Advances in Computer Science Research, volume 58
Modeling, Simulation and Optimization Technologies and Applications (MSOTA 2016)

Research on Civil Aviation Emergency Decision-making Based on System Dynamics

Weijun Pan[1], Chuyang Yang[1] and Heping Shi[2]
[1]Affiliation: School of Air Traffic Management, Civil Aviation Flight University of China, Guanghan in Sichuan, 618300, China
[2]Affiliation: Xiamen Air Traffic Control Station, Xiamen in Fujian, 361000

***Abstract*—This paper is different with those paper which combined with the analytic hierarchy process (AHP) and grey prediction model to construct the accident emergency response plan (ERP), but used a system dynamic theory to analysis the key parameters in the evolution of civil aircraft accident and we put forward a new evolutional dynamical flow graph for the appeared aircraft incident in civil aviation system, and next step we combine with the improved K2 method based on Bayesian network to establish a more comprehensive and practical than the traditional decision model based on prior knowledge, and it can provide aided decision for civil aviation aircraft accident emergency action.**

Keywords-civil aircraft accident; emergency response plan; system dynamic theory

I. Introduction

According to annual safety report of international air transport association (IATA) in 2016, there are total of 68 cases of safety accidents in the global aviation industry in 2015, less than 77 in 2014. The major accident is 4, less than 4 in 2014, less than the average 17.6 before the 5 years. Last year, 136 people died in the accident, but the German Wings A320 aircraft and the Russian Kogalym airlines A321 crash accidents were not be counted to consideration, the reason is that the two major aviation accident was identified as "deliberate illegal interference behavior", and are related to "personal mental health diathesis and security holes". If add these two accidents, death toll for 510 people. From 2000 to 2014, the global aviation unsafe accidents a total of 2726, 194 on average per year, the air crash 421, need to search for the aircraft, a total of 19[1-2].

Most relevant research results in home and abroad focus on the evolution law of a particular incident, and mainly concentrated in the earthquake disaster, flood disaster, nuclear accident, disease spreading, terrorist attacks, etc. In this kind of emergency for civil aviation aircraft accident and emergency decision-making, Pan Weijun, Wang Rundong and others set up search and rescue ability evaluation model based on improved fuzzy analytic hierarchy process (AHP), and built the evaluation index system of the search and rescue ability; Wang Wen-bo based on aerodynamics built crash prediction model and the optimal search model of the civil aircraft search area.

II. Modeling

Based on the structure and process of emergency decision-making system of analysis, and combined with involved various influential parameters of the civil aviation emergencies evolution, we can divided the involved key parameters of emergency decision-making and the emergencies evolution process into the following four parts: environment parameters, equipment parameters, artificial and emergency parameters[3].

A. The Environmental Parameters Analysis Of Civil Aviation Emergencies

Emergencies' evolution often has close relations with the objective environment and, its every evolution stage corresponds to the different external objective environment. The environmental factors of emergencies' evolution will be considered subsystem from a large system, contains the following influential factors: the environmental monitoring data, environmental damage, environmental hazard factor formation, unexpected events triggered. The environmental hazard factor is to intensify environmental damage, when the environment's damages reach a certain degree, events will be triggered, the outbreak of the incident will cause the environment monitoring data abnormal, thereby will have obstacle function to the implementation of emergency or the preventive measures, and the implementation of relevant measures can reduce the environment damage. The causality diagram of environmental factors feedback system is shown in the figure below.

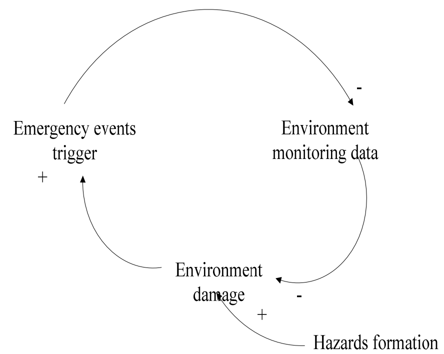

FIGURE I. CAUSAL FEEDBACK OF ENVIRONMENT FACTOR SUB SYSTEM

Environmental hazard factor formation means emergencies' hazard factors come to occur, including human and natural factors which can lead to dangerous situations, environmental hazard factor formation is an important driving factor of environmental damage. With the degree of environmental damage increasing, and the damage accumulated to a certain degree then it will trigger events. Environmental monitoring data is to point to by certain detection means of relevant data, the abnormal environmental monitoring data shows that shall take corresponding measures to prevent and repair it.

According to above analysis, we can get the system dynamics figure of environmental factor as shown in FIGURE 2.

Among them,

- State variables (Level): L_1: Emergencies' evolution Level; L_2: Environmental degradation level;
- Decision variables (Rate): R_1: L_1 accumulation; R_2: L_2 accumulation;
- Auxiliary variables: A_1: Environmental damage; A_2: Emergency trigger;
- Constants: C_1: Environmental hazard factor formation.

