

Research on the Diffusion Model of Passenger Mass Emergencies under Flight Delay Situation

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Abstract. The number of passenger mass emergencies caused by flight delay is currently increasing, therefore how to prevent and reduce the adverse effects of such incidents becomes very urgent. The diffusion process of passenger mass emergencies is similar to that of virus spreading. This paper uses the classical virus model to establish a diffusion model of passenger mass emergencies under flight delay situation. Through the analysis of the three situations, the paper preliminarily discusses the general law of passenger emergency diffusion phenomenon.

1. Introduction

With the total civil aviation transport volume ranked second in the world since 2005, China has become one of the civil aviation powers worldwide. By the end of 2017, there were altogether 3,150 registered transport aircrafts in the civil aviation transport industry, increasing by 260 over the previous year, and 3,326 regular flight routes with a route length of 7.8 million kilometers (Adler & Gellman, 2011). In 2017, airlines in the Chinese civil aviation transport industry carried 552 million passengers, increasing by 10.2% respectively over the previous year. China ranks second in the world for 9 consecutive years in terms of civil aviation transport volume. However, civil aviation is a high-risk industry. With the continuous increase in the volume of transport and the number of passengers, the probability of occurrence of various emergencies caused by delays is also surging [1]. Civil aviation emergencies lead to mismatches in transportation service resources, affect passengers' travel plans, impair the quality of air transport services and harm the image of air transport companies. Besides, without transparent and shared flight delay information, emergency disposals and timely guidance, mass emergencies are likely to happen, which can negatively affect aviation safety.

For the special group of civil aviation passengers, foreign scholars have conducted researches focusing on the following themes. First of all, McLay et al. used theories such as risk management and non-linear control to emphasize the importance of screening passengers from the perspective of aviation safety to prevent the occurrence of unexpected events [2]. Second, Cosper & Mclean focused on the behavior of civil aviation passengers, information security and protection of their legitimate rights and interests in the context of emergencies [3]. Third, Terwilliger et al. analyzed and constructed a rapid response and rescue system for civil aviation passengers in flight emergencies [4]. Fourth, Lettovsky et al. explored the process, phase and consequences of the impact of flight delays on mass emergencies among passengers [5]; Oztekin & Luxhoj studied early warning on flight delays [6].

Along with the growing popularity of network and speedy expansion of netizens in the 21st century, network has made great differences in people's lives. From ordinary people to government, the diffusion effect of network in impacting emergencies has increasingly attracted widespread attention



of the society [7]. Once unexpected events of passenger occur, relevant reports can spread rapidly, catching netizens' attention in a short period of time and forming the diffusion of unexpected events of passenger group [8]. As can be seen from the cases of unexpected events, at the initial stage of the emergencies, along with the advance of the emergencies, various and relevant information would be spread through media public opinion and various communication channels [9]. Especially, the baneful influences caused by the spread of some negative information, rumors and gossips in the society increased the difficulty of handling conflict events. This paper adopts the virus infection model to construct the diffusion model of passenger mass emergencies in the situation of flight delay.

1.1 Factions of Passengers in Mass Emergencies

Due to the improvement of people's living standards and the decrease in ticket prices, more and more people choose to go out by plane, making the composition of civil aviation passengers even more complicated, including almost all social strata, which to some extent has increased the risk of emergencies. The complex identity background of passengers also makes it more difficult to deal with emergencies. Passengers of different identity backgrounds travel for different purposes. Therefore, once flight delays occur, the way they claim for compensation varies from person to person. Some passengers tend to rush to their destinations as soon as possible, whereas those who are not in a rush tend to prefer economic compensation.

1.2 Key Figures in Mass Emergencies among Passengers

The key figure is the diffuser of a mass emergency. Mass emergencies caused by flight delay can directly and indirectly involve hundreds of participants or even more. All kinds of chaos and conflicts become increasingly fierce, but it does not mean that all passengers play a role during the occurrence and evolution of the mass events. Among them, there are initiators, active participants, onlookers and even unwitting individuals. In fact, the formation of the energy field of mass emergencies among passengers mainly depends on some active key players. Some passengers who have lost their interests due to flight delays expect to be compensated to a certain extent by making the emergencies bigger. These passengers are direct stakeholders of mass emergencies. Since they cannot have the problem solved by negotiating with the airlines through the normal channels, or their rights and interests have not been properly protected, they prefer to defend their rights by making a big deal out of the emergencies. They firmly believe that everything they do is justified and they stand on the side of justice.

