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The Transport Environment Risk Evaluation Research of Missile Container based on Grey Clustering

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Abstract

Grey clustering is a kind of evaluation method that combines subjective evaluation with objective calculation. Using this method into the transport environment risk evaluation of missile container could effectively predict and control risks. The transport environment of missile container is regarded as the research object, all kinds of risks that affect missile container transport are analyzed. Establishing a risk evaluation system, through the analytic hierarchy process (AHP) to determine the weight of each evaluation index, formulating risk evaluation grade standard, grey clustering method is used to analyze the whitenization weight function and grey clustering coefficient of missile container transport environment risk indexes so as to determine the comprehensive risk level.

Key words

Grey clustering; weight; Whitenization weight function; environmental risks; evaluation

1. Introduction

With the unceasing change of international situation, the modern information war has become mainstream, the performance and power of the missiles determines the strength of a nation's military force. Along with the appearance of various missiles, the transport mode of missiles has been changed. And there appear many choices as well. Using the appropriate transport means not only meets all kinds of harsh conditions in the process of transport, but also could alleviate the expenses and burden of the army, which could get twice the result with half the effort.

Trucks are usually used for missile transport, which are slow and can't keep up with the rhythm of the warfare. At the same time, truck transport has poor missile protection, which could

not adapt to modern high-tech information warfare. While the emerging container transport of missiles has the advantages such as good safety performance, great transport speed, continuous transport, universal for all kinds of missiles, easy link between missiles and the containers, which is loved by soldiers so as to get rapid development.

There are many risk researches at home and abroad, but most of them are about projects, network, geological disasters and natural disasters. There is few risk researches about missile transport, especially the researches about missile container transport environment risk. The risk researches mainly focuses on matter element method, for example, Weiwei Sun evaluated the dam risk using matter element method; Shuguang Tian evaluated the station operational risk using matter element method; Zhihua Wang established the mathematical model of subway station safety risk using matter element method; Baoshan Jiang carried on the risk analysis of the cash flow of big, medium and small communication enterprise using matter element method.

In this paper, on the basis of the previous researches, the influencing factors of missile container transport environment are carried on the risk analysis. The main factors influencing missile container transport environment are determined, and the evaluation index system of missile container transport environment risk are established. The analytic hierarchy process (AHP) is used to determine the weight coefficient of each index. According to the collected data, the grey clustering of missile container transport environmental risk is classified.

2. The risk evaluation system of missile container transport environment

2.1 The risk analysis of missile container transport environment

There are many risk factors in the process of missile transport. It could be concluded that the design risks of missile itself, the process risks of producing missiles, missile transport environment risks, missile transport mode risks, national policy and regulation risks and etc.. The missile environment risks in the process of container transport are only discussed in this paper. Integrated a large number of reference and the interviews to the experts, the missile container transport environment risks are divided into four categories: mechanical environment factors, climate environment factors, chemical environment factors, and biological environment factors.

(1) Mechanical environment factors

From leaving the factory to being sent to the designated place, the missile transport process includes loading and unloading, carrying, storage, transport, and use. All these links are inseparable from machinery. Therefore, it is restricted by the mechanical environment.

(2) Climate environment factors

The missile container transport has high demand for the climate environment, which is affected a lot by climate environment. The north-south span is large in China, and the climate change obviously, in the process of long distance transport, climate environment factors must be considered. The sealing performance of containers is good, which is affected by temperature, container temperature, solar radiation, wind speed, and oxygen content, etc.

(3) Chemical environment factors

The missile container transport has high demand for the chemical environment as well. Chemicals are often easy to cause some damage to metal and organic materials, especially the precision instruments and equipment of missiles are easy to be corroded and damaged. At the same time, in the container transport process, dust could bring some influence to the missiles. These chemicals may come from industrial pollution, human factors, and corrosive gas. Therefore, chemical environment factors should be paid attention to in the container transport process.

