

# Safety Management System of Dangerous Chemicals Transportation in Airlines

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This paper sets to analyze the management of transportation Safety of dangerous goods transportation by the airline companies. It adopts the preliminary hazard analysis to understand the risk factors in dangerous goods transportation for the airline companies, and selects the transportation method of dangerous goods based on the relative weights of the risk factors. The result is reached that the airline companies need to establish a hierarchical analysis approach in dangerous goods transportation with clear-cut management responsibilities. It is the conclusion of this paper that quality inspection on dangerous goods is an important direction for the constructing the transportation safety management system.

## 1. Introduction

In this new age, safety is a concern for all industries in all aspects of work. China has also launched the Law on Production Safety in 2002. The civil aviation companies are important players in the Chinese transportation sector. From the data for 2011 to 2015, the transportation turnover has been improving (see Figure 1), as indicated by the growth rate (in yellow line) and transportation turnover (in blue columns, unit 100 million ton kilometers).

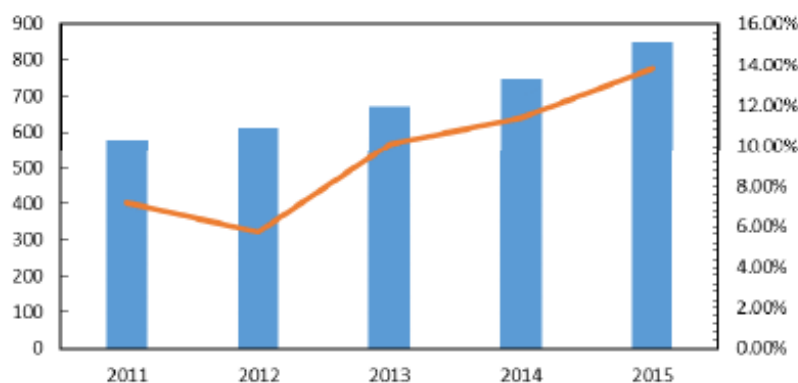


Figure 1: The transport turnover of civil aviation industry is on the rise

In the meantime, we should note that a number of transportation accidents have taken place in the international civil aviation industries, which are attributable to the issues related to dangerous goods transportation. Though China's aviation industry has not experienced such accidents, to enhance the safety control and management is necessary. Presently, the domestic airline companies, following the requirements of International Civil Aviation Organization and domestic laws and regulations, have established the Safety management system, which has been active since 2010 and serves to improve the overall safety of airline industry. From the perspective of Safety management, research on the dangerous goods transportation Safety contributes to enhanced safety and stability of the aviation transportation chain, and to steady development of

the industry. This paper, setting out from the safety management system, based on the practices on dangerous goods transportation, determines the risk factors and finds the risk factor weights using the analytic network process on the causes and approaches.