2. Model Establishment and Solution

2.1 Model Assumption

- ① All possible diffusion paths in passenger mass emergencies are regarded as direct contact with negative information.
- ② The whole crowd is regarded as the combination of the informed player system and the uninformed system of emergencies.
- ③ Members of the uninformed player system have immediate access to the informed player system upon receipt of the negative information.
- ④ Agencies like airlines and airports would not control the incident for quite some time.

2.2 Model Establishment

- ① $N(t)$: At time t , an informant with the ability to spread.
- ② N_n : On the n th day, an informant with the ability to spread.
- ③ $K(t)$: The rate of transmission at time t , that is, the number of people per informed person per unit of time.

④ K_n : The rate of transmission on the n th day, which is the average number of people per informed person on this day.

⑤ $O(t)$: At time t , the number of people exiting the spread of information.

⑥ O_n : On the n th day, the number of people exiting the spread of information.

⑦ $O(t)$: the rate of exit at time t , that is $O(t) = O(t)N(t)T$.

3. Model Establishment and Solution

At an early stage of passenger mass emergencies caused by flight delay, the general public is less aware of propagation speed and injury extent of the incident; in this connection, airlines, airports and the public think nothing of it. When people find that the network communication of the events give rise to the ever-increasing public opinions, airlines, airports and government start to take several steps to control the further spread of events. Therefore, the spread of passenger emergencies can be divided into three stages.

① The stage of natural propagation mode before control.

② The transitional period is a period of time before the general public begins to realize the seriousness of emergencies and airlines as well as airports adopt measures.

③ Control stage signifies the stage in which airlines and airports take control measures.

However, no matter what stage the propagation of unexpected events is in, the factors that affects the nature of propagation include the number of informed players with transmission ability $N(t)$, transmission probability $K(t)$ and the transmission ability of the event (measured by $O(t)$ and $D(t)$). In this connection, it should give consideration without stages. The number of transmitters on Day n indicates that the number of transmitters on Day $n-1$ adds new spreaders and subtracts the number of the people who quit the communication system, namely: After the transposition, the following equation can be obtained.

$$N_n = N_{n-1}(K_n + 1) - O_n \tag{1}$$

$$1 \times K_{n-1} = \frac{N_n + O_n}{N_{n-1}} - 1 \tag{2}$$

After the conversion, the following equation can be obtained. The following continuous equation can be obtained by taking the differentiation.

$$1 \times K_{n-1} N_{n-1} = N_n - N_{n-1} + 1 \times O_n \tag{3}$$

Namely:

$$dt K(t) N(t) = dN(t) + O(t) dt$$

$$\frac{dN(t)}{dt} = K(t) N(t) - O(t)$$

Thus it can be obtained that the propagation model of online public opinion of unexpected events is as below.

$$\begin{cases} \frac{dN(t)}{dt} = K(t)N(t) - q(t)N(t) \\ q(t) = d(t) + o(t) \\ N_0 = N(0) \end{cases} \tag{4}$$

Suppose that $K(t)$ (the transmission rate at t) is a constant k and b .

$$N(t) = \begin{cases} \left[\frac{k}{k-b} + \left(\frac{1}{x_0} - \frac{k}{k-b} \right) e^{-(k-b)t} \right]^{-1} & k \neq b \\ \left(kt + \frac{1}{x_0} \right)^{-1} & k = b \end{cases} \tag{5}$$

Provided that $\rho = \frac{k}{b}$, ρ means the average number of effective contact participants of the unexpected events within a transmission period, naming contact number.

In accordance with the above-mentioned equation, when $t \rightarrow \infty$,

$$x(\infty) = \begin{cases} 0, \rho \leq 1 \\ 1 - \frac{1}{\rho}, \rho > 1 \end{cases} \tag{6}$$

Thus it can be seen that the number of emergency contact people, $\rho = 1$, is a threshold value. If $\rho > 1$, the increase and decrease degree of $x(t)$ function is determined by x_0 , that is, the successful recovery of the emergencies is mainly determined by the scale of the group events. There are three situations as below.

