Research on the Application of Optimization Allocation Methods of Equipment Support Personnel

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***Abstract*—Combined with the status of personnel entering, training, and exiting, the state transfer method is analyzed, and the state transfer probability matrix is constructed, and the dynamic model of the support personnel is constructed. Dy defining the safeguard efficiency of different levels of support personnel for different tasks, the optimal configuration model is constructed according to the task of maximum efficiency of support personnel. The example shows the application value of optimization allocation methods of equipment support personnel**

***Index Terms*—robability matrix, dynamic model, support personnel, optimization allocation methods**

I. INTRODUCTION

At present, there are mainly assigned models for the optimization of personnel configuration models and methods [1], target planning model [2], entity relationship model [3]. And borrow the marginal theory in economics [4], no difference curve [5], and so on. However, there is often a dynamic change in the staffing situation. For example, Jing haiying and Yang zhaoyu established a dynamic model based on control theory. Based on the characteristics of equipment support personnel level, this paper considers the dynamic transfer of personnel, and uses the linear programming model to assign the support personnel according to tasks, so as to make the guarantee task comprehensive support efficiency highest, so as to realize the optimal allocation of the support personnel.

II. SECURITY PERSONNEL DYNAMIC DESCRIPTION

Equipment support personnel are mainly divided into three categories: equipment operators, equipment maintenance personnel, and equipment management personnel. After equipment operators or equipment maintenance personnel obtain certain qualifications through training, they can be transferred to the next category. According to the needs of the task, they can directly make adjustments between various types of personnel.

If it is assumed that the various states in which the guarantor is at a certain point in time T form a system $\mathbf{S}$, the state of the guarantor in the system is divided into the following two types: First, the training state l_i (i=1,2,3 indicates that the guarantor is in training); The second is normal k_i (i=1,2,3 indicates that the security personnel are in three categories, respectively). Among them, the training state l_3 for the personnel to reach the equipment management personnel training, in practice has no meaning, so can be abandoned. Thus, at a certain point *t* the system can be represented as a set of state spaces, $\mathbf{S}=[l_1,l_2]\cup[k_1,k_2,k_3]=[l_1,l_2,k_1,k_2,k_3]$.

The system $\mathbf{S}$ is defined as a personnel system. Assuming that the dynamic transfer of personnel in the system has random and no latency, that is, obeying the non-homogeneous Markov process, the random transfer probability of personnel at time t obeys the probability matrix $\mathbf{P}_S(t)$.

$$\mathbf{P}_S(t)=\begin{array}{c} \\ l_1 \\ l_2 \\ k_1 \\ k_2 \\ k_3 \end{array}\begin{array}{ccccc} l_1 & l_2 & k_1 & k_2 & k_3 \\ \end{array}$$

$$\mathbf{P}_S(t)=\begin{array}{c|cc:ccc} & l_1 & l_2 & k_1 & k_2 & k_3 \\ \hline l_1 & P_{l_1l_1}(t) & 0 & 0 & P_{l_1k_2}(t) & 0 \\ l_2 & 0 & P_{l_2l_2}(t) & 0 & 0 & P_{l_2k_3}(t) \\ \hdashline k_1 & P_{k_1l_1}(t) & 0 & P_{k_1k_1}(t) & P_{k_1k_2}(t) & P_{k_1k_3}(t) \\ k_2 & 0 & P_{k_2l_2}(t) & P_{k_2k_1}(t) & P_{k_2k_2}(t) & P_{k_2k_3}(t) \\ k_3 & 0 & 0 & P_{k_3k_1}(t) & P_{k_3k_2}(t) & P_{k_3k_3}(t) \end{array}$$

$P_{ij}(t)$ represents the proportion of people transferred from state *i* to state *j* to those who were originally in state *i*, that is, the probability that state *i* is transferred to state *j*.

