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A Study on Modeling and Simulation Engineering of Emergency Resources Supply Based on System Dynamics

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Abstract

Emergency resources supply includes emergency resources reserves and emergency resources mobilization. This study utilizes system dynamics to model emergency resources supply and simulate to give engineering presentation. Simulation results show that emergency resources supply is decided by the need, the aim of employing quantity and mobilizing quantity is to bridge employing error and mobilizing error. The results also show oversupply of emergency resources, namely excessive employing and excessive mobilization, is decided by transportation and demand error which is caused by arrival supply quantity.

Key words: system dynamics; emergency resources; modeling; simulation engineering;

Emergency resources are the material basis of emergency management, which is the support and key factor to ensure effective emergency management. Recently, the status of emergency resources is being fully addressed, yet some problems that restrain effectiveness of emergency resources supply (ERS) cannot be solved properly, such as what decides supply quantity and oversupply of emergency resources. This study aims to illustrate modes and factors of ERS through modeling and simulation by system dynamics.

1. Characters of Emergency Resources

In a broad sense, emergency recourses refer to all kinds of resources that are needed in emergency management; in a narrow sense, it means various material guarantees in disaster management.

Whether in a broad sense or narrow sense, emergency resources are characterized by the following features: large demand fluctuation, short demanding period, and hard to forecast demand kinds.

Once occurs emergency, emergency resources demand will grow to an unprecedented scale. Many resources of little market needs in peacetime, such as tent, will be in great demand in rescue process.

Emergency response is pressing and time limited. For example, the best time to save survivors is within 72 hours after earthquake. Hence, in the special 72 hours, emergency resources demands upsurge and requires timely supply. Except life-saving emergency resources, other resource demands also surge right after disaster happens.

Emergency usually happens unpredictably. It's hard to predict the time, place, intensity and damage degree of emergencies. Therefore, to predict corresponding emergency resources demand is also difficult.

2. Modes of Emergency Resources Supply

Base on the three characters of emergency resources, there are usually two supply modes that meet their demands. One is employing emergency resources reserves(EERR), that is, the government reserves some core resources in advance to prepare for emergency. The other is emergency resources mobilization(ERM), that is, the government makes use of emergency resources production and

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distribution capacity which is reserved in peacetime to increase output of emergency resources and meet the resource demands in emergency moment.

Both EERR and ERM are comprehensive system engineering, not only involve a lot of complex factors, but also have high-order, non-linear and time varying characteristics. Therefore, In order to clarify the supply modes of emergency resources, this study utilizes system dynamics and Vensim DSS 5.6a system simulation platform to analyze the factors of emergency resources supply and build some simulation models.

3. Modeling and Simulation

Assuming there is no information delay, that is to say when the emergency resources demandsarise, resource providers can immediately get access to all the information, without the needto spend time in analyzing the demand.

3.1 Modeling and Simulation of EERR

This study sets stock quantity, employing quantity in transit and arrival employing quantity as level variable, employing quantity and transportation efficiency as rate variable, employing error as auxiliary variable, demand error, arrival mobilizing quantity, employing efficiency and transportation time as constant.

(1)Flow graph

EERR flow graph is Figure 1 .The meanings of variables are shown in table 1.

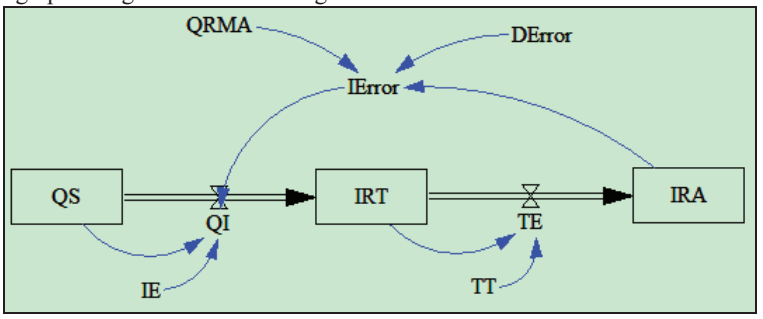

Figure 1 EERR flow graph

Table 1 Meanings of variables in EERR

Variable	Meaning	Variable	Meaning	Variable	Meaning
QS	stock quantity	IRT	employing quantity in transit	DError	demand error
QI	employing quantity	IE	employing efficiency	TT	transportation time
IError	employing error	QRMA	arrival mobilizing quantity	TE	transportation efficiency
IRA	arrival employing quantity				

(2) Systemdynamic equations

Systemdynamic equations of EERR are shown in table 2.

Table 2 Systemdynamic equations of EERR

Equation	Meaning
L:IRT.K=IRT.J+(QI.JK-TE.JK)×DT	IRT is equal to the integral of QI minus TE in a certain period of time.
L: IRA.K=IRA.J+TE.JK×DT	IRA is equal to the integral of TE in a certain period of time.
R: QI=min(IError, QS×IE)	QI is equal to the smaller of IError and QS×IE. Whenthe formeris greater thanthe latter, IError cannot besatisfied, QI is equal toQS×IE. When the latter is greater than the former, IError canbe satisfied, QI is equal to IError.
R:TE=IRT/TT	TE is equal to IRT divides TT to express material delay.
A: IError.K=DError-QRMA-IRA.K	IError at a time is equal to DError minus QRMA and IRA at a time.