Research on Flight Ground Taxi Time of Large Airports

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Abstract. Flight taxi time is a key index to measure the operation efficiency of large airports. There are many factors affecting the taxiing process of the flight at the airport. Firstly, the taxi time of arrival and departure flights was defined and its composition was analyzed. Based on the taxiing time of actual flight operation, the average taxi time of flights at many large airports in China and the world was compared. The taxi out time of departure flights was mainly concentrated on 15–20 min. Arrival flights took significantly less taxi in time than departure flights, usually about 10 min. Four main reasons leading to the increase of taxi time were analyzed. Finally, the improvement measures were proposed from five aspects, including coordinated utilization of airport resources, improvement of runway release efficiency and optimization of taxiing hot spot area.

Keywords: airport · taxi time · airfield · air traffic · simulation

1 Introduction

With the continuous improvement of passenger throughput and cargo throughput of civil aviation, the ground operation of large hub airport is becoming more and more complicated. The smooth operation of airfield area has gradually become a key link to improve the operation efficiency of airport. During the taxiing process of the airport, the flight is affected by many factors, such as the taxiway system layout, the allocation of gate resources, the service of flights, the air traffic control and the requirements of the airline. Flight taxiing time has strong randomness and uncertainty, so it is difficult to predict it accurately.

At present, domestic and foreign scholars have carried out a lot of research on the prediction of flight taxi time and the control of departure time of flight. In the aspect of flight taxi time prediction, simulation modeling and analysis modeling are mainly used. The simulation modeling method establishes the ground operation model of the airfield area through the airport simulation software [1–4]. After loading the flight schedule, the ground taxiing time of take-off and landing flights is analyzed. Statistical methods or mature machine learning algorithms are used for analysis modeling [5–8]. The above studies mostly focus on specific airports and analyze by setting preconditions.

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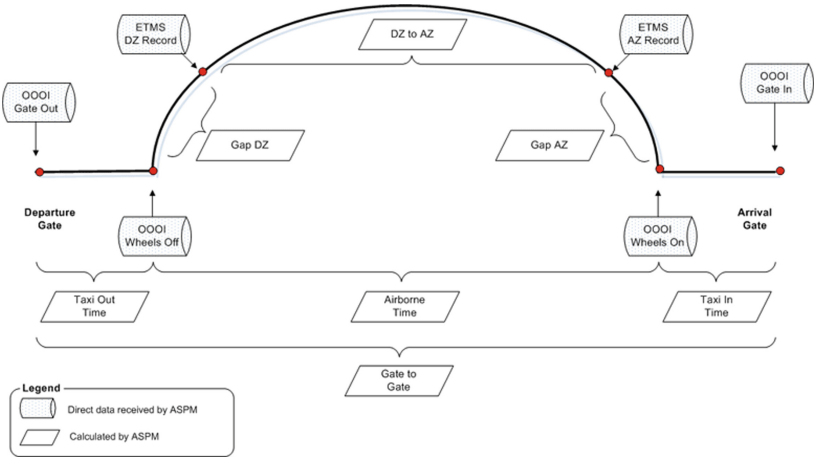


Fig. 1. Flight operation time phase

This paper will be based on the actual operation statistics of the airport flight ground taxiing time as a comparative analysis of domestic large airports and Europe and the United States and other large airports of flight taxi in and taxi out time. The reasons for the long taxi time of the flight are analyzed, and the optimization suggestions are put forward.

2 Flight Taxi Time Definition

Average taxi out time of airport departure flights: the difference between the actual wheels off time and the actual gate out time of airport departure flights within the statistical period, and the average value is calculated by adding up the flights. The departure taxi out time shall be calculated from the time when the flight gears are withdrawn to the time when the flight takes off, including flight push back time, taxi time, runway entrance waiting time and take-off time.

Average taxi in time of airport arrival flights: the difference between the actual gate in time and the actual wheels on time of airport arrival flights within the statistical period, and the average value is calculated by adding up the flights. The arrival taxi in time shall be calculated from the landing time to the end of the gear time of the flight, including the landing time, taxi time and gate-in time. The flight operation process diagram including the time of taxi in and taxi out is shown in Fig. 1.