The analysis matrix $\mathbf{P}_S(t)$ shows that the state transition process can be described as four situations:

(1) A certain category of personnel meets the training conditions to enter the training state (the lower left of the matrix $\mathbf{P}_S(t)$);

(2) After the training, the assessment does not pass the continuation of the training state (the upper left of the matrix $\mathbf{P}_S(t)$);

(3) The training is completed, that is, entering the next normal state (the upper right of the Matrix $\mathbf{P}_S(t)$);

(4) Direct adjustment between normal States (the lower right of the matrix $\mathbf{P}_S(t)$).

III. EXAMPLE ANALYSIS

The personnel status of a unit in 2017 is shown in Table 1. Table 2 shows the value of the guaranteed manpower requirements for the tasks of the 2018 plan. If the unit’s equipment operators and equipment maintenance personnel conduct training at a probability of 8% and 6% per year, no category conversion will be carried out in the year after the training; Each of the three categories of security personnel has 90% of personnel without category adjustment, and equipment operators and equipment maintenance personnel have a 5% and 2% probability of being transferred to the next category, and there is no cross-category (k1→k3) and descending category (k2→k1, k3→k1, k3→k2) adjustment. The percentage of security personnel who have to undergo pre-service training to enter the system is 75%, 20% and 5%. At the end of 2017, the exit probability of equipment operators, equipment maintenance personnel and equipment management personnel was 5%, 3%, and 2%, respectively. People in training status do not exit the system. Through the method of ensuring the dynamic control of personnel, the optimal configuration of personnel in 2018 is solved.

TABLE 1. STATISTICS ON THE STRENGTH OF A CERTAIN UNIT IN 2017

Type	Training l1	Training l2	Equipment operator k1	Equipment maintenance staff k2	Equipment manager k3
Number	5	2	101	71	10

TABLE 2. MANDATE MANPOWER REQUIREMENTS FOR 2018

Type	Duty	Programme-Controlled Switching	Fiber Transmission	Satellite communications	Fault Detection
Manpower	25	30	11	19	35

Solution: The following two steps to solve this problem are dynamic adjustment and staffing.

(1) Dynamic adjustment

The order means 2017 and 2018. From the question,

$$P_{k_0S}\left(t-1\right)=0$$

$$\mathbf{N}_A\left(t-1\right)=\left[5,2,101,71,10\right],$$

$$\mathbf{P}_{l_0K}\left(t\right)=\left[0,0,0.75,0.20,0.05\right],$$

$$\mathbf{P}_{Sk_4}\left(t\right)=\left[0,0,0.05,0.03,0.02\right].$$

$$\mathbf{P}_S(t)=\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0.08 & 0 & 0.9 & 0.05 & 0 \\ 0 & 0.06 & 0 & 0.9 & 0.02 \\ 0 & 0 & 0 & 0 & 0.9 \end{bmatrix}$$

Substituting the above data,

$$\mathbf{N}_A(t)=\left[5,2,101,71,10\right]\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0.08 & 0 & 0.9+0.0375p & 0.05+0.01p & 0.0025p \\ 0 & 0.06 & 0.0225p & 0.9+0.006p & 0.02+0.0015p \\ 0 & 0 & 0.015p & 0.004p & 0.9+0.001p \end{bmatrix}$$
$$=\left[13.08,6.26,90.9+9.2p,68.95+1.47p,10.42+0.369p\right]$$

In the formula, $p=P_{l_0S}\left(t-1\right)$.

It can be seen that the number of dynamically adjusted equipment operators, equipment maintenance personnel and equipment management personnel in 2018 is 90.9, 68.95 and 10.42, respectively, given the training rate, the probability of class adjustment, and the personnel withdrawal rate. Changes from the number in 2017 (101, 71 and 10) are largely in line with the actual situation.

The probability of personnel entering the system is a variable that is not currently given. If all types of personnel change and cannot meet the requirements of the task, the unit can control the variable to staffing.

(2) Staffing

For example, the ability factor for equipment maintenance personnel to complete duty tasks is standardized with 0.844, and the matching value for duty tasks is standardized with 0.790, and the value for the first column is filled with 0.844 × 0.790 = 0.667.

