Operational Effectiveness Evaluation of the Naval Gun Fire Hit based on UAV Cooperative Combat

Haitao Yao[1, a] and Liang Ma[2, b]

[1]Department of Surface Ship Command, Dalian Naval Academy, Dalian, 116018, China

[a]446982051@qq.com, [b]maliang2014@tom.com

Keywords: Operational capability; Operational effectiveness; The naval gun fire

Abstract. Based on the analysis of UAV security under the condition of naval gun fire support on demand, on the basis of the fuzzy comprehensive evaluation and analytic hierarchy process (ahp) for UAV security under the condition of naval gun fire support on operational effectiveness were evaluated, affecting the naval gun fire support on operational effectiveness of various factors in quantitative analysis and comparison of the related conclusions will help to increase the efficiency of the comprehensive fire support.

Introduction

In landing operation, the naval gun across the attack main mission is to fire support. Generally speaking, fire support is on the landing forces will and mount lu, lu against interferes with my sas attack target conducted by the fire. UAV security across the amphibious assault ship formation, fire support, can be achieved by UAV to combat area for large deep, many-sided, all-weather surveillance monitoring, to solve the amphibious assault ship formation, the other side in the process of fire support targeted observations, battlefield surveillance, artillery ballistic correction shoot and battle damage assessment has important practical significance[1].

Drone Guarantee under the Condition of Naval Gun Fire Support Demand Analysis on the Other Side

In the Amphibious UAV Security Fire Support the Necessity of Research on the Other Side. In amphibious, the UAV can in formation security amphibious assault ships fire support play an important role in the other side, the necessity of a strong, mainly embodied in the following aspects [2]:

Battlefield Reconnaissance. Because of the influence of the earth curvature and complex geographical environment, shipboard radar detection range limited to line-of-sight range, far from to meet the requirements of the first discovery, attack before enemy. Shipboard far/intermediate drones can play a good concealment, the flight time, the advantages of no life-threatening, before entering the war zone and contact of concern for their own waters or goal for long, long time of real-time surveillance and monitoring, find out the enemy troops deployment situation, for the ship fire forces prepared to intelligence. Fleet of unmanned spy plane can cooperate with each other, use alternately, large batches for enemy, depth, all-weather, three-dimensional reconnaissance monitoring. Using UAV flight level is high, the distance and reconnaissance means diversity, before a distance along a certain route to patrol alerts, and through the data chain real-time feedback information [3].

Target Designation and Evaluation of Results. Someone use of UAV for naval gun, missiles or aircraft search and identify targets, determination of target parameters, help ship computing shooting the yuan, to target distribution, can also carry a laser designator light source for laser guidance weapon, precise guidance. After the campaign, the determination of playing, naval gun firing correction, check the target damage degree, determine whether to continue to attack or transfer of power. In addition, the U.S. navy in the development of amphibious landings on the beach in the surf zone, beach zone and inland areas of mine (mine) for detection, localization and classification of UAV, in order to provide effective support for landing operations[4].

Amphibious UAV the Feasibility Study of the Fire Support on Safeguards. The Feasibility of Tactical. Fast Attack. Modern warfare, from finding it to attack the length of time needed for the serious influence to the operational effectiveness of high and low, who shorten the "kill chain" period of the target, who can gain the initiative in the war, win the advantage. Carrier-based UAV group, can be observed in carrying out tasks at the same time, with the aid of data link the information back to the amphibious assault ship fleet fire center, greatly shorten the cycle of the "kill chain", "integration" reconnaissance strike, improve the amphibious assault ship fleet combat effectiveness of the entire attack system[5].

Combined with Attack. Because the UAV has the front ability, can be a significant number of the amphibious assault ship configuration school front drones, and reconnaissance drones, the front machine before, and release the decoy signal, or based on signal amplification to simulate combat aircraft itself, in the enemy's radar screen, able to display for the mainframe, minicomputer can show single objective target for the cluster, information to the enemy air defense system cause serious pollution and excessive load, lure the enemy air defense radar boot, exposed to air defense system, and by the subsequent reconnaissance is shot， UAV will be an enemy immediate feedback of information, and guide the naval gun attack.

Technical Feasibility. The feasibility of reconnaissance technology. In the early 1960 s, the United States kept BQM-34 e, aqm-34s go and GFD - 21 types of unmanned aircraft used for reconnaissance, and extensive use in Vietnam battlefield. UAV security amphibious assault ship fleet across the fire support has been successful in the world, both can compensate each other, maximum firepower superiority into full play. In addition from the respect such as reconnaissance, communication relay and the school of technology continues to mature and develop, and successively in the gulf war, kosovo war been tested in actual combat [6] [7]. The above situation will guide us further deepen the carrier-based UAV security amphibious assault ships across the fire support research, operations and training work.

