

# Analysis of Countermeasures to Improve School Bus Safety

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## Abstract

School bus safety troubles in all kinds of traffic safety troubles accounted for a small proportion, but due to the particularity of the victim group caused by troubles bring stronger risk, greater uncertainty. In this paper, combined with the previous trouble statistics and research experience, the application of Fault Tree Analysis method to analyze the causes of school bus troubles at all levels, and for the main reasons to improve the school bus safety trouble countermeasures and suggestions.

## Keywords

School Bus Trouble; Fault Tree; Primary Student.

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## 1. Introduction

In recent years, with the increasing level of urbanization and an aging population, getting children to and from school has become a new challenge. The number of left-behind children is decreasing. The number of primary schools in rural areas is decreasing year by year. The distance for primary school students to go to school is increasing, and the traffic problem to go to school is becoming more prominent. Although the school bus is widely used in China, but because of the school bus technology and system development has been lagging behind, school safety awareness and management ability is low. In recent years, school bus trouble occur frequently. Some scholars statistics of 74 times school bus safety trouble reported by the media in the past five years found that 74% of the deaths were rural students; 49% of school bus trouble occur in compulsory education [1]. These problems have caused widespread concern in children's parents about safety, it is urgent to solve the problem of school bus safety.

## 2. Research Object and Method

### 2.1 Research Objects

According to statistics, more than 18,000 people under the age of 14 die in traffic troubles in China every year, which is 2.6 times that of the U.S. and 2.5 times that of Europe [2]. That figure already accounts for half of all school bus fatalities each year. Considering the particularity of children and their weak awareness of self-protection [3], school buses of kindergartens and primary schools are taken as research objects for analysis[4].

### 2.2 Research Methods

Through consulting data and analyzing cases, find out the main problems of school bus safety in China and the main factors leading to trouble. Then using the Fault tree analysis method to analyze the causes of school bus trouble at all levels, the basic reason set and the importance, and then according to the analysis results combined with the current situation of school bus safety in China to put forward suggestions and measures.

### 3. Establishment and Analysis of Fault Tree

#### 3.1 Concept of Fault Tree

Fault tree analysis (FTA) is a top-down deductive failure analysis method, which combines low-order events using Breen logic to analyze undesirable states in the system. Fault tree analysis is mainly used in the field of safety engineering and reliability engineering to understand the cause of system failure and find the best way to reduce the risk, or to identify the incidence of a safety issue or a specific system failure. Fault tree analysis is also used in software engineering, for debugging purposes, and is closely related to techniques for eliminating the cause of errors.

