Air Traffic Management Bureau, CAAC

2020 Report of Civil Aviation Airspace Development in China

August 2021

Air Traffic Management Bureau, CAAC

Foreword

With the continuous development of China's civil aviation industry, China witnesses a growing traffic flow and an ever-increasing demand for the use of airspace resources. At present, airspace's utilization, operation and development has become the focus of attention for various airspace users. In light of this, the Air Traffic Management Bureau of CAAC (ATMB) has conducted a comprehensive study and analysis of the annual data on civil aviation airspace development, aiming to assist relevant departments or industry professionals in understanding civil aviation airspace development in China. This report, which consists of five parts, not only provides basic information on civil aviation airspace using objective and detailed data, but also analyzes the operation of civil aviation airspace in 2020. The report covers such essential elements as airports, waypoints, route segments, temporary routes, control sectors and busy terminal areas.

2020 marked an extraordinary year as the world was mired in the COVID-19 pandemic. Amid the sudden outbreak of the epidemic, China's ATM system united as one in overcoming the difficulties. Under the strong leadership of CAAC, ATMB strictly followed the general CAAC guiding principles of "One, Two, Three, Three, Four", namely implementing one perception, ensuring simultaneous development of transport aviation and general aviation, guarding the three bottom lines, establishing and improving three systems, and shoring up the four inadequacies, focused on "establishing an ATM system strong in four areas", made proactive efforts in fulfilling the goal of achieving high-quality airspace development, and went all out to press ahead with the following ATM related work in the face of the adverse effects of the epidemic. We assisted the construction of a world-class national airport clusters in the Yangtze River Delta, completed the airspace structure adjustment in Hangzhou area, and provided the airspace needed for the independent

operation of the double runways at Xiaoshan Airport. We improved the structure of air routes to and from Hainan Province, to ensure that flights to and from Hainan Province "operated separately on different routes" and enhance airspace's capacity. Also, we implemented the airspace optimization program in Xinjiang to achieve one direction cyclic operation of flights of other areas in China to and from southern Xinjiang; and strengthened the application of new technologies by advancing the regular application of continuous descent/climb operation (CDO/CCO) at airports in Chongqing Jiangbei, Xi'an Xianyang and Urumqi Diwopu. In 2021, the whole ATM system will work together, in an effort to make progress in the fulfillment of the strategic goal of building China into a civil aviation power and achieve outstanding performance as the country is marking the 100th anniversary of the founding of the Communist Party of China.

We are very grateful to the international aviation community for its long-term support and assistance. Information sharing and mutual exchanges have enabled us to perform better. It's our hope that this report can provide aviation stakeholders with useful information or references.

Sincerely,

Che Jinjun
Director General
Air Traffic Management Bureau, CAAC
August, 2021

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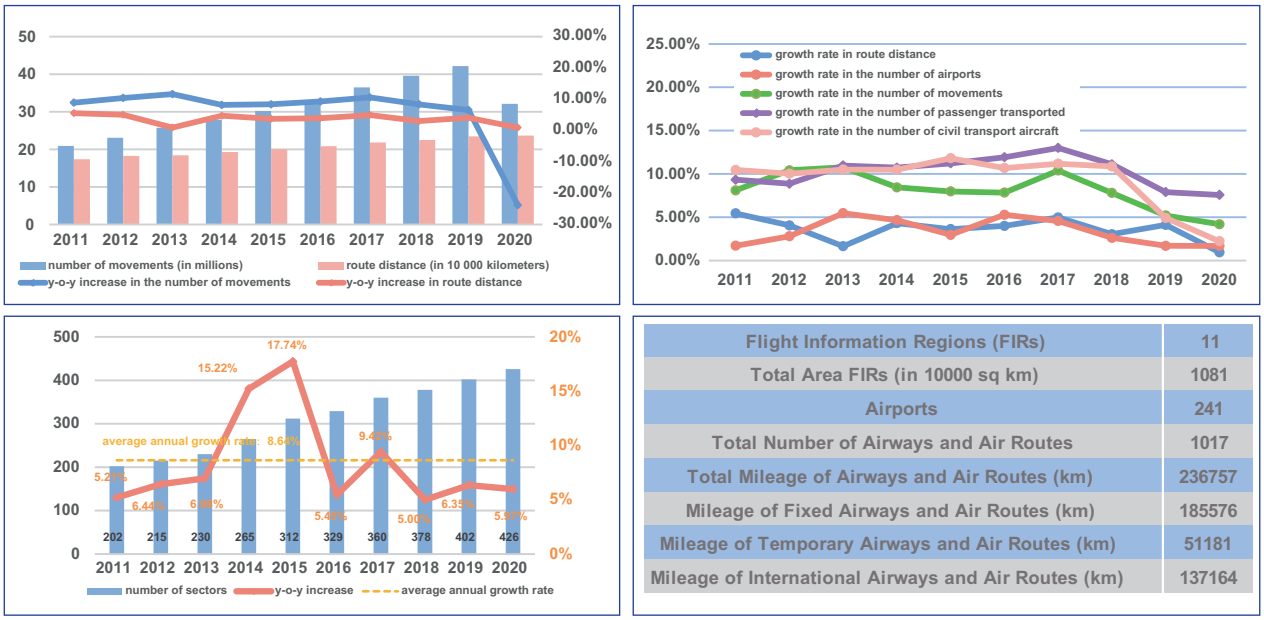


Flight Information Regions (FIRs)	11
Total Area FIRs (in 10000 sq km)	1081
Airports	241
Total Number of Airways and Air Routes	1017
Total Mileage of Airways and Air Routes (km)	236757
Mileage of Fixed Airways and Air Routes (km)	185576
Mileage of Temporary Airways and Air Routes (km)	51181
Mileage of International Airways and Air Routes (km)	137164

Figure 1 Overview of Chinese civil aviation airspace in 2020

By the end of 2020, there were a total of 1017 airways and air routes in China, with a total distance of 236757 km, a net increase of 2248 km over the previous year. Route density was about 0.023 km per sq km of airspace, while traffic density was about 0.39 flights per sq km of airspace. 241 transport airports spread across the country. There were 17878 city pairs and 11358 flight routes, and the non-linear coefficient of flight routes between city pairs was averaged at about 1.14. The number of entry and exit points totaled 47, allowing efficient connection with neighboring countries and regions (Figure 1).

There are currently 11 FIRs in China (including those of Taipei and Hong Kong), covering a total area of about 10.81 million sq km. By the end of 2020, there were 15 high-altitude control areas, 28 medium and low altitude control areas and 46 approach (terminal) control areas across the country. A total of 426 area and approach (terminal) control sectors have been approved.

In 2020, amid the worldwide pandemic, ATM system provided control services for 7.538 million transport flight movements, a y-o-y decrease of 29.98% and slightly lower than the 2015 level (7.77 million). Throughout the year, the ATM system provided control services for a total of 32.143 million flight movements (including general aviation), representing a y-o-y decrease of 23.80%. At the 45 airports at which the ATM system provided control services, around 6.074 million movements were made, which accounted for 80.58% of the national total and represented a y-o-y decrease of 24.70%.

II. Static Airspace Structure

1. Airports

In 2020, there were a total of 241 airports in China, including 70 international airports and 171 domestic airports. 233 airports, accounting for 96.68% of national total, have made public their PBN procedure design, with the remaining 8 airports yet to publish their PBN procedure design (Figure 2).

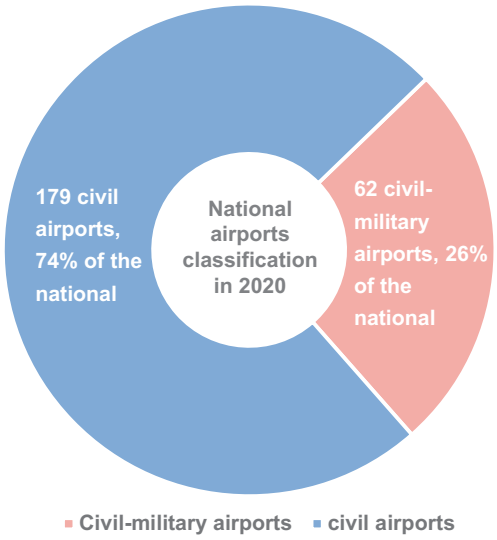


Figure 2 Transportation airports across China

At present, 45 airports at which the ATM system provides control services have finished their PBN procedure design. Among them, 44 have implemented PBN procedures, and 38 have achieved partial or full separation of the arrival and departure routes.

By the end of 2020, the number of runways in the 241 transport airports across the country totaled 264. There were 2 airports with four runways, 3 airports with three runways and 11 airports with two runways, accounting for 0.83%, 1.24% and 4.56% of the total number of airports respectively.

