Establish a plateau aviation search and rescue system
Improving the ability of civil aviation to search and rescue lost-aircraft in plateau and mountain areas

Weijun Pan, Li Chen¹ and Hengheng Zhang
Civil Aviation Flight University of China, Guanghan, Sichuan, 618307, China
¹Email: chenlili051017@163.com

Abstract. In view of the current lack of a mature plateau aviation search and rescue system both in China and internationally, this paper summarizes the existing organizational system and rescue equipment of China’s plateau search and rescue aircraft through the analysis of typical aircraft out-of-connection incidents occurring in helicopters operating in the plateau in western China. And major issues such as personnel and materials, from institutional mechanisms to specific fleet construction, equipment personnel and materials construction, service assurance and safety culture construction, etc., suggestions were made to improve the ability of civil aviation to search and rescue missing aircraft in high mountain areas.

1. Background

1.1. Plateau emergency search and rescue faces practical problems
The Department of Earthquake Emergency Response of the former China Earthquake Administration pointed out the difficulties of high altitude, limited logistical support and complex terrain that will be faced in the rescue work in the western plateau. Rescue workers and search and rescue dogs will show different altitude sickness in high altitude plateau areas, and search and rescue efficiency will be affected to varying degrees compared to normal conditions. The logistical support of the rescue team is very limited in the high-altitude plateau area, and it is difficult for the rescue team to achieve self-protection and the external guarantee it can obtain. Rescue teams will encounter complex terrain and inconvenient traffic during the search and rescue process. The longer the distance and the higher the altitude, the more difficult the search and rescue will increase. In addition to the three difficulties of high altitude, limited logistical support and complex terrain, civil aviation plateau search and rescue also faces the difficulties of lacking necessary search and rescue helicopters and lacking necessary plateau search and rescue equipment.

1.2. Lack of international search and rescue guidance materials
Since its establishment, the Global Satellite Search and Rescue System (COSPAS-SARSAT) has been providing search and rescue information for vehicles, aircraft, ships and individuals around the world [1]. After the 2008 Wenchuan earthquake, China's civil aviation aviation search and rescue capabilities were demonstrated, and the state paid more attention to the construction of aviation search and rescue capabilities. Especially after the Yushu earthquake in 2010, in response to the current situation of weak plateau mountainous search and rescue capabilities, China Civil Aviation supported the construction of plateau mountainous areas A large amount of investment has been made, and after ten
years of development, many progresses have been made. China has independently developed the Beidou satellite positioning and navigation system. Since the formal provision of services, it has been in transportation, marine fisheries, hydrological monitoring, weather forecast, forest fire prevention, disaster relief and national Security and other fields play an important role [2]. China's search and rescue work started later than the aviation developed countries, and it is still in its infancy, and there is a large gap between the rescue level and the developed countries [3]. For search and rescue (SAR) in areas with complex terrain, the International Civil Aviation Organization (ICAO) lacks corresponding recommendations and measures, especially for plateau search and rescue with complex terrain.

1.3. Introduction to the case of typical out-of-link aircraft incident in China's plateau region
Since Malaysia Airlines 370 lost contact incident, there have been many aircraft lost contact incidents in our country. The most typical one is the aircraft lost contact incident in the mountainous areas of Xinjiang Plateau. One of them has not been searched so far, and the other successful search and rescue incident was the loss of connection of Fengxiang in Yunnan in 2018. The brief process of the incident is as follows.

On September 1, 2018, Yunnan Fengxiang General Aviation B-7459 / AS350B3 helicopter carried out a mountain survey mission in Kashi Tash Township, Hetian County, Xinjiang, Xinjiang, with 3 people on board. 35″ as the center, within a radius of 45 kilometers; at 20:17 in the evening, Fengxiang General Aviation found that the helicopter flight path disappeared through the Beidou positioning system, the emergency position transmitter (ELT) was not triggered, and it did not return to the landing point at the scheduled time. Beidou locates the missing area of the aircraft as a mountain area with an altitude of 3831 meters. After receiving the information report from the Yunnan Supervision Bureau, the Xinjiang Regional Administration immediately notified the relevant units, and at the same time initiated the emergency response plan, immediately reported the incident information to the Civil Aviation Administration and the autonomous region, and established a search and rescue investigation team. After 9 days of intense and orderly search and rescue, 2 military Mi-171 helicopters and 1 navigable B-70RG / AS350B3E and 1 PC-12 helicopter were dispatched and 6 search and rescue missions were carried out. In high-altitude, unmanned mountainous areas, the terrain is complex, the canyons are vertical and horizontal, the weather conditions are harsh, there are many coordination departments, and it is extremely difficult to carry out search and rescue work. Finally, on September 9, the lost helicopter and three trapped persons left the lost contact area and returned to the search and rescue base safely, with man-machine safety.