(4) Biological environment factors

In the missile container transport process, there may be some creatures, such as microorganisms, termites, pests and rats and so on. There small creatures may have great influence to the electric and electronic products of the missiles, especially the microorganisms.

2.2 Construct the risk evaluation system of missile container transport environment

Under the premise of full analysis and recognition of missile container transport environment risk factors, combined with the expert opinion, the evaluation index system of missile container transport environment risks is finally determined. The details are shown in table 1.

Table 1 the risk evaluation index system of missile container transport environment

Target layer	Criteria layer (risk source)	Index layer
The risk evaluation index system of missile container transport environment	Mechanical environment factors	(1)Vibration; (2)Impact; (3)Static electricity;
	Climate environment factors	(1)Temperature; (2)Humidity;

		(3) solar radiation (4)wind speed;
	Chemical environment factors	(1)Salt fog; (2)Corrosive gas.
	Biological environment factors	(1)mold; (2)Termites;

3. Establish the risk evaluation model of grey clustering missile container transport environment

3.1 Determine the weight coefficient of each level evaluation index

In the gray clustering evaluation model of missile container transport environment risks, the analytic hierarchy process (AHP) is used to determine the weight of evaluation indexes at all levels. First of all, construct the hierarchy structure: criteria layer factors set $X=(X_1,X_2,X_3,X_4)$, index evaluation set $X_i=(X_{i1},X_{i2},\cdots)$, then construct the multiple comparison matrix of each risk factor, using program MATLAB to calculate the weight of each evaluation index, and making sure that it could pass the consistency check.

Table 2 the evaluation index weight of missile container transport environment risks

Indexes	X_1	X_2	X_3	X_4	weight W_i
	0.445	0.333	0.238	0.084	
X_{11}	0.41				0.182
X_{12}	0.38				0.169
X_{13}	0.21				0.093
X_{21}		0.36			0.120
X_{22}		0.31			0.103
X_{23}		0.21			0.070
X_{24}		0.12			0.040
X_{31}			0.46		0.109
X_{32}			0.54		0.129
X_{41}				0.62	0.052
X_{42}				0.38	0.032

3.2 Determine the gray clustering

According to the risk degree of missile container transport environment, whether or not to take necessary measures and the experts' opinions, the missile container transport environment risk could be divided into four levels, that is, level Ⅰ level Ⅱ level Ⅲ and level Ⅳ. There are 4 corresponding evaluation grey clustering, that is, the grey clustering $k=1,2,3,4$. The corresponding level description of missile container transportation environment risks is shown in table 3.

Table 3 The risk level classification standards of missile container transport environment safety

Risk level	Classification standards
level Ⅰ	The transport environment risk can be accepted. The current countermeasures are effective. No more other measures are needed.
level Ⅱ	The transport environment risk can be accepted conditionally. The current countermeasures are mostly effective. But further more measures are needed in order to ensure the transport safety.
Level Ⅲ	The transport environment risk can be accepted conditionally. The current countermeasures are bad. The prevention measures must be taken and the corresponding emergency plans should be prepared.
Level Ⅳ	The transport environment risk cannot be accepted. The current countermeasures are very bad. The necessary measures must be taken to decrease the risk into level Ⅲ or under it. Or change the missile transport scheme directly.

According to the missile transport risk guidelines and the missile transport technology indexes, combined with the demand of container transport environment, consulting the relevant experts, referring to the related literature, using Delphi method, the grey number of 4 grey clustering of missile container transport environment risk evaluation clustering indexes are obtained. The details are shown in table 4.