2. Waypoints, and unit route segments

By the end of 2020, there were 538 waypoints where 3 or more routes converge or intersect (Figure 3).

3. Airways and air routes

By the end of 2020, there were 1017 air routes nationwide, covering a total distance of 236757 km if calculated on a non-repetitive basis. Among them, there were 761 fixed routes, covering a distance of 185576 km, accounting for 78.38% of the total; and 256 temporary routes spanning 51181 km, accounting for 21.62% of the total.

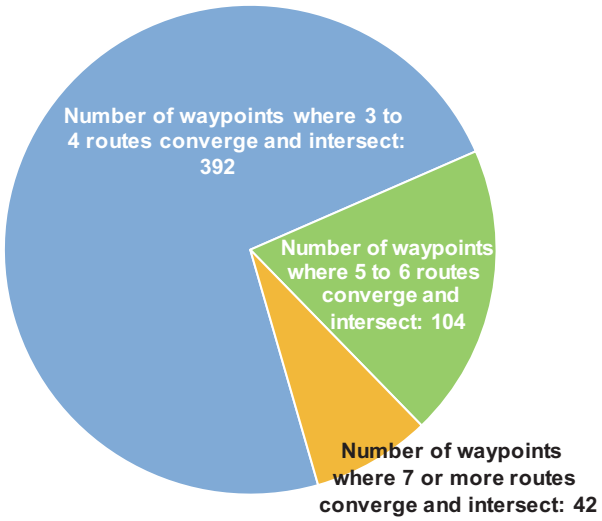


Figure 3 Convergence and intersection of air routes

Compared with 2019, 2020 saw a net increase of 25 air routes, covering a total distance of 2248 km, a y-o-y increase of 0.96% (Figure 4). To be more specific, there was a net increase of 18 fixed routes, covering a total distance of 1610 km, and a net increase of 7 temporary routes, totaling 638 km.

Overall, China saw a gradual transition from "prioritizing quantity" to the phase of "achieving quality-based adjustment" as the country sought air routes expansion. While optimizing our airspace, China strictly followed the general principles guiding civil aviation work, aimed to serve social and economic development, and focused on adjusting the layout of system structure. Also, we intended to "achieve generally stable expansion while making further progress, facilitate expansion through adjustment, and enhance quality and efficiency":

— the five large-capacity air corridors, including Beijing-Kunming, Guangzhou-Lanzhou, Shanghai-Lanzhou, Shanghai-Harbin, China-South Korea air corridor, were put into successive operation, and the two parallel routes from Lanzhou to Urumqi and Chengdu to Lhasa were successively launched. As a result, a trunk route network featuring mainly unidirectional operation was initially formed, the reform of the national air route structure progressed, and the overall safety performance and capacity of the route network was gradually enhanced.

— to ensure the allocation of airspace resources among regional airport clusters, we coordinated our efforts in optimizing the airspace structure in busy areas, gradually strengthened the "dual circulation" development pattern, further opened air routes to the outside world, and steadily improved connectivity with international route networks.

— steady progress has been made in the construction and relocation of transport airports, and results have been achieved for this phase in the optimization of airspace in the approach (terminal) area of busy airports. The total distance of arrival and departure routes reached 33095 km, with an average annual growth rate of 6.61% over the past five years.

4. Control areas and control sectors

By the end of 2020, there were 15 high-altitude control areas, 28 medium and low altitude control areas, 44 approach control areas and 2 terminal control areas.

By the end of 2020, a total of 426 control sectors had been approved nationwide, including 267 area control sectors and 159 approach (terminal) control sectors. The whole year saw the approval of additional 11 area control sectors and 13 approach control sectors, representing a respective increase of 4.30% and 8.90%.

During the decade from 2011 to 2020, the average annual growth rate in the number of sectors approximated 8.64%. 2020 witnessed a y-o-y growth of 5.97%, slightly lower than the average annual growth rate.

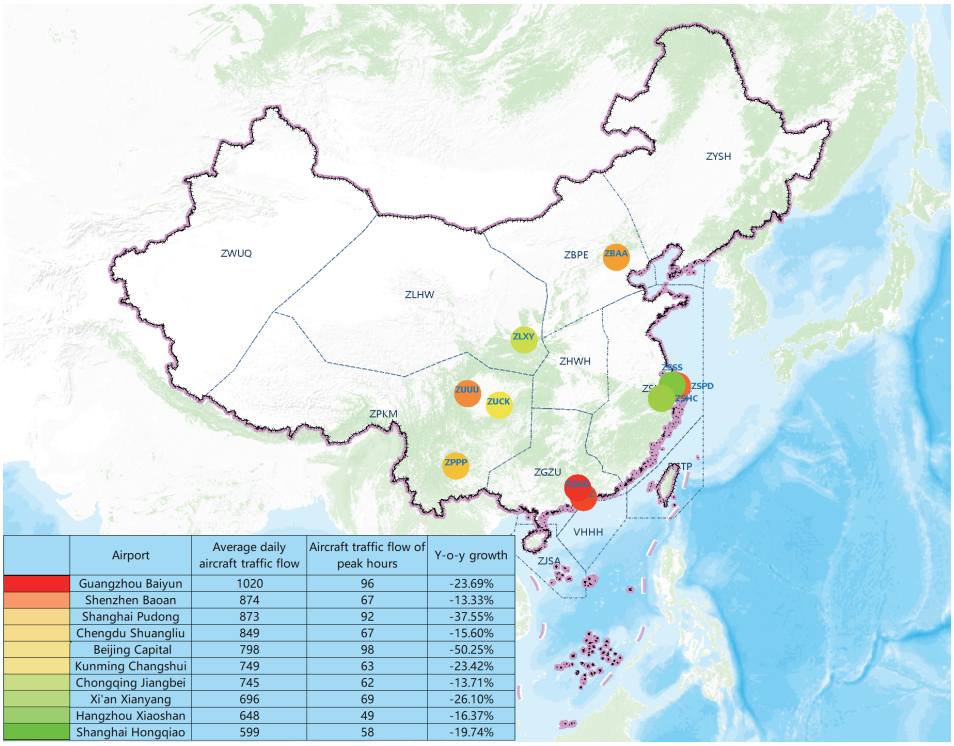
5. FIRs and special airspace

There are currently 11 FIRs in China, which are Beijing, Shanghai, Shenyang, Guangzhou, Wuhan, Lanzhou, Urumqi, Kunming, Sanya, Taipei and Hong Kong FIRs, covering a total area of 10.81 million sq km.

III. Analysis of Airspace Operation

1. Airports

In 2020, the ATM system provided ATC services for 7.538 million transport movements, a y-o-y drop of 29.98%. Major airports[1] saw a y-o-y decrease of 25.26% in the number of movements to 6.074 million, with the average daily number of movements standing at 369, a y-o-y fall of 25.90%. Guangzhou Baiyun, Shenzhen Baoan, Shanghai Pudong, Chengdu Shuangliu and Beijing Capital airports were the top five in terms of the annual number of movements, accounting for 6.15%, 5.27%, 5.26%, 5.12% and 4.81% of the total handled by major airports (Figure 4).



	Airport	Average daily aircraft traffic flow	Aircraft traffic flow of peak hours	Y-o-y growth
	Guangzhou Baiyun	1020	96	-23.69%
	Shenzhen Baoan	874	67	-13.33%
	Shanghai Pudong	873	92	-37.55%
	Chengdu Shuangliu	849	67	-15.60%
	Beijing Capital	798	98	-50.25%
	Kunming Changshui	749	63	-23.42%
	Chongqing Jiangbei	745	62	-13.71%
	Xi'an Xianyang	696	69	-26.10%
	Hangzhou Xiaoshan	648	49	-16.37%
	Shanghai Hongqiao	599	58	-19.74%

Figure 4 Top 10 airports in average daily aircraft traffic flow

In 2020, the throughput of Guangzhou Baiyun International Airport surpassed for the first time Atlanta Airport of the United States, ranking first in the world. Also, the airport's average daily number of aircraft movements reached 1020, the highest in the country, which was in line with its overall strength as a world aviation hub. Beijing Capital International Airport, however, experienced a slide in its ranking for two reasons: on the one hand, a large percentage of its traffic was international which was seriously impacted by COVID-19; and on the other hand, part of the traffic at the airport was diverted to Daxing Airport since the operation of the latter. In contrast, Daxing Airport has seen a relatively rapid growth in traffic since its inauguration,

1 Major airports refer to the 45 airports at which the ATMB provides control services.

with its average daily number of movements increasing from 214 in 2019 to 364 in 2020, a y-o-y increase of 70.09%. In particular, China Southern Airlines transferred all of its operation in Beijing to the Daxing Airport, resulting in a sharp rise in its passenger traffic.