Economic Feasibility. Due to develop a pilot now costs, long cycle, military aircraft research and development, the production cost is also a trend of increase, the corresponding use of military aircraft for the battlefield reconnaissance the cost-effectiveness ratio is too low, and the development of carrier-based UAV, the economic advantage is obvious: small volume, light quality, relatively simple structure, low purchasing cost. Training operator rather than real pilots, the training cost is low; Guarantee low cost; Fighting drills mainly through simulation, training expenses low.

UAV Security under the Condition of Naval Gun Fire Support Comprehensive Effectiveness Evaluation on the Other Side

UAV security under the condition of naval gun fire support on operational effectiveness assessment procedures, can be divided into determine the effectiveness of the targets, standards and assessment of three phases, the process is shown in Fig. 1[8].

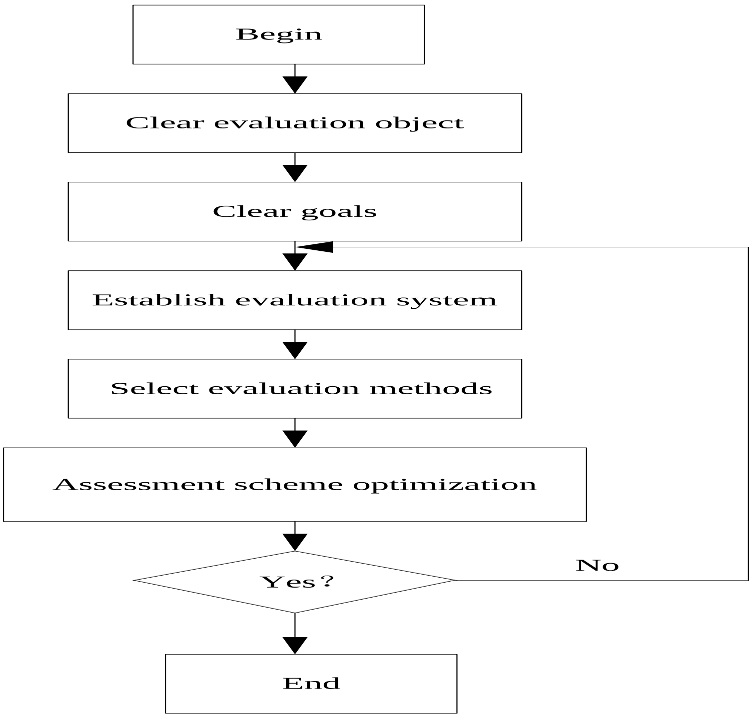

Figure 1. Fow chart of system operational effectiveness assessment

Establish Evaluation Purpose. On UAV guarantee under the condition of naval gun fire support on the other side of the comprehensive effectiveness evaluation method, the analysis of various factors in the system as a whole system of the comprehensive efficiency of the role of the size, for UAV security under the condition of naval gun fire support on operational use of rationalization proposal is put forward [9].

Establish the Evaluation Index System. Based on UAV security conditions, the naval gun fire support on demand analysis, that the influence factors of comprehensive efficiency and its subset, as shown in Table 1.

Table 1 Operational Effectiveness factors

Goals	Factors	Factor subset
Operational Effectiveness	System stability U1	The average time between failures U11
		Mean time to repair U12
		Security confidentiality U13
		System fault tolerance U14
		System survivability U15
		Environmental adaptability U16
	Communication control ability U2	A few words with ability U21
		Long distance communication ability U22
		Uninterrupted ability of communication U23
	UAV reconnaissance capability U3	Round-the-clock reconnaissance capability U31
		Found target ability U32
		Ability to locate U33
		Target identification ability U34
		Automation information transmission capacity U35
	Battle command ability U4	System auxiliary decision-making ability U41
		Commander decision-making ability U42
		Shooting and tactical computing power U43
		Human-computer interaction ability U44

Establish Evaluation Set. According to the UAV security conditions, the factors affect the naval gun fire support on the analysis of the degree of the comprehensive efficiency of selecting evaluation sets:

$$V = \{V_1, V_2, V_3, V_4, V_5\} = \{\text{very good}, \text{good}, \text{normal}, \text{poor}, \text{bad}\} \tag{1}$$

According to expert opinions, the membership degree of statistical results of various factors are shown in Table 2.