#### 3.2 Steps for Establishing the Fault Tree

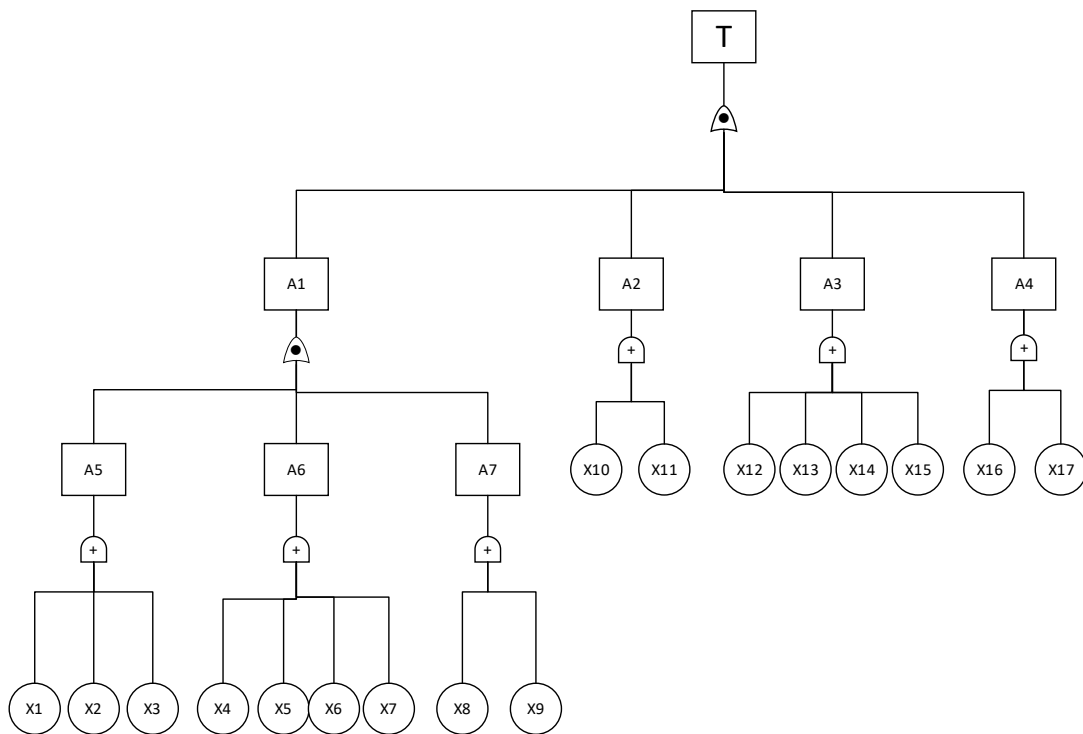


Figure 1. School bus fault tree

Table 1. School Bus Fault Tree Notes

|  |   |  |                                |  |
|--|---|--|--------------------------------|--|
| T<br>School bus trouble                  | A1<br>Human factors                                   | A2<br>vehicle factors                  | A3<br>Management factors       | A4 environmental factors                 |
| A5<br>teacher factor                     | A6<br>driver factor                                   | A7<br>student factor                   | X1<br>lack of safety awareness | X2<br>carelessness                       |
| X3<br>not strong sense of responsibility | X4<br>overspeed driving                               | X5<br>overload driving                 | X6<br>distracted driving       | X7<br>not strong sense of responsibility |
| X8<br>lack of safety education           | X9<br>lack of self-management ability                 | X10<br>lack of operation qualification | X11<br>poor car condition      | X12<br>poor school management            |
| X13<br>school bus company mismanagement  | X14<br>traffic police vehicle supervision is not good | X15<br>traffic management is not good  | X16<br>severe weather          | X17<br>dangerous roads                   |

(1) Determine the fault treetop event.

Due to the need to analyze the kindergarten, primary school bus issue, so the school bus issue as the top of the fault tree. Start from the top of the trouble layer by layer down analysis.

(2) Analysis of school bus trouble.

According to previous research experience and analysis of trouble data, school bus trouble are caused by human factors, vehicle factors, management factors and environmental factors, and there is a complex relationship between the four factors and the trouble. The basic event formed by each event is analyzed down by several events.

(3) Analyze basic events

Human factors include teachers' carelessness, weak safety consciousness and weak sense of responsibility; Drivers of overspeed driving, distracted driving, poor sense of responsibility; The lack of safety education and self-management ability of students result in the trouble. Therefore, the relationship between the three factors are "and". Factors of vehicles include lack of operating qualifications and poor condition of vehicles, while factors of management include poor management of teachers and students by schools, poor management of school bus companies, poor supervision of traffic police vehicles and poor traffic management. Environmental factors include severe weather and steep roads, either of which may cause troubles, determining the relationship between the two factors are "or".

### 3.3 Qualitative and Quantitative Analysis of Fault Tree

Minimum cut set of fault tree:

$$\begin{aligned} T &= A1 * A2 * A3 * A4 \\ &= A5 * A6 * A7 * A2 * A3 * A4 \\ &= (X1 + X2 + X3) * (X4 + X5 + X6 + X7) * (X8 + X9) * (X10 + X11) \\ &\quad * (X12 + X13 + X14 + X15) * (X16 + X17) \end{aligned}$$

The minimum cut set is {X1,X4,X8,X10,X12,X16}, {X2,X5,X8,X11,X16,X15}, {X2,X6,X9,X10,X15,X16}, etc. 384 species. According to the minimum cut set, the order of structural importance follows the following principles:

- (1) The basic event in the minimum cut set of single event has the highest structural importance.
- (2) All the basic events in the same minimum cut set have the same structural importance.
- (3) The structural importance of the basic events in the minimum cut sets with the same number of basic events is determined by the number of occurrences, and the structural importance of the basic events with the same number of occurrences is equal; Structures that occur more often are more important, and structures that occur less often are less important.
- (4) If two basic events only appear in some minimum cut sets with different numbers of basic events, and if they repeat the same number of times in each minimum cut set, the basic events that appear in the minimum cut set with few events have a large structural importance coefficient.

