Efficient Management of Aircraft Taxiing Phase by Adjusting Speed Through Conflict-free Routes

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Abstract   Air traffic congestion is considered to be the main problem in air traffic management. It represents a real handicap in the current rising air traffic flows without a corresponding enhancement in airport infrastructure. This issue leads to more workloads for air traffic controllers, air stakeholders and other airport operations. The following paper aims to minimize the departure aircraft taxiing time in the movement area. This duration can be affected by several factors such as routing, taxiing speed, holding while taxiing ... etc. In this work, we are going to solve the previous problem by using a tactical planning tool: it consists on assigning efficient and nonstop routes to the scheduled traffic on departure. This tool, using a real-time algorithm, will detect in advance routing conflicts and solve them before aircraft leave stands and approach the hotspots in taxing network. Furthermore, the proposed method will optimize the use of the available ground network by acting on the taxiing speed in order to reduce departures' delays, fuel consumption and gas emissions.

Keywords   Air traffic management, Ground movement, Predicting taxi time, Conflict-free taxiing routes, Air traffic optimization, Airport surface operation, aircraft taxiing speed.

AMS 2010 subject classifications 90B50, 90C59, 90B06

DOI: 10.19139/soic-2310-5070-1162

1. Introduction

The air traffic volume has made a new record in the year of 2018 with an increase of 3,8 in air transportation movements. Statistics show that the summer months were particularly the busiest and had more delays. These delays were nevertheless eased via specific routing measures put in place by the Network Managers, making the best use of all available capacity in the network as revealed by EUROCONTROL [1]. The same report was established at the International Air Transport Association IATA when it comes to the continuous expansion of air transportation. Its growth rate is around 3,5 compound annual rate. Forecasting suggest that passengers' numbers could reach 8,2 billion by the year 2037 leading to a doubling in the passengers' numbers from today's level [2]. The first problem to be solved is the ground movement of aircraft at airports. It represents the beginning of the all following congestion problems, and leads to increased flight delays and costs. On another hand, aircraft engines are inefficient at low speed on the ground. Which makes a large contribution to the running cost and aircraft emissions' by wasting more fuel (while waiting in holding areas, stopping and restarting taxiing many times during ground movement for separation). Most previous works have discussed two major ground issues: allocating the shortest route, and improving taxiing time prediction. This work aims to avoid holding and braking action during the taxiing phase. It is going to apply optimized speed adjustments, (which can be controlled all along the taxiing phase) and assist air traffic controllers with a decision support tool. This tool is allocating efficient and conflict-free taxiing

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routes, in order to reduce congestion, fuel consumption (space befor fuel), emissions and predict more accurately the taxiing time. It also optimizes the planned departure routes by taking into account several evaluation functions and different aspects of departure management in order to enhance capacity and efficiency.

2. Related work

2.1. Ground movement problem

Managing efficiently the ground movements is the main key to optimize the air traffic flow and the use of the air network. It has a significant impact on other important airport operations such as runway sequencing and gate assignment. [3] Redefined the taxiway model from a pure graph of nodes and edges to a zone-based partition of the taxiways. [4] Addressed the ground movement problem as a network congestion control problem, making use of a probabilistic model based on Erlang random variables for taxi-out times at Boston Logan Airport. [5] Considered the similarity of ground movement to road traffic flows, proposing a modeling approach based on the cell transmission model for simulating the evolution of flow and congestion on taxiways. [6] Proposed a Management of speeds, time slots, landing runway, and pushback delay to optimize taxi times. The authors in [7] and [8] managed the gate/stand allocations to optimize Ground Movement. The papers [9] and [10] used the shortest path algorithm and heuristic search algorithms (such as genetic algorithms) and they selected an appropriate route and wait points for each aircraft. [11] Showed that arriving aircraft can indeed produce a lot of delay to overall taxi movements, and they noted the importance of having an accurate model for the pushback process. The work [12] Described the QPPTW algorithm, an adaptation of Dijkstra's shortest path algorithm that accounts for the movements of previously-allocated aircraft rather than optimization of routes. [13] used genetic algorithms to evolve the routes rather than choosing predefined ones. The papers [14], [15], [16] and [17] formulated Ground Movement as a mixed-integer linear programming problem.

