Research on the summer meteorological support method of Yan Liang Airport for flight test

Ying Zhang¹,²*, Hongbo Ni¹,², Ping Ni¹,², Wenhui Yan¹,²
¹Meteorological Observatory of Field Affairs Department Chinese Flight Test Establishment, Xi’an, China
²Aeronautical Meteorological Research Center of Aviation Industry Corporation, Xi’an, China

*Corresponding author: 1449665788@qq.com

Abstract. Based on the demand of the aircraft flight test of wet braking distance, wiper function and high temperature subject flight test on the meteorological conditions. The surface meteorological observations of Yan Liang Airport were used to statistically analysis the characteristics of summer precipitation and high temperature weather. Based on the demand of the flight test management, organization and command department to implement the airborne meteorological radar detection performance flight test, formulate the risk prevention plan of thunderstorm and other strong convective weather to ensure the safety of flight test. The surface meteorological observations of Yan Liang Airport and Doppler weather radar detection data of Xi’an Jing Yang Station were used to statistically analysis the characteristics of summer thunderstorm weather at Yan Liang Airport and airspace. In recent years, it has provided strong technical support to ensure the quality, efficiency, progress and safety of the flight test.

Keywords: Summer, precipitation, high temperature, thunderstorm, guarantee countermeasures, Yan Liang Airport

1. Introduction
Summer is the golden season of flight test at Yan Liang Airport, with richer weather conditions of wet braking distance, wiper function, high temperature and airborne meteorological radar detection performance flight test (hereinafter referred to as detection flight test) [1]. At the same time, heavy precipitation and convective weather represented by thunderstorms can have an impact on flight test quality, efficiency, progress and safety.

In recent years, the flight test mission "urgent, difficult, dangerous, heavy, scattered, new" characteristics are increasingly prominent. The aircraft in complex and harsh weather conditions to carry out performance and quality verification requirements are increasingly high. The flight test meteorological support has gradually moved from the traditional "behind-the-scenes" auxiliary work to the "foreground", becoming one of the main forces involved in the development of the aircraft flight test. In order to assist the wet braking distance, wiper function, high temperature subject test to choose a suitable concentrated flight test "window", statistical analysis of Yan Liang Airport summer precipitation and temperature data for 2018-2020 many models of the above subject flight test to provide
technical support. Using the surface meteorological observation of Yan Liang Airport and Doppler weather radar detection data of Xi'an Jing Yang Station, statistical analysis of the characteristics of thunderstorm weather at Yan Liang Airport, combined with the practice of flight test guarantee, refined and formed the weather guarantee measures for flight test in convective weather background, which were promoted and applied in the summer flight test weather guarantee in 2018-2020. The flight test accidents or symptoms caused by thunderstorm weather process did not occur.

2. Data use and method

There are two main parts of data use, Yan Liang Airport 24h surface meteorological observation continuous records and Xi'an Jing Yang station Doppler weather radar detection data.

When the seasons were divided into natural seasons, i.e., spring from March to May, summer from June to August, autumn from September to November, and winter from December to February [2]. Precipitation was graded using the 24h precipitation scale, i.e., <0.1 mm as scattered rain, 0.1-9.9 mm as light rain, including short-term showers, intermittent light rain and light rain; 10.0-24.9 mm as moderate rain; 25.0-49.9 mm as heavy rain; 50.0 -99.9 mm as heavy rain [3]. The daily average temperature of Yan Liang Airport is the average of the temperature at 02:00,08:00,14:00 and 20:00 day by day.

The number of thunderstorm statistics method, thunderstorm duration across the daily boundary but did not stop, as a thunderstorm. The same day occurrence of multiple thunderstorms when the interval between the two thunderstorms is not more than 2 hours, or the interval between the paroxysmal precipitation continues, or the presence of cumulonimbus clouds, then recorded as a thunderstorm, otherwise, recorded as two thunderstorms.

3. Analysis of the summer weather characteristics for the flight test mission

3.1 Summer precipitation characteristics and meteorological support of suggestions

3.1.1 Summer monthly precipitation and its interannual characteristics. Providing the type management and flight test organization departments with the monthly precipitation and interannual characteristics in summer can provide a basis for their decision on the flight test.