In the minimum cut set with few events and the minimum cut set with many events, the structural importance of the former is generally greater than that of the latter. The structural importance of basic events can be calculated according to the principle:

$$\begin{aligned} I(8) &= I(9) = I(10) = I(11) = I(16) = I(17) > I(1) = I(2) = I(3) > I(4) = I(5) = I(6) \\ &= I(7) = I(12) = I(13) = I(14) = I(15) \end{aligned}$$

This shows that school bus safety trouble human factors, vehicle factors accounted for a larger proportion. Among them, the overspeed driving of vehicles, overloading driving, teachers' carelessness and students' poor self-management consciousness are the main causes of school bus troubles, so we should focus on improving the human factors.

## 4. Countermeasures and Suggestions for School Bus Safety Troubles

In view of the key factors of school bus troubles, the following suggestions are made first:

### 4.1 Strengthen the Training of Personnel

As the main body of traffic troubles, people are not only the participants of all kinds of traffic activities, but also the direct victims of traffic troubles. Strengthening education for people plays a very important role in improving school bus traffic troubles. In school bus traffic safety troubles, the training of people should include the training of teachers, drivers and students.

**Teacher Training:** teachers should strengthen their awareness of safety, strengthen their legal knowledge and sense of responsibility for the safety of students' lives, and raise the sense of responsibility for every student to a political height. Carry out relevant business training for teachers, so that teachers are familiar with matters needing attention in the process of school bus picking up students, possible emergencies and countermeasures. As the main responsible person, teachers should make accurate judgment, effective avoidance and correct disposal in the prevention and disposal of troubles.

**Driver training:** to strengthen the driver safety driving education and auxiliary management education. School bus drivers should not only ensure the safety of the school bus, more carefully avoid any possible traffic troubles, but also assist teachers to do a good job in the safety management of students. Drivers should be trained in driving skills, including not only excellent driving skills and emergency handling ability, but also training for elementary school passengers, such as slow start, slow deceleration, steady parking, ensuring that there is no hidden danger before opening the door. Auxiliary management training should strengthen the students of the school bus driver, auxiliary management mainly occurs in the student check personnel for our car before you get on whether already arrived, students observe whether students should get off this site is out of the car as he got off the bus, whether parents or other guardians to pick, students and teachers together form the security of the "double insurance".

**Student Training:** students above the age of three have language ability and self-awareness, and can express their ideas clearly. Through the training of students, students can develop the awareness of following the teacher and expressing their own ideas. When they are forgotten by teachers and drivers to take the initiative to respond, can effectively avoid the occurrence of forgotten troubles.

### 4.2 Strict Approval Authority for School Bus

School bus safety troubles in the "black school bus" phenomenon is common, "black school bus" is difficult to ensure the operation qualification, for the condition of the vehicle and the basic quality of the driver is difficult to ensure, more even the driver has a history of 10 years of drug abuse, which has caused great hidden dangers to the safety of students' lives. Many schools use the vehicle itself is not designed for transporting students professional school buses, safety performance is not up to standard[5]. To strictly approve the use of the school bus, for sick car, performance does not match the car and no operation qualification car firmly out of use, at the same time, the regulatory authorities to strengthen supervision, for overloading and overspeed driving school bus increase penalties; Strict daily safety inspection of the school bus, the traffic control department regularly on the school bus security check, urge the existence of vehicle safety hidden dangers of the school bus rectification, for the school bus and institutions refused to rectify the corresponding punishment; Strict school bus driver approval, for political thought is not strong, poor physical fitness, moral quality of the driver firmly banned, to ensure that the driver's license driving type and school bus.

### 4.3 Optimaze School Bus Routes

School bus routes can be abandoned when necessary the shortest route to take the safest route. For the road section with multiple choices, we can avoid the crowded and busy city according to the situation, and choose the relatively safe road section for the steep road section, even though this choice may lead to the increase of form mileage. At the same time, limit time can be set up in necessary

sections to ensure the safe and smooth running of the school bus. For private cars that rob the road with school buses, penalties will be increased and education on traffic rules will be compulsory. The choice of bus route should not be the optimal solution of the minimum driving distance, but should be the result of the comprehensive effect of many factors such as real-time road conditions, safety risks, driving mileage, weather conditions and so on.

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