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From: General Aviation Human Factors Program Manager, ATO-P R&D HF
To: General Aviation Human Factors TCRG, (POC: Mike Brown, AFS-800)
Subj: Enhanced General Aviation Decision Making Through On-Line Training and A
CFI Resource Library Execution Plan
Ref: (a) FY04 GA TCRG "FAA/Industry Training Standards (FITS)" requirement

1. Requirement Background: In the general aviation (GA) environment, pilots fly in uncertain situations that can include a range of meteorological phenomenon. Pre-flight and in-flight decisions about a course of action are made by the pilot based on a complex integration of piloting experience, weather information from a range of sources, the need to reach a destination, time pressure, personal attitude, human psychological tendencies, etc. Inadequate pilot decision-making is strongly linked to aviation accidents.

Training aeronautical decision-making skills is a difficult challenge. Traditional training is based on decades-old decision-making theory that was founded on research predominantly done in laboratories using isolated decision tasks. It is now known that these theories do not reflect decision-making behavior in natural settings. Current GA pilot training is primarily based on this outdated theory as well as anecdotal evidence. More recent research completed in field settings holds important implications for improved training. The purpose of this project is to develop interactive, dynamic WEB-based aeronautical decision-making training products based on current theory and published empirical research.

Because these training solutions are needed as soon as practical, this project will use only existing published research in problem solving, planning, decision making and judgment, situational awareness, training techniques, expertise development, stress management, and training-the-trainer. These processes can be indistinguishable during the decision making process and training must include a delicate balance of their impact.

How decisions will be altered with advancements in GA cockpit technology is unknown. To fly in Technically Advanced Aircraft (TAA) raises many new issues for the GA pilot. Due to TAA's speed and longer range (distance traveled),

pilots can encounter more weather systems. In addition, there are more items to manage in the cockpit.

One recurring issue for GA pilots flying either Technically Advanced Aircraft (TAA) or a traditional six-pack involves weather-related decision-making and problem solving in the operational environment. Accident and incident reports show recurring patterns of novice and expert pilots making poor risk assessments and sometimes fatal decisions to fly into adverse weather.

2. Study's Approach: Use general principles of Aeronautical Decision Making (ADM) to develop a web-based training product using weather decision-making as an illustrator. The goal is to accelerate weather related decision skill-development. Decision-making skills are based on experience and training. To train enhanced ADM, the issue can be more precisely defined as how to develop and use experiences with only a brief amount of practice. Expertise requires experience in the field setting and decision-making training does not generalize to dissimilar situations, therefore the context of the training will take place within rich, realistic scenarios including such factors as time pressure, dynamic conditions, and uncertainty. To avoid duplication, the project will complement and enhance ongoing work to ensure that this project does not result in a separate (and possibly conflicting) aeronautical decision making (ADM) web-based training product. The unique contribution of this project will focus on building four areas known to be linked to expert versus novice decisions; recognizing typicality and therefore anomalies, mentally simulating a course of action, prioritizing cues, and developing expectancies. At the request of the sponsor, the project will concentrate on weather phenomenon that occurs in the Northeast region of the United States.
3. Collaboration: This study is in collaboration with the NASA Aviation Safety and Security Program who will contribute at least fifty percent of the costs. While the FAA has asked that the focus be on weather related decision-making, NASA has requested training in traffic avoidance. Scenarios will include both of these issues.
4. Deliverables:
 - a. First product will be an interactive, validated framework for training enhanced judgment and decision making (D-M) to pilots. This tool could be extended to enhance decision-making with other aeronautical experts such as dispatchers, controllers, and Aviation Safety Inspectors. They could gain a better understanding of the complexity of the decision-making environment that the pilot faces.
 - b. Second product will be a web-based training tool to assist Certified Flight Instructors (CFIs) to better teach effective and adaptive decision making to today's pilots. The CFI Resource Library will consist of a library of human factors issues involved in current pilot weather related judgment. CFIs can either take the course or pull immediately pertinent articles from

the shelf to brush-up on how to train students with particular needs. Optimally, the CFI Resource Library would be developed simultaneously with the Pilot's Enhanced Decision Making product. However, limited manpower defined by budgetary boundaries requires that they be developed sequentially.