An analysis of the coefficient of variation of the hourly flows[2] and the peak hour flow at the above five airports was made using traffic data from the peak day (January 19, 2020). As can be seen from Figure 5, on the whole, most airports were in heavy-traffic operation from 08:00 to 21:00 during which most of the arrival/departure flights of the day were handled. There was a trough between 12:00-14:00. To be more specific, Beijing Capital International Airport saw small fluctuation in its coefficient of variation of the hourly traffic flows, yet its traffic flow during the peak hour was huge. The airport maintained heavy-duty operation for a long time during the day, and its flight density was high. Compared with other airports, Shanghai Pudong Airport saw larger fluctuation in its coefficient of variation of the hourly flows, with a flow spike during the peak hour. Characterized by arrival of flight in waves, the airport saw clear boundaries between busy and idle hours, which was conducive to fulfillment of the hub's role as a transfer center.

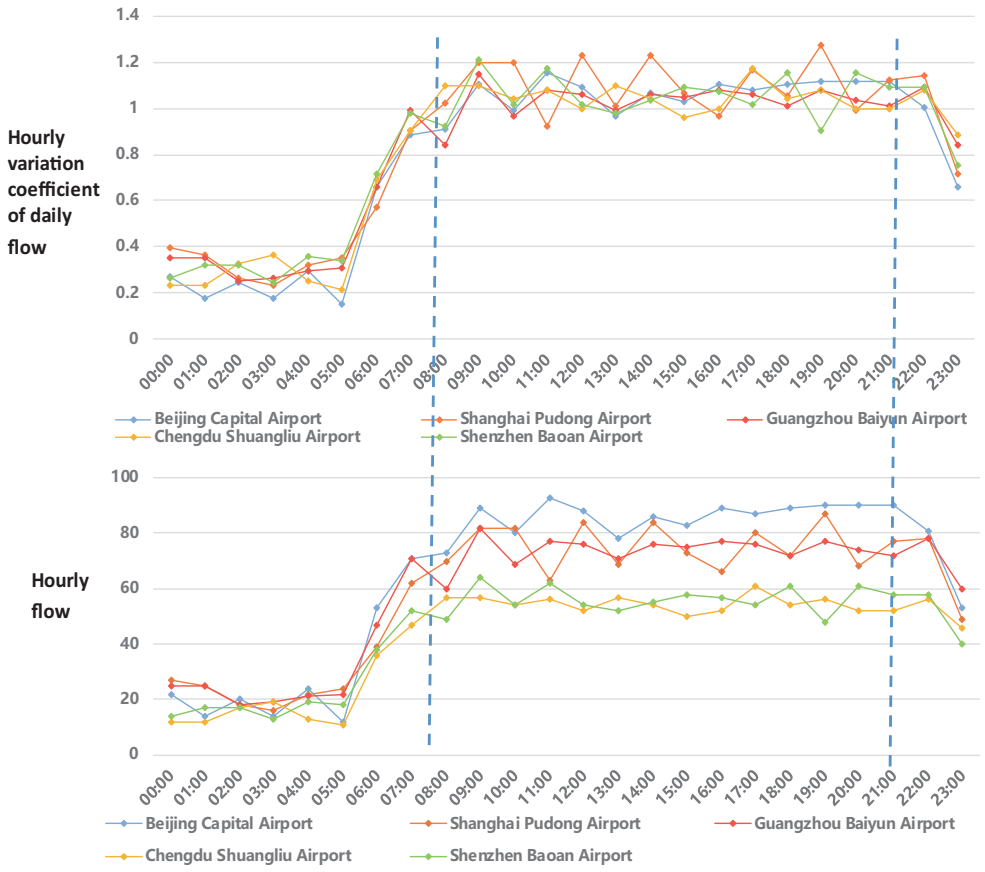
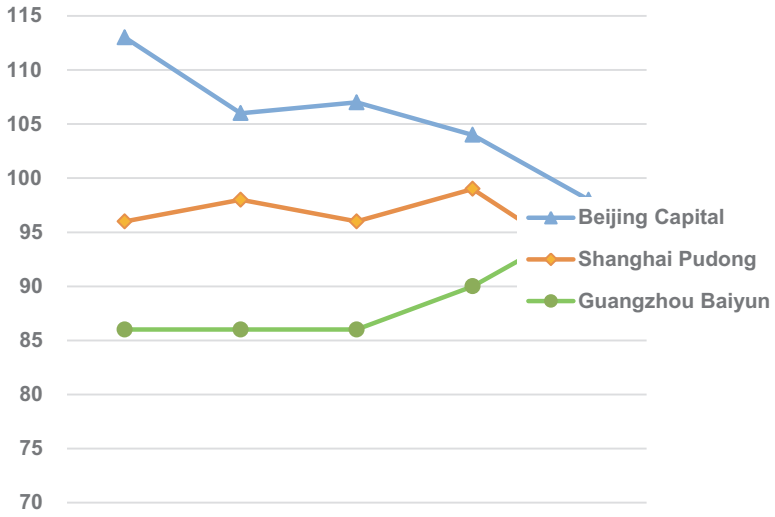


Figure 5 Peak day daily flow time - varying coefficient of the top five airports

2 Daily flow time-varying coefficient = airport hourly traffic flow/median hourly traffic flow.

In addition, the top five airports featured similar peak and trough distribution during the arrival and departure peak hours, and generally the same difference between the number of movements during the peak hour and the hourly average. Guangzhou Baiyun Airport handled a relatively large number of flights during the peak hour, with the number of flights during the peak hour exceeding the daily hourly average by over 50%.

In terms of the number of movements handled during the peak hour and the peak day, Beijing Capital (98 for the peak hour/1669 for the peak day), Guangzhou Baiyun (96/1511) and Shanghai Pudong (92/1502) ranked top three. The hourly peak of Guangzhou Baiyun Airport even exceeded the pre-epidemic level, indicating high demand at busy hub airports following the stabilization of the COVID-19 (Figure 6).



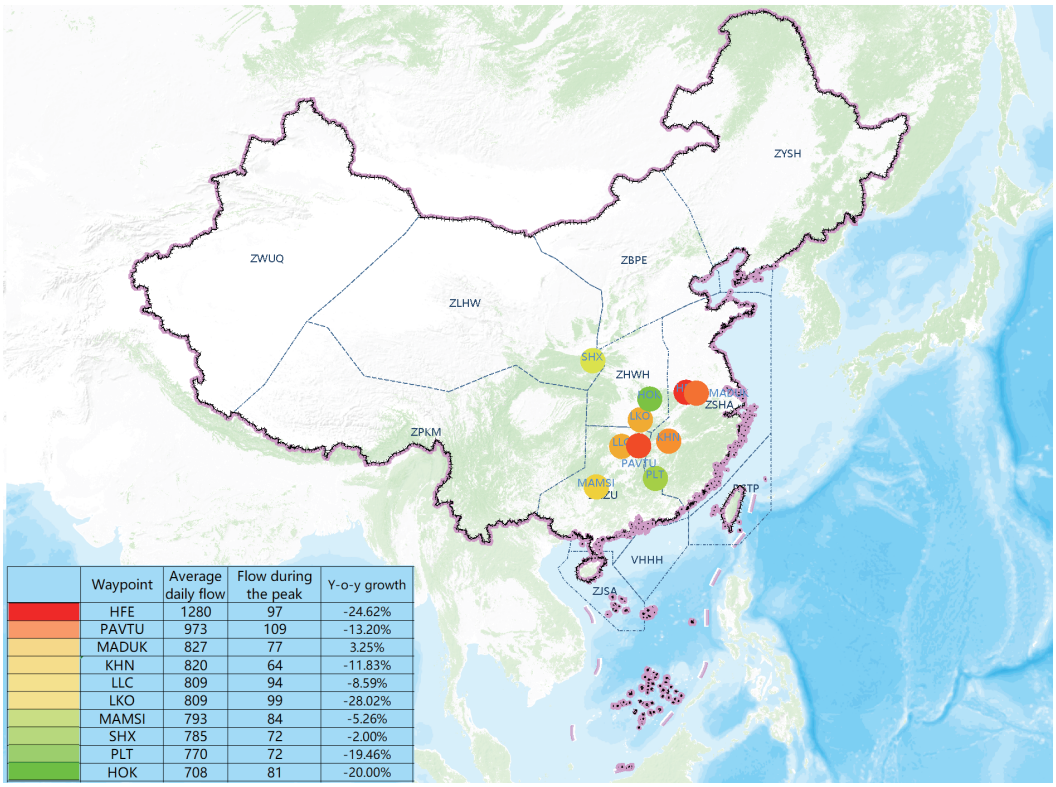
	2016	2017	2018	2019	2020
Beijing Capital	113	106	107	104	98
Shanghai Pudong	96	98	96	99	92
Guangzhou Baiyun	86	86	86	90	96

