Simulator Networking in Helicopter Air-to-Air Combat Training

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Introduction

IN August 1988, the Singer Corporation demonstrated a relatively simple networking of the AH-64 combat mission simulator (CMS), AH-1 flight and weapons simulator (FWS), and UH-60 flight simulator (FS) at Fort Rucker. At the end of this demonstration, three night shifts were made available for a quick research evaluation of this capability. One AH-64 and one AH-1 crew volunteered to participate in an air-to-air combat (ATAC) pilot study involving their respective aircraft. The sample size of this pilot study is inadequate to draw any conclusions with certainty. However, in this instance, there is so little information on the use of simulators in training helicopter ATAC that even the tentative suggestions of a pilot study are of interest. All reference to weapons performance has been deleted for security reasons.

Procedure

A total of 45 runs was conducted according to the following scenario:

1) Each run began at 1000, 2500, or 4000 m distance between the two aircraft with both aircraft at an altitude of 50 m.

2) Each run began with one of three aircraft orientations: a) Head-on; b) AH-64 advantage, i.e., AH-64 behind the AH-1; and c) AH-1 advantage, i.e., AH-1 behind the AH-64.

3) The disadvantaged aircraft, if there was one, would either be instructed to run for cover, then turn and fight after reaching cover, or would be instructed to turn immediately and fight.

4) In 30 runs, each crew had its choice of weapons. However, in order to insure a greater amount of data on the rockets, HELLFIRE, and tube-launched, optically-tracked, wire-guided (TOW) weapons, one of these weapons was dictated for use in each of 3 min.

Results

Only the AH-64 CMS provided suitable data on each firing episode. The AH-1 FWS only provided a summary snapshot for each run. With the exception of these summary data, no AH-1 FWS data were available. The AH-64 CMS data are valuable, but provide weapons effectiveness information that is classified and therefore unavailable for this report. The most valuable data in a pilot study such as this are frequently the comments of the highly qualified aviators who participated in the study. These comments are provided below.

AH-1 Pilot

1) The crew should be able to talk securely rather than having an open mike where they can be overheard in the other simulator.

2) You should leave out the pitch and roll constraints. Leave in the mast bumping restriction.

3) You should use vectors to assure the opposing aircraft meet each other rather than having an advantaged and disadvantaged aircraft.

4) An overtorque of 120% would crash us. Leave it in the simulator. That is good.

5) The 3-min time limit on the run was good, but you should fight it out.

6) Concerning cockpit fatigue, you are tired during the graveyard shift, but that is a realistic combat condition.

7) You need a wingman.

8) With a load of 2 TOW, 500 20-mm and 12 rockets plus full fuel, you obviously did not consider weight and balance.

9) This exercise on the simulator teaches patience. You must be within range for the 20 mm to be effective.

10) The limited field of view behind, below, and above was a real handicap, but the training was great.

AH-1 Copilot Gunner

1) It was a good learning experience.

2) The experience level between the AH-64 and AH-1 crews was very different.

3) A crash in the cobra occurs with a high angle of bank. A "g" load criterion should be used instead.

4) You need a top canopy to be able to follow in steep banking maneuvers.

5) Simulators do not show the incoming rounds. They should.

6) Tracers are needed on both aircraft simulators. They helped on the AH-1 FWS.

AH-64 Pilot

1) The scenarios used in the study would be a good introduction to acquisition and recognition training.

2) This is basic air-to-air training.

3) You should go into more advanced scenarios with terrain, mission, and orders, and see what the trainees do.

4) To be a superb air-to-air trainer, you need better visuals and a "g" seat. A wider field of view is required. Better detail would help, but is not critical.

5) How do you deploy to acquire, i.e., do you conceal yourself and go into an overwatch? This should be investigated.

6) A better data recording capability is needed.

7) You need dedicated crews. The tactical expertise was poor in this study.

8) You need isolated communications within crews.

AH-64 Copilot Gunner

1) Test results are not valid because of crew inexperience in the first part of the test. Late Friday night, the data was fairly good.

2) No planned setup and ability evaluation.

3) For valid data, 4000 m should have been first, then moved in closer. The 3-min scenarios were good.

4) Communications within the crew must be isolated.

Conclusions

According to the aviator participants, the networking of the simulators proved to be a very valuable training experience that could easily be enhanced by better planning if the equipment were more routinely available. The networked AH-1 and AH-64 simulators allowed an evaluation of the effectiveness of various weapons and tactics used in helicopter ATAC. This included the ability to obtain comparative hit and kill ratios for each aircraft as a function of range and weapon. It was also possible to evaluate the additional simulator requirements for helicopter ATAC simulation. The field of view of the visual system was insufficient both horizontally and vertically. In close range engagements, one or both simulated aircraft were frequently out of the visual field of the other for extended periods of time. The automated weapons-scoring capa-

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bilities of both simulators were inadequate for testing purposes.