Factors affecting flight taxi time mainly include: taxiway layout, mutual interference between aircrafts, mutual interference between aircrafts and service vehicles, gate position setting, runway release interval, runway crossing and detour taxiway, etc.

3 Comparison of Flight Taxi Time

With reference to the flight data statistics of the Civil Aviation Administration of China in recent three years, the airports with long taxi time or representative airports in China are selected for statistical analysis. The average taxi out time of departure flights and

average taxi in time of arrival flights are shown in Table 1. The statistical unit of taxi time is minute. The statistical data in the table cover 2019–2021 [9–11]. In 2019, the airport was not affected by the epidemic, the flight volume was relatively full, and the taxi time of the airport would contain a high proportion of taxiing interference and waiting time. In 2020 and 2021, the airport flight volume drops sharply, and the taxi time of flights will be more similar to the taxi time without disturbance. In addition, Beijing Daxing International Airport was launched in September 2019, while Chengdu Tianfu International Airport was launched in June 2021. The statistical analysis of these two airports has certain particularity.

The average taxi time of 8 representative airports in the United States in 2019 and 2021 was queried through FAA official website ASPM (Aviation System Performance Metrics). The screenshot of statistical report and summary table are shown in Fig. 2 and Table 2. The statistical unit of taxi time is minute.

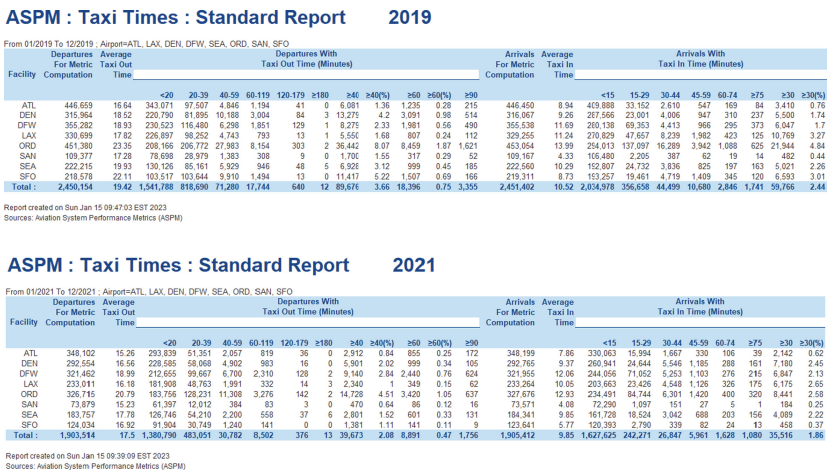
The runway configurations of 8 American airports (ATL, LAX, ORD, DFW, DEN, SFO, SEA and SAN) are shown in Fig. 3.

Select some large airports in Europe and Asia to do further comparative analysis of taxi time, as shown in Table 3. This part of statistical data comes from the taxi time of the world's major airports in the summer season in 2021 released by Europe, which does not cover the whole year and is temporarily for reference. The statistical unit of taxi time is minute.

According to the comparative analysis of the above materials, there is no significant difference between the average taxi time of Chinese airports and similar large airports in the world in terms of horizontal comparison with the same size (such as configuration layout, land area or passenger throughput). There are 2 airports with taxi out time of more than 20 min in the United States, ORD and SFO. In 2021, for example, we analyzed

Table 1. Taxi time of large domestic airports (2019–2021)

Airport	2021		2020		2019	
	Taxi out	Taxi in	Taxi out	Taxi in	Taxi out	Taxi in
Pudong (PVG)	19.44	12.18	18.67	12.17	18.96	13.54
Harbin (HRB)	16.66	6.12	16.99	6.38	17.74	6.15
Shenzhen (SZX)	16.58	8.23	15.75	8.4	17.25	7.94
Guangzhou (CAN)	15.81	7.44	15.48	7.04	17.03	7.93
Daxing (PKX)	15.46	11.09	16.09	11.19	14.02	12.04
Capital (PEK)	11.96	10.37	14.64	10.38	18.94	12.20
Kunming (KMG)	14.98	7.74	15.86	7.95	16.51	7.44
Hongqiao (SHA)	13.85	8.99	13.37	8.52	14.02	8.75
Xiamen (XMN)	15.02	4.61	14.87	4.51	18.77	4.21
Chongqing (CKG)	12.87	7.70	13.06	7.6	12.88	7.52
Tianfu (TFU)	13.73	8.22	/	/	/	/



