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COMBAT EFFECTIVENESS EVALUATION-ORIENTED AVIONICS SYSTEM MODELING

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Abstract

As a significant part of a modern combat aircraft, the avionics system is modeled for combat effectiveness evaluation. Through the uniform interfaces, each relative independent subsystem can be added or removed flexibly for adjusting the accuracy of the model to satisfy different evaluation. Through the avionics system model, the design parameters of the avionics subsystem can be mapped to the system performance then to the combat effectiveness. The model can be applied by single module or integrated into SoS simulation system for different level simulation. A sample case is provided for the verification.

1 Introduction

The avionics system has become a significant part of a modern combat aircraft[1]. Therefore, it is necessary to evaluate the demand of avionics by simulation in the demonstration phase.

At present, research on the hardware-in-the-loop simulation of avionics equipment has a wide range[2-6]. However, regarded as the engineering level, these simulations are often used for the verification of the avionics products and do not apply to the demonstration without entities or details. In addition, a lot of simulations focus on a single subsystem such as the radar without comprehensive evaluating the impact of an aircraft's whole avionics system on the combat effectiveness[7-13]. Therefore, a kind of flexible avionics system model which can be developed as a software module is desirable.

To analyze the impact of the avionics technology on the combat effectiveness through the simulations, an avionics system modeling approach which is applicable to the demonstration is researched in this paper.

2 Model Architecture

For the research on the impact of the avionics system, several accurate subsystem models should be integrated together. Through the uniform interfaces, each relative independent subsystem can be added or removed flexibly for adjusting the accuracy of the model to satisfy different evaluation. The simulation of the complete avionics system of a combat aircraft can be achieved by adding the subsystems. The data interaction among the subsystem models is realized by a data bus (Fig. 1). Figure 1 shows a typical model architecture for air-to-air engagement.

Moreover, the separated calculation nodes boost the computing performance of the simulation system and make the users monitor the status of the subsystem models easily. In addition, the network architecture of the data bus is not restrictive. Such as reflective memory network used in the sample case of this paper or high level architecture (HLA) can be available for the model.

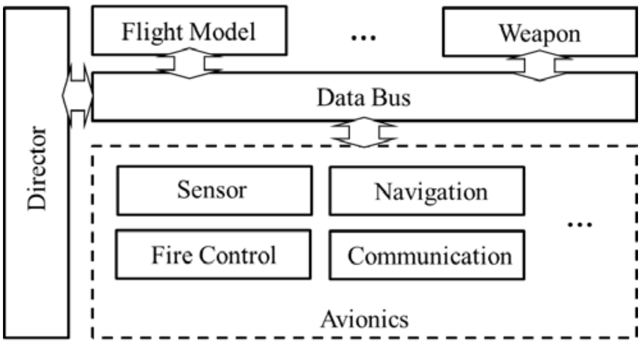


Fig. 1. Model architecture for air-to-air engagement

3 Evaluating Method

Through the avionics system model, the design parameters of the avionics subsystem can be mapped to the system performance then to the combat effectiveness shown in Fig. 2. If the relationship between the techniques to design parameters represented by dotted line in Fig. 2 can be achieved by expert analysis, the technique can be mapped to the combat effectiveness. Therefore, the development planning of the aero technology can be more directivity.

Take the radar for example, the techniques include computer technology, electronic component technology etc. The design parameters include emitting power, emitting antenna gain etc. The performance parameters include detection range, detection accuracy etc. And in an air-to-air combat, a typical effectiveness index will be the damage ratio. The developing electronic component technology may improve the radar's emitting power. Then the detection range can be enlarged. Finally, in a air-to-air engagement, the longer detection range may cause the better damage ratio.

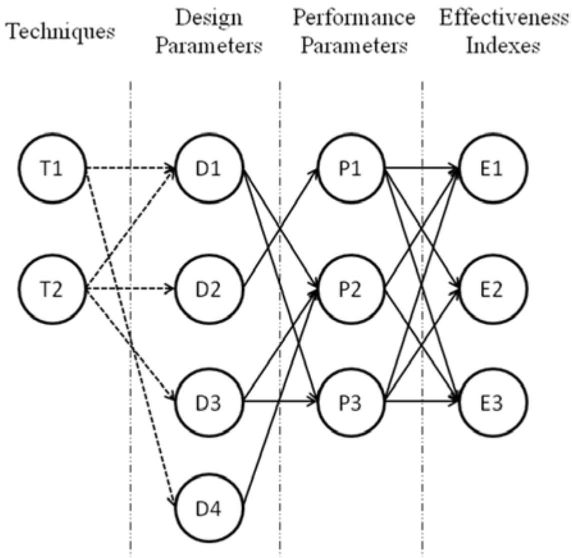


Fig. 2. Mapping techniques to effectiveness indexes

Figure 3 shows the evaluation process through the avionics system model. After multiple simulating for different value of single parameter, through the effectiveness comparison of the results and the historical data in the database, the impact of this avionics system's parameter can be identified.