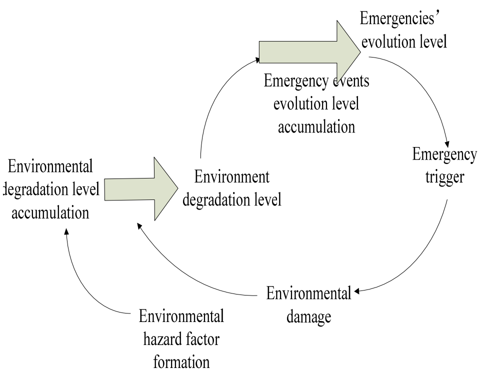

FIGURE II. SYSTEM DYNAMIC FLOW CHART OF ENVIRONMENT FACTOR

B. Equipment Parameter Analysis of Civil Aviation Emergencies.

Equipment factor is a basic influencing factor of civil aviation occurrence and evolution. Both emergencies occurrence and emergencies emergency management are closely linked with the device factor. The causality diagram of equipment factors feedback system is shown in the FIGURE 3.

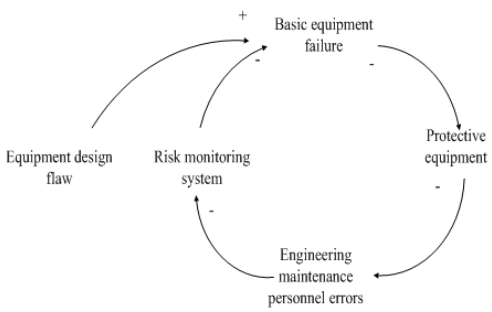

FIGURE III. CAUSAL FEEDBACK OF EQIUPMENT FACTOR SUB SYSTEM

The equipment design flaws means the existed flaws which caused by limited science and technology manufacturing level at the beginning of design, such as the limited navigation equipment accuracy, or smaller communication range communicate equipment. According to above analysis, we can get system dynamic diagram of the equipment factors as shown in following figure.

Among them,

- State variables (Level): L_1: Emergencies' evolution Level; L_3: Basic equipment failure level;
- Decision variables (Rate): R_1: L_1 accumulation; R_3: L_1 negative accumulation; R_4: L_3 accumulation ; R_5: L_3 negative accumulation;
- personnel errors; A_4: Risk monitoring system; A_5: Protective equipment
- Constants: C_2: Basic equipment design flaw.

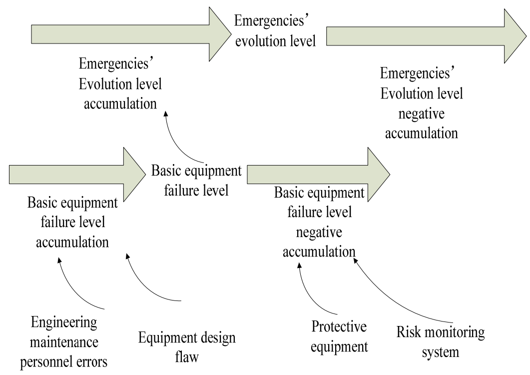

FIGURE IV. SYSTEM DYNAMIC FLOW CHART OF EQUIPMENT FACTOR

C. Human Factors Analysis of Civil Aviation Emergencies

Human factor is an important external factor of civil aviation incidents occurrence and evolution, and it has the most obvious influence on the event evolution process. Anthropogenic factor of causal feedback system diagram as shown in FIGURE 5.

Human unsafe behaviors mainly include: (ground controllers or cabin crew) in violation of the provisions of operation error and dereliction of duty, prevention and reduction of human unsafe behavior is an important aspect of civil aviation incident prevention.

Organization management include the unit leadership attaches great importance to the human error, reasonable work event arrangement, whether provide a friendly working environment or not, etc.

Among them,

- State variables (Level): L_1: Emergencies' evolution Level; L_4: Human unsafe behavior level;

- Decision variables (Rate): R_1: L_1 accumulation; R_3: L_1 negative accumulation; R_6: L_4 accumulation ; R_7: L_4 negative accumulation;
- Auxiliary variables: A_1: Environmental damage; A_6: Negative physical influence; A_5: Negative mental influence; A_5: Individual quality ; A_5: Organization management.