## 2. Literature review

Safety management system has become a well-known topic in the field of civil aviation. The United States studied safety management system earlier. In 2003, it compiled safety management system manual and began to carry out safety risk management in the field of civil aviation. Since 2006, the United States Federal Aviation Administration (FAA) has committed to promoting the construction of the safety management system of related organizations and issued an advisory bulletin on the aviation operator safety management system, introducing the concept of the safety management system to the airline operators and asking them to build the system. In 2011, the Federal Aviation Administration (FAA) encouraged airline operators to complement and mature the safety management system and integrate risk management into daily business activities through the improvement of the security management system, as well as other management functions, such as finance, quality, marketing, etc., and considered safety management. It will become a "core business function". In 2012, the FAA urged air traffic control systems and airports to establish a safety management system. In September 2015, the FAA issued an advisory circular requiring all airlines in the country to complete the construction of the safety management system in 2018. Canada is also a country that implemented safety management system earlier. The Canadian Department of transport (transport Canada - TC) is the first civil aviation authority to set up a safety management system. The security management system is defined as "the document handling process of managing security risks, integrating financial and human resources into various operating systems or technical systems to ensure aviation safety or public safety.". Since 2000, Canada has gradually improved its safety management system in various sectors of the civil aviation sector. From 2012 to 2013, the Canadian Department of transport (transport Canada - TC) assessed the safety management system of the airport and air service providers to ensure that the security management system built by the above-mentioned institutions met the requirements of the laws and regulations. Recently, the transport Canada - TC issued a "guide to the construction of a safety management system for small aviation organizations" to encourage small civil aviation organizations to build a safety management system to improve the overall security of the civil aviation industry. Gholami and others believe that the security management system is a formal, top-down organization management approach that can control security risks through continuous cyclic management. Security management is based on the existence of trust. If lacking of trust, the various components of the security management system cannot work for a long time. The security management system will be a dead water and cannot meet the requirements of the security management system (Gholami et al., 2015). Wakata and other people applied the compliance management philosophy to safety management, studied the psychological activities of navigable pilots before sailing, and carried out risk analysis and safety measures before starting the voyage to ensure no flight (Wakata et al., 2015). Jharko and Sakrutina applies the risk decision model to pre-flight preparation, analyses the influence of weather conditions on flight, makes pilots more rational to cope with environmental factors such as weather conditions, and makes safety precautions against the risks caused by meteorological conditions (Jharko and Sakrutina, 2017). Bayazit and Zorba, through the study of organizational security culture, believes that the infiltration of security culture is a learning process, which is both clear and imperceptible. When the security culture is deeply rooted in the hearts of the people, the people in the organization will unconsciously pay attention to security, and what they do will meet the requirements of safety management (Bayazit and Zorba, 2017). Benekos and Diamantidis reviewed the strategy of risk management institutions, analysed the past and present positions of occupational health and safety management institutions, reviewed the occupational health and safety management institutions, and proposed that in the field of dynamic risk management, the occupational health and safety management institutions need to constantly improve their own strategies to make the institutions consistency of mission and role. It also provides reference for other professional organizations in risk management to solve strategic problems (Benekos and Diamantidis, 2017).

The domestic civil aviation industry safety management system is relatively late, so we need to learn from the advanced experience of foreign safety management system. In November 2005, to adapt to the development of China's economy, the CAAC determined the pilot construction unit of sea air as a safety management system, which required the construction of the safety management system in accordance with the basic concepts and implementation requirements of the safety management system, which conforms to the national conditions and adapted to its own characteristics. In 2006, the Civil Aviation Administration of China began to promote the construction of safety management system in civil aviation related units. In 2011, China Civil Aviation Administration promulgated the "safety management rules for air traffic management and operation units of civil aviation". The regulations require the establishment of safety management system for air traffic

services, aviation information services, communication and navigation surveillance services, and aviation meteorological services. From 2012 to 2013, the audit work of the national civil aviation maintenance unit safety management system was carried out in full swing, and the civil aviation authorities in various places supplemented the safety management system for civil aviation maintenance units in the area. The safety management system was initially built in the civil aviation maintenance units. Liu and others, starting with the concept of modern safety management, studied the safety management system of Changsha airport, discussed the core part of the construction of safety management system, tried to use the accident tree to carry out risk management, and improved the former method of safety management relying on subjective judgment, which has practical guiding significance (Liu et al., 2016). On the base of explaining the concepts of safety, risk and safety management, Wang and others analysed the importance of the safety management system in the aviation maintenance units. The safety management system was constructed and the risk management was carried out by the maintenance Engineering Department of China cargo aircraft maintenance engineering. The maintenance capacity of the maintenance department was expanded and the safety management was improved. Deng Yuelian discussed the concept of safety management and the actual operation of China Eastern Airlines and believed that the risk source control should be carried out in the operating environment. The safety management system should emphasize risk management and closed loop feedback control. The airlines should strengthen the safety culture construction to ensure the safety of their operation (Wang et al., 2016). An and others have studied the current situation of the implementation of the safety management system of the mountain, and analysed the problems arising in the implementation of the safety management system, such as low employee participation, lack of risk management, and the poor safety education and training effect. The improvement measures were put forward to the above problems. Finally, the implementation of the safety management system was considered. We must change ideas and pay attention to the implementation of measures (An et al., 2015).

Based on the above research situation at home and abroad, this paper mainly studies the transportation safety management system of dangerous chemicals.

### 3. Approach

#### 3.1 Constructing Transportation Safety Management System

The dangerous goods are classified as in Figure 2 by the airline companies.



Figure 2: Classification of aviation dangerous goods

Dangerous goods transportation safety system is designed to provide assurance of safe transportation of dangerous goods through pre-crisis safety management. The goal is to mitigate the safety implications of dangerous goods transportation on the relevant entities and avoid the hazardous accidents or accident proneness from happening.

