Airport Rescue and firefighting Way in the 5g era

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Abstract. With the maturity of the fifth generation of mobile communication technology (5G), the new technology associated with 5G will have a great impact on the way of Rescue and firefighting in airports. Based on the development of existing technologies in the 5G era, the personnel in the aircraft Positioning technology, real-time scenario monitoring, measurement and data transmission technology for drones, real-time simulation and prediction technology of the aircraft fire situation, and the combination of remote fire hydrants and unmanned RFF vehicles will greatly improve the efficiency and success rate of fire rescue, and reduce the risk to fire rescue workers.

1. Introduction
With the maturity of the fifth generation of mobile communication technology (5G), China is vigorously building the infrastructure of 5G network. 5G communication is based on its continuous wide area coverage, hot spots, high capacity, low power large connection and low latency, high reliable scene will bring a lot of technological changes. The innovation of these technologies has a profound impact on the social system. Specifically, airport fire rescue methods will undergo drastic changes. This article analyses the constraints of modern airport fire rescue methods and proposes that the author himself the concept of airport fire rescue in the 5G era.

2. Constraints in modern fire rescue methods
At present, the airport's rescue and fire is around the fire engine, after receiving an initial call, rescue and firefighting vehicles need to be equipped to start the vehicle and arrive at the scene. Upon arrival at the scene, rescue and firefighting personal needed to control the fire in the critical area for the first time, followed by the evacuation of trapped people inside the aircraft. The fire may lose control in a very short time after the plane is in danger. Therefore, the early arrival of the scene and evacuation of people is critical to the trapped people. This section mainly analyzes the constraints affecting rescue and fire protection.

2.1. Response time
One of the core indicators of airport fire rescue is response time, the operational objective of the rescue and firefighting service shall be to achieve a response time not exceeding three minutes to any point of each operational runway, in optimum visibility and surface conditions [1].

According to the definition of response time, there are two factors that have a greater impact on response time: one is the time required for personnel to wear equipment and the characteristics of the RFF vehicles itself; the other is visibility and ground conditions.
The modern airport fire rescue method mainly relies on RFF vehicles. At present, the Civil Aviation Administration of China stipulates that the airport fire station staff must not exceed one minute from receiving the police to leave the garage after receiving the signal. It takes almost one minute to start the RFF vehicles. At present, main foam RFF vehicles commonly used in domestic airports, for example Oshkosh New Striker 3,000 (6x6). This RFF vehicle can carry 11,356L of water, 1590L of AFFF concentrated foam, and the vehicle is rated the maximum total weight is 42,184kg, the maximum vehicle speed is 115kmp, and it can accelerate from static to 80kmp in 33s. RFF vehicles are extremely heavy due to the large amount of water loaded on it, which makes it difficult for the vehicle to accelerate and decelerate. The maximum driving speed of the RFF vehicles is limited. In the case of poor visibility such as rain, snow, haze and ground conditions, the driver can only reduce the speed of the vehicle, which also results in an extended response time.

2.2. Continuous water supplies
Calculating the total water required for aircraft firefighting usually uses the formula [2]:
\[ Q = Q_1 + Q_2 \]
Among them, \( Q \) —— the total water required
\( Q_1 \) —— the water for control of the fire in the practical critical area, and,
\( Q_2 \) —— the water required after control has been established and is needed for such factors as the maintenance of control and/or extinguishment of the remaining fire.
Under normal circumstances, the amount of water carried by the RFF vehicles can meet the requirements of \( Q_1 \), but it cannot meet the subsequent water quantity \( Q_2 \). RFF personnel also need to consider finding the nearest water source to replenish, and even return to the fire station to replenish. So, a continuous water supply is essential and is usually not available at all points [2].

2.3. Restrictive factors of rescue and firefighters themselves
The first batch of rescue and fire fighting vehicles that arrived at the scene of the accident was to cover the area affected by fuel in advance [2], and continue to spray fire extinguishing agents for more than 1 minute to control the fire in key areas. Evacuation or other tasks. If the response time of an airport is 3 minutes, it will take one minute for the first RFF vehicles to control the fire in a critical area, which means that in the most unfavourable situation, the people trapped inside the aircraft will not be able to get rescue within the first 4 minutes from external forces.
In addition, there is the safety risk of rescue and firefighters themselves. Firefighters formulate a fire suppression plan based on the fire situation of the aircraft, determine the location of the RFF vehicles, the path of the personnel close to the ignition point, and the target and direction of the fire extinguishing agent spray. From the perspective of protecting firefighters Considering that sometimes the best fire extinguishing position cannot be occupied, only a relatively reasonable position can be selected, thereby reducing the rescue efficiency.