2.2. Estimating taxiing time

In paper [17] the authors compared several modeling approaches and found that fuzzy approaches are the most accurate modeling to yield the problem. In [18] They used a dynamic programming approach combined with a model drawing on taxi times, to determine the optimal pushback times at Logan International Airport. Mitigating the effect of delays in taxing phase. The work [19] developed a probability distribution function to model taxi times for JFK Airport. [20] Used a regression model to estimate taxi times at Newark Liberty Airport and the paper [21] demonstrated a log-linear regression analysis to estimate taxi time.

2.3. Uncertainties of taxiing time

An accurate taxi time forecast is useful to various air stakeholders. This allows a better certainty in taxiing prediction and provides important forecasts for all parties in the airport. It will be increasingly important to have precise control of the aircraft on the ground through an advanced decision support system to reduce conflicts and minimize delays. [22] Proposed the use of time margins around aircraft trajectories. [23] Gave a comprehensive assessment of the predictability impacts of airport surface automation. A wide range of the impacts was considered, which included variability in taxi-out time. The paper [24] Reflected the impact of uncertainty on ground movement using a simulation with speed variations in profile at Detroit International Airport. Studying Variations in taxi speeds showed significant increases in ground delay for departures. The works [25] and [26] reflected the strong impact of taxi time uncertainty on the airport's efficiency.

3. Problem description and proposed solution

Jet-engines operate optimally at cruising in the air, but they are inefficient while propelling an aircraft at low speed on the ground [27]. As mentioned above, previous works in ground movement has tackled two major axes: taxiing

time problem by allocating the shortest route, and the prediction of taxiing time. This work aims to optimize ground movement management. It consists on allocating efficient and conflict-free routes to avoid waiting in holding areas by applying optimum taxiing speed. In this paper, we are going to start by handling the apron conflicts, then tackle the hotspots management and finally minimize the delay by applying specific taxiing speed.

3.1. Management of conflicts in the Apron

First of all, we will Start by managing apron's conflicts. As shown in Figure 1 the stands in orange will be condemned once the blue aircraft start taxiing. Which means that the other aircraft occupying these stands cannot taxi or push back till the blue aircraft clears the way. Using Table 1 as data base accurately reflects the situation of all stands:

Figure 1. Stands map (example: part of Mohammed V International Airport) From AIP Morocco.

Modelization of the variables in the database:

A_i is the aircraft(i) at the stand(i) P_i, $tb_i(K)$ is the Estimated lock time of the stand P_i by the Kth aircraft. $td_i(K)$ is the Estimated deadlock of P_i by the Kth aircraft. $ETD(i)$ is the Estimated departure time of A_i. $EOBT(i)$ is the estimated out of block time of A_i, according to $ETD(i)$ and taxi time as estimated value published by local authority. $TxT(i)$ is the Calculated taxi time according to the type of aircraft A_i and stand Pi. Let $CTxT(i)$ be the calculated taxi out of the block time of A_i from the stand Pi, Time for "(Pi) forme non mathématique" aircraft A_i to clear the stand P_i is: $td_i(K) = CTxT(i)$. If P_k is blocked by A_i so $td_i(K) > CTxT(i)$. The aircraft A_i locks the stand(k) from the time $tb_i(K)$ until the time $td_i(K)$ and the nearest available time of the stand(k) is: from $td_i(K)$ until $tb_{i+1}(K)$.

Table 1. Condemned stands.

