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In-Flight Icing Training for Pilots Using Multimedia Technology

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Abstract

Over the last five years, the Aircraft Icing Project of the NASA Aviation Safety Program has developed a number of in-flight icing education and training aids to support increased awareness for pilots of the hazards associated with atmospheric icing conditions. Through the development of this work, a number of new instructional design approaches and media delivery methods have been introduced to enhance the learning experience, expand user interactivity and participation, and, hopefully, increase the learner retention rates. The goal of using these multi-media techniques is to increase the effectiveness of the training materials. This paper will describe the mutlimedia technology that has been introduced and give examples of how it was used.

Background

The National Aeronautics and Space Administration (NASA) has adapted and implemented the use of multi-media technologies to increase effectiveness in their in-flight icing education and training aids. NASA's Aviation Safety Program, Aircraft Icing Project, Education and Training Element is charged with: providing educational and training materials on in-flight icing to pilots and dispatchers, and to work with pilot trade organizations, safety foundations, and airline operators to develop icing education and training materials that will improve safe operations in atmospheric icing, implement the widest possible distribution of the materials, and examine the use of these and new training delivery methods to improve learner retention.

The training materials use multimedia delivery platforms that include video and Digital Versatile Disc (DVD), computer-based training (CBT) modules, on-line learning, lecture series with pilot and subject matter experts, and combinations thereof.

In the construction of these products, it is important to not only determine and deliver the information relevant to the pilot audience, but to understand the most effective way to present information so that it will be assimilated and used by the target audience.

Effective Engagement Approaches

The pilot testimonial has proven to be a very effective means to gain a pilot's attention and convey operational information. A video clip of a pilot describing the cues of an icing encounter, the aircraft's response and recovery procedures resonates with other pilots. These lessons carry even greater import and credibility when delivered by an experienced, expert-level pilot, often identified and endorsed through either NASA, military, or senior airline pilot-in-command status (Figure 1). This technique was often used to emphasize key points and introduce major sections. Through prototype evaluations and feedback from viewers, the experienced/expert pilot carries a mantle of respect and authority in terms of believability that other on-camera figures do not command.

Figure 1. NASA Chief Pilot Bill Rieke giving expert advice.

Visual storytelling is an essential technique used to teach pilots about the details of in-flight icing. Video or still images of ice accretion on the wing and other aircraft surfaces obtained during icing research flights and icing wind tunnel testing can provide a "virtual experience" for the viewer. These images, particularly the first signs of ice, show the pilot what to look for should they fly in atmospheric conditions conducive to icing. With the aid of close-up, time-lapse, and high speed photography, sequences of images can relay the nature of how ice starts to form, the ice-growth process, and the kinds of ice features that result based on atmospheric conditions and aircraft configuration. These visual sequences can then offer a reference for comparison in real life icing conditions to help determine characteristic information about a current icing event. This kind of imagery can also be used to offer lessons about where to look for the onset of icing, what visual cues may be expected, and important features about ice type and severity. This can increase general knowledge and provide a pre-exposure to hazards, thus enhancing good decision-making.

NASA has recorded video footage of yarn tufts attached to the lower surface of a turboprop aircraft tailplane. With artificial ice on the tailplane leading edge surface to represent a failed pneumatic boot, the aircraft was exercised through a series of maneuvers to examine handling quality changes versus aircraft configuration. Using a camera to record the events, the tufting technique provided information about the air flow-field characteristics. As the tailplane entered a stall, the tufts pointed upstream, indicating separated flow and, eventually, full stall behavior (Figure 2). In addition, video cameras located in the flight deck captured pilot actions and the transition from sky to ground as the aircraft suddenly pitched down. The pilots immediately responded to recover the aircraft. This visual story of the change in flow over the tailplane surface and the attendant aircraft response at stall provide a compelling lesson about the hazards of ice-contaminated tailplane stall. The actions the pilots took to recover the aircraft re-enforce the differing recovery techniques between a tail stall and a wing stall. They require nearly the opposite actions, with potentially severe consequences if incorrectly diagnosed. This video footage provides a pictorial story of a tail stall event that has had tremendous impact in giving pilots a visual lesson that words could not deliver.