ASPM : Taxi Times : Standard Report 2019

From 01/2019 To 12/2019 : Airport=ATL, LAX, DEN, DFW, SEA, ORD, SAN, SFO

Facility	Departures For Metric Computation	Average Taxi Out Time	Departures With Taxi Out Time (Minutes)										Arrivals For Metric Computation	Average Taxi In Time	Arrivals With Taxi In Time (Minutes)							
			<20	20-39	40-59	60-119	120-179	≥180	≥40	≥40(%)	≥60	≥60(%)	≥90			<15	15-29	30-44	45-59	60-74	≥75	≥30	≥30(%)
ATL	446,659	16.64	343,071	97,507	4,846	1,194	41	0	6,081	1.36	1,235	0.28	215	446,450	8.94	409,888	33,152	2,610	547	169	84	3,410	0.76
DEN	315,964	18.52	220,790	81,895	10,188	3,004	84	3	13,275	4.2	3,091	0.98	514	316,067	9.26	267,566	23,001	4,006	947	310	237	5,500	1.74
DFW	355,282	18.93	230,523	116,480	6,298	1,851	129	1	8,275	2.33	1,981	0.56	490	355,538	11.69	260,138	69,353	4,413	966	295	373	6,047	1.7
LAX	330,699	17.82	226,897	98,252	4,743	793	13	1	5,550	1.68	807	0.24	112	329,255	11.24	270,829	47,657	8,239	1,982	423	125	10,769	3.27
ORD	451,380	23.35	208,166	206,772	27,983	8,154	303	2	36,442	8.07	8,459	1.87	1,621	453,054	13.99	254,013	137,097	16,289	3,942	1,088	625	21,944	4.84
SAN	109,377	17.28	78,698	28,979	1,383	308	9	0	1,700	1.55	317	0.29	52	109,167	4.33	106,480	2,205	387	62	19	14	482	0.44
SEA	222,215	19.93	130,126	85,161	5,929	946	48	5	6,928	3.12	999	0.45	185	222,560	10.29	192,807	24,732	3,836	825	197	163	5,021	2.26
SFO	218,578	22.11	103,517	103,644	9,910	1,494	13	0	11,417	5.22	1,507	0.69	166	219,311	8.73	153,257	19,461	4,719	1,409	345	120	6,593	3.01
Total :	2,450,154	19.42	1,541,788	818,690	71,280	17,744	640	12	89,676	3.66	18,396	0.75	3,355	2,451,402	10.52	2,034,978	356,658	44,499	10,680	2,846	1,741	59,766	2.44

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Sources: Aviation System Performance Metrics (ASPM)

