COURSE OF ACTION TRAINING FOR HELICOPTER PILOTS

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Abstract

A number of studies by various helicopter safety organizations have concluded that pilot error in decision-making is a root cause in a significant percentage of helicopter accidents. The studies have also indicated that instruction and practice in critical decision-making is not a part of many helicopter pilot training programs. To address this problem, a project to develop a low-cost simulator for pilot decision training was initiated. The decision training tool is a combination of computer-based simulation, full motion video, still photography, audio, and feedback. For the purpose of developing robust and realistic mission scenarios for the simulation tool, 17 emergency medical service pilots participated in interviews to identify events that require critical decision-making. This paper describes the development of the first mission scenario, formative evaluation, and implementation plans for fielding the decision trainer.

Biographical Sketch:

Rick Archer is a Principal Analyst at Micro Analysis and Design. He was involved with the early design and development of the Micro Saint simulation software and has been developing simulation models for 15 years for a number of training, human performance, and process reengineering applications.

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INTRODUCTION

Good pilot judgment and decision making are critical to safe flight operations. A recent study of helicopter accidents investigated the National Transportation Safety Board (NTSB) database from 1990-1996 and analyzed 1165 accidents [1]. Pilot decision making was found to be a factor in 10% of all accidents and 15% of all fatal accidents in this database. This is also borne out in incident data. The Aviation Safety Reporting System (ASRS) performed an analysis of 833 helicopter incidents that occurred from 1989 through 1996 [2]. This study found that 362 of the incidents or 43% had pilot judgement as a major issue. However, judgement and decision making are not a formal part of the initial rotary wing training, nor recurrent training.

The emergency medical service (EMS) industry is especially susceptible to this problem. The current project was undertaken to develop a judgement/ decision making trainer for EMS pilots that will help them to evalaute changing conditions and unanticipated events that can occur during routine EMS missions and recognize the available courses of action.

The Helicopter Accident Analysis Team (HAAT) addressed this training need when they analyzed a series of helicopter accidents to identify common elements associated with crash causation and outcome [3]. They found accident helicopters involved in Part 135 operations (air medical transport, logging, sightseeing etc.) had some common causal factors; in virtually every accident, better judgment training may have mitigated the effects of other links in the chain of events. A NASA workshop focused on helicopter risk assessment and risk reduction also identified a need for training aids that were timely and cost-effective [4]. Due to the EMS' identified paucity of decision-making training, this domain was selected as the first in which to develop a decision training scenario – as an area that potentially can gain the most benefit from improved pilot decision making techniques.

The technical approach for providing mission training for helicopter pilots on the dynamic conditions and alternative courses of action that occur is a combination of computer-based simulation, full motion video, still photography, and audio. These techniques will be accessed, driven, and displayed by a Windows graphical user interface (GUI). This combination of technologies, along with feedback, provides helicopter pilots with a low cost simulator named the Coarse of Action Training Tool (COATT) for investigating and learning about the potential impacts of the decisions they can make during a mission scenario. The beta test version of the first mission scenario has been completed.

SCENARIO DEVELOPMENT

To identify a helicopter scenario that included a rich set of dynamically changing conditions, 17 EMS pilots were interviewed using a semi-structured questionnaire containing 30 questions, most of which were open-ended. The questions encouraged pilots to describe situations where they had to make difficult decisions and the circumstances surrounding those decisions.

A content analysis of the interviews revealed two areas in particular which pilots find problematic for decision-making — the weather and the conditions at sites where they have to land. They cited weather-related decisions as among the most important pre-flight, in-flight, and stressful decisions they make;

judging safe landing zone conditions were important in-flight decisions and were also rated as hard to make.

When asked what they would like to see in a simulation/training tool, pilots answered on a number of levels. They gave instances of the types of situations they would like to practice, variables they would like to see included in a scenario (e.g. fuel), features of the tool itself (e.g. a replay facility; the type of feedback they could receive), and general properties of the tool. Among the most frequent requests were that the tool should be interactive, ever changing (dynamic) and hence absorbing, and have many variables.