The summer precipitation of Yan Liang Airport from 2008 to 2017 varies greatly from year to year. The 10a summer average precipitation is 230.2 mm, and the maximum summer precipitation is 463.2 mm in 2008, reaching 84.2% of the annual average precipitation of 550 mm at Yan Liang Airport, which is twice of the average summer precipitation. The 10a summer precipitation in 2011 was at least 140.3 mm, which was 60.9% of the average summer precipitation. The average monthly precipitation of Yan Liang Airport in 10a summer was 76.8 mm, and the average monthly precipitation gradually increased from June to August. The average precipitation in June was 20 mm less than the average summer precipitation, and the average precipitation in July and August were more than the average monthly summer precipitation. For the 10a summer months, the precipitation amounts in June, July and August are greater than the average monthly summer precipitation amounts in 3, 4 and 5 months respectively. Therefore, Yan Liang Airport has suitable weather conditions for wet braking distance and wiper function subject flight tests from June to August, and the flyable weather conditions are gradually increasing.

3.1.2 Number of days of summer precipitation level. Flight test of aircraft wet braking distance and wiper function subject require the precipitation level to be medium rain or above. The number of precipitation days in summer at Yan Liang Airport can show the feasibility of above flight test.

The total number of precipitation days in 10a summer at Yan Liang Airport is 371 days, accounting for 40.3% of the total number of calendar days in summer. The most occurrence of precipitation is light rain (including trace of precipitation), which occurs 295 d in 10a, accounting for 79.5% of the total number of precipitation days. Moderate rain occurred for 49 days and heavy rain occurred for 25 days,
accounting for 13.2% and 6.7% of the total number of precipitation days respectively. There were two heavy rainstorms in the summer of 10a. On July 19 2008, the precipitation was 75.6 mm, and on August 20 2008, the precipitation reached 95.2 mm.

The monthly occurrence days of each precipitation level in 10a summer at Yan Liang Airport, light rain was the most in July with 113 days, followed by June with 95 d, and less in August with 87 days. The number of days of moderate and heavy rain suitable for wet braking distance and wiper function flight tests was 74 days in total, accounting for 8.0% of the total number of summer calendar days and 19.9% of the number of summer precipitation days. Among them, August had the most with 29 d, followed by July with 24 days and June with 21 days. Therefore, Yan Liang Airport has flight tests for wet braking distance and wiper function subjects in summer, and there are testable weather conditions from June to August, and the number of suitable weather days is gradually increasing (Figure 1).

Figure 1. Number of days of each precipitation level in summer of Yan Liang Airport 2008–2017.

3.2 Summer high temperature characteristics and meteorological support of suggestions

3.2.1 Distribution of high temperature days. In order to assist the flight test of management and organization department to make decision on the feasibility of Yan Liang Airport on high temperature subject when the temperature is >30 ℃. There are different temperature zones of the average and maximum daily temperature of each month in summer of 2008-2017 at Yan Liang Airport were counted as 30.1-35.0, 35.1-40.0 and >40.0 ℃.

Table 1 Number of high temperature days in summer 2008-2017 at Yan Liang Airport.

| Item                        | June | July | August | Total |
|-----------------------------|------|------|--------|-------|
| Average number of days with temperature (d) |      |      |        |       |
| 30.1-35.0 °C                | 3    | 5    | 3      | 11    |
| 35.1-40.0 °C                | 9    | 11   | 6      | 26    |
| >40.0 °C                    | 0    | 0    | 0      | 0     |
| Maximum temperature days (d) |      |      |        |       |
| 30.1-35.0 °C                | 18   | 32   | 16     | 66    |
| 35.1-40.0 °C                | 61   | 75   | 39     | 175   |
| >40.0 °C                    | 4    | 11   | 0      | 15    |