- c. Quarterly (December, March, June, September) research progress status reports: Informal e-mail reports from the program manager aviation maintenance human factors to General Aviation Human Factors TCRG.
- d. Annual Report: Grantee will submit an annual report.
- e. Program Review: Grantee will participate in the annual program review.

5. AFS-800 Responsibility

- a. Identify AFS-800 FITS point of contact who will serve as AFS-800 representative between the researcher and ATO-P R&D HF for this project.
- b. Make available personnel and resources to investigator
- c. Implement project deliverable into the FITS program

6. Schedule

- Monthly telephone meetings will be conducted between the investigator, ATO-P R&D HF representative, and AFS-800 FITS team representatives. The purpose of the telephone meetings will be to monitor the project's progress and to obtain sponsor feedback.
- The researcher will present three times the status of the project to ATO-P R&D HF and AFS-800 FITS representatives. Unless directed by ATO-P R&D HF, primary location of meeting location will be FAA headquarters.
- Table 1 presents a detailed schedule of deliverables for two web-based training products. The Product Team, consisting of domain experts including ATO-P R&D HF, ASF-800, and NASA will be involved throughout product development. Reviews by the team and quarterly/yearly reporting requirements are shown in blue within the Table. Software modules are highlighted by the use of italics. Each module will focus on a cluster of skills.

Table 1. Deliverables and delivery schedule for the web-based tool for enhancing GA pilot decision-making (reporting requirements shown in blue; software modules in italics)

Milestone	PLANNED COMPLETION DATE
Enhanced Decision Making Web-Based Training tool	Mo/Yr
<u>Product Team Kickoff: AAR-100 & ASF-800:</u>	11/04
Foundational Research: Decision making, WEB-based tools, Training strategies, Risk Perception, ASRS incident and NTSB accident statistics, current pilot training tools, transition issues, etc.	10/04-8/05

Product Team Review: AAR-100 & ASF-800:	2/05
Validation Strategy Defined	2/05
Quarterly Report	3/05
Preliminary training tool definition and philosophy	5/05
Narrative outline for “A Pilot’s Guide...”	6/05
Quarterly Report	6/05
Flowchart with software engineer (cue insertion id)	7/05
<i>Scenario Development Software</i>	8/09
White paper to be published in “A Pilots Guide to Preflight Planning” providing a practical application to research material toward the development of the decision training tool and Yearly Report	8/05
<i>Pilot Level Of Knowledge Assessment</i>	9/05
Product Team Review	9/05
<i>TAA-Specific Knowledge Module</i>	10/05
<i>Flying Assistant: Low-res cockpit developed</i>	12/05
Product Team Review	11/05
Quarterly Report	12/05
<i>VFR Pilot Instrument Training Module</i>	1/06
<i>Resource Management Training Module</i>	3/06
Quarterly Report	3/06
Product Team Review	4/06
<i>Weather Training Module</i>	6/06
<i>Self/Situation/Positional Monitoring Module</i>	7/06
Quarterly Report	7/06
<i>Risk Perception Module</i>	8/06
<i>Pilot/software Interactive Capabilities</i>	9/06
Product Team Review	9/06
<i>Regulations Module</i>	10/06
Yearly Report	10/06
<i>Final Skill and Expertise Module</i>	12/06
Quarterly Report	1/07
White paper (potentially to be published in the Pilot’s Handbook of Aeronautical Knowledge) that teaches – in words – enhanced and adaptive decision-making	2/07
Quarterly Report	4/07
A narrative describing a simulation for overall validity of the WEB-based training tool for GA pilots.	5/07
ENHANCED DECISION MAKING WEB-BASED TOOL GOES ON-LINE	6/07

The writing of an Advisory Circular to inform today's pilots about the enhanced decision making publication and WEB-based training tool.	7/07
Quarterly Report	7/07

A Preliminary Glimpse at the Pilot Training Tool:

Product Development: The project begins with research into recent, relevant cognitive psychological literature, a critique of current pilot training strategies and tools, and a synopsis of recent GA accident and incident reports.