3.1 Analysis of the first situation

It can be found that the increase or decrease of x changes with time variation. As can be seen from Figure 1, when $\rho > 1$, $x_0 < 1 - \frac{1}{\rho}$, at the very beginning of unexpected events, the proportion of participant passengers $x_0 < 1 - \frac{1}{\rho}$. As can be seen from Fig 1 and is finally close to $1 - \frac{1}{\rho}$.

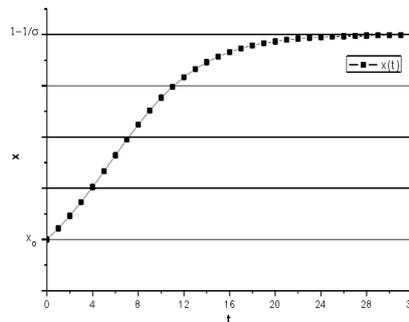


Figure 1. The variation relationship of x , the participant proportion over time (days)

3.2 Analysis of the second situation

When $x_0 > 1 - \frac{1}{\rho}$, $\rho > 1$, the number of participants in the event, x , changes over time. As can be seen from Figure 2, the number of participants at the first stage $x_0 > 1 - \frac{1}{\rho}$ in the event x gradually decreases. At last, it approaches. Since $\rho > 1$, $1 - \frac{1}{\rho} \neq 0$. The number of participants in the final events is not equal to 0.

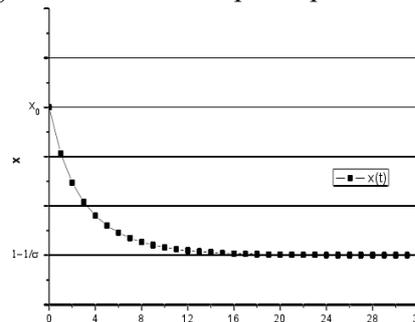


Figure 2. The variation relationship of participant ratio x over time (days)

3.3 Analysis of the third situation

When $\rho \leq 1$, the number of the participants in the events changes with the increase and decrease of time. As can be seen from Figure 3, the numerical value of participants slowly reduces and the number of participants finally disappears, which means that the unexpected events of passenger group are effectively controlled at last. It illustrates that relevant department organizations like airlines and airports proactively communicate and coordinate with tourists, eventually controlling the spread of rumors and gossips. At last, the events quiet down.

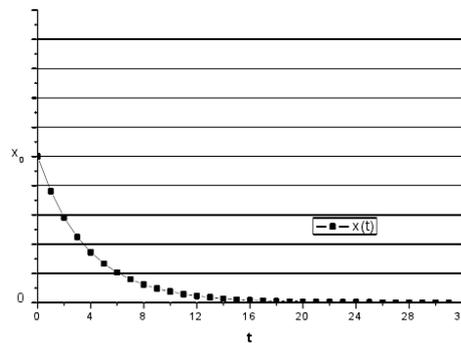


Figure 3. The variation relationship of the participant ratio x over time (days)

4. Results and Discussions

Through the above-mentioned analysis, when passenger mass emergencies occur, airports and airlines should take various types of measures to make the number of contact passenger group, $\rho < 1$. After unexpected events of passenger group occur, the best intervention time is the initial growth stage of the incident. When passengers need to express their feelings, relevant departments should give passengers sufficient attention and guidance in time, so that their depressed negative emotions are fully released. The early intervention stage makes passengers' panic and anxious mood relieved. In the next place, airlines and airports should communicate with passengers and the public timely, and issue the fact of the events to the public timely through the leadership of authoritative media airline, in order to meet the different needs of tourists as far as possible. In this connection, the general public can get the truth, the number of tourists and the public who pay attention to this event is on the gradual decrease, and the number of passenger participant gradually reduces. If the proportion of contact passengers is less than 1, the number of participants in the whole event (t), would gradually decrease. The numerical value drops to 0, which means that the group events are effectively controlled. If the service attitude of the airline and the airport staff is indifferent, and they are neither enthusiastic nor thoughtful of accommodation and dieting arrangements for passengers, all aspects of services appear to be very passive, contributing to the breeding of discontent emotions among the passengers. It may make $\rho > 1$ the scale of passenger mass emergencies is increased and the reputations of airlines are affected, thus causing adverse effects on the society.

5. Conclusions

In this paper, we use the classical virus model to establish a diffusion model of passenger mass emergencies under flight delay situation. The three situations of emergencies are analyzed in detail. It is important to interfere with the adverse effects resulted from passenger mass emergencies.

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