ASPM : Taxi Times : Standard Report 2021

From 01/2021 To 12/2021 : Airport=ATL, LAX, DEN, DFW, SEA, ORD, SAN, SFO

Facility	Departures For Metric Computation	Average Taxi Out Time	Departures With Taxi Out Time (Minutes)										Arrivals For Metric Computation	Average Taxi In Time	Arrivals With Taxi In Time (Minutes)							
			<20	20-39	40-59	60-119	120-179	≥180	≥40	≥40(%)	≥60	≥60(%)	≥90			<15	15-29	30-44	45-59	60-74	≥75	≥30	≥30(%)
ATL	348,102	15.26	293,839	51,351	2,057	819	36	0	2,912	0.84	855	0.25	172	348,199	7.86	330,063	15,994	1,667	330	106	39	2,142	0.62
DEN	292,554	16.56	228,585	58,068	4,902	983	16	0	5,901	2.02	999	0.34	105	292,765	9.37	260,941	24,644	5,546	1,185	288	161	7,180	2.45
DFW	321,462	18.99	212,655	99,667	6,700	2,310	128	2	9,140	2.84	2,440	0.76	624	321,955	12.06	244,056	71,052	5,253	1,103	276	215	6,847	2.13
LAX	233,011	16.18	181,908	48,763	1,991	332	14	3	2,340	1	349	0.15	62	233,264	10.05	203,663	23,426	4,548	1,126	326	175	6,175	2.65
ORD	326,715	20.79	183,756	128,231	11,308	3,276	142	2	14,728	4.51	3,420	1.05	637	327,676	12.93	234,491	84,744	6,301	1,420	400	320	8,441	2.58
SAN	73,879	15.23	61,397	12,012	384	83	3	0	470	0.64	86	0.12	16	73,571	4.08	72,290	1,097	151	27	5	1	184	0.25
SEA	183,757	17.78	126,746	54,210	2,200	558	37	6	2,801	1.52	601	0.33	131	184,341	9.85	161,728	18,524	3,042	688	203	156	4,089	2.22
SFO	124,034	16.92	91,904	30,749	1,240	141	0	0	1,381	1.11	141	0.11	9	123,641	5.77	120,393	2,790	339	82	24	13	458	0.37
Total :	1,903,514	17.5	1,380,790	483,051	30,782	8,502	376	13	39,673	2.08	8,891	0.47	1,756	1,905,412	9.85	1,627,625	242,271	26,847	5,961	1,628	1,080	35,516	1.86

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Sources: Aviation System Performance Metrics (ASPM)

Fig. 2. ASPM taxi time standard report 2019 and 2021

Table 2. Taxi time of representative airports in the United States (2019, 2021)

Airport	2021		2019	
	Taxi out	Taxi in	Taxi out	Taxi in
Atlanta (ATL)	15.26	7.86	16.64	8.94
Los Angeles (LAX)	16.18	10.05	17.82	11.24
Chicago (ORD)	20.79	12.93	23.35	13.99
Dallas (DFW)	18.99	12.06	18.93	11.69
Denver (DEN)	16.56	9.37	18.52	9.26
San Francisco (SFO)	16.92	5.77	22.11	8.73
Seattle (SEA)	17.78	9.85	19.93	10.29
San Diego (SAN)	15.23	4.08	17.28	4.33

airports where the taxi out time of flights was 16 to 20 min. There were 4 airports in China (PVG, HRB, SZX and HKG), 4 airports in the United States (LAX, DFW, DEN and SEA). Besides, there were two airports, SIN and HND.

The taxi in time of flights is usually less than the taxi out time. In some airports, taxi in time is more than 10 min, such as PVG, PKX, PEK, LAX, ORD, DFW, SEA and CDG.

4 Taxi Time Analysis

From the analysis of airport average taxi time, there is no obvious difference between Chinese airport and foreign similar large airports. However, some airports or some flights of an airport have a long taxi time, which is restricted by the objective conditions of airport

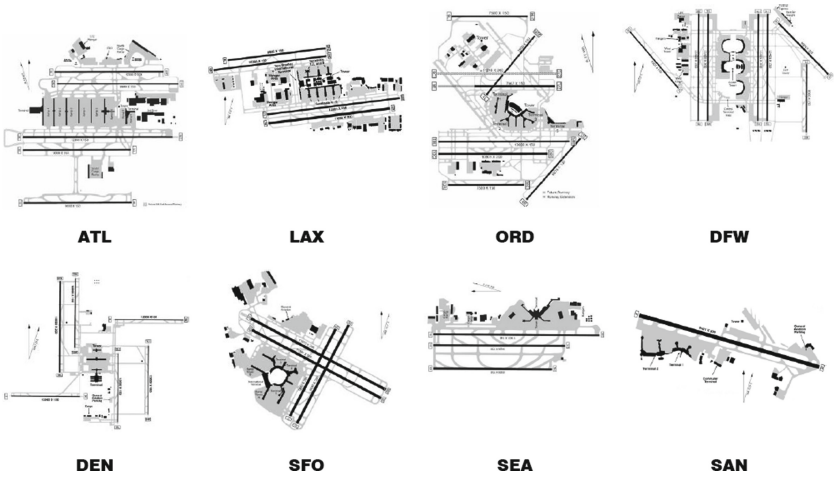

Fig. 3. Runway configurations of 8 American airports

Table 3. Taxi time of large airports in Europe and Asia (2021)