Stand	P_1	P_2	P_3	P_4	P_i	P_{i+1}	..	P_n
Condemned /n	0	1	1	0	1/0	1/0	...	1/0
Lock time(1)	$tb_1(1)$	$tb_2(1)$	$tb_3(1)$	$tb_4(1)$	$tb_i(1)$	$tb_{i+1}(1)$	..	$tb_n(1)$
Deadlock time (1)	$td_1(1)$	$td_2(1)$	$td_3(1)$	$td_4(1)$	$td_i(1)$	$td_{i+1}(1)$	..	$td_n(1)$
Lock time (2)	$tb_1(2)$	$tb_2(2)$	$tb_3(2)$	$tb_4(2)$	$tb_i(2)$	$tb_{i+1}(2)$	..	$tb_n(2)$
Deadlock time (2)	$td_1(2)$	$td_2(2)$	$td_3(2)$	$td_4(2)$	$td_i(2)$	$td_{i+1}(2)$	..	$td_n(2)$
...	...	...	...	...	...	...	...	

3.2. Management of conflicts at the hotspots

In this section we will tackle hotspots management as shown in Figure 2. Using Table 2 as data base accurately reflects the situation of all hotspots.
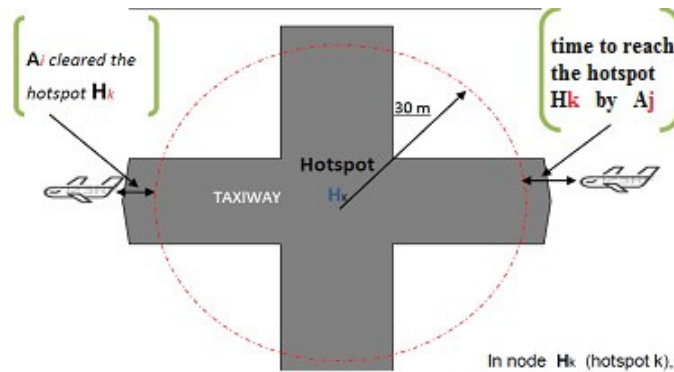
Figure 2. Conflict management at hotspots.

Table 2. Condemned stands.

Hotspot	H_1	H_2	H_3	H_4	H_i	H_{i+1}	..	H_n
Time for A_1 to enter the Hotspot H_i	$E_{1,1}$	$E_{1,2}$	$E_{1,3}$	$E_{1,4}$	$E_{1,i}$	$E_{1,i+1}$	...	$E_{1,n}$
Time for A_1 to clear the Hotspot H_i	$C_{1,1}$	$C_{1,2}$	$C_{1,3}$	$C_{1,4}$	$C_{1,i}$	$C_{1,i+1}$	...	$C_{1,n}$
Time for A_2 to enter the Hotspot H_i	$E_{2,1}$	$E_{2,2}$	$E_{2,3}$	$E_{2,4}$	$E_{2,i}$	$E_{2,i+1}$	...	$E_{2,n}$
Time for A_2 to clear the Hotspot H_i	$C_{2,1}$	$C_{2,2}$	$C_{2,3}$	$C_{2,4}$	$C_{2,i}$	$C_{2,i+1}$	...	$C_{2,n}$
...	...	...	...	...	...	...	...	

The aircraft A_i occupies the hotspot(k) from the time $E_{i,k}$ until the time $C_{i,k}$ and the nearest available time to cross the hotspot(k) is from the time $E_{i,k}$ until the time $C_{i+1,k}$.