Based on these findings, a weather-related scene pick-up mission was developed as the first training scenario. In this scenario, the user has to pick up a patient at an accident scene and transport him to a designated hospital. The scenario contains potentially changing weather, radio and crew communication, possibly equipment malfunctions, and varying terrain.

THE SIMULATION MODEL

Any process that can be described as a flow of events can be modeled using discrete event simulation. For example, the activities or processes that occur in a helicopter mission can be described as events in a simulation model. Once a process has been defined in this way, discrete event simulation can be used to examine many different aspects of the process in order to improve it. Typically, this technology has been used to identify bottlenecks and resource limitations. Users provide input to the models, execute them, and analyze the results. However, the use of discrete event simulation is unique in this project in that it allows pilots to interact with the simulation while it is executing, providing dynamic input to the model.

After mission scenarios are defined, network flow diagrams are developed to depict all of the alternative processes that could occur in the execution of the mission. Using the network diagrams as blueprints, discrete event simulation models are developed using the Micro Saint simulation tool [5]. These simulations include rule-based and probabilistic logic for the stochastic portions of the simulations such as weather conditions. However, the alternative course of action (COA) choices that are made by the pilot are not programmed into the simulation. These decisions are made by pilots as they interact directly with the simulation. Each node in a network diagram represents either an action that is made by the pilot or an indication of the current environmental conditions (Figure 1).

Although the model represented in Figure 1 is simplistic from a mission scenario point of view, it does allow the description of several key concepts. Each oval-shaped node in the diagram represents one task, action, or event. For example, the first node, "Take Off" represents the action of the helicopter taking-off. "Take off " is followed by "Fly 1st Segment." The arrows between nodes represent the basic sequence of activities. The diamond-shaped node following "Fly 1st Segment" is a decision point that can branch to one of the three following nodes. The "P" inside the diamond indicates that the decision is based on a probability. This is an example of the stochastic element of the simulation that is beyond the pilot's control. It shows how the environmental conditions can change based on probability.

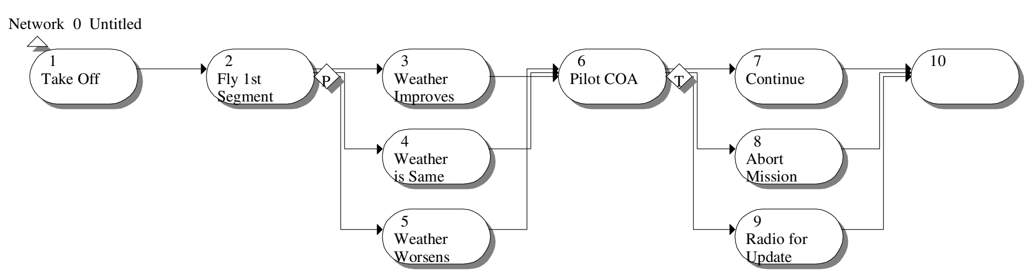

Figure 1. Network diagram

The next node in the model represents a pilot's decision of a course of action given three possible choices based on the current conditions. When a pilot decision point in the simulation is encountered, the simulation pauses and waits for the pilot to respond. As the simulation progresses, the combination of the stochastic branches and the pilot's decisions determine future paths through the network and future pilot options.

THE USER INTERFACE

The user interface presents pilots with combinations of full-motion video clips, still photography, audio, and text to depict the activities that are occurring in the simulation model and the options that the pilot has as the simulation progresses. The model itself is not visible to the user but runs in the background to tell the GUI application which video clip, audio segment, or text message to present to the user.

The main display of COATT (see Figure 2) contains a window for viewing video clips, a window describing the current activity of the scenario (e.g., En route), warning indicators for low fuel and a faulty MR chip, a clock, an altimeter, a air speed indicator, a fuel gauge, a button for relaying coordinates to air traffic control (ATC), a button to declare instrument meteorological conditions, and a button to land immediately at any time.

