The System of Demand Analysis for URAV Based on Offense and Defense

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Abstract

Because of its advantage of zero casualties Unmanned Reconnaissance Aerial Vehicle (URAV) plays an important role in battlefield monitoring and information acquiring, thus caught great attention of the world. URAV is developed fast in our country, yet no scientific assessment methods was ever given due to different fight needs of armed forces. Considering demand of the missile artillery about the martial information, the model of information requirement of combat force, reconnaissance ability of URAV, survivability of URAV, and task reliability of URAV were constructed respectively. Synthesizing mathematic models above, the model of developing demand was constructed about URAV equipment. It simulated and calculated some URAV equipment developing scales, and explores a way of settling the problem of URAV equipment developing demand.

Keywords: *URAV; demand; survivability; reliability*

1. Introduction

At the present time, URAV is developed greatly in our country, but because all services and arms are different in combat requirement, there is no scientific way to evaluate the developing scope of URAV and troops. This paper aims at the Second Artillery combat requirement, and tries to find a new way to solve four urgent problems in URAV developing.

(1) How to improve the URAV operational efficiency?

(2) How to improve the URAV survivability?

(3) How to improve the URAV task reliability?

(4) How to rationally define the URAV developing scope?

2. Headings and Footnotes Construct the model of developing scale of URAV

The model of developing scale is as follows:

(1) Information of the missile artillery in wartime and reconnaissance ability of URAV is quantified. The paper has realized the unification of the quantification by building connections between target numbers and reconnaissance ability of UAV, with the result of laying the foundations for analyzing and calculating the number of UAV.

(2) The model of reconnaissance ability of URAV is constructed. The paper points out some methods to improve URAV's penetration ability by supplementing and innovating analytical methods of military airplane survival ability.

(3) The model of reconnaissance ability of URAV is constructed

Synthesize mathematic models above, the model of developing scale of URAV is constructed. Figure 1 shows a structure diagram of the model of developing scale of URAV.

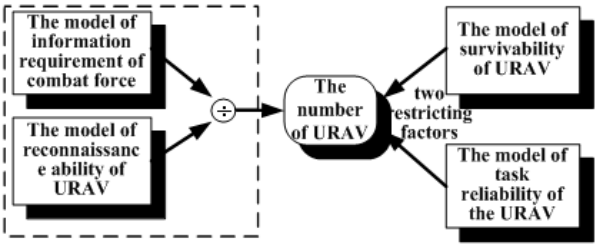

Figure 1 structure diagram of the model of developing scale of URAV

We get the number of URAV needed of one campaign unit in one campaign day:

$$N = \frac{M}{M' \times P_{S/E} \times P_R} \quad (1)$$

"M" is the number of targets which could be attacked by a campaign unit in a day, "M'" is the number of targets that the URAV can scout, "$P_{S/E}$" is the survival probability of

URAV, and " P_R " is the task reliability probability of URAV.

Because of its destruction when breaking through the enemy defense and the reliability of URAV system, new supply is needed every day. Based on the tasks of the Second Artillery Force in the battle, the missile attack time is estimated "T", and campaign units is supposed "K", so the loss of the URAV during one battle is:

$$K \times T \times (2 - P_{S/E} - P_R)$$

The number of the URAV needed is:

$$N' = K \times N + K \times T \times (2 - P_{S/E} - P_R) \qquad (2)$$

3. The model of method and blue print about subsystem

3.1 Construct the model of information requirement of combat force

The core of the model is quantifying information requirement for the missile artillery in wartime. The missile artillery needs information about the characteristic of targets and effects of striking in wartime. How to quantify and calculate the information in mathematical model? The paper connects the information with targets and quantifies them to target numbers in wartime. Thus, it could complete the quantifying calculation of model.

The model of information requirement is as follows:

(1) Take a fighting unit as a template, analyze the average number of the missiles can be launched in a day and the number of the missiles which can break the defense and attack targets , then let the number be "m".

(2) Analyze the type of targets and the number of missiles to destroy every type of targets. Define the number of type of targets to be "i", and the number of missiles to destroy the target " n_i ".

(3) Analyze the method of attack .As the launch of missile has two modes: salvo and dartling, the difference of attacked effects and penetration and the number of missiles to expend is analyzed .Correct the necessary number of missiles to destroy the target and define it as " n_i' ".