Table 4 The grey number of 4 grey clustering of missile container transport environment risk evaluation clustering indexes

Indexes	Weight	Level □	Level II	Level III	Level IV
X_{11}	0.182	$10 \le X_{11} < 15$	$15 \le X_{11} < 20$	$20 \le X_{11} < 25$	$25 \le X_{11} < 30$
X_{12}	0.169	$24 \le X_{12} < 30$	$30 \le X_{12} < 35$	$35 \le X_{12} < 41$	$41 \le X_{12} < 50$
X_{13}	0.093	$3 \le X_{13} < 8$	$8 \le X_{13} < 12$	$12 \le X_{13} < 18$	$18 \le X_{13} < 22$
X_{21}	0.120	$12 \le X_{21} < 20$	$20 \le X_{21} < 26$	$26 \le X_{21} < 31$	$31 \le X_{21} < 36$
X_{22}	0.103	$10 \le X_{22} < 16$	$16 \le X_{22} < 22$	$22 \le X_{22} < 27$	$27 \le X_{22} < 33$
X_{23}	0.070	$4 \le X_{23} < 10$	$10 \le X_{23} < 14$	$14 \le X_{23} < 20$	$20 \le X_{23} < 25$
X_{24}	0.040	$11 \le X_{24} < 17$	$17 \le X_{24} < 22$	$22 \le X_{24} < 25$	$25 \le X_{24} < 30$
X_{31}	0.109	$8 \le X_{31} < 12$	$12 \le X_{31} < 16$	$16 \le X_{31} < 24$	$24 \le X_{31} < 32$
X_{32}	0.129	$40 \le X_{32} < 50$	$50 \le X_{32} < 60$	$60 \le X_{32} < 70$	$70 \le X_{32} < 80$
X_{41}	0.052	$6 \le X_{41} < 12$	$12 \le X_{41} < 17$	$17 \le X_{41} < 24$	$24 \le X_{41} < 30$
X_{42}	0.032	$0 \le X_{42} < 7$	$7 \le X_{42} < 15$	$15 \le X_{42} < 22$	$22 \le X_{42} < 28$

3.3 Establish the Whitenization weight function of missile container transport environment risk evaluation model, and calculate the function value

Grey clustering method is on the basis of analyzing different clustering objects, calculating the whitenization weight function of different index object, and then integrating all the index weights to calculate grey clustering number so as to carry on the inductive research to all the indexes according to the different grey number. Which type the grey clustering of clustering objects belongs to has great relation with the impact these calculated indexes to the clustering objects. The clustering objects in this paper are the 4 risk sources of missile container transport environment, and its clustering indexes are the corresponding evaluation index of missile container transport environment risk of these 4 risk sources. Here we choose the grey evaluation method based on the endpoint triangular whitenization weight function.

Let

$$f_i^k(x_i)=\begin{cases} 0, & x_i \notin [a_{k-1}, a_{k+2}] \\ \dfrac{x_i - a_{k-1}}{\lambda_k - a_{k-1}}, & x_i \in [a_{k-1}, \lambda_k] \\ \dfrac{a_{k+2} - x_i}{a_{k+2} - \lambda_k}, & x_i \in [\lambda_k, a_{k+2}] \end{cases} \tag{1}$$

And x_i is the scoring value of index i, k indicates its evaluation grey clustering.

Substitute the expert evaluation value of missile container transport risk evaluation indexes x_i into the formula (1), the triangular weight function of 4 grey clustering of each risk evaluation index $f_i^k(x_i)$ could be got,and $\lambda_k = \dfrac{a_k + a_{k+1}}{2}$, $a_0 = a_1 - 5$, $a_6 = a_5 + 5$.

3.4 Calculate the Whitenization weight clustering coefficient and clustering vector of missile container transport environment risk evaluation model

Call the formula

$$\sigma_i^k = \sum_{i=1}^{m} f_i^k(x_i) W_i \tag{2}$$

The grey variable weight comprehensive clustering coefficient of k grey clustering, and x_i is the evaluation value of missile container transport environment risk evaluation indexes, $f_i^k(x_i)$ is the whitenization weight function of k subclass of index i, W_i is the weight of index i among the comprehensive clustering.

Using the formula (2), software MATLAB is used to calculate the comprehensive clustering coefficient of each grey clustering. And get the clustering coefficient set $(\sigma_i^1,\sigma_i^2,\sigma_i^3,\sigma_i^4)$ of clustering objects, according to the maximum membership principle to judge the clustering level of clustering objects.

