Comparison of a Manned Helicopter Simulation to a Computer-Based Human Performance Model[1]

R. Jay Shively
Aeroflightdynamics Directorate (AMRDEC)
US Army Aviation and Missile Command

Mark D. Burdick
San Jose State University

Army/NASA Rotorcraft Division
Ames Research Center
Moffett Field, CA

Michael Brickner
Pamam HFE Ltd.
Tel Aviv, Israel

Itsik Nadler
Israeli Air Force

Jacob Silbiger
Synergy Integration Ltd.
Tel Aviv, Israel

Abstract

The Man-machine Integration Design and Analysis System (MIDAS) tool combines human performance and cockpit models for evaluation through computer-based simulation. MIDAS was developed to support concept exploration and development in software, rather than hardware, thereby reducing design cycle costs. The current MIDAS study replicated a part-task experiment performed by the Israeli Air Force. The purpose of this study was to validate several of the operator models in MIDAS. Specifically under test was the computational model of situational awareness as described in Ref 1; however the entire range of cognitive models, from perception to decision making, was ultimately tested. The experiment was a simulation of an air-to-ground mission performed by the Co-Pilot Gunner (CPG) in an attack helicopter.

Introduction

MIDAS began as a proof of concept project in the mid 1980s as described in Ref 2. Since then, it has demonstrated utility in a wide variety of environments from aircraft cockpits to displays for 911 dispatchers to nuclear control rooms. This work has been performed at Ames and modifications have been made for each new project. Recently, MIDAS was re-designed for more robust functionality and to make it easier to use, with the aim of creating a commercial system at the end of 2000. The current study is the first in a series of experiments to validate the MIDAS human performance models.

MIDAS combines graphical equipment proto-typing, dynamic simulation, and human performance modeling with the aim to reduce design cycle time, support quantitative predictions of human-system effectiveness, and improve the design of crew stations and their associated operating procedures. MIDAS can be thought of as comprising models of two major components of human-systems integration;

[1] This work has been performed under the auspices of the US/Israel Memorandum of Agreement on Rotorcraft Aeromechanics and Man-machine Interaction Technology.

Presented at the American Helicopter Society 56th Annual Forum, Virginia Beach, Virginia, May 2-4, 2000.

1) the human operator, and 2) the system, or environment.

The human model consists of perception, cognitive processes such as working memory, scheduling, decision making, long-term memory, and situational awareness. The systems model includes the cockpit, or workstation model, the environmental model, and the human figure model. The cockpit model is a fully functional high-fidelity representation. Figure 1 displays an AH-64 Longbow cockpit used for demonstration. The multi-functional displays (MFD) shown are fully functional and animated. The environmental model consists of elements in the world with which the crew-station interacts, for example, trees, other aircraft, or tanks. The human figure anthropometric model is Jack®, developed by the University of Pennsylvania. Jack® can be scaled in several anthropometric dimensions from 5th percentile female, to 95th percentile male. For a more detailed description of the current MIDAS design, and a description of the re-design see Ref 2.

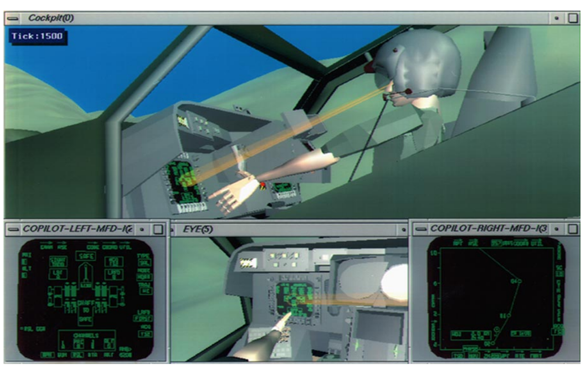

Figure 1. MIDAS depiction of the AH-64D

Method

The mission of the co-pilot gunner (CPG) in this task was to hover and scan a battlefield that contained target and non-target vehicles. The CPG was responsible for first designating a vehicle as a target and then specifically identifying the designated target. No actions were required for non-target vehicles. In the manned simulation performed by the Israeli Air Force, the CPG used a helmet mounted display (HMD) to view the battlefield and designated/identified objects with a computer keyboard. The visual scene of the HMD normally encompassed a 45° field of view but could be toggled to a 15° field of view (FOV), representing a 3x magnification. The MIDAS CPG viewed the battlefield in its normal graphical mode and designated/identified objects by pressing buttons on the instrument panel. The CPG's visual system was also modified to mimic the action of the HMD by allowing the pilot to "zoom-in" on a fixated object with a 3x magnification.

The experiment manipulated target clutter (three or seven non-target vehicles), local contrast (high or low vehicle contrast with background), visibility (2.5 km or 1.5 km) and target location intelligence (pre-trial briefing or no briefing). A fully factorial 2 x 2 x 2 x2 within subject design resulted in 16 conditions. The manned simulation used six CPGs who each performed the sixteen separate trials. The MIDAS simulation performed one of each of the sixteen trials.

The MIDAS simulation proceeded in the following manner. The trial began with the rotorcraft hovering at 300' with a nose-down attitude to allow visibility of the staging area. After a command to begin scanning, the pilot located the first vehicle and fixated on it until detection, i.e., the simulated pilot recognized that an object was there. The pilot then toggled the FOV button to zoom-in on the vehicle, giving a three-fold increase in magnification, and continued to fixate until the object was recognized. At recognition, the pilot was able to determine if the vehicle was a target or a non-target. If a non-target, the operator 'zoomed-out' the FOV and continued scanning. If it was a vehicle, the operator continued to fixate on the vehicle until his perception level reached identification. At the identification level the pilot pressed the appropriate identification button, zoomed his FOV back to 45°, and continued on with the scan. This process was repeated until all five targets were found or until the trial time limit of 75 seconds was reached.