Airport	Taxi out	Taxi in
London Heathrow (LHR)	15.7	7.3
Frankfurt (FRA)	12.6	7.8
Paris Charles de Gaulle (CDG)	14.7	10.1
Singapore Changi (SIN)	16.9	7.2
Tokyo Haneda (HND)	19.8	8.4
Hong Kong (HKG)	17.9	7.3

geometric scale and airfield area layout, but there are also many reasons worth in-depth analysis.

(1) Cross-region operation of flights from large airports.

The flight ground taxi across the runway as the separation line of different flight areas, such as PEK, ORD; In the flight area enclosed by two or more runways, the flight east/west or south/north span taxi, such as PKX, DEN, TFU etc. Due to the corresponding relationship between airport runway and air route direction, and the relationship between apron division and airline use, it is usually difficult to avoid cross-region taxi of flights in large airports. For example, after landing on the west runway of the Capital International Airport, the flight will cross or taxi around the middle runway and enter the T3 terminal. The taxi time of the flight will be about 15–20 min. However, by optimizing airspace structure, flight allocation and apron division, and strengthening air-ground coordination, the proportion of flights taking off and landing nearby can be appropriately increased,

and the number of cross-regional flights can be moderately reduced, thus shortening the average taxi time of flights.

(2) The increase of waiting time at the runway entrance leads to a longer time of taxi out.

Comparing the taxi time data of 2019 and 2021, the taxi time of departing flights in 2019 is significantly longer than that in 2021 at some airports, such as CAN, SZX, PEK, XMN, LAX,ORD, etc. The reason is mainly due to the increase of flight flow, which leads to the extension of the queue time of the flight waiting for departure at the entrance of the runway, which is included in the flight taxi out time.

(3) A few airports taxiway operation interference problems are prominent.

There are many hot spots in the airfield areas of some airports. In the case of a large number of flights, taxiing to avoid interference leads to an increase in the time of taxi in and out. Taking Harbin Airport as an example, the taxi distance of flights is longer. The operation period of the airport in winter is long, and the deicing/defrosting time of the departing flight is included in the taxi out time.

(4) Safety redundancy control of airport ground operation rules.

In the early stage of the new terminal, some airports usually formulate strict rules for the use of the new apron layout and operation mode. On the premise of ensuring safety, a moderate and flexible operation and management mode is conducive to improving the taxiing efficiency of flights in and out of the apron.

In addition, different airports also have different safety margin control for the use of runway-crossing taxiway. Due to safety or economic factors, some airlines will make relevant restrictions on the aircraft ground taxi speed. Similar to the above situation, will have an impact on the airport taxi time.

5 Conclusions

Based on the analysis of flight ground taxiing time of large airports in China and the world, the optimization suggestions of flight ground operation are put forward to shorten flight ground taxi time and improve airport operation efficiency.

(1) Strengthen the delicacy management and coordination of airport gate resources, runway resources and flight resources, and reduce the proportion of flights operating across regions. Focus on the flight path with long taxi time, and improve and optimize it. For multi-runway airports, the operation deployment of "distant apron + distant runway" should be avoided as far as possible.
(2) Improve the runway release efficiency and shorten the queuing time of flights taking off at the entrance of the runway.
(3) Formulate scientific and reasonable operation rules or propose transformation and optimization plans for taxiway hot spots in the airfield area, so as to meet the smooth operation under the large flight throughput.

(4) Innovate the coordination management mechanism, promote the deep coordination between airport apron control and tower control, and make full use of taxiway resources. Continue to deepen the A-CDM coordination mechanism to provide support for accurate support of airport ground operation.
(5) Strengthen the training of airport ground support personnel and promote the application of new technologies.

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