4. Calculating taxiing out time of the block Ctxt

4.1. Calculating Ctxt according to hotspots and condemned stands

Begin
for each i;
A_i aircraft in the P_i stand with ETD_i ;
Generate route;
Generate the list of hotspots in the route;
Generate the list of condemned stands;
Calculate Txt_i; /* using the type of aircraft and position of the stand
$CTxT_i = ETD_i - TxT_i$; /* Calculate $CTxT_i$, taxiing Time to reach holding point at ETD_i
while $k < M$ /* Calculate r_i
if $td_k < CTxT_i$ and $tb_{k+1} > CTxT_i$
$r_i = 0$ /* No delay expected
if $td_k > CTxT_i$
$r_i = td_k$ /* Correction of $CTxT_i$
End while
$CTxT_i = r_i$; /* update $CTxT_i$
for $k = 1$ to N do; /* calculate Wi time to wait in hotspot i
calculate the $E_{i,k}$; /* Time to reach hotspot k
calculate the nearest $C_{i,k}$ /* Time for A_i to clear the hotspot k; /* A_j the precedent aircraft passing by the hotspot
if $E_{i,k}$ - $C_{j,k} > 0$
$W_i = 0$; /* No delay expected
Else
$W_i = E_{i,k} - C_{j,k}$ /* Delay added to $CTxT_i$
End if;
$CTxT_i = CTxT_i + W_i$;
$k = k + 1$;
end for;

update condemned stands then conflict slots; /* Check the impact of stands then the hotspots situation

   end for;
end.

4.2. *Updating aircraft position*

After Calculating $CTxT_i$, we get a new estimate out of the block time and estimated total taxi time, to make this data more accurate we need to update the position of each aircraft by comparing the real position with the estimated one. let A_i be the aircraft(i) at the real position $\Pi(i)$ with estimated position $\Omega(i)$, and $\Lambda(i)$ is the estimated time to reach the position $\Omega(i)$ from $\Pi(i)$;
begin
for $t = 0$
for each i;
Calculate $\Pi(i)$; Calculate $\Omega(i)$; calculate $\Lambda(i)$;
If $\Lambda(i) > 0$
$CTxT_i = CTxT_i + \Lambda(i)$;
End if
end for
$t = t + \Delta(t)$ /* $\Delta(t) = 60s$ is the needed time to update the situation
end for
update condemned stands;
update conflict slots;
end.

4.3. *The saved time by applying Ctxt*

As shown in Table 3, applying a case study of this method in real traffic, we noticed that a delay of around 16 minutes was accumulated by only 10 of the 274 aircraft scheduled for the same day, so the application of the "CTxT" Method saves a significant time and improves taxiing time prediction as it is proved by this experiment.

Table 3. Example of the situation from Mohammed V Airport

TP	Std	Fly	Act	Stp Nm	Y/CTxT	N/CTxT	Delay
A320	E06	3O335	06:00	4	430s	250s	180s
A320	B14	3O457	06:50	3	330s	200s	130s
B738	D03	AT778	07:30	2	220s	130s	90s
A320	E02	AF1497	07:40	4	460s	280s	180s
A320	D06	AT728	07:40	2	210s	120s	90s
B738	C03	AT946	07:45	3	50 s	300s	200s
B788	J11	AT760	08:00	3	390s	300 s	90 s
B738	E07	AT1634	09:25	4	440s	240s	200 s
B789	J09	EY612	09:50	4	440s	300s	140 s
E190	B12	AT411	10:10	4	340s	250s	90s

Std: stand
Fly: flight
Act: Activation time
Stp Nm: number of stops expected

Y/CTxT: Estimated taxiing time Using CTxT
N/CTxT :Estimated taxiing time without Using CTxT

5. Predict the taxiing time and minimize the burned fuel

5.1. The importance of taxiing time prediction and its uncertainty

When an aircraft arrives at the $\Pi(i)$ position at a different time than expected, it can cause conflicts with other aircraft leading to delays. Therefore, predicting taxi time is an essential process to optimize ground movements. [25] Demonstrated a log-linear regression analysis to estimate taxi time. And to cope with the uncertainty of taxi time, [28] used an increased temporal separation between aircraft. In [25]; [26] authors reflect the strong impact of taxi time uncertainty on the airport's efficiency. [15] Showed that Uncertainty in taxi times can be explicitly recognized and tackled, they Suggest that punctuality figures should be adjusted to use take-off times rather than push-back times, and [27] showed that Adaptive Mamdani fuzzy rule-based system, generating multiple routes for different levels of uncertainty, reduced delays by 10–20% over the original QPPTW, he proved that at Manchester Airport, And [29] at Zurich Airport. [22] Used a simulation to explore the effect that the size of buffers around taxiing aircraft has upon throughput and robustness, finding that taxi time uncertainty is a major factor preventing the optimal use of the taxiways and runways.