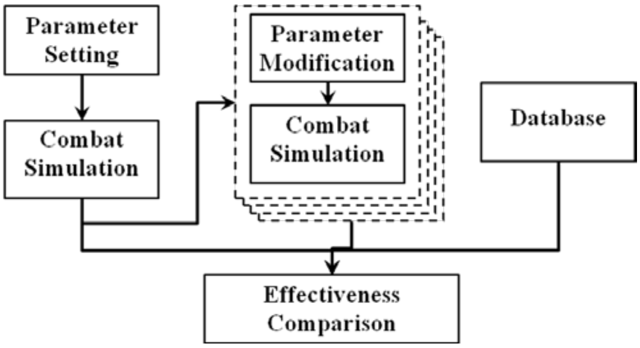


Fig. 3. Evaluation process

4 Application Pattern

This avionics system model can be applied by two main patterns for different evaluation.

4.1 Single Module

Through the custom development based on this model, a single module can be used for the effectiveness evaluation of engagement level simulation.

Shown in Fig.1, the module for air-to-air combat is composed of the avionics system model, flight model, weapon model(air-to-air missile), and simple task management model(director). Including sensor, fire control, navigation, and communication, etc., the avionics model can be integrated with the weapon and flight models to achieve the simulation of a air-to-air strike process as the engagement level through the director system.

4.2 Integrated into SoS Simulation System

To evaluate the avionics system in a complex mission or a campaign which can be regarded as a system-of systems (SoS), this avionics system model can also be integrated with much more models as a module of a single aircraft. The relevant avionics device can be simulated through this model. As a whole, all the avionics subsystems communicated with each other through the interior data bus interact with other models through the exterior data bus (Fig. 4).

The other models can be provided by some mature SoS simulation systems, therefore this avionics system model will have universal usability.

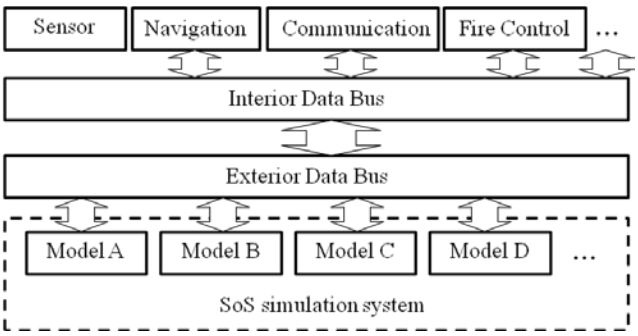
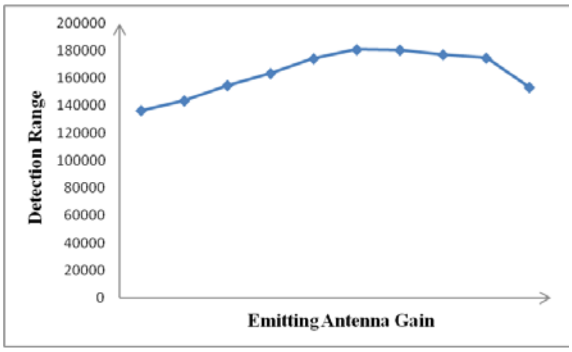


Fig. 4. Integrated into SoS Simulation System

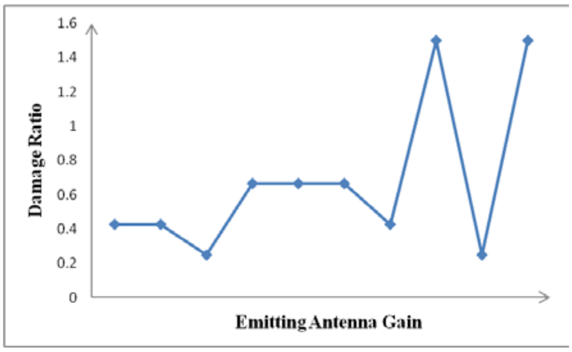
5 Sample Case

For the verification of the model, the sample case is the simulation of head-on air-to-air combat with only medium-range air-to-air missiles between two fighters as the engagement level. The key design parameter is the emitting antenna gain of the radar. Ten simulation plans change the emitting antenna gain with the step length of 1dB.

The result shows that the detection range of the radar increases with the emitting antenna gain within limits and slight declines after reaching the peak value (Fig. 5a). However, the relationship between the damage ratio and the emitting antenna gain is not obvious (Fig. 5b), because the limited range ability of the detection range due to the emitting antenna gain and the effective missile firing range which is much less than the detection range result in the random results of the battle.



(a)



(b)

Fig. 5. Result of the sample case

6 Conclusion

The proposed avionics modeling approach can add or remove different subsystems flexibly for the design parameters sensitivity analysis. Through the model, the design parameters of the avionics subsystem can be mapped to the system performance then to the combat effectiveness. This avionics system model can be applied by single module or integrated into SoS simulation system. Through the simulations, the analysis of the avionics technology's impact on the combat effectiveness can be achieved for the demonstration.

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