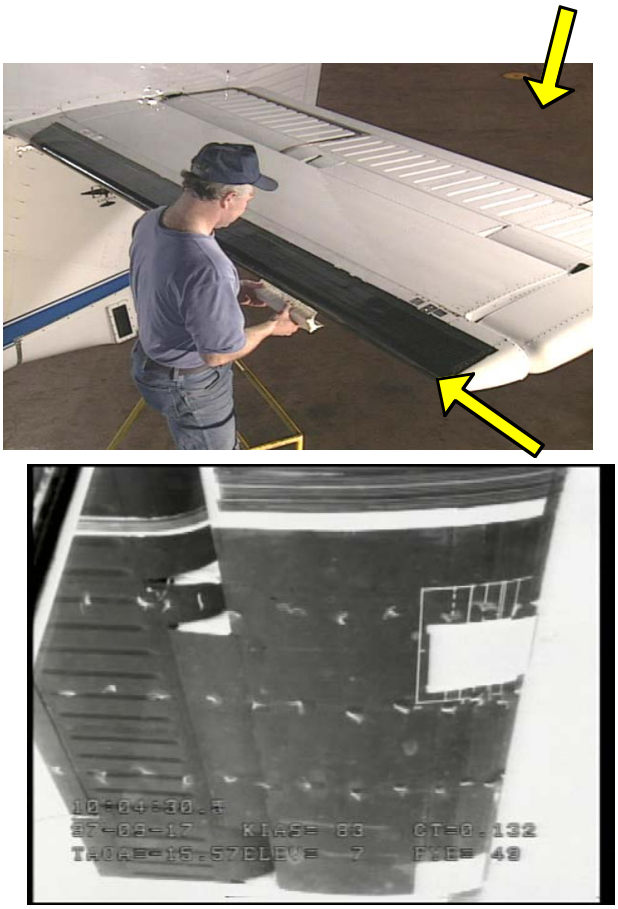


Figure 2. Top: Technician applying artificial ice shape to the leading edge of the tailplane. Bottom: Flow reversal as the ice-contaminated tail becomes fully stalled.

In addition, well-constructed animation and graphics can quickly and accurately illustrate complex topics in a fairly simple manner, e.g., a dynamic flight event, the effects ice accretion on lift and drag, or even engineering data. This media technique allows the presentation of technical information that is the basis of why physical events are happening and transforms the lesson into a better understanding of the phenomena. The video and CBT products use a collection of animations, two examples are: to explain general aerodynamic principles of an ice-contaminated airfoil (Figure 3) and the relative size of supercooled large droplets compared to those required for certification (Figure 4). Graphics are used to illustrate many ideas through a single image

that captures the essence of the technical issue through a simple visual story.

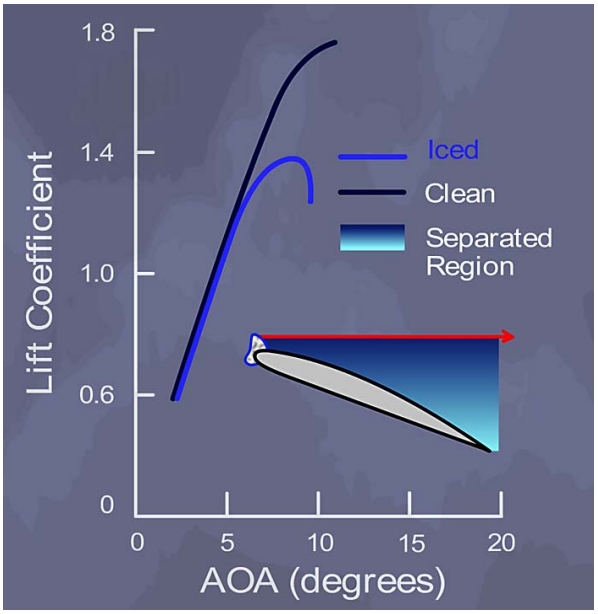


Figure 3. Still from animation illustrating that an ice-contaminated airfoil stalls at a lower angle of attack.