On the second day, the military dispatched drones to the suspected location for aerial photography. According to the Beidou satellite positioning signal sent by Fengxiang General Aviation to determine the location coordinates of the helicopter, the military sent 2 Mi-171 helicopters to reach Hotan Airport to refuel and ship rescue materials, but due to the approaching sunset time, the helicopter did not With the ability to sail at night, the search and rescue mission was forced to cancel that day. On the third day, it was found that the missing helicopter landed on the flat ground of a valley near the missing coordinates, and all three personnel were able to move. Due to the limited terrain of the valley and the performance of the Mi-171 helicopter, it was impossible to land and hover. It was air-dropped with relief supplies and satellite phones and returned. Afterwards, the pilot of the lost aircraft contacted the rescue team through the satellite phone, and reported the status of the aircraft and personnel. At the same time, it was determined to call the B-70RG / AS350B3E helicopter of West Asia Helicopter Navigation Company to transfer from Shihezi to Hotan for rescue work. Until the sixth day, the helicopter was still unable to perform rescue missions due to weather, and on the eighth day, the West Asia General Aviation helicopter failed during the landing and rescue site, and only returned to Hotan Airport for troubleshooting. On the same day, Fengxiang General Aviation's loss-of-connection helicopter attempted to start the engine at the loss-of-connection point, then took off, and landed at the Kashi Tash Township station. All three personnel on board returned to the station.
2. The main problems of China's plateau search and rescue lost aircraft

In today's world, helicopters are the main tools for aviation emergency search and rescue. Generally, emergency search and rescue are carried out through the use of relevant aviation technologies and corresponding aviation search and rescue equipment [4]. Helicopter out-of-link incidents in the western plateau often occur in high-altitude, unmanned mountainous areas. These areas have complex terrain, canyons, and harsh climatic conditions. Through the analysis of the above typical cases and the analysis of other aircraft loss-of-connection incidents, it can be found that China's plateau search and rescue lost-aircraft has a problem that the search and rescue system itself is not perfect and the general aviation enterprises and flight personnel operating in the plateau have to face. Since the corresponding search and rescue system is not fully established, the lack of resources such as aircraft and search and rescue equipment that can be used for plateau emergency search and rescue can easily lead to untimely search and rescue. Because there are many departments in the plateau search and rescue that need to be coordinated, the existing search and rescue coordination mechanism based on plains and densely populated areas cannot be well reflected in the plateau mountain area. At the same time, there is also a phenomenon that search and rescue personnel lack corresponding training and equipment, resulting in a reduction in search and rescue efficiency. On the other hand, there are also some problems in the airlines operating on the plateau, aircraft pilots, support personnel and resources, which are prone to loss-of-connection incidents and pose certain obstacles to the search and rescue of aircraft and personnel.

2.1. The aviation emergency search and rescue system is not sound enough

The lack of available helicopters that meet the performance requirements of the plateau is an important reason for the low efficiency of air rescue in the mountainous areas of our country. In recent years, in various natural disaster rescues organized by China, helicopters have made great contributions to search and rescue work with their unique advantages [5]. Although the military has some plateau helicopters, there are many links for approval of military helicopters, it is difficult to coordinate in time, and most of them are large helicopters with many rescue restrictions. China originally lacked helicopters with plateau performance, and the geographical distribution was uneven. As a result, once the aircraft lost contact and urgent search and rescue were required, it was difficult to find helicopters that met the plateau performance requirements in a timely manner, and search and rescue could not be implemented immediately. On the other hand, aircraft search and rescue, especially in high mountain areas, fixed-wing aircraft can not effectively play the search and rescue role, aviation rescue work can only be done by helicopter.

Aircraft search and rescue requires high professionalism, and it is particularly important to research and judge the information obtained within the first time. Local governments lack relevant experience and search and rescue work is difficult to prepare in place. The current problems such as lack of communication between civil aviation search and rescue agencies and local governments, and inadequate coordination and linkage mechanisms have led to frequent occurrences of inaccurate and timely information notification.

The personnel of the plateau rescue ground search and rescue team are insufficiently trained. High altitude rescue not only requires excellent physical qualities, but a tough will also plays an important role. In the past, there have been many reports of casualties among rescuers. In the plateau search and rescue, there has even been a phenomenon that the ground search and rescue personnel themselves had a plateau reaction, but instead became the target of rescue. For example, during the rescue of Xinjiang Fengxiang Airlines, some ground search and rescue personnel have severe altitude sickness and severe overdraft. After reaching the rescue point, it is difficult to return on their own. It is not only the victims who are waiting for rescue, but the people who went to the rescue have also become rescued. The difficulty and complexity of rescue have greatly increased.

