necessary to know the equipment and the situation at a particular airport. It is also necessary to know the available means of aircraft handling, the entire aircraft handling process, the individual activities to which it is necessary to focus on optimizing the use of available resources. Another part consists of the optimization of the aircraft handling process of a particular aircraft, Boeing 737-300.

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REPÜLŐGÉPEK FÖLDI KISZOLGÁLÁSI FOLYAMATÁNAK OPTIMIZÁLÁSA

A repülőgép földi kiszolgálása olyan folyamat, amely magában foglalja az összes olyan műveletet, amelyek az állóhelyen kerülnek végrehajtásra. A cikk célja, hogy megvitassa a repülőgép földi kiszolgálási folyamatának optimalizálási lehetőségeit. A hozzájárulás lényege a légi jármű földi kiszolgálásának folyamata során elvégzett tevékenységek leírása, időzítése és rendje. A légi jármű földi kiszolgálási folyamatában fontos meghatározni azokat a tényezőket is, amelyek befolyásolják ezen folyamatok hatásfokát. Végül a probléma megoldást hálózati elemzési módszerekkel vázoljuk fel, és megváltoztatva a szűk keresztmetszeteket a Boeing 737-300 repülőgép földi kiszolgáló folyamatának optimalizálása érdekében, és létrehozzuk a tevékenységek ütemezését időzítésük és pontos sorrendjük alapján.

***Kulcsszavak**: optimalizálás, repülőgépek, földi kiszolgálás, folyamat, fékrögzítés, fékoldás*

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