Figure 6 Movements handled during the peak hour in recent 5 years by Beijing, Shanghai and Guangzhou airports

2. Heavy-traffic waypoints

The top 10 waypoints handling the highest average daily traffic flow in 2020 are shown in Figure 8. HFE (Luogang VOR), PAVTU, KHN (Xiangtang VOR), LLC (Laoliangcang VOR) and LKO (Longkou VOR), mainly located in east and central-south China, ranked in the top five, all handling a daily average of more than 800 flights. Despite the impact of COVID-19, these waypoints still handled a large number of flights, and were the ones where several heavy traffic air routes converged or intersected. They have been handling traffic flow on the north-south

and east-west trunk air routes, and were surrounded by a dense network of air routes. Located in a complex airspace structure, they could serve as the core nodes of route network and were conducive to the optimization and improvement in the overall operation efficiency of regional air route network (Figure 7).



	Waypoint	Average daily flow	Flow during the peak	Y-o-y growth
	HFE	1280	97	-24.62%
	PAVTU	973	109	-13.20%
	MADUK	827	77	3.25%
	KHN	820	64	-11.83%
	LLC	809	94	-8.59%
	LKO	809	99	-28.02%
	MAMSI	793	84	-5.26%
	SHX	785	72	-2.00%
	PLT	770	72	-19.46%
	HOK	708	81	-20.00%

Figure 7 Top 20 ACC waypoints in average daily flow

The top five waypoints in terms of the y-o-y change in average daily flow were SHX (Shangxian VOR), MADUK, MAMSI, FYG (Fuyang VOR) and LLC (Laoliangcang VOR), with y-o-y changes being -2.00, 3.25, -5.26, -5.84 and -8.59 percentage points respectively. Please refer to the following for the detailed description of these waypoints:

— MADUK was where trunk route R343 converged with W51 and W73. Since a large number of flights connecting Shanghai Hongqiao and Pudong airports and airports in Jiangsu Province with areas in and beyond northwest and northeast China passed through this waypoint, it has become the only busy waypoint with a positive flow growth (+3.25%) amid COVID-19.

— MAMSI, located in Guilin, was a busy waypoint where B330, G586 and R343 converged. It handled flights connecting Guangxi and Hainan with north part of central-south, north China, and northeast China, as well as a large number of flights connecting the Pearl River Delta region with

southwest and northwest China. The waypoint was high in traffic flow throughout the year.

— SHX (Shangxian VOR), located in Xi'an, was where multiple air routes converged. Flights between the northwest and the east and between southwest China and areas in and beyond Shandong, Shanxi and Henan must pass through this waypoint. It ranked first in the northwest in terms of the traffic handled, and was almost immune to the effects of COVID-19 (y-o-y change being -2.00%).

— FYG (Fuyang VOR) was the waypoint through which flights connecting east China and Fujian with northwest China must pass. Traffic passing through the waypoint saw no significant change (-5.84%) due to the large flow throughout the year and a rebound in the number of flights after COVID-19 was under control.

— LLC (Laoliangcang VOR) was a "traffic fortress" on the west side of the Changsha area. It handled a large number of flights connecting the east with the southwest, as well as connecting Guangxi and Hainan with the north part of central-south, the north and the northeast China.

The analysis shows that the above 5 waypoints were barely affected by COVID-19 and all ranked among the top 10 in terms of traffic flow. Despite most of them having a negative growth, they neither experienced a significant decline in flow compared with other waypoints, nor saw a significantly lowered level of busyness.

In general, the busy waypoints in 2020 were mainly on such trunk routes as A461, A470, A599 and R343, serving as the core points to ensure the smooth operation of the "main traffic artery" in the air. As traffic continued to recover and grow after the epidemic, further efforts should be made to optimize local airspace, mitigate operation pressure at each waypoint, and achieve capacity expansion and efficiency improvement of the route network.

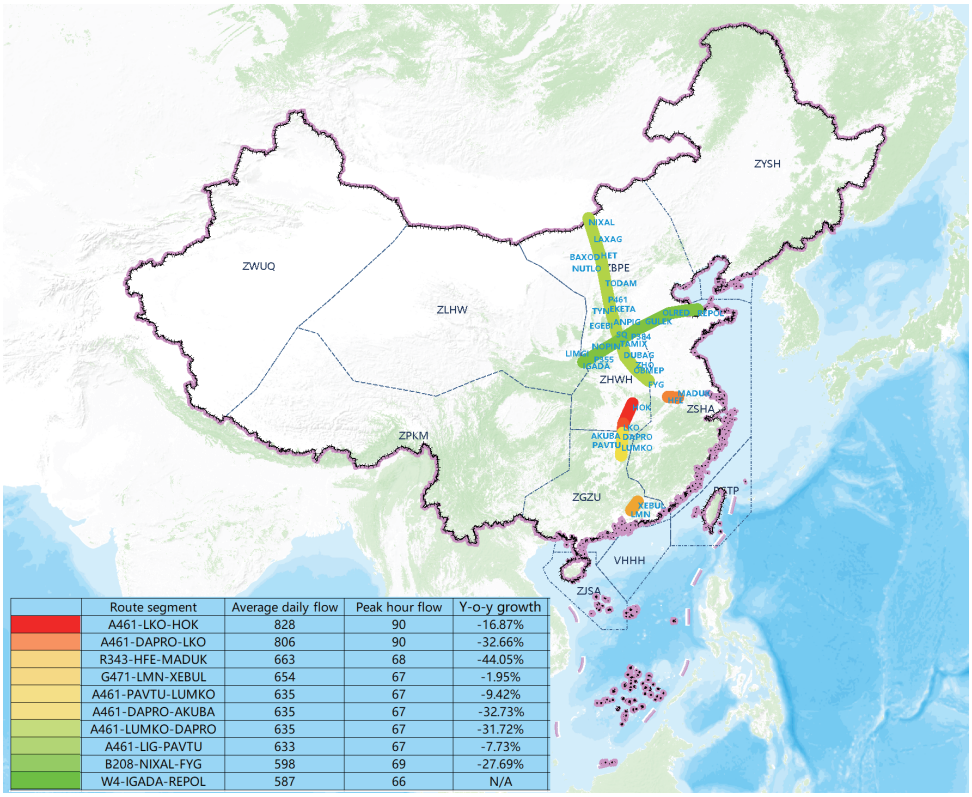
3. Heavy traffic entry and exit points

In 2020, China saw a total of 721827 inbound and outbound flights, a y-o-y decrease of 50.83%. In general, due to the worldwide COVID-19 prevention and control efforts and the sharp decline in the number of international flights, various entry and exit points saw their yearly traffic flow going downward in different degrees. The waypoint IKELA (Hong Kong) experienced the biggest drop of 71.70% in flow. However, the point SIERA (Hong Kong) saw a significant y-o-y growth of 65.44%. Over the past three years, traffic at LAMEN-SADLI (China-Japan), AGAVO (China-South Korea), and IKELA (Hong Kong) went downward every year, while traffic at some entry and exit points such as SIKOU (Hong Kong), TAMOT (Hong Kong), DOTMI (Hong Kong) fluctuated.

4. Busy route segments and route operation efficiency

1) Traffic volume

In 2020, the top 20 domestic route segments with the largest average daily traffic flow were mainly located on such trunk routes as A461, B208, R343 and G471, with a daily average of 614 flights passing through these segments. G471-LMN-XEBUL, A461-PAVTU-LUMKO and A461-LIG-PAVTU all experienced an insignificant y-o-y drop of less than 10% in flow, at -1.95, -9.42 and -7.73% respectively. The route segment R343-HFE-MADUK saw the most significant drop of 44.05% in flow (Figure 8).