Since the personnel in the training state does not participate in the guarantee task, only the number of security personnel in the three categories is considered. Based on the formula, the guarantee staffing model can be expressed as

$$\max Z=\sum_{i=1}^{3}\sum_{j=0}^{6}N_{k_i j}\left(t\right)\eta_{k_i j}$$

The constraint is

$$\begin{cases} N_{k_1 0}(t)+N_{k_1 1}(t)+N_{k_1 2}(t)+N_{k_1 3}(t)+N_{k_1 4}(t)+N_{k_1 5}(t)+N_{k_1 6}(t)\le 90.9+9.2p \\ N_{k_2 0}(t)+N_{k_2 1}(t)+N_{k_2 2}(t)+N_{k_2 3}(t)+N_{k_2 4}(t)+N_{k_2 5}(t)+N_{k_2 6}(t)\le 68.95+1.47p \\ N_{k_3 0}(t)+N_{k_3 1}(t)+N_{k_3 2}(t)+N_{k_3 3}(t)+N_{k_3 4}(t)+N_{k_3 5}(t)+N_{k_3 6}(t)\le 10.42+0.369p \\ N_{k_1 0}(t)+0.667N_{k_2 0}(t)+0.234N_{k_3 0}(t)\ge 25 \\ 0.231N_{k_1 1}(t)+0.875N_{k_2 1}(t)+0.890N_{k_3 1}(t)\ge 30 \\ 0.263N_{k_1 2}(t)+0.892N_{k_2 2}(t)+0.767N_{k_3 2}(t)\ge 11 \\ 0N_{k_1 3}(t)+0.950N_{k_2 3}(t)+0.878N_{k_3 3}(t)\ge 19 \\ 0.226N_{k_1 4}(t)+0.892N_{k_2 4}(t)+0.738N_{k_3 4}(t)\ge 12 \\ 0.691N_{k_1 5}(t)+N_{k_2 5}(t)+0.984N_{k_3 5}(t)\ge 35 \\ 0.984N_{k_1 6}(t)+0.625N_{k_2 6}(t)+0.370N_{k_3 6}(t)\ge 40 \\ j=0,1,2...n;i=1,2,3 \end{cases}$$

This paper solves the problem through MATLAB software programming. When calculating, the shilling P = 0, that is, assuming that no one enters the system, there is no feasible solution at this time. Adjust P. When P gets about 0.5, the optimal solution can be:

$N_{k_i j}\left(t\right)$ = [38.3176, 0, 0, 0, 26.6946, 30.4878, 0, 17.1429, 12.3318, 10.2034, 13.4529, 16.5540, 0, 0, 0, 0, 10.6, 0, 0], the number of security personnel needs to be rounded up, as shown in Table 3.

TABLE 3. GUARANTEED STAFFING PROGRAMME

Task Type	Duty	Programme-Controlled Switching	Fiber Transmission	Satellite communications	Fault Detection
Operators	39	0	0	0	27
Maintenance	0	18	13	11	17
Manager	0	0	0	11	0

Among them, because the number of people is rounded upwards, the number of people that need to be supplemented is more than the theoretical calculation value. That is, in 2018, when equipment operators supplement $39 + 27 + 31 - 91 = 6$ (people), equipment maintenance personnel supplement $18 + 13 + 11 + 14 + 17 - 69 = 4$, the required tasks can be accomplished with maximum efficiency.

It should be noted that this example only dynamically adjusted and configured the proportion of personnel entering the system through training. The method of personnel adjustment and configuration also includes controlling the exit probability of personnel, adjusting the internal personnel transfer ratio of the system, etc. The adjustment method is similar to this example, and this article will no longer discuss it.

IV. CONCLUSION

In this paper, by defining the safeguard efficiency of different levels of security personnel for different tasks, the optimal configuration model is constructed according to the task of maximum efficiency of security personnel. The next step needs to continue to study the probability of personnel flow within the system, and on this basis, optimize the configuration.

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