The number of days with daily average temperature >30.0°C in 10a summer at Yan Liang Airport was 37 days, among which 11 days occurred in the interval of 30.1-35.0 °C and 26 days occurred in the interval of 35.1-40.0 °C, all of which were the most in July, the second most in June and the least in August. Yan Liang Airport did not have a daily average temperature >40.0 °C in 10a summer. The number of days with daily maximum temperature >30.0 °C in 10a summer was 256 days, among which 66 days occurred in the interval of 30.1-35.0 °C, 175 days occurred in the interval of 35.1-40.0 °C, and 15 days occurred in the interval of >40.0 °C, which was also the most in July, the second in June and the least in August (Table 1).
According to the analysis, Yan Liang Airport has the highest number of flyable days in July, relatively less in June, and significantly less in August for the flight tests of high temperature subjects in different temperature zones. Concentrating on high temperature subjects with temperature ≥ 35 °C, there are certain weather conditions from June to August in summer, among which, the maximum number of testable days are in July, followed by June and relatively less in August (Figure 2).

3.3 Summer thunderstorm characteristics and weather support of suggestions

3.3.1 The number of thunderstorm occurrences in summer. The number of thunderstorm occurrences in summer is discussed to consider whether Yan Liang Airport has sufficient weather conditions for detecting flight tests.

The total number of thunderstorm occurrences in summer at Yan Liang Airport from 2008 to 2017 ranged from 7 to 12, with little interannual variation. The monthly distribution of the annual number of thunderstorms in summer is uneven, and generally shows the characteristic of more in one month and less in the other two months. For example, 2 thunderstorms occurred in June 2010, none in July, and a total of 9 in August. And no thunderstorms occurred in June, 3 in July, 5 in August in 2015. Another characteristic of the monthly distribution of the number of thunderstorms in summer is that the number of thunderstorm occurrences is low and relatively close in all three summer months. This was the case for 2, 4 and 4 thunderstorms in June, July and August 2013, respectively. And 3, 3 and 2 thunderstorms in each summer month in 2017.

The interannual variation in the monthly occurrence of summer thunderstorms shows that the annual distribution of the number of thunderstorm occurrences varies considerably from month to month. Among them, the greatest variation is seen in the difference between the most years (2010) and the most juveniles (2014) in the number of thunderstorm occurrences in August with 8 occurrences. The difference between the highest number of thunderstorms in July (2011) and the lowest number of thunderstorms in July (2010) is 7, with the second highest variation. The difference between the most years of thunderstorm occurrence in June (2008, 2016) and the most juvenile (2015) is 6 (Figure 5).

Therefore, the weather conditions for conducting detection flight tests are available at Yan Liang Airport in summer, but the advantages of weather conditions for implementing detection flight tests are not obvious in different months.
Figure 3 Monthly distribution of summer thunderstorms occur times at Yan Liang Airport 2008-2017.

3.3.2 Time of thunderstorm onset. Discussing the time of thunderstorm onset can provide a decision basis for determining the flight test window for airborne weather radar detection performance flight tests.

The occurrence time of thunderstorms in Yan Liang Airport in 10a summer is relatively concentrated. The number of thunderstorms in each summer period can be seen by taking 2 h as the interval, 16:00-22:00 is the high occurrence time of thunderstorms, and 56 thunderstorms occurred in 10a summer. The 18:00-22:00 is the main time of night flight test in 10a summer which occurred 42 thunderstorms totally. In addition, 00:00-02:00 is another high incidence of thunderstorms in summer. 06:00-16:00 is the less frequent time of thunderstorms, and only 16 thunderstorms occurred in 10a summer, among which, 3 thunderstorms occurred from 10:00-14:00 (Figure 4).

From the perspective of ensuring the efficiency, quality and progress of the detection flight test, it is advisable to choose the afternoon time for the detection flight test, but at the same time, the difficulty of the flight test safety will be significantly increased.

Figure 4 Number of thunderstorms at Yan Liang Airport 2008-2017 in 10a summer.

3.3.3 Orientation of the start of thunderstorm. In the planning stage of flight test detection, it is also necessary to plan the preparatory flight test routes and airspace. Discussing the initial occurrence direction of thunderstorms at Yan Liang Airport in summer can reflect the development path of
convective weather affecting Yan Liang Airport which can provide a basis for planning the preparatory flight test routes and airspace.