	Route segment	Average daily flow	Peak hour flow	Y-o-y growth
	A461-LKO-HOK	828	90	-16.87%
	A461-DAPRO-LKO	806	90	-32.66%
	R343-HFE-MADUK	663	68	-44.05%
	G471-LMN-XEBUL	654	67	-1.95%
	A461-PAVTU-LUMKO	635	67	-9.42%
	A461-DAPRO-AKUBA	635	67	-32.73%
	A461-LUMKO-DAPRO	635	67	-31.72%
	A461-LIG-PAVTU	633	67	-7.73%
	B208-NIXAL-FYG	598	69	-27.69%
	W4-IGADA-REPOL	587	66	N/A

Figure 8 Top 10 route segments in average daily flow

2) Horizontal flight efficiency

In 2020, the average non-linear coefficient of domestic flight routes between city pairs stood at around 1.14, meaning, on average, each flight actually flew a distance approximately 14% longer than on the optimal route. Figure 9 shows the top 10 busiest routes between city pairs with a flight distance of more than 1500 km (shown in a descending order in terms of traffic volume), whose average non-linear coefficient was 1.13, slightly better than the national average of 1.14. The non-linear coefficient of the route from Guangzhou to Beijing was the lowest, at about 1.02, and that of the route from Xi'an to Shenzhen was the highest, at about 1.25.

	Number of flights	Non-linear coefficient	Distance (in km)
Chengdu Shuangliu-Beijing Capital	7784	1.20	1701.36
Beijing Capital-Chengdu Shuangliu	7752	1.18	1634.61
Shenzhen Baoan-Beijing Capital	7687	1.03	1823.77
Beijing Capital-Shenzhen Baoan	7645	1.15	2203.86
Beijing Capital-Guangzhou Baiyun	6645	1.11	1943.08
Guangzhou Baiyun-Beijing Capital	6581	1.02	1659.11
Hangzhou Xiaoshan-Chengdu Shuangliu	5982	1.10	1522.64
Shenzhen Baoan-Xi'an Xianyang	5972	1.19	1511.01
Xi'an Xianyang-Shenzhen Baoan	5969	1.25	1631.75
Shanghai Hongqiao-Chengdu Shuangliu	5969	1.08	1610.43

Figure 9 Non-linear coefficient of the busiest flight routes between city pairs with a flight distance of over 1500 km

3) Vertical flight efficiency

An analysis was made of the route segments highest in average daily flow, using the traffic data from the peak day (January 19, 2020). It can be seen that route segment A461 had the largest traffic flow at the three flight levels of 8400, 9200 and 9500 meters, accounting respectively for 10.09%, 9.55% and 8.56% of the total traffic at all of the flight levels from 6000 to 15500 m. For other busy route segments, there was a concentration of flights at the flight levels of 6600, 6900 and 8400 meters.

5. Temporary routes

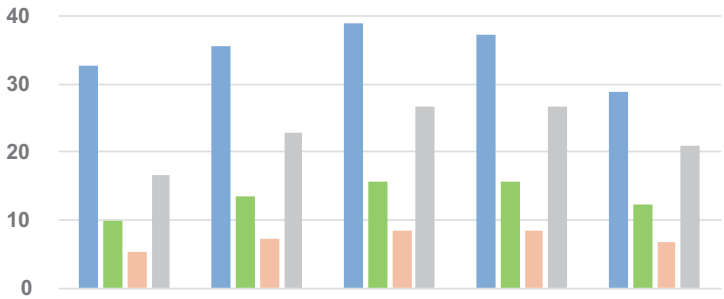
Due to the impact from COVID-19, the use of temporary routes in 2020 showed a significant downward trend compared with the previous year. A total of 289700 flights used temporary routes, shortening the flight distance by 12.32 million km, saving 66500 tons of fuel consumption and reducing carbon dioxide emissions by 209600 tons, a respective y-o-y decrease of 22.33, 21.53, 21.58 and 21.50 percentage points (Figure 10).

For example, in the central-south region, statistics shows that three new temporary routes were added in 2020 and a total of 127800 flights used temporary routes throughout the year, which cut the total flight distance by 6.13 million km and effectively improved regional operation efficiency. In east China, three temporary routes, including V11 in south Jiangsu, were put into use. By connecting with the routes to/from Nanjing, these three routes diverted some of the traffic from route R343 and improved the operation environment of local airspace. As airspace is managed in a meticulous manner, temporary routes will be used more efficiently.

6. Busy area sectors

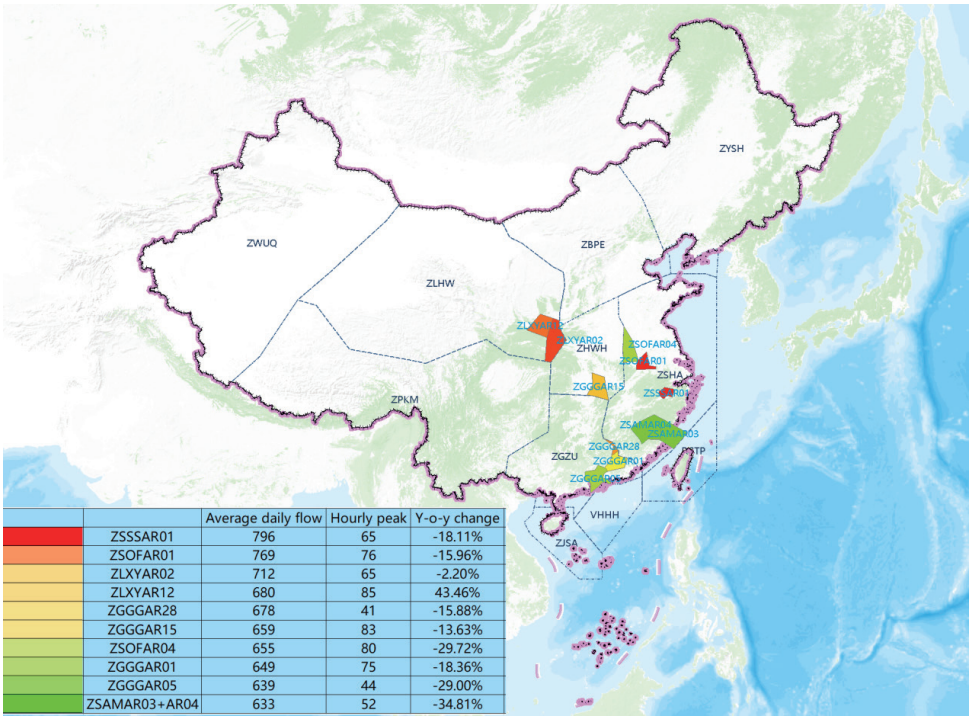
In 2020, 70% of the top 10 regional sectors with the highest average daily traffic were located in east and central-south China. Due to the impact of COVID-19, about 85% of these

10 sectors saw a decrease to varying extents in their traffic flow (Figure 12). Data shows that the three sectors with the largest increase in traffic were sector No. 12 in Xi' an (+43.46%), sector No. 03 in Zhengzhou (+15.66%) and sector No. 05 in Xi' an (+3.56%), while sector No. 02 in Guangzhou saw a biggest drop (−37.75%) (Figure 11).



	2016	2017	2018	2019	2020
Flights using temporary routes (in 10000)	32.6	35.5	39	37.3	28.97
Shortening flight distance (million km)	9.79	13.43	15.74	15.7	12.32
Saving fuel consumption (in 10000 tons)	5.3	7.2	8.5	8.48	6.65
Reducing carbon emissions(in 10000 tons)	16.6	22.8	26.8	26.7	20.96

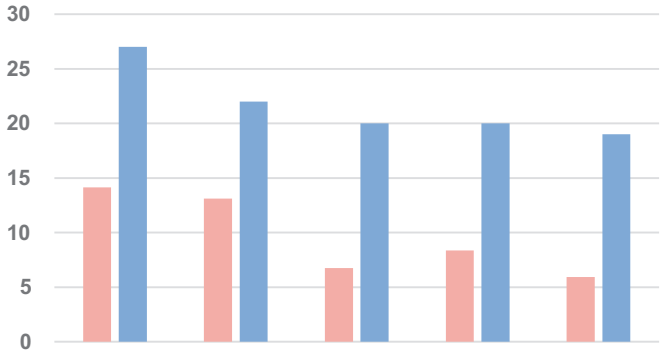
Figure 10 Changes in relevant indicators for temporary routes during 2016−2020



	Average daily flow	Hourly peak	Y-o-y change
ZSSSAR01	796	65	-18.11%
ZSOFAR01	769	76	-15.96%
ZLXYAR02	712	65	-2.20%
ZLXYAR12	680	85	43.46%
ZGGGAR28	678	41	-15.88%
ZGGGAR15	659	83	-13.63%
ZSOFAR04	655	80	-29.72%
ZGGGAR01	649	75	-18.36%
ZGGGAR05	639	44	-29.00%
ZSAMAR03+AR04	633	52	-34.81%

Figure 11 Top 10 sectors in average daily traffic

Figure 12 shows the average flight time, maximum instantaneous number of flights and route network density. An analysis shows that, Xi'an sector No. 2 featured a large instantaneous number of flights[3], relatively short average flight time, dense route network, complex sector airspace structure, limited time and space available for ATC controllers, vulnerability to the disturbance from uncertain factors, and huge operation pressure. As far as the maximum instantaneous number of flights in a sector was concerned, the sectors handling a high concentration of flights in a narrow time-frame mainly included Zhengzhou 03 and Guangzhou 13, and such sectors required provision of more reliable ATC services during peak hours. By analyzing such data as average flight time, maximum instantaneous number of flights and route network density, the maximum value was 1.50-3.70 times that of the minimum, indicating that there were significant differences in sector structure and operation complexity in different regions.