As is analyzed above, information demand of the missile artillery in wartime can be quantified by the number of targets which could be attacked by a campaign unit in a day .For the convenience, suppose every campaign unit can attack one kind of target in a day:

$$M = \frac{m}{n'_i} \qquad (3)$$

3.2 Construct the model of reconnaissance ability of URAV

The core of the model is quantifying reconnaissance ability of URAV. In this paper, according to the characteristics of URAV of the missile artillery, the reconnaissance ability of URAV is quantified by the number of targets which can be scouted in a day.

The model is as follows:

(1) Define the number of targets which can be scouted on the condition of a safe out and home course to be "l".

(2) Reckon the number of sorties which each flight could take in a day.

It is the mid-altitude long-range of URAV that is discussed in the paper .To reckon the number of targets which can be scouted in each sortie, time of an out and home course (" t_1 ") , time spent on scouting after arrive at the termini (" t_2 "), the prepare time from the launch position(" t_3 "), time spent on withdrawing the equipment from launch position(" t_4 "), time of next launch after normally callback (" t_5 ") , and time of time-lapsed maintaining (" t_6 ")——the average time for each flight, are required.

Then the sorties receivable in a day is:

$$n = \frac{t}{t_1 + t_2 + t_3 + t_4 + t_5 + t_6}$$

In this formula, " n" refers to the sorties per day, and " t" means the overall time in a day.

Since URAV needs to scout the target in advance and evaluate the effects of attack, there have to be at least two flights to make sure that the mission can be fulfilled. So the number of targets that the URAV can scout should be:

$$M' = \frac{l \times n}{2} \qquad (4)$$

So the paper has realized the unification of the quantification by building connections between target numbers and reconnaissance ability of URAV, with the

result of laying the foundations for analyzing and calculating the number of URAV.

In order to get the information about the number of targets that troops attack in a day, the number of URAV required to fly to the targets can be known due to formula (3) and (4):

$$N = \frac{M}{M'} \qquad (5)$$

3.3 Construct the model of survivability of URAV

3.3.1 Define scheme of model

URAV and manned planes are similar in appearance and threats they may face in a battle. In the paper, the model survival ability of URAV is constructed by using the approaches of analyzing the survival ability of military airplane and also making some necessary complements according to the characteristics of the URAV. Figure 2 shows a structure diagram of the model of survivability of URAV.

" P_K " is the destroying probability of URAV. It is made up of allergy (P_H) and vulnerability ($P_{K/H}$). P_H multiplied by $P_{K/H}$ is P_K :

$$P_K = P_H \cdot P_{K/H} = P_d \cdot P_{H/d} \cdot P_{K/H}$$

" P_d " is the probability of detecting a URAV by radar; $P_{H/d}$ is the hitting probability?

The survival probability of URAV is showed :

$$P_{S/E} = 1 - P_K$$

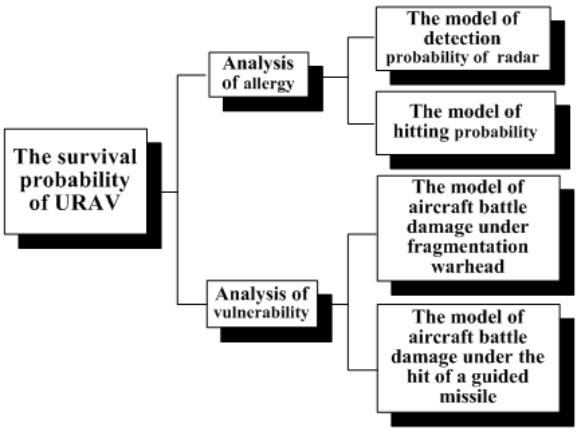

Figure 2 structure diagram of the model of survivability of URAV

3.3.2 Algorithm of the survival probability of URAV

Calculating steps about the survival probability of URAV against air defense firepower are:

(1) According to URAV and early warning radar's technical parameter, the utmost distance of detecting a URAV by radar is calculated;

(2) According to flight speed of URAV, the time that URAV spend on fling over enemy territory of air defense is calculated;

(3) According to the performance of enemy anti-aircraft weapons, the strength of enemy air defense firepower is evaluated;

(4) The $P_{H/d}$ and $P_{K/H}$ is calculated about different anti-aircraft weapons;

(5) The survival probability of URAV is calculated by the formula of $P_{S/E} = 1 - P_K$.