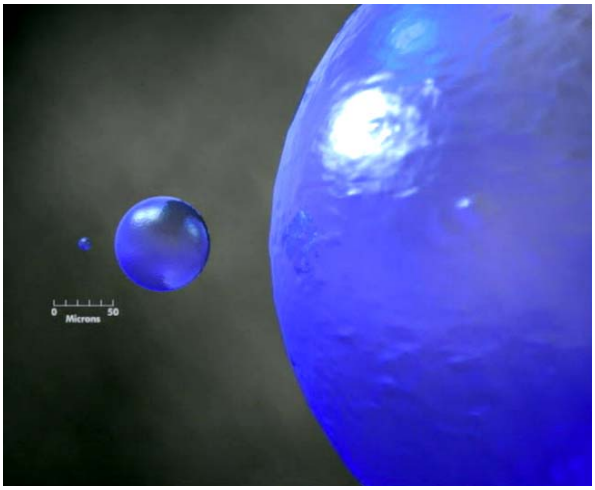


Figure 4. Still from an animation showing the relative drop size between one required for certification (left), freezing drizzle (middle) and freezing rain.

Media Delivery Formats

NASA has used the above multimedia presentation methods in all of its icing training aids. To date, these aids include[3]:

TV-based Media

- *Tailplane Icing*
- *Icing for Regional and Corporate Pilots*
- *Icing for General Aviation Pilots*

Computer-based Media

- *In-Flight Icing, Instructor-Led Version*
- *A Pilot's Guide to In-Flight Icing, Self-Paced Training Aid*

These methods continually simplify and communicate complicated technical issues and concepts into easier-to-understand lesson segments.

TV-based Media

NASA recently completed a new TV-based training product using a scenario-based presentation format instead of the lecture-based style of its first two videos, *Tailplane Icing* and *Icing for Regional and Corporate Pilots*. In *Icing for General Aviation Pilots*, routine, real-life flight situations were presented as a means to guide the learner through the icing-related content (Figure 5). The pilot–passenger dialog carried the lesson through the appropriate decision-making responses with explanations for each action. This technique of situation-based role-modeling was used to create the story in each phase of flight. The technique was enhanced by providing scripted dialogue from FAA Air Traffic Controllers who used past real-life experiences to relay the imminent impression of real circumstances to the pilots and passengers. This was a very engaging technique that was readily adaptable to the scenario-based method. The scenario-based method did require a thorough mapping of the delivery strategy and transitional shots that kept the viewer on-track for the scenes that were watching.

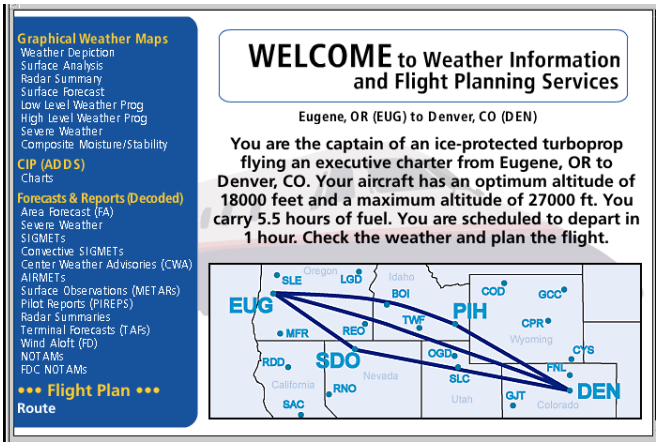
The Aircraft Operators and Pilots Association (AOPA) Air Safety Foundation, who helped in the initial development of this video, had found from previous training media development experience that general aviation pilots more readily assimilated the lesson information if it was presented in this manner.