Communication between the underlying Micro Saint simulation model and the GUI application is accomplished using Microsoft Component Object Model (COM) functionality. COM is a model for binary code developed by Microsoft. It enables component objects to be developed that can be accessed by any COM-compliant application. COM provides the underlying services of interface negotiation, determines when an object can be removed from a system, and controls event services. Micro Saint COM Services allows users to send commands and data from software that is external to Micro Saint. The external software can receive variable and event data from Micro Saint, along with messages indicating the status of model execution. The COATT application uses Visual Basic as the

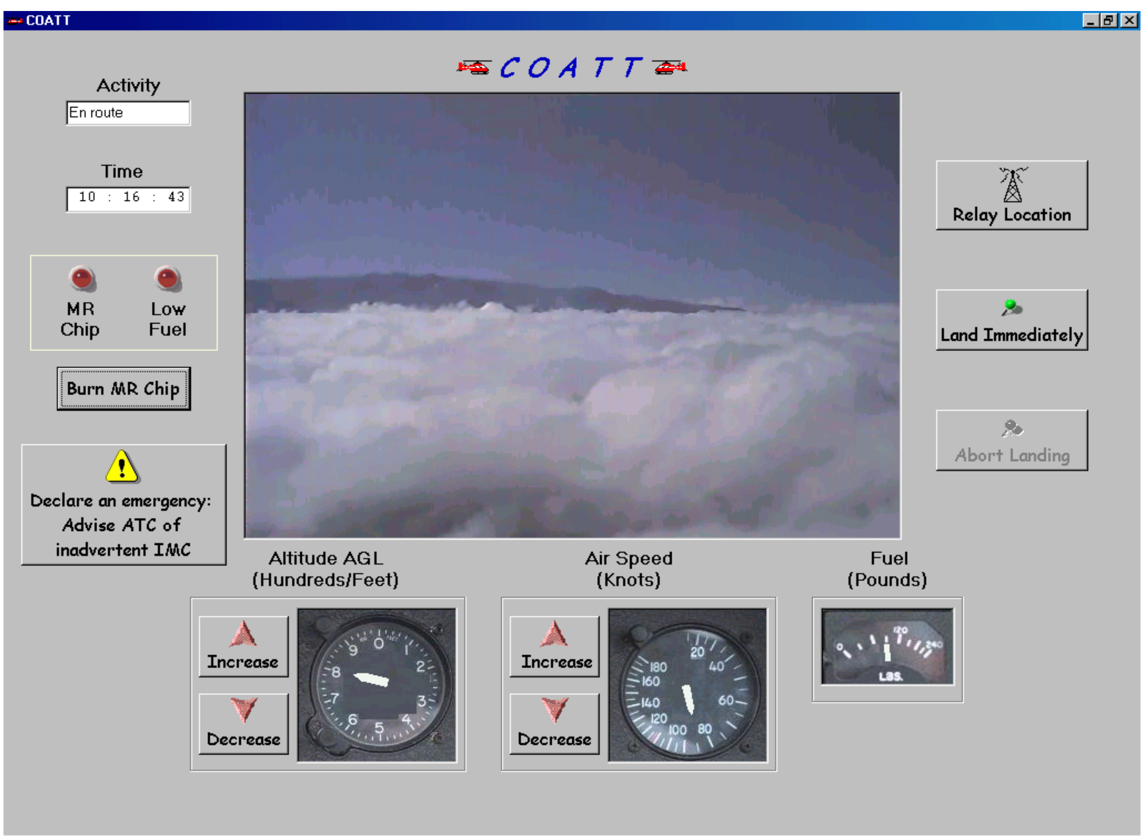

Figure 2. The main display used in COATT.

external COM compliant software for the GUI development.