5.2. Taxiing speed effect in ground movement optimization

[9] Tried to predict taxi time by defining initially taxi speed, such uncertainty has been modeled as a fixed percentage of the initially defined taxi speed. [24] Reflected the impact of uncertainty on Ground Movement using a simulation with speed variations in profile, at Detroit International Airport. They found that variations in taxi speeds resulted in significant increases in ground delay for departures. It is necessary to take into account the problem of speed profile optimizing, which is not saving time only but also fuel and reducing airport emissions. One of the aims of this work is Calculating $CTxT$ for each aircraft to Improve the Prediction of taxi time on Ground Movement by maintaining a constant speed as long as possible and avoid deceleration and braking actions all along the taxiing route as shown in Figure 3:
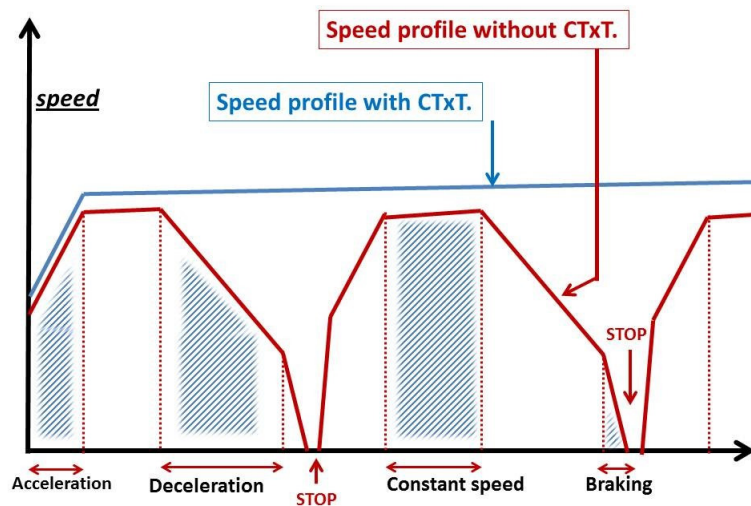

Figure 3. Speed profile on a straight segment passing by 2 hotspots with and without CTxT.

6. Acting on taxiing speed

By Applying our method, we can attribute a taxiing route without any stop or hold during all the taxiing phase. The aircraft can keep a constant taxiing speed during all the taxiing phases, as shown in Figure 3, which able us to apply a change to the taxiing speed value to minimize the taxiing cost. It will have also other advantages like operational safety, efficiency, and predictability, towards optimal use of infrastructure, even with higher and more complicated traffic expected.

6.1. Taxiing speed adjustment TSA

During the taxiing phase, the main key is to ensure continuous taxiing and maintaining constant speed as long as possible is the management of hot spots, as mentioned in point III-B, next part of our work is to enhance the use of the airport network by acting on the taxiing speed to minimize the delay caused by the hotspot conflicts.
To apply our method, we calculate an estimated time of each aircraft to leave the stand and start taxiing, this $CTXT$ is known as a delay received from the air traffic management service ATS, the next step in our work is to minimize the generated delay by attributing specific taxiing speed respecting all constraints.