Dangerous goods transportation policy and goal lays the foundation for the safety management system by the airline companies. It falls under the scope of Plan, in which phase 5 factors are addressed, including: establishing dangerous goods transportation commitments, defining the roles and responsibilities, appointing key managerial persons, and formulating emergency response plans and dangerous goods transportation management documentation. The airline company should follow the steps and establish strict dangerous goods transportation policy, and base on it, lay down the relevant goals for dangerous goods transportation, and detailed implementation plans.

In terms of training and education of dangerous goods transportation safety, the airline companies should advocate the policies and concepts of dangerous goods transportation safety among the staff while offering relevant training in this area. The training should be offered on varied levels corresponding to the responsibilities of the trainees: the senior management should receive training on the improving the safety awareness by offering accident case analysis so that they would prioritize dangerous goods transportation and resource allocation in this regard; the middle managers should receive training on the methods and approaches of dangerous goods transportation, getting updates about the parts where accidents are most likely to occur and how to implement enhanced controls on these parts, so that they are fully knowledgeable on the transportation safety of dangerous goods and can make relevant decisions on dangerous goods transportation utilizing the knowledge gained through the training; while for the front-line staff, the training should focus on offering accident cases of dangerous goods transportation, educating them on the operations steps where accidents are most likely to occur and the damages resulting from improper operations, and improving their awareness on safety when handling the dangerous goods. The dangerous goods transportation safety training should be tailored in line with the business needs and serve to involve the relevant persons in the safety management system. The detailed process is in Figure 3.

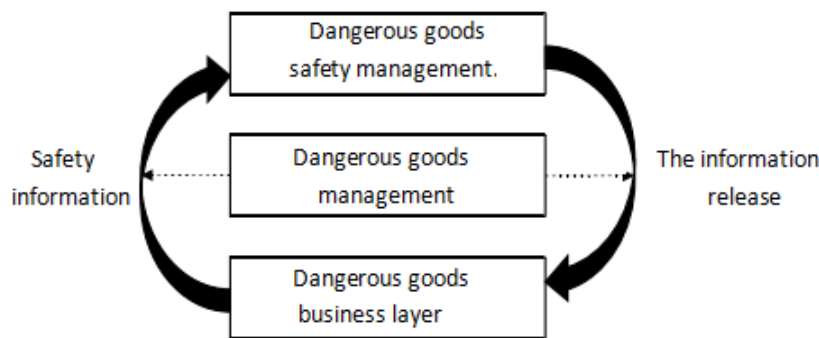


Figure 3: Dangerous goods transportation safety information exchange ring

**3.2 Transportation Safety Risk Identification**

The dangerous goods transportation, undertaken by the airline companies, involves different parties. These parties should work closely to ensure safe transportation of the dangerous goods. This section discusses the relevant departments and parts in the airline company involved in dangerous goods transportation, and identifies the risk factors that may have implications on the safety in the process of dangerous goods transportation. The Figure 4 below lists departments in an airline company that are involved in dangerous goods transportation.

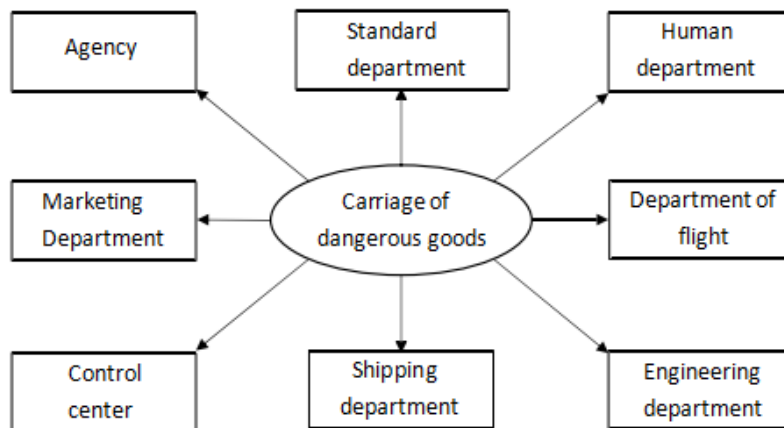


Figure 4: The department concerned with the transport of dangerous goods within the airline