The relief materials were not fully prepared. In the Wenchuan earthquake and other plateau rescues, there were repeated hasty materials preparations. There was a lack of emergency supplies lists. The airdropped mineral water, milk, and food were all packed in cartons, without outer anti-fall protection,
which caused Mineral water and milk are basically damaged. Especially in unmanned areas, broken and scattered food will attract wild animals such as wolves, posing a potential threat to human life.

The aeronautical information service did not support search and rescue sufficiently, including insufficient attention to the role of the geographic information system in search and rescue work. It appeared that the route selection was not optimal and the search and rescue location could not be reached in time. Obstacles, even in the plateau search and rescue due to lack of detailed geographic information, resulting in rescue helicopters unable to implement take-off and landing rescue due to performance limitations, missed the best rescue opportunity.

2.2. Pilots of lost-aircraft pilots and their affiliated companies are not in place
There is insufficient knowledge about the role of emergency location transmitters (ELT). Due to the large number of false alarms and non-triggering problems in ELTs in various countries, some general aviation companies will consider strict management of the use of ELT, requiring pilots not to touch the ELT switch at will, and even when it is really necessary to actively trigger the ELT device, consider It may cause unnecessary negative impact on the company without manually triggering ELT. This brings difficulties to the normal search and delays the search timing.

In the preparation phase of general aviation operations, the strengthening of military-civilian cooperation was insufficient, information was not reported in time, and communication with local authorities was inadequate. A good information communication mechanism was established. Once search and rescue were needed, timely and effective support from the military and local authorities could not be obtained.

Some general aviation airlines operating on the plateau have not prepared sufficient relevant pre-flight data, equipment and facilities do not meet the requirements of the plateau operations, and they have not even prepared for backup communication facilities and means in advance, such as the operation of the plateau mountainous area Satellite phone and other equipment.

3. Suggestions and countermeasures for establishing a plateau aviation search and rescue system to improve the capability of the civil aviation plateau search and rescue
There is a golden rescue period after the geological disaster, and 72 hours after the disaster. During this period, the survival rate of the victims is extremely high, so it is called "golden 72 hours", which is the consensus in the rescue community [6]. The data shows that international rescue within 72 hours is the most effective rescue method in the world's major earthquakes [7]. Therefore, it is necessary to search for the target in time. Even if the target cannot be rescued in time, the golden rescue period can be extended by actively sending communications equipment, food, water and other materials after the target is found, so that the subsequent rescue tasks can proceed smoothly. Ensure the success of rescue missions. International aviation and maritime rescue have established a fairly sound system [8]. In view of the special terrain and high altitude characteristics of the plateau region of western China, it is particularly important to establish a system in the search and rescue process. The ability to search and rescue lost connections. The specific recommendations are as follows:

3.1. Improve search and rescue organization coordination mechanism
In view of the current lack of communication and search between civil aviation search and rescue and local governments, and the inadequate coordination mechanism, it is recommended to strengthen work in this area. The standardization of disposal procedures should be strengthened, the accuracy of emergency coordination notification should be improved, and effective communication, coordination and linkage mechanisms should be established with local governments.

In view of the insufficient coordination between civil aviation and the military, the search and rescue resources for military and civil aviation should be fully coordinated, including military and civil aviation drones, helicopters, etc., to achieve multi-linkage between military and civil aviation. Simplify the coordination of military helicopters to participate in the rescue approval process, and formulate an operable linkage mechanism at the response level of the plan to reduce response time.
3.2. Strengthen the construction of plateau search and rescue helicopter team

In view of the lack of available helicopters that meet the performance requirements of the plateau, the air rescue efficiency in the mountainous areas of China’s plateaus is low, and the plateau search and rescue helicopters have the plateau search and rescue advantages that fixed-wing aircraft cannot replace. Therefore, the plateau search and rescue helicopter team must be built as soon as possible. It may be considered to establish at least one search and rescue helicopter team in the province and autonomous region with complex terrain in the western plateau and mountainous area of China, each equipped with at least two helicopters, and establish a national search and rescue helicopter center in the central and western regions of China. Strengthen local search and rescue forces.

At the same time, the construction of a high-level, large-scale plateau search and rescue helicopter team is also the need for China's integration of peace and war and integration into the national emergency rescue system. In the specific construction, the cooperative construction of fixed-wing aircraft and drones can also be considered, and an all-round three-dimensional search and rescue work method can be established. By adopting a combination of air and ground search and rescue, the three-dimensional search and rescue method can quickly determine the status and position of the lost aircraft and crew. Earn precious time for rescue work. By adopting corporate trusteeship, emergency special management and other methods for management and operation, the pressure of national construction and operation is reduced.