3. New technologies and applications brought by 5G
Characteristics of 5G are continuous wide area coverage, hotspot high capacity, low power consumption, large connection, and low delay and high reliability. The 5G white paper released by IMT2020 (5G) clearly puts forward the indicators for 5G technology requirements [3]: User Experience The rate reaches 1Gbps, the peak rate reaches 10Gbps, the connection density is greater than 1,000,000/m², the end-to-end delay is 1ms, and the transmission reliability needs to be 99.9999%. In addition, 5G can provide communication services for users with a speed of 500km/h. 5G, the network can truly realize the interconnection of all things, the data can be transmitted at high speed and reliability, and the device can realize remote zero-delay control. The technologies that have a significant impact on airport fire rescue in the 5G era will include: the personnel in the aircraft Positioning technology, and real-time scenarios of drones Monitoring, measurement and data transmission technology, real-time simulation and prediction of aircraft fire conditions, and the combination of remote fire hydrants and unmanned RFF vehicles.
4. Airport fire rescue methods in the 5g era

4.1. The personnel in the aircraft Positioning technology

According to statistics, from 1998 to 2008, commercial jet aircraft worldwide suffered injuries due to accidents on the ground caused by controllable flight touchdowns, aircraft out of control (ground), and aircraft off the runway. The total number of people is 1,515. After the plane crash, due to the rapid spread of the fire, the fuselage was full of smoke, rescuers must wear breathing apparatus to enter the aircraft for search and rescue. The inhalation of high-temperature, smoke containing a large amount of toxic substances can cause in a short time People trapped inside the aircraft lost consciousness and the ability to move. So, improving search and rescue efficiency is a research topic for rescue researchers.

The US FAA has explored the application of thermal imaging technology in the rescue field as early as 2017 [4]. But thermal imaging technology Due to the limitation of its principle, in the case of fire, the temperature situation is complicated, and once a person loses consciousness in an area close to his body temperature, the thermal imaging technology may not be found. At present, the application of thermal imaging technology in the field of fire protection is still in discovery and early warning of ignition points.

At present, there are relatively few studies on the rapid positioning of aircraft internal personnel. The personnel in the aircraft Positioning technology can play an active and effective role in Rescue and firefighting service. Based on the high reliability of 5G technology, the positioning system worn by passengers and crew members can be real-time the position of the sender can further reflect the physical condition of the person. The rescuer can fully understand the situation of the rescued person before entering the aircraft, which greatly improves the efficiency and accuracy of the rescue.

Table 1. Casualties of commercial jets worldwide from 1998 to 2008 [5].

| Cause of the accident                  | Casualties |
|---------------------------------------|------------|
| Plane out of control (air)            | 1926       |
| Controllable aircraft touches the ground | 961       |
| Off track                             | 408        |
| System / component failure            | 539        |
| Ground control service error          | 156        |
| Plane out of control (ground)         | 146        |
| Encounter wind shear                  | 193        |

4.2. Drones and real-time simulation and prediction technology of the aircraft fire situation.

UAV's preliminary investigation, real-time scenario monitoring, measurement and data transmission during rescue. High-speed and reliable data transmission, remote zero-latency control of equipment, and ultra-high-speed scene service at 500km / h, which means that the aircraft is in danger in the air. At that time, drones can quickly take off and get a closer look at the situation of the aircraft. After the plane landed, multiple drones can be sent to the accident site, and multiple drones can transmit real-time scenes of the aircraft in the first time. Give the control and command center to make rescue commanders more efficient and accurate decision-making. When rescuers and equipment are in place, drones can play a greater role. Multiple drones cooperate on multiple angles of aircraft danger Shooting can overcome the problems of shooting dead angles and poor measurement accuracy of a single drone, so as to accurately measure the fire and fuel leakage of the aircraft. The monitoring center uses the measurement data to model the fire of the aircraft in real time, and can fully understand and even predict Fire Spread: The rescue plan will be more scientific and reasonable, which will greatly improve rescue efficiency and rescue success and reduce the dangers that rescuers encounter during the rescue process.

4.3. The combination of remote fire hydrants and unmanned RFF vehicles.

In the 5g era, remote fire hydrants have become a reality due to the remote zero-delay control of the equipment. A fire pipe network is set up at the airport, and remote fire hydrants are installed at the end
of the fire network. It can be remotely controlled to rise to a certain height above the ground. Within the equipment protection distance, the angle and pressure of the water spray can be freely adjusted to extinguish the aircraft or add water to the RFF vehicles. Each remote fire hydrant can provide a certain range of protection. Reasonable configuration can make the entire airport be protected from all corners. Due to the existence of remote-controlled fire hydrants, RFF vehicles do not have to carry a large amount of water but can still be supplemented with water at any part of the airport. This allows RFF vehicles to greatly reduce their own weight. Compared to main foam cars, RFF vehicles of the 5G era only need to carry about 1200L of concentrated foam concentrate, foam mixing equipment and water cannon to extinguish the fire. This load is only equivalent to the weight of a pickup truck. The highest performance pickup truck can reach a maximum speed of 180km/h. It can accelerate from standstill to 100km/h in 15s. The performance in speed is far better than that of an RFF vehicle.