6.2. Modelization of the proposed model

Air traffic management is a task that requires proactive decision making by air traffic controllers, and the main used tool is the estimated time and duration of each execution part in all phases, that's why we choose a concept based on Time rather than distance, and by acting on the speed we get a clear set of estimated times and duration expected in all segments of the taxiing route in a network of segments and nodes as illustrated in Figure 4:
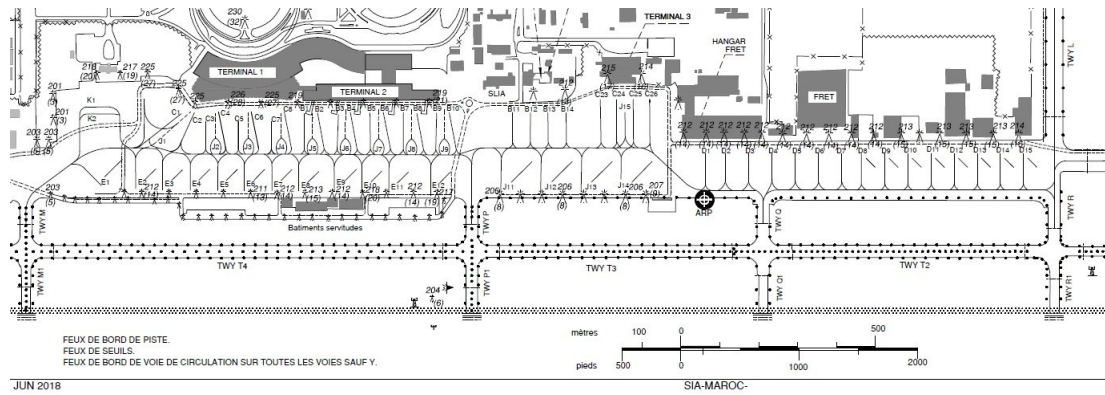

Figure 4. Mohammed V airport taxiing chart.

Let V_i be the taxiing speed of the aircraft A_i;
d_i the crossed distance by A_i from the stand S_i to reach the hotspot H.
$f_i(d_i)$ is the needed time to cross the distance d_i between stand S_i and the hotspot H.

$$f_i(d_i) = \frac{d_i}{V_i} \tag{1}$$

r_i is the generated delay of the aircraft A_i due to conflicts in route.
So the multi-objective minimizing problem to solve is:

$$\min \sum_{i=2}^{n} |f_i(d_i) - r_i| \tag{2}$$

The problem was solved by the meta heuristic method: Partial Swarm Optimization.

tx_i is the estimated time of aircraft A_i to reach the first holding point H_1, The aircraft A_i may cross the hotspot from $tx_{i-1} + 1min$, so the problem is minimizing tx_i under the following condition: $tx_i \geq tx_{i-1} + 1min$.

6.3. Simulation

We're going to simulate our algorithm in a defined period, generating a random set of: activation time; type of aircraft (A_i); stand (P_i). We calculate the new speed based on the following formula:

$$V_{k+1} = c_1 V_k + c_2(best_p - X_k) + c_3(best_v - X_k) \tag{3}$$

$$X_{k+1} = X_k + V_{k+1} \tag{4}$$

With:

X_k is the position of the particle at the k iteration.

V_k is the speed of the particle at the k iteration.

$best_p$ is the best position of the particle.

$best_v$ is the best position of the particle vicinity at the k iteration.

c_1 is a coefficient during iterations. c_2 et c_3 are coefficients randomly generated at each iteration.

7. Algorithms and comparative study

7.1. Applying adjustments on taxiing speed

Speed modification is a useful technique during the taxiing phases with the instruction: slow down or speed up, and it can go up to 20% applied to the V_i the stored taxiing speeds in the database according to the type of aircraft. After Calculating $CTxT(i)$, we get a new estimate out of the block time and estimated total taxi time, afterwards, we apply the speed adjustments, we proceed by optimization to calculate (a_i) which is the predicted percentage changes in speed, so the aircraft A_2 can cross the conflicted hot spot at $testv_2$ with:

$testv_2 \geq testv_1 + 1min$; and so on for the rest of A_i, with:

$$testv_i \geq testv_{i-1} + 1min \tag{5}$$

finally, we calculate:

$$Rv_i = testv_i - tp(i) \tag{6}$$

$tp(i)$ is the estimated cross time of hotspot without conflict resolution; Rv_i is the delay of A_i. The percentages' computation of A_i, is a minimization problem which formulated as follows:

$$\min |tv_i(a_i) - testv_i| \tag{7}$$

u:c: -20%$\leq a_i \leq$ 20% with:

$$tv_i(a_i) = \frac{d_i}{(1 + a_i)V_i} \tag{8}$$

$$testv_i = testv_{i-1} + 1min \tag{9}$$

d_i is the crossed distance by A_i; To make the set of data more accurate, we proceed by updating the position of each aircraft A_i.