3.3.3 Simulative calculation and analysis

(1)When RCS is reduced, detecting distance will be reduced obviously. It is showed on table 1;

Table 1 H=5000m, different RCS corresponding radar's detecting distance

RCS (m^2)	1.0	0.5	0.1	0.01
detecting distance (km)	202	103	56	34

(2)RCS=1m^2,When the URAV flights on the different high, radar's detecting distance is showed on table 2.

Table 2 RCS=1m2, radar's detecting distance on the different high

H(m)	5000	1000	500	100
detecting distance (km)	200	144	87	75

According to setting URAV and early warning radar's technical parameter, the survival probability of URAV is simulated. The result is showed on Figure 3.

To advance penetration capability about URAV, Some conclusion can be acquired by analysis and calculation. It is as follows:

(1) It is important for RCS to influence detection probability of radar. If RCS is reduced effectively , detection probability of radar can be reduced. The way above markedly advances survivability of URAV, but it cost much.

(2) The mobile low altitude flight can advance survivability of URAV. When URAV flight on flat landform, some way are adopted, such as low altitude flight, continual changing flight path and pose. Clutter noise can keep out detecting by radar on the land or sea. When URAV flight on a mountainous area, the mobile flight is adopted to control URAV's attitude and pose by hand.

(3) To advance survivability of URAV, some measure such as reducing the area of vulnerable parts and standby important parts can be done, which will make weight of UAV increased, so it is given an overall consideration.

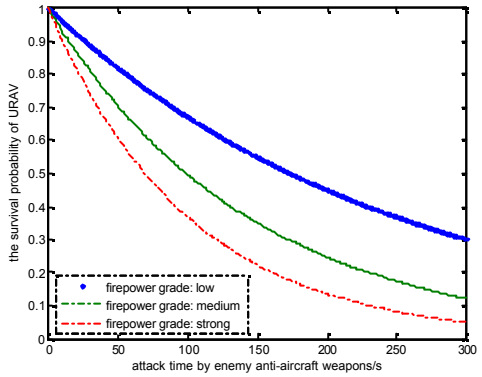

Figure 3 the survival probability of URAV

3.4 Construct the model of task reliability of URAV

3.4.1 The traditional reliable model of system

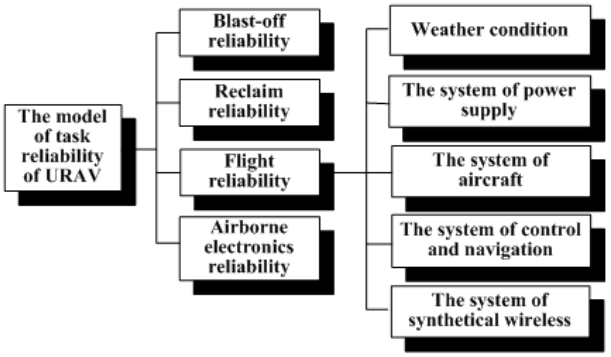

Figure 4 structure diagram of the model of task reliability of URAV.

When the URAV performs tasks, the course from blast-off to reclaim is evaluated. Capacity that URAV finishes task is analyzed, and it calculates reliability probability. Reliability of the system of URAV is divided into four subsystems: blast-off system, reclaim system, flight system, airborne electronics system. Figure 4 shows a structure diagram of the model of task reliability of URAV.

By analysis above, Four subsystems are series arrangement, So Reliability probability of the system of URAV is product representation.

3.4.2 The integrated reliable evaluation model

The model is based on the fault that the URAV cannot be repaired when carrying out tasks, and analyzes reliability of each function unit. According to fuzzy mathematics and malfunction analysis, the integrated reliable evaluation model is constructed. Figure 5 shows fault tree about the system of UARV.