Unmanned driving will also be applied to RFF vehicles. The airport flight area is relatively simple compared to the urban road network. The driving environment is single, the interference factors are small, and the driving route is relatively fixed. In this scenario, it is easy to train in rainy and snowy days, and on the road. The driving strategy on wet terrain, so as to get the fastest driving speed in various scenarios, which means that the theoretical optimal rescue efficiency can be achieved under any weather conditions. In fact, after removing the cockpit, the RFF vehicles also can get better acceleration performance and higher maximum speed. The low-weight body has lower requirements for the vehicle chassis, and even the existing ordinary off-road vehicle chassis can be competent, which can greatly reduce the technical threshold of RFF vehicles, and directly reduce the cost. RFF vehicles technical threshold and lower cost can make the airport bear more unmanned RFF vehicles.

Airports that were originally not equipped with RFF vehicles will also be equipped. This is a broad market and the scale effect of the market will further increase. Reduced the cost of RFF vehicles.

The unmanned RFF vehicles also mean that there is no need to carry firefighters, and it can be dispatched at the same time as receiving the instruction, saving 1 minute of time for response time. Before the unmanned RFF vehicles arrived at the scene, the drone had already sent the scene the situation is transmitted to the command center in real time, and the command center can use the time when the unmanned RFF vehicles rushed to the scene making a decision to determine the docking position and fire extinguishing method of the unmanned RFF vehicles. This brings two benefits: one is the unmanned RFF vehicles There are no rescue and firefighters on the scene, so it is not necessary to consider the safety situation of rescuers, so that they can implement more flexible and effective fire extinguishing tactics. The second is to control the fire in key areas before rescue and firefighters arrive at the scene. Time can be devoted to the evacuation and rescue of trapped people.

Compared with modern RFF vehicles, the combination of remote fire hydrants and unmanned RFF vehicles theoretically shows great advantages.

Table 2. Comparison of remote-control fire hydrant + unmanned RFF vehicles and RFF vehicles.

| Contrast item                              | Unmanned RFF vehicles | Traditional RFF vehicles |
|-------------------------------------------|-----------------------|--------------------------|
| RFF vehicle dispatch time                 | 0                     | Nearly 1 minute          |
| RFF vehicle acceleration performance      | High                  | Low                      |
| Top speed of RFF vehicles                 | High                  | Low                      |
| RFF vehicles carrying amount of fire extinguishing agent | Many | Less |
| Fighting time of a single RFF vehicle     | Long                  | Short                    |
| RFF vehicles cost                         | Low                   | High                     |

5. Summary and conclusion.
The technology mentioned in this article is not a distant scientific fantasy. Indoor positioning technology has been commercialized, and some studies have shown that 5g combined with Beidou satellite navigation can already achieve centimetre-level positioning. The shape of the aircraft is single, and the structure It is simple and has less interference from electronic equipment, which is easier to
appear than the positioning technology in the building. The remote-control fire hydrant is essentially a combination of remote-control technology and telescopic boom, which has already been widely used in raising RFF vehicles. Machines and unmanned vehicles have been widely used in many fields. The combination of unmanned vehicles and RFF vehicles has not brought new technical challenges to the automotive industry, but instead has brought new opportunities: lower technology Thresholds, lower costs, and a broader market size. The combination of improved cost reduction and superior firefighting methods can give airports more incentive to upgrade existing fire equipment.

The new technology brought by the 5g era can change the definition of response time: the first person to arrive at the scene is no longer an RFF vehicle, but a drone; the RFF vehicles can reach it in 1 to 2 minutes under any weather and road conditions. At the scene, before that, the remote-controlled fire hydrant has been ready to add water to the RFF vehicles or directly spray water to extinguish the fire; the firefighters know the situation of the aircraft at the rescue site and can develop a rescue plan for each trapped person. It is not explored in smoke. This is the 5g era airport fire rescue method envisaged by the author. Advances in technology will not only change the rescue method, but will also profoundly affect the construction of the airport fire rescue system. In the future, the author will also make corresponding research on the transformation of the rescue system.

References
[1] International Civil Aviation Organization, July 2018. Civil Aviation-Annex 14 Aerodromes Volume I Aerodrome Design and Operations;
[2] International Civil Aviation Organization, 2015, Airport Services Manual Part 1 — Rescue and Firefighting Fourth Edition
[3] IMT-2020 (5G) Promotion Group, 2017. 5G economic and social impact. White Paper.
[4] Matthew, S., Jonathan T., *Jack K. (2017) Thermal Imaging for Aircraft Rescue and Fire Fighting Applications, Federal Aviation Administration, Atlantic City.
[5] Cheng F. (2017) Based on the Human Factors of Evaluative Research about the Ability of Student Pilot Dispose Flight Special Situation. Civil Aviation Flight University of China, Guang Han.