In Proceedings of the Sixth International Conference on Cognitive Modeling, 396-397.
Mahwah, NJ: Lawrence Earlbaum.

# Modeling Visual Behavior of Pilots in the Human Performance Model – Air MIDAS

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## Introduction

Increases in automation change the operator's information seeking behavior. New technologies involve important issues of information selection, information integration requirements, and design of operations and interfaces. Prediction of a pilot's control behavior under varying visibility conditions and with new automation, like synthetic vision systems (SVS), can be improved if their visual behavior can be modeled. The role of a pilot in the glass cockpit is that of a supervisor with the main task of monitoring the health of the avionics in an aircraft.

The visual scan pattern is intrinsic to the task of monitoring the instruments in the glass cockpit. Various researchers (Bellenkes et al., 1997) have studied the visual scan pattern of pilots, and concluded that there are differences in the information seeking pattern of novices and experts, and there are also differences is the pattern based on phase of flight (Mumaw et. al, 2000). Pilots have a mental model they use for seeking information in the glass cockpit, that involves T-Scan pattern and cross checking different instruments.

### Human Performance Model

The visual behavior of pilots was modeled in the human performance model – Air MIDAS (Man-Machine Integrated Design and Analysis System). MIDAS has agent based architecture and is a closed loop model. The model has been briefly described here, for a detailed description see Corker & Smith (1993). The main components of the model are comprised of the virtual operator's world representation, and a symbolic operator model (SOM) that represents perceptual and cognitive activities of an operator. An important element of the SOM is the Updateable World Representation (UWR). The world representation information (environment, crew-station, vehicle, physical constraints, and the terrain database) is passed through the perceptual and attention processes of the SOM to the UWR. The world information is a complex environmental representation that is created by the researcher or programmer and serves to trigger activities in the virtual operator. The UWR represents the operator's cognitive constraints on procedural completion – it contains the Working Memory (WM), domain knowledge, and required procedural activity structure. The UWR passes information to a scheduler within the SOM that determines the resources available for the completion of the activity. The scheduler views WM and the measures contained within it as a capacity-limited resource. A four-channel activity loading mechanism (Visual, Auditory, Cognitive, and Psychomotor) is representative of the measures contained within WM and these activity load factors are used as constraints on the scheduling process. The scheduler controls the flow of UWR into and out of WM based on its knowledge of activities to be performed, ensuring that the number of nodes in WM at any given time does not exceed the WM node capacity. This cognitive structure interacts with the physical constraints on a virtual operator's performance.

Empirical research data was used to create an augmented visual model within the perceptual process of the SOM. The visual scan pattern data (Mumaw et al., 2000) was used to calibrate the simulation's input data. The researchers (Mumaw et al., 2000) studied the scan patterns of pilots during different flight phases and collected data on dwell durations and dwell percentages.

### The Scan Pattern Model

Two forms of information seeking were modeled, the first one was a fixed sequential fixation pattern that scans the instruments and Out The Window (OTW) that pilots are trained to do. The other form of information seeking was directed-fixation, which is coupled with a specific goal or activity, e.g. look at gears when changing them. In both the forms of information seeking; the instruments, their display values, dwell durations, and percentages were a part of the database that resides in the equipment agent. The dwell percentages were used to select the instrument that the agent fixated on. The duration of dwell was calculated in Monte Carlo fashion on the mean and SD dwell durations specified by Mumaw et al. (2000) for that instrument. It was also assumed that every fixation did not result in updation of the UWR. The theoretical basis of modeling the update of UWR was the speed-accuracy function i.e. longer dwell durations resulted in an update of the UWR. If the estimated dwell duration was shorter than the mean duration + _ SD (high speed), the information from that display was not imbibed (low accuracy), and the agent did not update its information. For sake of simplicity, "all or none" information intake was assumed that formed the basis for modeling the speed-accuracy function. If the changing values on the display in the flight deck were correctly perceived by the agent, it triggered activities that were based on those values such as callouts, flap extensions and the like. See Figure 1 for the augmented visual model in Air MIDAS.