Standards on dangerous goods transportation and relevant documents should be stipulated. The airline companies should, based on the regularly reviewed and updated Technical Rules for Safe Air Transportation of Dangerous Goods and Dangerous Goods Regulation, establish their own internal business standards. The standard-setting on dangerous goods transportation is relevant to proper management on dangerous goods transportation. The standards should define the changes in business. In line with the principle of safety management systems, business change could be a risk factor which may pose danger on safety operation of the company upon certain triggers. Pursuant to the Measures for the Management of the Air Goods Transport Conditions by the Transportation Department of the Civil Aviation Administration, the airline companies are responsible for the acceptance of authentication agency of air goods transportation conditions, and should file accordingly with the Civil Aviation Administration. The authentication agency decides if the goods is dangerous, and if anything goes wrong with the decision, the airline companies may transport the dangerous goods as regular goods, and put themselves in danger. As the authentication results made by the agencies may affect the airline companies' safe operation, they are an external risk factor for dangerous goods transportation by airline companies.

### 3.3 Analytic Network Process

Triangular fuzzy number assessment is based on fuzzy theory. This assessment method is in line with the logical way of thinking, and sets to describe the objects using degree language and obtain quantitative results. This method meets the purpose of subjective decision making issues where multiple indicators are applicable. To be specific,  $I = (1, m, u)$

These are the most pessimistic value, the most probable value and the most optimistic value from expert estimation. As the risk factors are categorized in varied risk factor groups, in addition to the relations among factors in the same group, considerations should be taken on the implications on a certain risk factor from risk factors in other groups, a complementary judgement matrix of triangular fuzzy number is constructed and the partial weight vectors are calculated.

## 4. Results and Discussion

*Table 1: Risk factors for transport of dangerous goods in airlines*

Factors	Sub factors
Internal management factor	Transport of dangerous goods Quality inspection Marketing personnel business level.
Human factor	Safety personnel awareness Operator's operation level.
Risk factor	Dangerous goods transport documents The goods labels
Hardware and software factor	Dangerous goods manual Dangerous goods monitoring equipment
External environmental factors	Sales agent Authentication institutions

The external environment factor exert the highest level of implications on safe operation of airline companies. The experts allocates it with higher weight taking into consideration of the actual operation of the business: firstly the airline companies do not have direct contact with the dangerous goods. The goods are not packaged by the airline companies, who only receive the goods after packaging. The collectors of the goods only conduct collection inspections on the packaged goods to check if the companies requirements are met; and secondly the airline companies do not have goods authentication capacity. They rely on the authentication agencies' reports on determination of dangerous goods, and if the report is wrong, the airline companies may treat the goods as regular goods and expose themselves to danger. The external environment factors directly influence the safe operations of the airlines. The second highest weight is allocated to internal management factor on dangerous goods, which include management responsibilities in setting up dangerous goods transportation safety policies, providing training, and emergency response plans. The experts believe that if the airline companies do not have proper division of roles and responsibilities in these regards, significant risks are created on the business and the operation of the airline companies eventually. The packaged

dangerous goods are delivered from sales agencies, who is among the external environment factors. The quality of package and their performance in the trip depend on these agencies, so the expert allocates it with a weight lower than the sales agency, but higher than other risk factors due to direct implications on the safety in case of fire, smoke or leakage of dangerous goods during transportation.

The expert also gives higher weight to quality inspection since the quality of goods being delivered has direct implications on the safety. The Dangerous Goods Regulation sets to ensure safe transportation of dangerous goods, stipulate quality requirements that the package documents should meet, and provide assurance to safe operation of the airline companies from a different angle. The airline companies can prioritize key points in dangerous goods transportation safety management based on the relative weights among the risk factors, improve the status quo on dangerous goods transportation, and reduce the implications this business on the company. The detailed risk factors are listed in Table 1.

## 5. Conclusion

Dangerous goods transportation is a key area of concern as it may expose airline companies to greater risks of safety. Safety management system on dangerous goods transportation provides guidance on the future safety-related work of airline companies. Taking into the interactions among the risk factors and experts judgement of disparity, we adopt the analytic network process for precise results on risk factors, which can be referenced by the airline companies in resource allocation for the purpose of resource saving and efficiency. Particularly on certain higher weights risk factors, corresponding risk controls should be formulated to improve the safety-related work in areas of management, transportation and prevention. In the future, with the implementation of the safety management system and business expansion, the assessment and control on dangerous goods transportation will also improve. The performance of the safety management system can be a potential area of research.

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