Pre-Training: The current level of expertise will be assessed with a set of preliminary questions.

Training: There will be a library of scenarios developed. Training will involve one or more cross-country flights so that the richness and complexity of actual flight can be captured. The pilot will fly a low-resolution "flight assistant" similar to that seen in available on-line courseware. The difficulty of the flight will be determined by the initial assessment of the pilot's capabilities during Pre-Training. The training will focus around specific types of strategic and tactical decisions and what variables make these decisions difficult. The cross-country flight will contain multiple critical decision points that are based on accident and incident reports and interviews with expert pilots.

During the cross-country flight the behavior and questions asked by the student pilot will be monitored. To know what "question" the pilot is asking, the display will contain icons for weather products, a maintenance log, required charts for VFR or IFR flights, weight and balance, avionics (for communications and navigation) and a generic student's log book. If the student wishes to review the weather forecast, for example, he can "click" on the weather products that he obtained during the pre-flight.

The typical behavior of a group of experts will be used to define expert behavior within each scenario. If the student does not recognize a cue when the average expert has been shown to recognize it, then the student will be prompted and the program will shift to a lesson about what the cue is, why it is relevant, and what to look for in that and similar situations. For example, if the scenario demonstrates a pilot encountering unforecasted weather such as a coastal marine layer or air mass thunderstorm at their destination airport, then the pilot should take action on acquiring appropriate information to amend their route of flight (e.g., requesting PIREPS and querying ATC or FSS about where other aircraft are diverting, then acquiring weather reports for those alternate destinations). Another example could tap into how a novice could underestimate the insidious nature of icing conditions. Suppose the scenario has the student pilot flying in actual meteorological conditions. The temperature is 3 deg C. The pilot notices that the airspeed has decreased by 7 knots for the given power-setting. This should be a powerful cue to the pilot that they are accumulating ice. The wings are shiny but it is very difficult to see any ice accumulation (clear ice). If he does not call ATC to request a PIREP for the area and consider an altitude change, then the program will prompt him to do so, explain why, and provide a lesson about ice types.

Depending on the decision to be made, the lessons could include:

- what to expect or what is typical when a situation such as this is encountered,
- what types of strategies are used by more experienced pilots,
- why one strategy works whereas another is not adequate,
- how to prioritize the current set of tasks to reduce workload,
- how to manage attentional resources in order to gather relevant and valuable information at appropriate times,
- how to mentally simulate a course of action to evaluate and diagnosis the situation and to imagine an outcome,
- how attitudes about schedule can affect decisions,
- during pre-flight, the decision requirements for this flight and how to identify weaknesses in the flight plan before take-off,
- why this decision is difficult,
- how to handle the stress of uncertainty, and
- examples or statistics behind cases where pilots have ignored the relevant cues.

The format of the lesson may involve graphics, animation, a hangar story, an ASRS report, or a traditional classroom mini-lecture depending on the best format for teaching the content of what is to be learned.

Post-Training: Although many training tools test the student’s knowledge using multiple-choice questions, typically the testing situation does not use current research about how to test knowledge. Three examples follow. In one product the questions are posed in “open book test” format. Rather than test the pilot’s deep knowledge, at any time, the student pilot can access the answer. In another product, it is assumed that the student has learned the material and is never actually put to the test. In a third available product, the questions asked are superficial and do not test the in-depth understanding that a pilot requires for safe flying.