	Zhengzhou sector No.03	Guangzhou sector No.13	Guangzhou sectors No. 03+04	Xi'an sector No.02	Qingdao sectors No. 03+09
Average flight time (min)	14.146	13.110	6.742	8.361	5.921
Maximum number of instantaneous operations	27	22	20	20	19
Route network density	0.042	0.054	0.108	0.068	0.046

Figure 12 Relevant indicators for some busy sectors

7. Busy approach (terminal) control areas

The top 10 approach/terminal control areas providing ATC support to the largest number of flights in 2020 are shown in Figure 13. Shanghai, Guangzhou and Beijing approach control areas ranked in the top three, providing ATC support to 711329, 646399 and 491878 flights respectively, representing y-o-y drop of 27.96%, 20.45% and 27.18% respectively. In

3 The maximum instantaneous number of flights refers to the maximum number of aircraft that fly in a sector in an instantaneous time period during a statistical period (for example, the national flow peak day in 2020) . Here, the instantaneous time period is 1 minute.

particular, Shanghai approach control area was particularly busy as it still managed to provide ATC support to 2902 flights during the peak day amid COVID-19, a slight drop of 2.22% compared with the previous year.

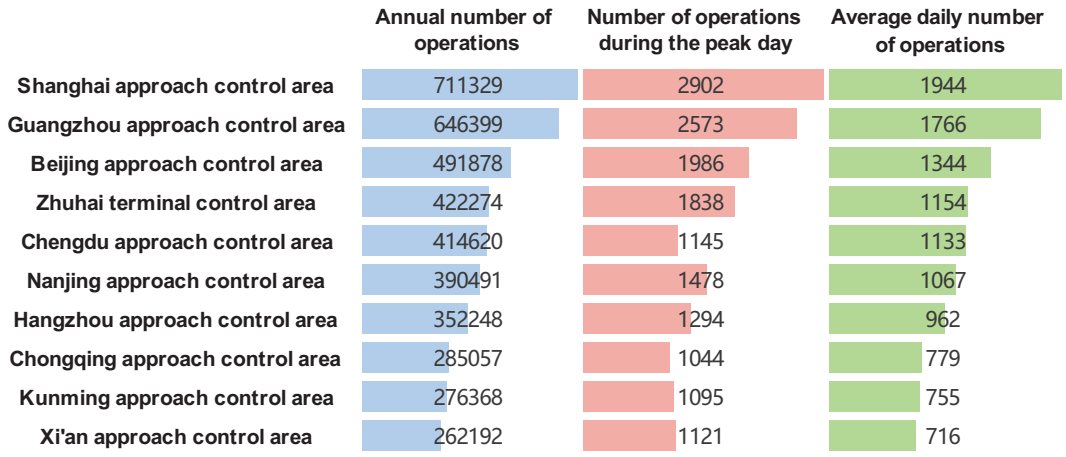
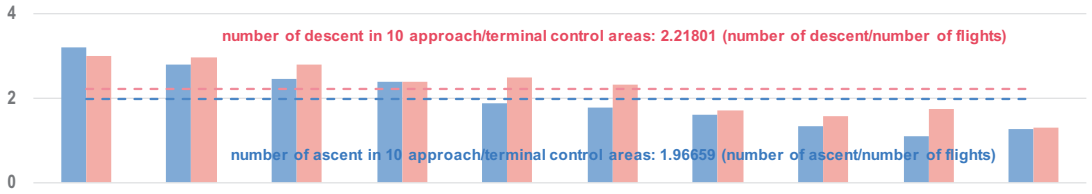


Figure 13 Top 10 busy approach/terminal control areas in 2020

The data of the peak day (January 19) was used to conduct the following analysis of relevant indicators associated with the above approach/terminal control areas. In terms of the average number of aircraft ascent and descent, Zhuhai terminal control area featured the highest at 3.19 and 2.99 respectively, followed by Nanjing approach control area at 2.78 and 2.95 respectively, much higher than the average of 1.97 and 2.22 in the 10 control areas (Figure 14).



	Zhuhai terminal control area	Nanjing approach control area	Xi'an approach control area	Guangzhou approach control area	Kunming approach control	Chongqing approach control area	Beijing approach control	Shanghai approach control	Chengdu approach control	Hangzhou approach control area
Average number of ascent	3.1886	2.7759	2.4484	2.3663	1.8803	1.7548	1.5838	1.3267	1.0915	1.2495
Average number of descent	2.9865	2.9513	2.7890	2.3903	2.4881	2.3123	1.6909	1.5504	1.7280	1.2932
Total	6.1751	5.7273	5.2374	4.7567	4.3684	4.0671	3.2747	2.8771	2.8195	2.5427

Figure 14 Average numbers of ascent and descent in approach/terminal control areas during the peak day

IV. Review of Airspace Management during the 13th Five-Year Plan Period

1. Overview of airspace development

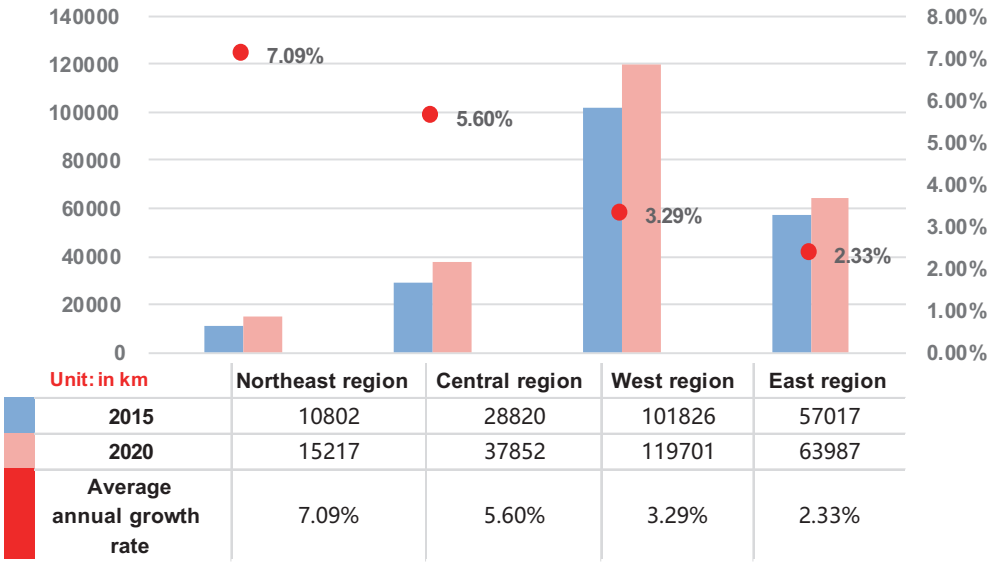
The 13th Five-year Plan period was five years when civil aviation ATM system was ushered into a phase of high-quality development. In carrying out civil airspace related work, we took into account of the features of airspace development of this period, strictly followed the general guiding principles of "One, Two, Three, Three, Four", focused on addressing inadequacies in airspace resources, and aimed at handling airspace development issues and real operation bottlenecks. We pursued progress while maintaining stability, explored new areas, put in place measures, and took multiple measures at the same time. Also, efforts were made to make solid progress in the achievement of main goals and performance of important tasks in airspace development for the 13th Five-Year Plan period, further promote the optimization and adjustment of the airspace structure, and focus on improving airspace operation efficiency and quality. Significant results have been achieved.

1) Over the past five years, civil aviation airspace resources witnessed a generally stable development. By the end of the 13th Five-year Plan period, there were 1017 air routes nationwide, covering a total distance of 236757 km, respective increases of 263 and 38292 km over those at the end of the 12th Five-year Plan, representing average annual increases of 6.17% and 3.59%. To be more specific, there was a net increase of 170 fixed routes totaling 25118 km, and 93 temporary routes covering 13174 km, with the distance covered by fixed and temporary routes showing increases of 15.65% and 34.66% respectively over those at the end of the 12th Five-year Plan. There were 11 358 flight routes nationwide, an increase of 67.45% over that at the end of the 12th Five-year Plan, and the average non-linear coefficient of flight routes between city pairs stayed at approximately 1.14, providing strong support to the layout of civil aviation transport route network. Nationwide, there were a total of 70 airports serving international flights, with international routes totaling 137164 km, respective increases of 7.69% and 36.11% over the end of the 12th Five-year Plan, opening China's aviation market more to the outside world.