For helicopter training, it is recommended to establish a plateau search and rescue helicopter training base in the western region. As a training institution, it not only trains search and rescue personnel, but also keeps search and rescue helicopters in good operation and maintenance. Moreover, the establishment of a training base in the west is close to the west plateau, which is convenient for prompt and corresponding search and rescue, and at the same time, it is also convenient to conduct special training for the west plateau during the training.

3.3. Recommendations for equipment and equipment for plateau search and rescue facilities

The search and rescue of aircraft in mountainous areas of the plateau is mainly limited by the lack of available helicopters that meet the performance requirements of the plateau. The helicopters participating in the search and rescue should be equipped with communication, navigation and surveillance equipment to meet the search and rescue tasks. In view of the high accuracy of the Beidou satellite positioning system in the search and rescue of China's lost aircraft, it plays a key role in locking the position of the last lost aircraft, and can be quickly transferred from the search to the rescue phase. The Beidou new generation satellite navigation system has complete independent intellectual property rights and belongs to the "independent and controllable" equipment encouraged by the state. Since the system was put into use, it has always been the mainstay of the sustainable development of the national economy and is in the construction of national defense. Play an important role. Faced with the huge security risks caused by foreign satellite navigation facilities to the country, it is recommended to accelerate the application of Beidou satellite positioning system on the satellite positioning system of navigable aircraft, especially the application of the positioning and tracking of China's plateau operating aircraft.

For existing search and rescue equipment, we must strengthen the use of standard requirements. For similar problems such as insufficient understanding of the role of ELT, we should strengthen use training, standardize the use process, strengthen the company’s safety culture, establish flight crew safety awareness, and avoid delaying search opportunities due to human factors.

3.4. Establish Plateau Rescue Material Center

Aiming at the problem of insufficient preparation of rescue materials, a plateau rescue material center should be built in synchronization with the helicopter search and rescue center. The daily storage of materials and food suitable for air search and rescue, and its packaging should meet the characteristics of suitable airdrops.
3.5. **Strengthen the quality of aeronautical information services**

Strengthen the aeronautical information service for the plateau and mountain operations. It is recommended to establish a national navigation information construction, provide special weather service and operation suggestions for the special plateau and mountain areas, provide special visual aeronautical charts, mark obstacle information that may affect flight and search and rescue, and provide auxiliary operations and rescue paths in response to the complex terrain of the plateau and mountain areas. Choose a guidance service. Correspondingly, it is recommended to install a geographic information system for the search and rescue helicopter.

3.6. **Strengthen the construction of safety culture for general airlines operating in plateau**

Promoting the development of general aviation does not mean that individual general aviation companies can act arbitrarily and break through the bottom line of regulations, so that people's lives are ignored. The general aviation companies that will carry out operations in the plateau and mountain areas should strengthen the pre-judgment of flight safety risks, understand the mountain terrain and meteorological conditions in advance, and avoid risky flights. If the emergency event occurs, the startup ELT will start, and at the same time, the relevant units should be notified in a timely manner to put people first and coordinate all available resources. It is recommended to raise the requirements for the construction of safety culture of general aviation companies, and secondly, establish corresponding punishment mechanisms to force enterprises to regulate their own behavior. Strengthen the requirements for the construction of safety culture of general airlines, and establish appropriate punishment mechanisms for companies that violate regulations.

3.7. **Strengthen the plateau search and rescue personnel team construction and qualification training**

The plateau rescue ground search and rescue team should consist of highly trained personnel. Aircraft search and rescue requires high professionalism. Due to the lack of professional search and rescue personnel training in China and the lack of relevant experience in search and rescue personnel, the efficiency of search and rescue work is low. Therefore, at the national level, training of plateau search and rescue personnel needs to be strengthened, and multiple professional search and rescue teams with plateau search and rescue qualifications must be established. According to Doc9731 and ICAO Annex 12 and other relevant documents, it is recommended to establish a team of plateau search and rescue professionals and/or conduct specific training courses for plateau search and rescue personnel. At the same time, we should also consider the establishment of a personnel system that focuses on professional search and rescue personnel and is supported by other search and rescue personnel.

3.8. **Introduce national financial support policy for search and rescue enterprises**

In addition to the daily emergency funds provided by the state and civil aviation for search and rescue helicopters, search and rescue materials and personnel, in order to encourage the general aviation enterprises to actively assume the social responsibilities and obligations of emergency emergencies, it is recommended to follow the "Interim Measures for Special Fund Management for General Aviation Development". The regulations provide corresponding special fund subsidies to the general aviation enterprises participating in the rescue, eliminating the worries of the general aviation enterprises participating in the rescue.

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