Table 2 Membership statistics results

factors	Factor subset	Memership				
		V_1	V_2	V_3	V_4	V_5
U_1	U_{11}	0.13	0.32	0.47	0.07	0.01
	U_{12}	0.06	0.20	0.60	0.10	0.04
	U_{13}	0.18	0.41	0.18	0.18	0.05
	U_{14}	0.10	0.42	0.38	0.07	0.03
	U_{15}	0.08	0.40	0.35	0.12	0.05
	U_{16}	0.08	0.13	0.58	0.20	0.02
U_2	U_{21}	0.13	0.50	0.24	0.07	0.06
	U_{22}	0.18	0.20	0.45	0.08	0.09
	U_{23}	0.15	0.25	0.41	0.15	0.04
U_3	U_{31}	0.19	0.50	0.24	0.07	0.06
	U_{32}	0.08	0.32	0.38	0.18	0.04
	U_{33}	0.12	0.43	0.29	0.13	0.03
	U_{34}	0.15	0.50	0.26	0.07	0.02
	U_{35}	0.10	0.22	0.43	0.18	0.07
U_4	U_{41}	0.17	0.55	0.24	0.04	0
	U_{42}	0.10	0.60	0.24	0.04	0.02
	U_{43}	0.12	0.34	0.40	0.12	0.02
	U_{44}	0.17	0.28	0.47	0.13	0.02

Using the AHP Method to Calculate Weight of the Factor Set. Through evaluating and comparing various factors on the basis of the relative importance of various factors using 1~9 scaling method and reciprocal constructing judgment matrix [10] [11].

$$C = \begin{bmatrix} 1 & 2 & 5 & 3 \\ 1/2 & 1 & 4 & 1 \\ 1/5 & 1/4 & 1 & 1/3 \\ 1/3 & 1 & 3 & 1 \end{bmatrix} \quad C_1 = \begin{bmatrix} 1 & 3 & 5 & 7 & 1 & 1 \\ 1/3 & 1 & 2 & 3 & 1/3 & \\ 1/5 & 1/2 & 1 & 3 & 1/4 & \\ 1/7 & 1/3 & 1/3 & 1 & 1/3 & \\ 1 & 3 & 4 & 3 & 1 & 1 \\ 1 & 2 & 3 & 5 & 1 & 1 \end{bmatrix}$$

$$C_2 = \begin{bmatrix} 1 & 3 & 5 \\ 1/3 & 1 & 3 \\ 1/5 & 1/3 & 1 \end{bmatrix} \quad C_3 = \begin{bmatrix} 1 & 1/2 & 2 & 4 & \\ 2 & 1 & 3 & 5 & 4 \\ 1/2 & 1/3 & 1 & 3 & \\ 1/4 & 1/5 & 1/3 & 1 & \\ 1/3 & 1/4 & 1/2 & 2 & \end{bmatrix} \quad C_4 = \begin{bmatrix} 1 & 1 & 3 & 2 \\ 1 & 1 & 3 & 3 \\ 1/3 & 1/3 & 1 & 1 \\ 1/2 & 1/3 & 2 & \end{bmatrix}$$

Using square root method to calculate the weight of each factor, the results as shown in Table 3

Table 3 Weight set

factors	Weight set
U	$A=\{0.48,0.24,0.08,0.20\}$
U_1	$A_1=\{0.29,0.11,0.07,0.04,0.25,0.23\}$
U_2	$A_2=\{0.64,0.26,0.10\}$
U_3	$A_3=\{0.26,0.42,0.16,0.06,0.10\}$
U_4	$A_4=\{0.34,0.38,0.11,0.17\}$

The consistency of judgment matrix is calculated the results were as follows:

$$\lambda_{\max}=4.05, CI=0.017, CR=0.019<0.1$$
$$\lambda_{\max 1}=6.18, CI_1=0.036, CR_1=0.029<0.1$$
$$\lambda_{\max 2}=3.02, CI_2=0.010, CR_2=0.017<0.1$$
$$\lambda_{\max 3}=5.06, CI_3=0.015, CR_3=0.013<0.1$$
$$\lambda_{\max 4}=4.06, CI_4=0.021, CR_4=0.023<0.1$$

According to the above calculation, judgment matrix C, C1, C2 and C3 and C4 has satisfactory consistency.

The Fuzzy Comprehensive Evaluation. The level of fuzzy comprehensive evaluation

According to Table 2 membership degree of each factor can be level fuzzy comprehensive evaluation of single factor matrix R1, R2, R3 and R4 are as follows:

$$R_1=\begin{bmatrix}0.13 & 0.32 & 0.47 & 0.07 & 0.01\\ 0.06 & 0.20 & 0.60 & 0.10 & 0.04\\ 0.18 & 0.41 & 0.18 & 0.18 & 0.05\\ 0.10 & 0.42 & 0.38 & 0.07 & 0.03\\ 0.08 & 0.40 & 0.35 & 0.12 & 0.05\\ 0.08 & 0.13 & 0.58 & 0.20 & 0.02\end{bmatrix} \quad R_2=\begin{bmatrix}0.13 & 0.50 & 0.24 & 0.07\\ 0.18 & 0.20 & 0.45 & 0.08\\ 0.15 & 0.25 & 0.41 & 0.15\end{bmatrix}$$

$$R_3=\begin{bmatrix}0.19 & 0.50 & 0.24 & 0.07 & 0.06\\ 0.08 & 0.32 & 0.38 & 0.18 & 0.04\\ 0.12 & 0.43 & 0.29 & 0.13 & 0.03\\ 0.15 & 0.50 & 0.26 & 0.07 & 0.02\\ 0.10 & 0.22 & 0.43 & 0.18 & 0.07\end{bmatrix} \quad R_4=\begin{bmatrix}0.17 & 0.55 & 0.24 & 0.04\\ 0.10 & 0.60 & 0.24 & 0.04\\ 0.12 & 0.34 & 0.40 & 0.12\\ 0.17 & 0.28 & 0.47 & 0.13\end{bmatrix}$$