Features of COATT

Decisions. At certain points during a simulated mission, pilots are presented with decisions they have to make before they can continue. For example, at the beginning of a mission, pilots are presented with the current weather conditions and the emergency call that has been placed to dispatch. At that point, the user has to decide whether to ask for more information (e.g., more extensive weather briefs) and then whether to accept the mission. At first glance it might make sense to ask for as much additional information as possible before accepting/declining a mission. However, if the user takes too much time waiting for and processing the additional information, there is a greater risk to the patient and/or the weather getting worse. The purpose of this tool is to make pilots think about their decisions, the different options available to them, and the tradeoffs that have to be made for each. It is important that COATT does not have obvious answers to the problems and decisions. More than one option needs to be viable at every decision point and/or more than one answer may be "right" at any point. In the example above, pilots have to balance the need to leave quickly with the need to plan. An important aspect of this tool is to make the tradeoffs of different options apparent so that the pilot thinks about the decision s/he is making. Also, the decisions pilots are asked to make and the options have to be consistent with their training.

At points throughout the mission, pilots are presented with an update of their situation. At these points, they are given different options, such as:

- Continuing the mission
- Aborting the mission and returning to base
- Taking an alternate route
- Landing immediately.

To make the COA decision-making process more realistic, some of the decisions are time critical. When a decision is time critical, some options may go away after a certain amount of time. For instance, if the user takes too much time in making a decision, the helicopter may be so far into bad weather that the option to abort the mission and return to base may no longer be valid. To simulate this situation, COATT disables that option after a period of time.

It is important that this tool not be predictable so that the pilots are not always sure of the flow of events that will occur. Again, because certain conditions in the simulation are controlled by the stochastic nature of the Micro Saint model, a user could be presented with the same initial conditions and make the same decisions at each point throughout a mission, and still end up with different results.

Equipment failures. Several different helicopter equipment failures can occur while a user runs a simulated mission. These include communication/radio problems, a faulty low fuel light indicator, and a faulty transmission. The probabilities of equipment failures occurring in COATT are higher than in the real world to give pilots practice in handling rare failures and problems. Ultimately, COATT will have a family of scenarios with different conditions and equipment failures that can occur.

Speed/altitude. Aside from taking off and landing (which the simulator controls), pilots have continuous control over the altitude and speed of the helicopter. This is one way to force the user to maintain their attention on the tool. Also, pilots do not have to wait for a decision point to be offered before they make speed and altitude decisions. Allowing pilots to control the altitude and speed of the helicopter provides the opportunity to show the importance of slowing down and prioritizing workload. Many pilots do not slow down to buy themselves time during stressful conditions. In COATT, this action is emphasized by increasing the probability of a crash when a user is flying too fast under poor conditions.

Communications. As a way of increasing workload for the user and making the simulation more realistic, intra-crew and inter-crew communications are used in COATT. This includes audio clips of nurses warning the user of potentially dangerous power lines or trees, nurses questioning the user as to whether it is safe to continue the mission based on the weather, and weather reports from ATC. There is also a "Relay Coordinates" button that the user is required to use to report his/her location to ATC and/or dispatch.

Playback. Another function included in the tool is a replay option. This option allows pilots to step through a completed scenario and discuss it with their instructors or other pilots. It also allows them to visualize their decision path throughout a mission and determine where they might have made mistakes. This in turn can help them start to reorganize the way in which they think. Once a simulation is over in COATT, pilots have the choice to save the simulation they just ran. Then, when COATT is restarted, pilots can simulate a mission under different scenarios (e.g., a mountain rescue or a water rescue) or replay a previously saved mission.

FEEDBACK

The positive effects of feedback during training on subsequent performance have been replicated in numerous studies. And, the research has shown that feedback is most effective when it is specific and immediately follows performance on a task. For example, Wigton, Poses, Collins, and Cebul [6] examined the effects of using computer-simulated patients to improve the diagnostic accuracy of medical students. Students were given feedback on their decisions after reviewing "patients" at one, three, and six-month training intervals. The results showed that the students' diagnostic accuracy increased as the training progressed and that the performance increase was due to the feedback the students received during training. Additionally, Wickens [7] suggests two training aids to provide a decision-maker to improve their performance. The first is to make decision-makers aware of the biases people tend to have when making decisions. The second training aid is to provide more comprehensive and immediate feedback so that decision-makers are forced to examine the effects of their decision rules.