7.2. Algorithm

1 Compute $testv_i$ for $i = 1, ..., n$
2 Compute tv_i using a_i minimizing (7) for $i = 1, ..., n$
3 Compute the delay/profit Rv_i for $i = 1, ..., n$

7.3. Application

for $n = 22$:
- Compute the time to reach the hotspot H for each A_i with stored speed V_i;
- Initially, we chose the increasing order of activation time as a reference order;
- Compute the delay according to (FCFS) as shown in Table 4;
- Establish a new permutation increasing order of estimation time to reach the hotspot H;
- Apply the change on taxiing speed value;
- Compute Rv_i for each A_i according to the taxiing speed adjustments (TSA) method as shown in Table 5:
Rv_i is the delay of aircraft A_i
Stand distance : Stdst
Type of aircraft: Tp
Activation time: Act
Time to clear the HotSpot: Cl Hpt
Authorized Time to enter the HotSpot: Aut Hpt
New Time to clear the HotSpot: Nw Cl Hpt

Table 4. results using FCFS

A	Stdst	Tp	Act	Cl Hpt	Aut Hpt	Nw Cl Hpt	Rv_i
1	9	6	1	184	163	184	0
2	6	5	1,4	109,4	184	202	92,6
3	8	6	2,3	167,3	202	223	55,7
4	9	4	3,8	126,8	223	238	111,2
5	6	6	4	133	238	259	126
6	8	5	5,2	143,2	259	277	133,8
7	5	4	6,4	81,4	277	292	210,6
8	8	3	6,6	90,6	292	304	213,4
9	7	4	7,8	106,8	304	319	212,2
10	6	5	9	117	319	337	220
11	8	3	10,2	94,2	337	349	254,8
12	7	4	11,4	110,4	349	364	253,6
13	6	3	12,6	78,6	364	376	297,4
14	4	4	13,8	76,8	376	391	314,2
15	5	2	14	53	391	400	347
16	4	5	15,2	93,2	400	418	324,8
17	5	4	16,4	91,4	418	433	341,6
18	4	2	17,6	50,6	433	442	391,4
19	5	3	17,8	74,8	442	454	379,2
20	6	1	18	42	454	460	418
21	4	2	20,2	53,2	460	469	415,8
22	3	1	21,4	36,4	469	475	438,6
	...	...	...	...	...	Second	5552

Table 5. results using TSA

P	Stdst	Tp	Act	Rt Reg	Cl Hpt	Aut Hpt	Nw Cl Hpt	Rv_i
22	3	1	21,4	0,8	35,8	24,32	29,72	0
20	6	1	18	0,825	41,475	29,72	35,195	0,02
18	4	2	17,6	0,8455	50,136	35,19	43,7315	0,02
15	5	2	14	0,99	52,98	43,73	52,71	0
21	4	2	20,2	1,1924	53,78	52,71	62,29	0,01
14	4	4	13,8	1,08	76,82	62,29	77,31	0,002
19	5	3	17,8	1,2	75,4	77,31	89,91	1,95
7	5	4	6,4	1,2	82	89,91	105,5	10,2
13	6	3	12,6	1,2	79,2	105,5	118,1	25,6
16	4	5	15,2	1,2	93,8	118,1	136,7	27,87
17	5	4	16,4	1,2	92	136,7	152,3	45,03
8	8	3	6,6	1,2	91,2	152,3	164,9	57,99
11	8	3	10,2	1,2	94,8	164,9	177,5	66,27
2	6	5	1,4	1,2	110	177,5	196,1	67,83
9	7	4	7,8	1,2	107,4	196,1	211,7	85,95
12	7	4	11,4	1,2	111	211,7	227,3	97,23
10	6	5	9	1,2	117,6	227,3	245,9	108,51
4	9	4	3,8	1,2	127,4	245,9	261,5	111,75
5	6	6	4	1,2	133,6	261,5	283,1	127,11
6	8	5	5,2	1,2	143,8	283,1	301,7	132,87
3	8	6	2,3	1,2	167,9	301,7	323,3	126,15
1	9	6	1	1,2	184,6	323,3	344,9	127,71
							Second	1220,16
							Min	20,336