4. The simulation calculation of missile container transport environment risk evaluation model

According to the grey number of four greys clustering of missile container transport risk evaluation clustering index above, combined with the marks that the 5 experts give to the 11 indexes of evaluation model, the grey clustering marking table of certain missile container transport environment risk evaluation could be obtained. The specific are shown in table 5.

Table 5 The grey clustering marking table of missile container transport environment risk evaluation

Indexes	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average mark X_{ij}
X_{11}	20	18	19	21	26	21
X_{12}	56	52	46	54	48	51
X_{13}	8	10	4	9	12	9
X_{21}	30	12	16	21	24	21
X_{22}	18	20	14	17	12	16
X_{23}	13	14	11	18	15	14
X_{24}	28	26	25	24	31	27
X_{31}	16	26	18	19	28	21
X_{32}	72	68	48	64	44	59
X_{41}	21	18	15	23	16	19
X_{42}	14	18	8	12	22	15

Substitute the experts' average mark X_{ij} in table 5 into formula (1), and we could get the 4 corresponding grey clustering whitenization weight function value of 11 evaluation indexes, and then get the whitenization weight function value of missile container transport environment risk index. The specific are shown in table 6.

Table 6 The whitenization weight function value table of missile container transport environment risk indexes

Indexes	Average mark X_{ij}	$f_i^1(x_{ij})$	$f_i^2(x_{ij})$	$f_i^3(x_{ij})$	$f_i^4(x_{ij})$
X_{11}	21	0.0000	0.5333	0.8000	0.1333
X_{12}	51	0.0000	0.0000	0.0000	0.4211
X_{13}	9	0.4615	0.8517	0.1429	0.0000
X_{21}	21	0.5000	0.8182	0.1176	0.0000
X_{22}	16	0.6667	0.6667	0.0000	0.0000
X_{23}	14	0.0000	0.7500	0.5714	0.0000
X_{24}	27	0.0000	0.0000	0.4615	0.9090
X_{31}	21	0.0000	0.3000	0.9167	0.4167
X_{32}	59	0.0667	0.7333	0.6000	0.0000
X_{41}	19	0.0000	0.5236	0.8235	0.2000
X_{42}	15	0.0000	0.6364	0.6957	0.0000

According the formula (2), using software MATLAB, the comprehensive clustering coefficient σ_i^k of 4 greys clustering of missile container transport project could be calculated. The specific details are shown in table 7.

Table 7 The comprehensive clustering coefficient of missile container transport project

Grey clustering	Clustering index				Total
	X_1	X_2	X_3	X_4	
Level Ⅰ	0.0431	0.1769	0.1593	0.0955	0.4749
Level Ⅱ	0.1288	0.2194	0.0725	0.0363	0.4569

Level Ⅲ	0.0086	0.1271	0.1775	0.0456	0.3588
Level Ⅳ	0.0000	0.0476	0.0651	0.0104	0.1231

5. Results and discussion

From table 7 we could get that $\sigma^1 = 0.4749$, $\sigma^2 = 0.4569$, $\sigma^3 = 0.3588$, $\sigma^4 = 0.1231$,the possibility size of the 4 grey clustering of missile container transport project is $\sigma^1 > \sigma^2 > \sigma^3 > \sigma^4$,according to the maximum membership degree principle, we could get that the overall risk evaluation level of this project is level Ⅰ.

6. Conclusion

The missile container transport environment risk evaluation is studied in this paper. On the premise of fully considering various factors, the 4 first-level indexes and 11 second-level indexes are chosen. And the grey clustering model is established. Compared with the traditional method, this method is more reasonable and makes the evaluation closer to the real value. It is of practical significance to use the gray clustering evaluation method to analyze missile container transport environment risk. And the calculated results could objectively reflect the actual situation of missile container transport.

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