Here we will provide a final Post-Training scenario that will be defined by the student’s skill level. The student pilot will be asked to fly a dynamic cross-country flight using the “flight assistant”. Decision points will be monitored and scored. For some decisions, to simulate time pressure, there will be a counter that will influence the final score achieved by the student. Therefore, at the end of the scenario, the student will have a skill level and a total score, which, if it is a passing score, will be printed on a certificate of completion. Insurance companies can use this skill level and score to define discount packages. If the student wishes to increase his score or skill level, he may undergo further training and then fly another post training scenario.

Training retention: Over the course of the following 9 months, a subset of pilots will be tested on a novel cross-country flight either 3, 6, or 9 months after training to determine the retention time for the WEB-based training. These data can be used to determine the recurrent training requirements for the product. There is a milestone listed in Table 2 addressing this research.

Table 2. Deliverables and Delivery Schedule for the CFI Decision Making Training Resource Library (reporting requirements shown in blue; software modules in italics)

Milestone	PLANNED COMPLETION DATE
CFI Decision Making Training Resource Library	
<i>Module: Train how to ID and utilize the student's current level of knowledge to enhance training</i>	8/07
<i>Module: How to teach decision making specifically for TAA</i>	9/07
Yearly Report	9/07
<i>Module: Teaching enhanced VFR instrumentation</i>	10/07
Product Team Review	11/07
Quarterly Report	12/07
<i>Module: Teaching resource management to GA pilots</i>	1/08
Recurrent Training Study (for pilot EDM WEB-based tool) Complete	3/08
Quarterly Report	3/08
Product Team Review	4/08
<i>Module: How to teach weather related decision making using current knowledge about human cognition</i>	6/08
Quarterly Report	6/08
<i>Module: Teaching Self/Situation/Positional Monitoring</i>	7/08
<i>Module: Effective methods to teach realistic risk perception</i>	9/08
Yearly Report	10/08
<i>Module: Proper debriefing techniques</i>	11/08
Product Team Review	11/08
A white paper (potentially being published in the Aviation Instructor's Handbook) linking current knowledge about human learning and memory and how this knowledge can be used by present day CFIs to improve instructing techniques.	3/09
<i>Final skill and expertise module for CFIs</i>	4/09
Validity of the WEB-based training tool for CFIs determined	8/09
INSTRUCTOR RESOURCE LIBRARY GOES ONLINE	9/09
Final Report	10/09

A Preliminary Glimpse at the CFI Training Resource Library (RL):

Table 2 presents the schedule for development of the CFI Resource Library.

People learn by taking new information and interpreting it in light of their existing knowledge and experiences. The flight instructor is critical to this process. To enhance and accelerate learning beyond the above web-based training tool we will identify those components of the process that offer the most benefit for instructor improvement.

For example, when a student is first learning to fly, he develops schema, or organized representations, of the concepts he is learning. As facts are learned, related concepts are linked together in memory. As expertise builds, clusters of concepts are linked to other clusters, the mental organization becomes more complex. If the instructor is aware of this progression toward expertise, he can accelerate it by linking related concepts during training (and teach the student to mentally conceive of potential relationships) that typically occur in the domain. The instructor can help to change an initially fragmented representation of the decision task in the novice into terms of interconnections between task components. For example, if the task is to land the aircraft in icing conditions, then the instructor can take the traditionally segregated training of no flaps landing, icing, and stalls and show the student how to integrate the information for a safe landing in these conditions.

Because the web-based pilot decision making training tool cannot anticipate all contextual variables presented during flight or simulator training, the CFI is necessary to take the student's state of knowledge into account. The instructor can see the specific surface characteristics and irrelevant details that are influencing, and inhibiting, the successful decision process in the novice student. The CFI Resource Library can provide enhanced training for the instructor toward identifying these variables and provide the CFI with strategies to accelerate expert decisions in the student pilot.

The CFI Resource Library will also provide the instructor with clear assessment criteria. Currently, there are large individual differences in the strategies used by instructors to evaluate a student's skill. The Resource Library will provide an initial path toward standardized assessment of decision-making skills.