2) Over the past five years, the approach/terminal control areas across the country saw a steady improvement in their operation efficiency, and control sectors of various kinds were designated in a more rational manner. By the end of the 13th Five-year Plan period, four newly approved/terminal control areas were added. In particular, the launch of the Beijing terminal

area not only rationally consolidated the airspace resources available for the three airports in Beijing and Tianjin, but also coordinated and optimized the allocation of various resources in the area, forming a new airspace operation pattern. Nationwide, there was an increase of 114 in the number of designated control sectors from 312 at the end of the 12th Five-year Plan to the current 426, with an average annual growth rate of 6.43%.

3) Over the past five years, the central, western, northeastern and eastern regions achieved more balanced airspace development, with the distances of air routes respectively at 37852, 119701, 15217 and 63987 km by the end of 2020, accounting for 15.99%, 50.56%, 6.43% and 27.03% of the national total and representing respective increases of 31.34, 17.55, 40.87 and 12.22 percentage points over the end of the 12th Five-year Plan. In particular, the northeast and central regions saw average annual growth rates of 7.09% and 5.60%, a continuously steady growth in air route resources, and a gradually improved and rationalized route network structure (Figure 15).



Unit: in km	Northeast region	Central region	West region	East region
2015	10802	28820	101826	57017
2020	15217	37852	119701	63987
Average annual growth rate	7.09%	5.60%	3.29%	2.33%

Figure 15 Growth of air route distances in some regions from the end of the 12th Five-year Plan to the end of the 13th Five-year Plan

4) Over the past five years, significant results were achieved in green development of civil airspace. Within the past five years, a total of 1.7337 million flights used temporary routes, shortening the flight distance by 66.98 million km, saving 361300 tons of fuel consumption and cutting 1.1386 million tons of carbon dioxide emissions. The 13th Five-year Plan period saw an average annual reduction of 5.84% in fuel consumption and of 6.00% in emission reduction compared with the 12th Five-year Plan period. All the above effectively facilitated the green

and sustainable development of civil aviation industry (Figure 16).

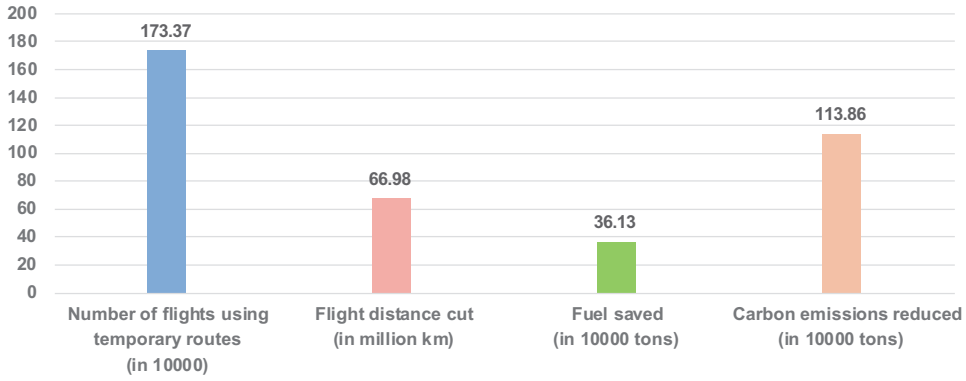


Figure 16 Relevant indicators for temporary routes during the 13th Five-year Plan period

2. Fruitful results achieved in airspace management

1) Phased progress made in the development of the national trunk route network

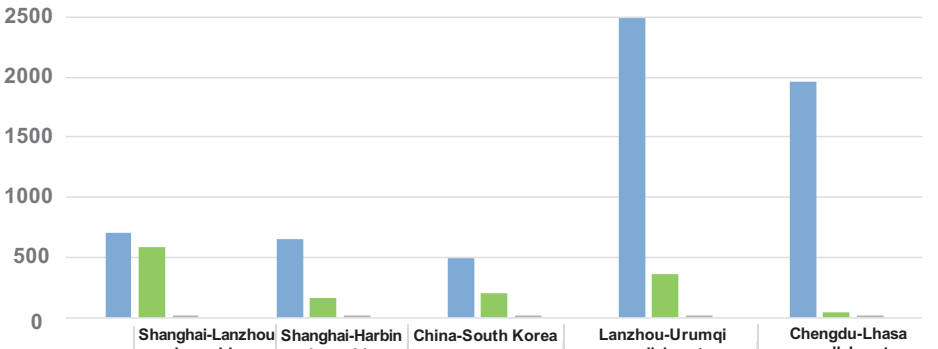
By the end of the 13th Five-year Plan period, more than half of the "10+3" backbone large capacity air corridors had been built. Five large capacity air corridors, i.e. Beijing-Kunming, Guangzhou-Lanzhou, Shanghai-Lanzhou, Shanghai-Harbin and China-South Korea, were put into successive operation. The two groups of parallel routes from Lanzhou to Urumqi and from Chengdu to Lhasa were successfully put into operation. As a result, a trunk route network featuring mainly unidirectional operation was initially formed, with the unidirectional operation implementation rate[4] hitting 62.7%, achieving practical progress in the implementation of the civil aviation trunk route network planning program.

During the 13th Five-year Plan period, the ATM System followed the principle of developing airspace plans with unidirectional cyclical air corridors in mind, and successfully completed the development of large-capacity Shanghai-Lanzhou, Shanghai-Harbin and China-South Korea air corridors and the Lanzhou-Urumqi and Chengdu-Lhasa parallel routes.

Statistics show that a total of 27 new routes were launched along the three large-capacity air corridors of Shanghai-Lanzhou, Shanghai-Harbin, China-South Korea, as well as the Lanzhou-Urumqi and Chengdu-Lhasa parallel routes, resulting in a new addition of 6289 kilometers in distance and adjustments to the orientation of 1340 flight routes. The continuous optimization of the trunk route network led to a balanced distribution of regional traffic flow and

4 Unidirectional operation implementation rate refers to the ratio of the actual distance of large capacity air corridors to the planned distance of large capacity air corridors.

a significant mitigation of potential flight risk. An initial unidirectional cyclical operation pattern was developed for the trunk route network (Figure 17).



	Shanghai-Lanzhou air corridor	Shanghai-Harbin air corridor	China-South Korea air corridor	Lanzhou-Urumqi parallel route	Chengdu-Lhasa parallel route
Distance newly added (in km)	702	650	489	2491	1957
Number of routes adjusted	580	154	200	360	46
Number of routes newly launched	6	2	3	8	8

Figure 17 Relevant indicators for large-capacity air corridors and parallel routes during the 13th Five-year Plan period

2) Remarkable achievements made in the optimization and adjustment of airspace in busy areas

During the 13th Five-year Plan period, airspace in busy areas was optimized and adjusted based on the abiding principle of serving the national strategy, and on a series of major strategies aimed at, among others, advancing "Belt and Road Initiative" cooperation, coordinated development of Beijing, Tianjin and Hebei, and integrated development of the Yangtze River Delta. Intensive efforts were made to optimize the airspace of Xinjiang, Beijing-Tianjin-Hebei, Guizhou-Guangxi, Gansu-Qinghai-Ningxia, Hainan and Hangzhou, to make the overall regional airspace structure increasingly more rational, route operation smoother, and operation efficiency higher.

3. Further improvement in level of research and application of new technologies

1) Steady progress made in the application and popularization of Continuous Descent/ Climb Operation (CDO/CCO)

During the 13th Five-year Plan period, the ATM system made continuous efforts to pilot and popularize Continuous Descent Operation (CDO) and Continuous Climb Operation (CCO). Guangzhou Baiyun, Beijing Capital and Kunming Changshui airports have applied CDO/CCO on a trial basis since 2016, and airports in various regions have popularized the application of CDO/CCO since 2019. By the end of the 13th Five-year Plan, six airports had already applied CDO/CCO, including Shanghai Pudong, Guangzhou Baiyun, Xi'an Xianyang, Chongqing

Jiangbei, Kunming Changshui and Urumqi Diwopu airports.