The initial occurrence orientation of summer thunderstorms at Yan Liang Airport from 2008-2017 has obvious patterns. The number of thunderstorms occurring from 225° clockwise to 45° in 10a summer accounted for 84.1% of the total number of all thunderstorms in summer. Among them, the number of thunderstorms from the southwest and west accounted for 38.1% where from the north and northeast accounted for 33.1% of the total number of thunderstorms in 10a summer. From a single direction, the most number of thunderstorm starts occurred in the west with 25 times in 10a, followed by the north with 21 times and the southwest with 20 times. The number of starting thunderstorm occurrences in the eastern, southeastern and southern parts of Yan Liang Airport in 10a summer were less than 10 times (Figure 5).

Therefore, the detection flight test route and airspace planning and declaration should be mainly in the southwest-west and north-northeast directions. Of course, the focus of flight test meteorological security should also be placed on the corresponding direction.

![Figure 5 Number of starting thunderstorms in the summer of Yan Liang Airport 2008-2017.](image)

3.3.4 Thunderstorm wind. The impact of thunderstorm gale on flight test quality, efficiency, progress and safety is manifested by side wind on the one hand, and wind speed exceeding the maximum wind speed required for takeoff and landing of the participating aircraft on the other hand.

There were 15 thunderstorm gales with average wind speed ≥ 8 m/s in the summer of Yan Liang Airport from 2008 to 2017, accounting for 15.2% of the total number of summer thunderstorms. Among which, there were two 45° sidewinds and eight 90° sidewinds. The average maximum wind speed of thunderstorm gale ≥ 12 m/s was 9 times, of which, 2 times the average maximum wind speed ≥ 15 m/s, the maximum instantaneous wind speed ≥ 17 m/s was 6 times, 4 times the maximum instantaneous wind speed ≥ 20 m/s. Therefore, during the detection flight test, the meteorological protection should also prevent the impact of thunderstorm gale and side wind on the flight test quality, efficiency, progress and safety.

4. Conclusion and discussion

1) The 10a summer monthly average precipitation and precipitation days at Yan Liang Airport are gradually increasing from June to August, and the moderate and heavy rain weather conditions suitable for the aircraft flight test of wet braking distance and wiper function subjects are available. Analyzing the maximum daily precipitation of Yan Liang Airport in summer, it is also found that the safety risk of wet braking distance and wiper function flight tests is relatively low when implemented in June and July,
however, the efficiency is also relatively low. But the safety risk is relatively high when implemented in August, but the efficiency is also relatively high.

2) The number of days with daily average and daily maximum temperatures in different temperature zones, as well as the number of days with daily maximum temperatures ≥ 35 °C, which show that June to August have certain weather conditions. Of which, July has the most days available for flight tests, June is the second, and August is relatively small.

3) Yan Liang Airport has the weather conditions to carry out the detection flight test in summer, and the difference in the distribution of the number of days in each month is small. 52.5% of the thunderstorms in Yan Liang Airport in summer meet the weather conditions for the detection flight test. The peak time of thunderstorm is from 16:00 to 22:00, so the flight test should be arranged in the late afternoon to evening. Meteorological support for flight test should not only capture the strong convective weather represented by thunderstorms to guarantee the completion of the detection flight test task, but also prevent the thunderstorm wind and side wind from affecting the flight test quality, efficiency, progress and safety.

4) At all times, meteorological support for flight test should be "active to ensure safety and complete the task". By analyzing and summarizing the surface meteorological observation of Yan Liang Airport and Doppler weather radar detection data of Xi'an Jing Yang Station in the summer of 2008-2017, Yan Liang Airport has formed the real-time monitoring and warning countermeasures and suggestions for thunderstorm weather in the preparation and implementation stage of flight test, which plays an important role in meteorological support of the summer from 2018 to 2020. In view of the demand for meteorological conditions in the summer of the flight test mission and the challenge that the meteorological support department operates according to the standardized process, which is the basis to ensure the flight test safety, guarantee the flight test quality, improve the flight test efficiency and support the flight test progress.

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