According to fuzzy transformation:

$$B_i=A_i\cdot R_i \qquad (i=1,\ 2\cdot;$$

The factors available fuzzy comprehensive evaluation sets:

$$B_1=A_1\cdot R_1=(0.10,0.29,0.45,0.13,0.33)$$
$$B_2=A_2\cdot R_2=(0.15,0.40,0.31,0.08,0.06)$$
$$B_3=A_3\cdot R_3=(0.12,0.42,0.30,0.11,0.01)$$
$$B_4=A_4\cdot R_4=(0.13,0.50,0.30,0.06,0.01)$$

The secondary fuzzy comprehensive evaluation

$$R=(B_1,B_2,B_3,B_4)^T,$$

$$B=A\cdot R=(0.12,0.369,0.374,0.102,0.035)$$

According to the maximum membership degree principle, can be thought of uav security under the condition of naval gun fire support on the level of comprehensive evaluation for normal.

Conclusion

UAV are given in this paper guarantee under the condition of naval gun fire support the comprehensive effectiveness evaluation method of the other side, the other side for naval gun fire support of comprehensive efficiency evaluation has a certain reference value. Evaluation results show that the naval gun across the fire support comprehensive efficiency needs to be improved, this major is currently under the condition of the UAV support the other side of the naval gun fire support system of the operational application experience also relatively lack, the system overall efficiency is not fully play. According to Table 3 factors weight set, the UAV security conditions, affect the overall effectiveness of the other side naval gun fire support according to the size of the effect of various factors in the, in turn, can be as follows: system stability (0.48), and communication control (0.24), and ability of operation command (0.20) (0.08), uav reconnaissance ability, namely the system stability and communication control of UAV security under the condition of naval gun fire support on the influence of the comprehensive efficiency is most obvious. Therefore, should be integrated in the actual deployment, weigh the various factors to ensure the stability of the system and improve the ability of communication control as an important link to grasp.

References

[1] Galay Barbarosoglu, Linet Ozdamar, Ahmel Cevik. An Interactive Appmach of Hierarchical Analysis of Helicopter Logistics in Disaster Relief Operations [J]. European Journal of Operational Research, 2002: 18-133

[2] Omid Shakernia. Vision-based Control and Coordination of Unmanned Vehicles[D].California: University of California, Berkely 2003

[3] Sriram Venkataramanan, Atilla Dogan. A Multi-UAV Simulation for Formation Reconfiguration [R]. AIAA2004-4800. Providence, Rhode Island: AIAA Modeling and Simulation Technologies Conference and Exhibit, 2003

[4] Donald W. Manned /unmanned common architecture program (MCAP): a review[C]// Proceed-- ings of the22nd Digital Avionics Systems Conference.2003: 6.B.4/1.6.B.4/7.

[5] M. Valenti, T. Schouwenaars, Y. Kuwata, E. Feron and J. How Implementation of a Manned Vehicle-UAV Mission System [C].AAIA Guidance, Navigation and control Conference, Providence, RI, August 2004, AIAA2004

[6] Sarit Kraus. Negotiation and cooperation in mulfi-ageat environments. Artificial Intelligence. 1997: 79-97

[7] M. Ben-Bassat. Knowledge Requirement and Management in Expert Decision Support Systems for (Military) Situation Assessment [J]. IEEE Trans. on SMC.1982, 12(4):479-490

[8] Jerome Azarewicz, Glenn Fala. Template-based Multi-agent Plan Recognition for Tactical Situation Assessment [A]. In: Proceedings of 5th conference on Artificial Intelligence Applications[C], March 1989: 247-254

[9] G.Peterson, L.Axelsson, T.Jensen, etal. Multi-source Integration and Temporal Situation Assessment in Air Combat [J]. Proceedings of Information Decision and Control.1999:371-375

[10] Ge S S, Cui Y J. Dynamic motion planning for mobile robots using protential field method [J].Autonomous Robots, 2002, 13:207-222

[11] Kowalczyk W, Kozlowski K. Artificial potential based control for a large scale formation of mobile robots [C].Poland:4th International workshop on Robot Motion and Control,2004