Feedback is provided by COATT to offer users a review and critique of the decisions they made during the mission and different courses of action they might have chosen to improve the safety of the mission. This feedback was developed to be consistent with the training that pilots receive and consistent with what is known about the types of scenarios and accidents that are used in COATT.

As a user progresses through a simulated mission, COATT keeps track of the changing weather conditions, the stochastic branches and paths parsed by the Micro Saint model, and the pilot COA decisions that are made. Once the simulation is over, the user is immediately presented with an online summary of the scenario, the decisions he/she made throughout the scenario, the amount of time the user took to make each decision, and the overall success of the mission. The risk factor of each decision made is also provided along with different courses of action the user might have taken.

FORMATIVE EVALUATION PROCESS

There will be several iterations of testing, evaluation and revision prior to making the COATT tool generally available to helicopter companies and organizations for training. The first test and evaluation step is a complete software verification.

The next phase is to evaluate whether the product accurately presents the mission scenario that was developed and that it meets with the robustness criteria that were determined for the project. These criteria are:

- The answers to the problems and decisions are not always obvious
- More than one viable course of action is available at each pilot decision point
- The trade-offs between different options should be apparent
- The decisions the pilots are asked to make are consistent with their training
- A user can execute a mission scenario multiple times and be presented with different conditions and events
- A user can select the same course of action for identical conditions and experience differing results.

During this step, the completeness and correctness of the mission scenario will also be evaluated. Any technically incorrect or missing aspects of any portion of the product will be revised before conducting the next step of evaluation.

After the project team completes their evaluation of COATT and the required revisions have been made, the application will be presented to the same pilots who were interviewed in the scenario development process. The pilots will be asked to review the tool for technical accuracy, robustness, and their perceived training effectiveness. Pilot comments will then be used to make additional revisions to the COATT application. The beta testing and product evaluation and revision process is currently scheduled for completion by the fall of 2000.

The final formative evaluation step will be to include COATT in a real training curriculum on a trial basis. This trial will not replace any existing training but will augment the training that the pilots usually receive. After the COATT application has been used in the real training setting, both the instructor and the student pilots will be interviewed to assess the perceived training effectiveness and to identify any improvements or enhancements to the tool. After the training field trial has been completed and all identified revisions have been made, the COATT application will be made generally available to other helicopter companies and organizations for use in their training programs.

FUTURE PLANS

The current project plan is to develop one EMS mission scenario. If this scenario is successful in its effectiveness and acceptance as a training tool by the EMS community, the project team will seek out funding for the development of additional EMS mission scenarios to give EMS pilots practice in making a wider variety of critical decisions. Another plan is to develop scenarios for other categories of helicopter missions such as off-shore oil rig missions, logging missions, and missions for the vacation tour industry. Again, if the usefulness and popularity warrants it, a plan to make COATT available as a world wide web application would make the tool easily accessible to a wider group of users. As any of the mission scenarios for COATT are fielded, the project team will continually assess the effectiveness of the tool and solicit ideas for techniques to improve the realism of the decision making simulator.

CONCLUSIONS

The COATT application represents an innovative approach for giving helicopter pilots practice in making critical decisions during typical mission scenarios. The current project has established that the concept of using an interactive discrete event simulation combined with multi-media presentation is technically viable and relatively low cost as compared to other types of man-in-the-loop simulators. The concept has also generated some initial enthusiasm from helicopter pilots and training professionals. As the project moves into formative evaluation and field testing it is also hoped that the COATT tool will prove to be effective in providing pilots essential practice in making critical decisions in a non-risk environment.

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