Rate of Regulation : Rt Reg

7.4. Comparative study

The sum of accumulated delays by the 22 aircraft using FCFS sequencing processes is: Rf = 5551,9 seconds (92,5316667 min) shown in Tab 4. And the sum of the delays accumulated using the proposed sequencing processes (TSA) is: Rn = 1220,2 seconds: (20,34 min) shown in Tab 5. The Profit by applying the new method is 72,19 min. According to the simulations appearing in Fig 5, the new algorithm with taxiing speed adjustments TSA provides outstanding results compared to FCFS.

7.5. Fuel consumption

Aircraft could delay starting their engines in the stand to save fuel. Once the aircraft start taxiing according to the speed profile in Figure 3 showing that Each segment is divided into four parts, corresponding to four different aircraft taxiing phases (acceleration, traveling at a constant speed, braking and braking with maximum deceleration) with a typical taxiing behavior. [30] Described a heuristic employed to find optimized speed profiles related to Fuel consumption reached by applying the "CTxT" which maintains the traveling at constant speed phase for a longer period.
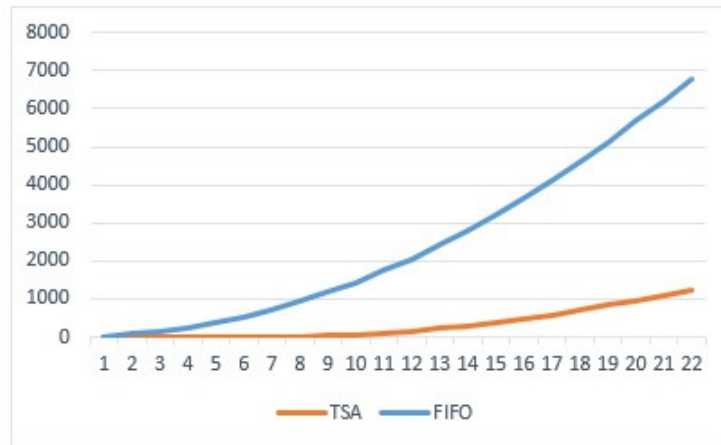
Figure 5. The delays accumulated by the 22 aircraft.

8. Conclusion and further development

On one hand the use of the proposed method has given remarkable improvements in terms of minimizing:taxiing time, air traffic controller workload, rapid acceleration, the burned fuel while waiting at hot spots, and excessive greenhouse gas emissions. On the other one, it allows the aircraft to maintain a constant speed as long as possible during the taxiing phase, which makes it possible to predict more accurately the taxiing time and the exact estimates of passing through conflict points and therefore ease the application of other optimization methods towards optimal use of the ground system at airports.

This contribution aims to facilitate the mission and reduce the workload of air traffic controllers with a decision-making support that increase the capacity of Air Traffic Management systems while ensuring a high level of safety. This tool (using real-time algorithms) will also reduce costs by acting on the taxiing speed during ground movement phases to reach an optimal air network management.

Our proposed work calculated the taxi out of the block time CTxT and taxiing speed adjustments TSA which provided outstanding results and benefits. It leads to an optimization of time, taxiing distances, fuel consumption, and green gaze emissions. Decrease the uncertainty of taxi time remains an important factor among others that could be introduced in further work, such as respecting allocated time slots, priority management and consideration of arriving operations.

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