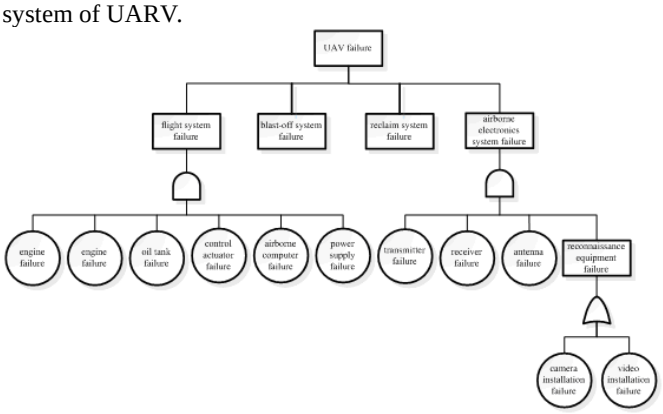

Figure 5 fault tree about the system of UARV

It is supposed the field $S_S = \{s_0, s_1, \cdots, s_k\}$. A and B show that system is in normal state and fault state respectively. A and B is fuzzy event of S_S, and can show:

$$A = \frac{m_A(s_0)}{s_0} + \frac{m_A(s_1)}{s_1} + \cdots + \frac{m_A(s_k)}{s_k}$$

$$B = \frac{m_B(s_0)}{s_0} + \frac{m_B(s_1)}{s_1} + \cdots + \frac{m_B(s_k)}{s_k}$$

A and B is fuzzy normal state and fuzzy fault state respectively, then the aggregative indicator about task reliability (task confidence level) is :

$$R_A = P(A) = E(m_A) = \sum_{j=0}^{k} m_A(s_j) P(s_j)$$

$P(s_j)$ is each function state probability, $m_A(s_j)$ is membership function, namely weight or importance.

3.4.3 Calculation and validation

Based on some UAV, reliability is calculated.

The result of first model is: 0.8598

The result of second model is: 0.8598

Two models have similar result, it is shows that models are correct, and reliability of the URAV is comparatively high.

4. Simulate and analyze the system of developing scale of URAV

A simulation of the system is carried out with the environment of MATLAB/SIMULINK? Figure 6 shows a structure diagram of the simulation of developing scale of URAV.

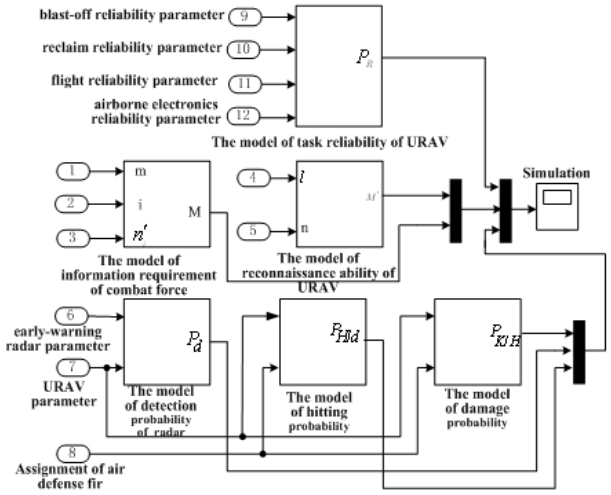

Figure 6 scheme of the simulation of developing scale of URAV.

Suppose enemy air defenses firepower is divided into three kind of Assignment, there are low, medium, and strong. The time of simulation "T" is the time of a campaign. The result of simulation is the number of URAV that is demanded in three kind of Assignment of air defenses fir. It is showed on figure 7.

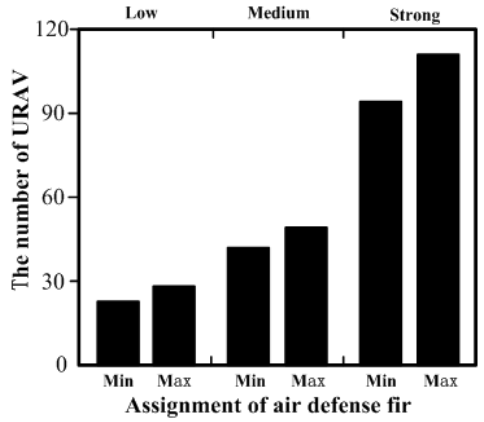

Figure 7 the number of URAV

The result shows that the modeling method and the train-of-thought are both correct.

5. Conclusion

The model of System of developing Scale for URAV is construed and simulated, that offers a scientific evaluating way for URAV equipment developing demand. To advance veracity of the simulation, the result of each sub-model is validated in feasibility and accuracy.

The model offers useful accessorial decision -making information for command, but it is comparative idealization. There are not enough for some complicated factor that is considered, such as military expenditure spending, maintenance capacity, tactical application of URAV, that influence end product. The model need be deepened and expanded to make the result press close to fact by more investigation.

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