Statistics shows that the above six airports applied CDO/CCO for a total of 2801 flights in 2020, reducing fuel consumption by 387.4 tons and carbon emissions by 1157 tons. As shown in figures 18 and 19, the implementation of CDO/CCO at Kunming Changshui and Urumqi Diwopu airports brought significant results in energy conservation and emission reduction. Kunming Airport applied CDO/CCO for an average of 152 flights each quarter, cutting fuel consumption by 30.26 tons and carbon emissions by 92.40 tons. Since the third and fourth quarter when Diwopu Airport started applying CDO/CCO, the airport applied CDO/CCO for an average of 419 flights each quarter, cutting fuel consumption by 65.49 tons and carbon emissions by 210.71 tons. As far as the vertical operation efficiency was concerned, relevant airports saw a significant drop in the average duration of level flight following the application of CDO/CCO. The average duration of level flight was cut by 22.36 minutes at Xi'an Xianyang Airport following the introduction of CDO, while the average duration of level flight was cut by 1.05 minutes at Shanghai Pudong Airport following the introduction of CCO.

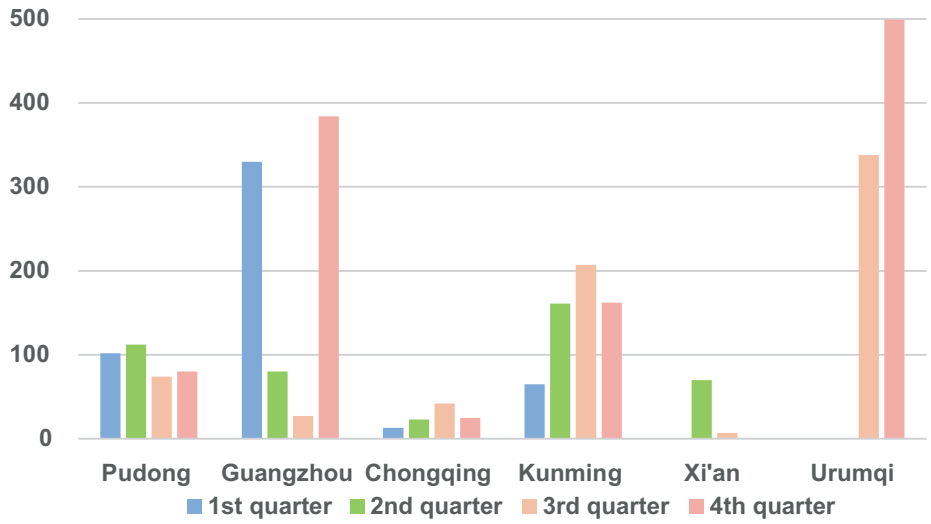


Figure 18 The number of CDO/CCO flights at above airports in 2020

2) Ongoing researches in the application of Point Merge System (PMS) technology

During the 13th Five-Year Plan period, in-depth researches on new technologies for omnidirectional approach to large airports has been carried out to provide additional airspace sequencing solutions for busy terminal areas. Such technologies focused on Point Merge System (PMS) and program design. By the end of the 13th Five-Year Plan period, Shanghai Pudong, Guangzhou Baiyun and Shenzhen Baoan airports had put in place PMS, and Beijing Capital Airport has carried out researches on PMS application.

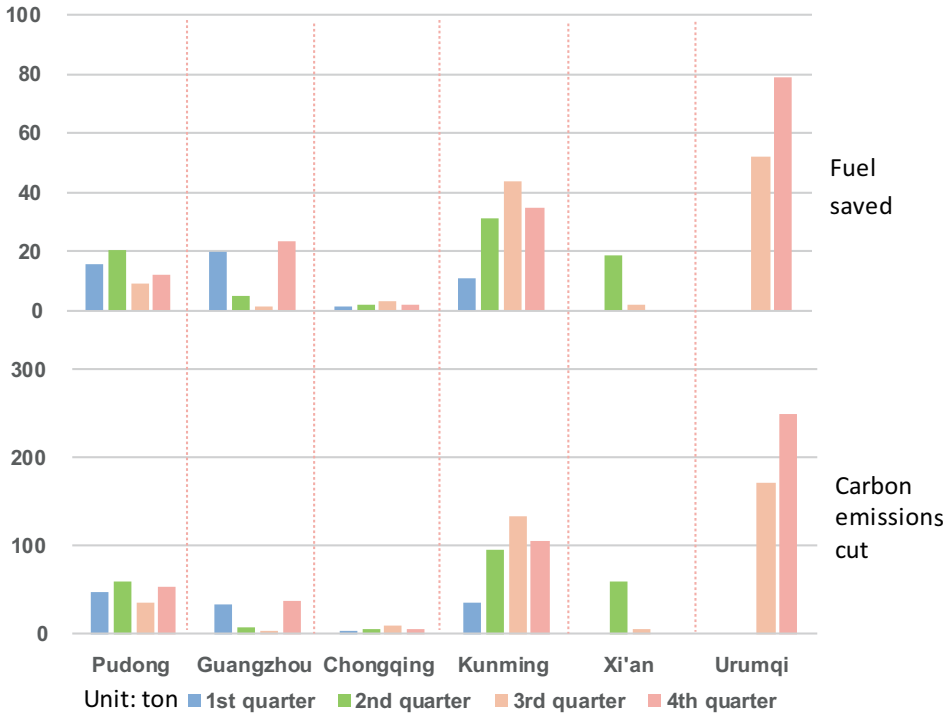


Figure 19 Fuel Consumption and Carbon Emissions Reduction from CDO/CCO at Various Airports in 2020

V. Prospect for Civil Aviation Airspace Work during the 14th Five-Year Plan Period

The 14th Five-year Plan period represents the first five years to embark on a new journey of building a modern socialist country in an all-round way and comprehensively shape a new development pattern. China's civil aviation industry will enter a period witnessing improvement in development quality, enrichment of development pattern and transformation of development stage. To carry out civil aviation airspace related work, we will always take into consideration the features of the current development environment at home and abroad, act in line with the national security and economic development strategy, keep abreast of the latest development in civil aviation, follow the new features of civil aviation development, and firmly adhere to the new general CAAC guiding principles of "One, Two, Three, Three, Four" with new connotations. To meet the fast-growing needs of all kinds of airspace users, we will start from the present, aim for the long-term development, keep pace with the times, and seek innovation while keeping on the correct path. Also, ATMB will coordinate domestic and international airspace resources, take into account both the medium and long-term plans, efficiently coordinate civil and military airspace, and make steady progress in all kinds of airspace related work, in an effort to proactively promote the sustained and high-quality civil aviation airspace development and meet the needs of economic development, national security and industry development.

During the 14th Five-year Plan period, efforts will be made to accomplish the following five tasks:

First, speed up the optimization of civil aviation route network. To perform the air corridor development tasks included in the national route network development plan, ATMB will make all-round efforts to facilitate building and operation of the "10+3" large-capacity air corridors, in a bid to build a national route network structure characterized reasonable layout, smooth connection and balanced flow.

Second, focus on airspace optimization and adjustment in key areas. In line with the national strategy and the needs of regional economic development, ATMB will continue to address the airspace structural problems at the terminals of busy airports (airport clusters), develop rational plans on the layout of arrival and departure routes, achieve smooth connection with the network of trunk routes, optimize, through coordination, allocation of airspace

resources, and make airspace resources more readily available in key areas.

Third, step up research and application of new technologies in an all-round way. Efforts will be made to make full use of technical standards for PBN, make reasonable improvement in the structure of existing air routes, popularize CDO/CCO operation at busy airports that have achieved separation of the arrival and departure flow, and put in place PMS in busy approach/terminal areas if conditions allow. Also, we will step up, as appropriate, researches and application of Established on RNP (EoR) operations at airports faced with airspace or terrain restrictions, seeking to complete the trial application of EoR procedures in areas with a need for such application if conditions allow.

Fourth, continuously enhance airspace assessment capacity building. Efforts will be made to organize and provide technical assistance to the airspace assessment in the ATM system, give full play to the role of the assessment platform, and boost the role of airspace assessment in supporting airspace planning, large-capacity air corridor building and new technology application. Also, efforts will be made to gradually establish a well-functioning airspace assessment working mechanism, standardize airspace assessment methods, incorporate assessment as part of the business process, improve the system of airspace evaluation indicators, and further promote the expansion and upgrading of the assessment platform.

Fifth, ramp up research on airspace planning. ATMB will plan holistically at a high level, conduct scientific analysis, cooperate in completing all the tasks included in the 14th Five-year Plan, give full play to the role of overall planning in guiding civil aviation airspace management, extensively explore new ideas, methods and concepts associated with airspace planning, and proactively promote the building of an "intelligent ATM" system and digitized and intelligent airspace management.

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