The simulation of the gun on the AH-1 included tracers, whereas the simulation of the gun on the AH-64 did not. According to the gunners, this made the simulated AH-1 gun much more effective.

Since neither simulator had an overhead visual system, one crew could fly over the other, then close and kill a blind target. These are artificial conditions. In most actual combat, the existence of surface-to-air missiles would prohibit ATAC at the altitudes practiced by these crews. Both an overhead visual system and the presence of realistic ground threats are mandatory for the realistic simulation of helicopter ATAC.

All four aviator participants stated that the training they received was very valuable. Simply networking two or more attack helicopter simulators together for the purpose of ATAC training will provide a substantial training benefit. However, the following factors should be considered as time and finances permit:

1) The simulators are already very close to full utilization. In order to provide all of our aviators with adequate networked training on our present simulator fleet, additional simulators would be required.

2) A wider field-of-view visual system would be of great benefit in helicopter ATAC simulation. An overhead visual scene is particularly important.

3) A better weapons-scoring system is required for most testing. The scoring available on the AH-64 CMS is marginal for test purposes. The scoring system available on the AH-1 FWS is very close to useless.

4) The crew in each simulator should be able to talk securely, i.e., without their conversation being overheard by the crew in the other simulator as was the case in this investigation.

5) Enough simulators should be connected to allow the use of air-to-air tactics, i.e., there should be a wingman.

6) The aviators in both simulators turned off the motion systems, but expressed a desire to have "*g*" seats to provide motion onset cues.

Recommendations

1) Provide a wider field-of-view visual system. An overhead visual is mandatory for realistic close range helicopter ATAC simulation.

2) Provide closed intracrew communications.

3) Network for at least a two-on-two contest.

4) Provide "*g*" seats for the crews. Allow the motion system to be turned off at the discretion of the aviators.

5) Delete any artificial pitch and roll constraints. Maneuver constraints should mirror the limitations of the aircraft. Exceeding those restraints should produce the expected results. A "*g*" load criterion would probably be most appropriate.

6) The visual should portray ordnance in flight accurately, including incoming rounds and tracers.

7) The following measures should be added to those already available on the AH-64 combat mission simulator: a) Time to first hit by each aircraft; b) Time to kill by each aircraft; c) If there is an advantaged aircraft, the number of times the advantaged aircraft is killed before his adversary is killed; d) Number and type of ordnance expended by each adversary at the time of each of the above criteria; e) Type of ordnance which resulted in each hit; f) Type of ordnance which resulted in each kill; g) Altitude difference between firing and target aircraft at time of hit or miss by missile, rocket, or gun burst (firing aircraft higher will be positive); h) Slant range between firing and target aircraft at time of hit or miss by missile, rocket, or gun burst; i) Difference between angular velocity of target aircraft and ordnance at time of hit or miss. (Gun fire will be considered in bursts. Greater target velocity will be positive.); and j) Difference between the angular acceleration of target aircraft and ordnance at time of hit or miss (Gun fire will be considered in bursts. Greater target acceleration will be positive.)

Evaluation of Three Turbulence Models in Static Air Loads and Dynamic Stall Predictions

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Introduction

THE flowfield surrounding modern rotorcraft and propeller configurations is highly complex and is dominated by three-dimensional effects, transonic flow, flow separation, and unsteadiness and can be properly modeled only through the numerical solution of the three-dimensional unsteady Navier-Stokes equations. Since full three-dimensional simulations are costly, historically researchers have used simpler three-dimensional analyses such as the lifting-line theory, which use a table look up of two-dimensional steady and unsteady airfoil characteristics. The airfoil tables needed may come from carefully performed experiments or from two-dimensional computer codes. To be useful, the two-dimensional computer codes should provide 1) reliable prediction of airfoil static load data and dynamic stall characteristics, 2) a method for evaluation of the flow-yaw effects on air-load characteristics, and 3) a suitable turbulence model for properly modeling separated flows.

In an effort to predict static and dynamic stall characteristics of airfoils, in this study, a two-dimensional compressible Navier-Stokes code has been developed. Three turbulence models have been implemented: 1) the Baldwin-Lomax algebraic model, 2) the Johnson-King ordinary differential equation (ODE) model, and 3) the two-equation k-ϵ model. This work summarizes the performance of these three turbulence models for a variety of steady and unsteady flow conditions. The effects of turbulence model on the predicted flow properties are also discussed. For a detailed description of the solution procedure, correction for flow-yaw effects, and several additional calculations, the reader is referred to Refs. 1 and 2.

Mathematical and Numerical Formulation

The compressible Navier-Stokes equations are parabolic in time and may be advanced in time using a suitable, stable, dissipative scheme. In the present work, a formulation similar to that described by Steger[3] was used. Standard second-order-accurate central differences were used to approximate the spatial derivatives and to compute the metrics of transformation. The nonlinear transport terms, which are unknown at a given time level $n+1$, were linearized about their values at a previ-

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