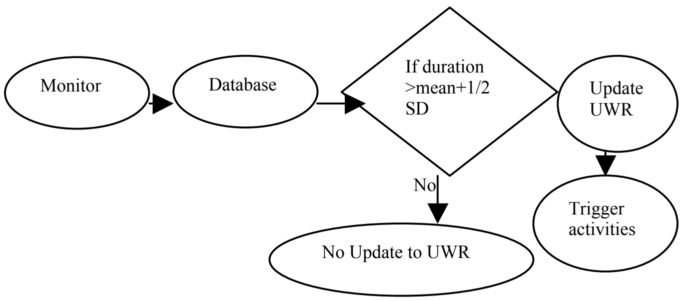


Figure 1: Pictorial representation of the augmented visual model

The model was adapted and data collected for three conditions- nominal approach without SVS, Nominal approach with SVS and Sidestep maneuver with SVS. NASA Human Performance Modeling (HPM) Element (2000) also collected data for the same scenarios using part-task simulation, where the flight deck had SVS superimposed on Primary Flight Display (PFD), and was simulated on a PC. Eye tracking data was collected for the pilots flying in the simulator. Since SVS as an instrument was not a part of the Mumaw (2000) data, the dwell durations and dwell percentages on OTW were used for SVS scan data. Some of the results have been detailed in the following section.

### Validation of model

The correlation between the NASA HPM (2000) part-task simulation and the Air MIDAS for percent of fixations data were generally high- normal approach without SVS ($\underline{r}$ = 0.7608), nominal with SVS ($\underline{r}$ = 0. 8782), and sidestep with SVS ($\underline{r}$ = 0. 5538). Only normal approach with SVS is discussed here, for a detailed description of all data see Corker et al. (2002). In the normal approach with SVS, the Air MIDAS model predicted lower dwells on the Navigation Display, OTW and the SVS

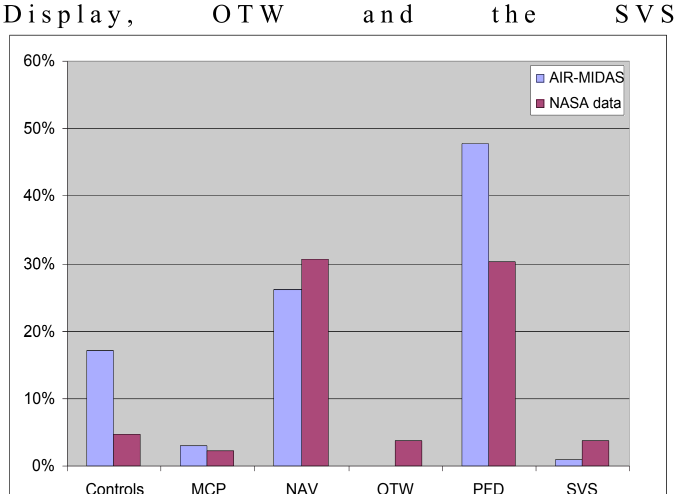


Figure 2: Comparison of fixation percentage between NASA HPM data and model (Air-MIDAS) data for Normal Approach with SVS

displays than did the NASA HPM (2002) simulation. This suggests that when flying with the SVS display, the NASA HPM (2002) flight crews looked at the SVS information to a greater extent than did the model. In short summary, the human flight crew received PFD information from overlays in the SVS, whereas the Air MIDAS model required looking at the PFD (not the SVS) for the same information. It is clear from Figure 2 that while the MIDAS agent looked at PFD about 50% of times, the human operator looked at the PFD and SVS about 35% of time. Thus one can presume that the human pilot was looking for the same information -attitude, altitude, airspeed on the SVS display that was superimposed on PFD, reducing the need to look at PFD separately.

## Conclusion

Empirical results on visual scan pattern for pilots in the approach phase of flight were used to model the visual scan pattern in Air MIDAS. The simulation runs were used to collect data in three different scenarios. The results of the simulation were compared against a separate part task simulation done at NASA Ames Research Center. The data correlated well for most of the scenarios, it was relatively low for the SVS scenarios because the SVS technology was not completely modeled. In general, the correlations proved the validity of the model.

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## Acknowledgements


This research was funded by the NASA Aviation Safety Program and the authors are grateful for the opportunity.