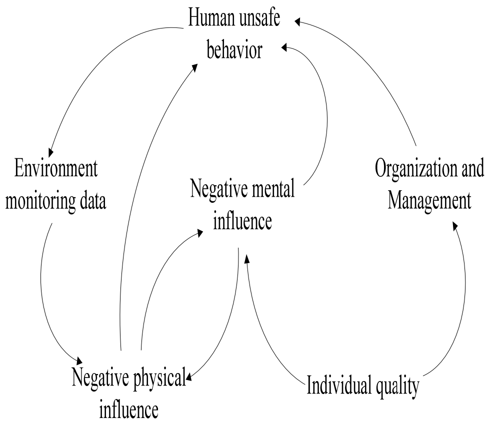

FIGURE V. CAUSAL FEEDBACK OF HUNMAN FACTOR SUB SYSTEM

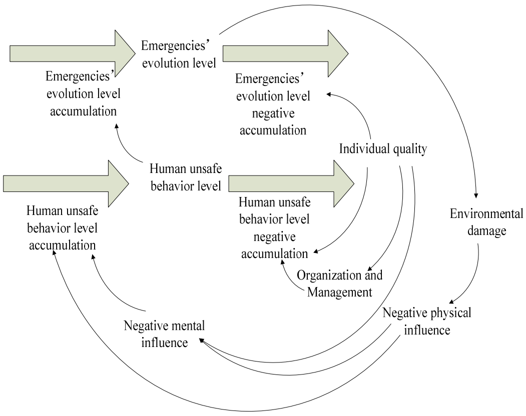

FIGURE VI. SYSTEM DYNAMIC FLOW CHART OF HUMAN FACTOR

D. *Emergency Parameter Analysis of Civil Aviation Emergencies*

The emergency factor mainly is a prevention of the aircraft crash consequences which reflected by the civil aviation administration, public security, and in the corresponding professional rescue departments as the main body. Emergency management level directly affects the civil aviation emergency evolution process, the implementation of search and rescue and the severity of the consequences. Emergency factors of causal feedback system diagram are shown as FIGURE 7:

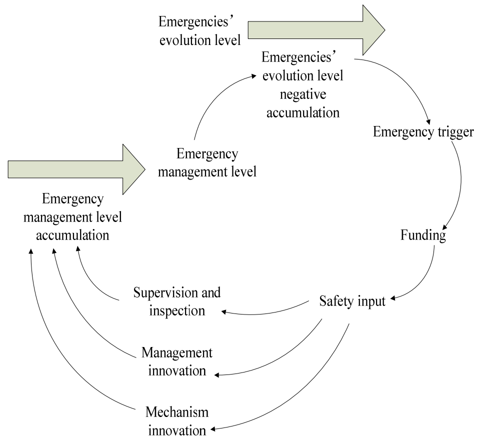

FIGURE VII. CAUSAL FEEDBACK OF EMERGENCY FACTOR SUB SYSTEM

E. *Key Parameters Analysis of Civil Aviation Emergency Evolution System*

According to the four parts analysis and the system dynamics graphs, we can get the whole system dynamics graph of civil aviation emergency evolution as following:

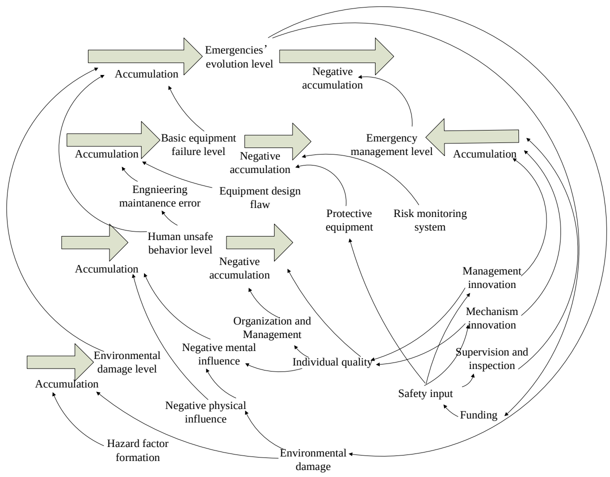

FIGURE VIII. SYSTEM DYNAMIC FLOW CHART OF CIVIL AVIATION EMERGENCY EVOLUTION

III. DISCUSSION

Base on the system dynamics of civil aviation emergency evolution, our next plan is to combine with the improved K2 Bayesian Network to build a complete aid decision making study plan.

ACKNOWLEDGMENT

Project support by Graduate Innovation Project.(Grant No.X2015-39)

Project support by Research on Organization and Coordination of Civil Aviation Search and Rescue (Grant No.TMSA1417)

REFERENCES

[1] Pan Weijun, Lu Guopan. Research on Organizational and Coordinated Mechanism of Civil Aircraft Search in China [J]. Journal of Civil Aviation Flight University of China,2016,05:9-10

[2] Wang Wenbo. Research of Search Technology for Civil Aircraft [D]. Civil Aviation Flight University of China.China.Sichuan.2015

[3] Xu Lei. Research on Emergent Events Decision Making Information Analysis Method based on Bayesian Network [D].Haerbin Industry University.2013

[4] Transmitting electric power system dynamics in SCADA using polynomial fitting [J]. Science in China (Series E: Technological Sciences),2009,04:937-943.

[5] Wu Yuzhe, CHAN E.H.W. Application of system dynamics for assessment of sustainable performance of construction projects[J]. Journal of Zhejiang University Science A(Science in Engineering),2005,04:90-100.

[6] Analysis and forecasts of investment scale and structure in upstream sector for oil companies based on system dynamics [J]. Petroleum Science, 2011,01:120-126.

[7] Liu Youjun, Jing Xiao.. Rational scale of urban rail transit network based on system dynamics[J]. Journal of Chongqing University (English Edition), 2011,01:26-34