Figure 5. Scenes capturing Pilot/ATC interaction.

Computer-based Media

Computer-based training methods allow an interactive learning environment, instead of passively watching a video. The interactive features and modular design allow the user to personalize their learning plan: track current and completed lessons, provide end-of-chapter and overall evaluations, with linkage to additional information to support enhanced learning, and customize the syllabus. The instructional design options range from slightly intelligent interfaces to very complex, layered, lesson architectures. NASA worked with instructional design experts at the University of Oregon Cognitive Sciences Department to develop the former as a first attempt to create a new learning method for in-flight icing training[1].

In addition, exercises can be constructed that mentally place the pilot in a situation, ask operational decisions, receive responses, and provide immediate feedback. For example, in *A Pilot's Guide to In-Flight Icing*, a preflight exercise identified a mission and asked the student to determine optimal route and altitude. All the information from a standard weather briefing (duats) was available (Figure 6). If the student does not develop a flight plan to avoid the icing hazard, he/she is directed to the weather briefing section where suggestions are offered on how to sift through all the weather briefing data. In an Emergency Operations exercise, the user's aircraft is iced up and on final approach. Visual, instrument and handling cues are illustrated. The student is asked to evaluate whether he/she is experiencing a wing or tail stall, and what the correct actions for recovery are. Once a response is given, feedback identifies the correct answers and why. These new approaches allow the learner a much more significant role in the actual lesson development and more opportunity to take the training materials and use them in problem-solving situations.



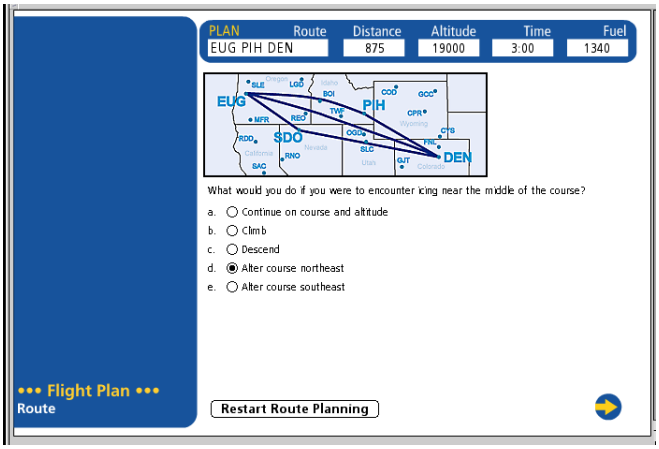


Figure 6. Preflight exercise example screens from *A Pilot's Guide to In-Flight Icing*.

Finally, interactive simulators and demonstrators are built-in throughout the CBT. These allow the user to interactively explore or apply the lesson just presented by immediately using the new information in an interactive task. This technique complements the lesson plan by re-enforcing the newly acquired materials.

Future Directions

NASA has defined a series of near term in-flight icing training products using both TV-based and CBT media methods[2]. The computer-based training will transition from CD-ROM to web-based learning where new partnerships with academic institutions and training academies will create a distance learning format to ensure that future training aids are suited to meet the needs of new learning environments. On-line, web-based learning will grow and provide much wider access to this icing content and serve the pilot audiences in on-demand formats that provide both organized and controlled curricula and user-defined lesson planning. The delivery of multimedia techniques highlighted in this paper will continue to be the cornerstones of learning that captivate the learner and keep them engaged.

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1. Mauro, Robert & Barshi, Immanuel, "Training Smart: Using Principles of Cognitive Science in Aeronautical Education and Training", AIAA-2003-0020, Jan. 2003.
2. Van Zante, Judith Foss and Bond, Thomas H. "Overview of NASA's In-Flight Icing Education and Training for Pilots", AIAA-2003-0018, Jan. 2003.
3. Information on available products can be found at http://icebox.grc.nasa.gov/ext/education

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