In addition to computed situational awareness data, three main performance measures were recorded from the MIDAS trials for comparison to the pilot-in-the-loop part-task trials. These were mean designation response time, mean number of correct designations made and the mean number of correct identifications.

Results

The following tables show the human CPG data in the top row and the MIDAS data in the bottom row. MIDAS, in its current form, does not support monte carlo simulations through stochastic processing, therefore no statistical analysis of these data were performed. The discussion of the data will be based on the pattern of results. Current efforts in MIDAS are adding stochastic processing to allow fuller analysis.

Table 1. Effect of visibility

	High	Low	High	Low	High	Low
	Mean Response Time		**Correct Designations**		**Correct Identifications**	
PILOT	15.76*	18.37*	4.10*	3.71*	2.41	2.35
MIDAS	11.75	14.95	4.75	3.00	4.62	1.75

* Statistically significant at the .05 level

Table 2. Effect of Contrast

	High	Low	High	Low	High	Low
	Mean Response Time		**Correct Designations**		**Correct Identifications**	
PILOT	15.44*	18.71*	4.02	3.79	2.85*	1.91*
MIDAS	13.79	12.90	3.87	3.87	3.62	2.75

* Statistically significant at the .05 level

Table 3. Effect of Pre-Briefing

	Yes	No	Yes	No	Yes	No
	Mean Response Time		**Correct Designations**		**Correct Identifications**	
PILOT	13.86*	20.27*	4.35*	3.46*	2.37	2.39
MIDAS	11.77	14.92	4.00	3.75	3.38	3.00

* Statistically significant at the .05 level

Table 4. Effect of Clutter

	High	Low	High	Low	High	Low
	Mean Response Time		**Correct Designations**		**Correct Identifications**	
PILOT	17.51	16.62	3.85	3.95	2.41	2.35
MIDAS	11.91	14.78	4.00	3.75	3.50	2.88

Table 5. Mean SA across trials

Effect	Contrast		Visibility		Clutter		Briefing	
Level	**High**	**Low**	**Fair**	**Low**	**5/3**	**5/7**	**Yes**	**No**
PILOT SA	1.84*	1.36*	1.73	1.48	1.64	1.57	1.91*	1.31*
MIDAS SA	.391	.375	.445	.321	.386	.380	.395	.371

*Statistically significant at the .05 level

Discussion

This is the first evaluation of MIDAS after a major re-design. Given that, and the inherent difficulty in modeling human behavior, the results are promising. This experiment was intended to test the SA model as well as other aspects of MIDAS. However, most of the manipulations were visual and therefore much of this evaluation focused upon the vision model in MIDAS. The basis of the vision model in MIDAS is as follows: the perception level is a function of dwell time and perceivability. Perceivability is a function of visibility, size, distance, local contrast ratio. Helicopter flying is predominantly a visual task, so testing this aspect of MIDAS is very important.

Visibility had similar effects on both the manned simulation and MIDAS. Low visibility increased designation times, decreased the number of correct designations and decreased the number of correct identifications. The last effect was stronger for MIDAS than the manned simulation. This degree of correspondence on this important variable is a positive finding for MIDAS.

The effects of contrast were more troubling. The manned simulation had faster designation times with high contrast, while MIDAS was slower. This was due to a confound in the way that MIDAS parses the visual scan task. In MIDAS, an item is *detected* based upon size, color and motion, that is, no contrast. Contrast and other variables are used in *recognition* and *identification*. This methodology, while useful in many contexts may have to be modified. Contrast has no effect on correct designations for either simulation. In both cases, however, high contrast leads to a larger number of correct identifications.

The briefing on target location showed similar effects for both simulations. The major locus of this effect was on designation time, as expected. If briefed on general location, the pilots (real or simulated) were faster to find the targets. They were also more accurate in their designations. The variable, however, had little or no effect on correct identifications. They were cued to the area, but once there had no additional information to help with identification.

The results of the clutter manipulation is problematic for the MIDAS model. While the actual pilots were somewhat faster to designate targets in the low clutter condition, the MIDAS pilots were actually somewhat faster with higher clutter, and also slightly more accurate in both designation and identification. The locus of this counter intuitive finding is not clear, and testing is currently underway to identify the problem.

In the manned simulation, the SA measures were sensitive to only to the contrast manipulation. In MIDAS, the trend for contrast was in the same direction, but was only statistically sensitive to visibility. The locus of this result may stem from the use of the a monochrome low-resolution monitor in the manned simulation. Therefore, the pilots visual performance may have already been degraded to a point where additional decrements due to decreased visibility had no further effect, at least in terms of their SA. However, they probably were using the contrast about an object as cues to identification, as evidenced by the data from the number of correct identifications. It is surprising that the SA measures from neither MIDAS nor from the piloted simulation were sensitive to clutter or briefing. MIDAS did however mimic the pattern of results from the manned simulation.

Conclusions

Modeling the complexities of humans in helicopter flight is a daunting task. MIDAS has come along way from the proof of concept stage to realistically simulating human behavior in this complex environment. Work continues to be needed on refinement of models, but as evidenced above, MIDAS has moved from development to refinement. Testing of the model will continue toward a goal of an industry wide release in the Fall of 2000.

References

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