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ABSTRACT

Emergencies that lead to ejection and egress parachuting are dynamic, highly stressful and dangerous events. They require rapid application of skills taught long before. Virtual Reality (VR) parachute simulation training has become a widespread and accepted standard in U.S. and foreign, Navy and Air Force Aviation Physiology, Survival, and Life Support training [1]. As the process of supporting evaluation studies, making installations, and interacting with training personnel has progressed, a number of observations and suggestions have been made and incorporated, resulting in a more complete training capability. The trainee now can be fully equipped with, and required to utilize helmet, visor, oxygen mask, and other equipment, including manual, AAD (Automatic Activation Device), and Oxygen release handles [2] for egress situations as shown in Figure 1. Thus the trainee now can actively participate in a dynamic VR experience that produces many of the same sensory and procedural demands as might be experienced in a real emergency [3]. Results of correct or incorrect actions are automatically displayed and scored, and a number of other program features are provided to facilitate instructor to student critique.

This paper discusses typical lesson plans and plans of instruction for teaching aircrew appropriate responses to parachuting emergency situations, and shows how these plans address training requirements using relatively low cost, simple, and robust VR simulation equipment, designed for easy operation and minimal maintenance by training personnel.

INTRODUCTION

The motivation for teaching parachute emergency procedures with a flight simulator reflects the well established military answer to a need to safely and inexpensively develop proficiency in a detailed and critical sequence of actions and skills. Real life parachute training is far too costly and dangerous to be required for aircrew personnel.

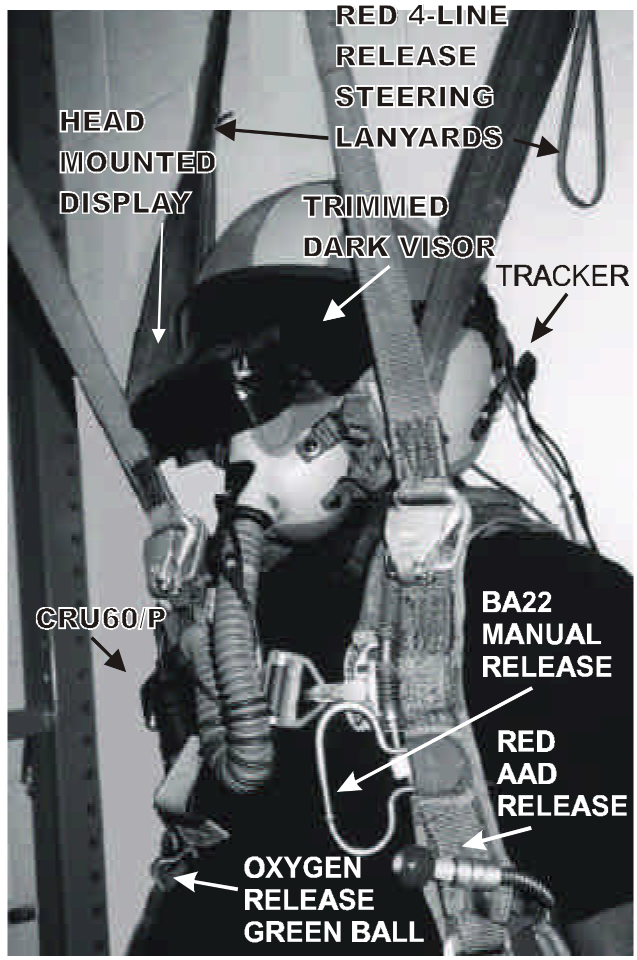

Figure 1. BA22 Parachute Harness with Egress Ripcords, and Single Visor Helmet with VR HMD and Head Tracker

Historically, these essential, although hopefully infrequent, actions and procedures have been rehearsed while hanging in a parachute harness. Trainees were required to pretend that they were under a canopy, and display actions without seeing timely correct results.

The training device described here was originally developed for USDA Forest Service (FS) smokejumpers [4] (civilian fire fighters operating round parachutes) to establish smooth basic parachute flight (canopy control) skills in extremely difficult conditions, but was soon adapted for aircrew emergency training [5], where accident investigations revealed that better training was essential. Aircrew may be in a far more trying situation than smokejumpers, since emergencies can occur without regard to the daylight, weather, altitude, terrain, etc. (all simulation-available) restrictions placed on even smokejumpers. Moreover, emergency parachute openings are much more likely to malfunction due to opening at severe speeds and adverse jumper body positions. A quick and accurate response is essential; there is no reserve parachute. Simulator program enhancements were made to provide the instructor with the ability to address these problems[3], as well as teach other essential equipment procedures in the same integrated experience, better replicating typical mishap situations.

The pedagological task is then to schedule the presentation of various simulator-provided challenges in some structured fashion (lesson plan or plan of instruction) to optimally develop a useful positive transfer of skills training within the tight time limits of aircrew training. Some guidance in this respect may be derived from the body of education research into adult learning.

LESSONS FROM ADULT LEARNING THEORY

The parachute simulator provides a large number of ways to vary the trainee's learning experience. These variations have been developed [6] to address specific requirements for a number of applications, including aircrew training but also sport jumping, arcade and theme park entertainment, operational military training, and mission planning and rehearsal including GPS navigation. All share a common goal of providing a participant with a positive experience, and for trainees, with development of self-confidence and a positive transfer of training. Given these goals, but faced with numerous variation possibilities, one immediate question is how to set up and use the simulator to best teach an aircrew-particular student body.

Here the simulator is being applied as a teaching aid for professional adult students. A substantial body of research and literature has been developed on the topic of optimal approaches to teaching adults, and this can be examined for guidance. Adult learners have distinguishing characteristics that differentiate them from pre-adult learners [7]. Adults are successful because they are self-directed with greater critical thinking skills, even though characterized by limitations such as time constraints. Adult learning should capitalize on trainee experience, (i.e. pilot experience with smooth controls), be challenged with increasing skills, and provide interaction with instructor through critiques.

CONDITIONS OF LEARNING

Robert Gagne has developed a theory termed Conditions of Learning with a special focus on military training[9] and instructional technology [8]. He postulates five major categories; different types or levels of learning, each requiring different types of instruction. Gagne identifies categories in a hierarchy by complexity: verbal information, intellectual skills, cognitive strategies, motor skills and attitudes. Different internal and external conditions are necessary for each type of learning. This theory identifies the prerequisites for learning at each level, which can be identified by a task analysis. Learning hierarchies provide a basis for the sequencing of instruction. For example, for cognitive strategies to be learned, there must be a chance to practice developing new solutions to problems; to learn attitudes, the learner must be exposed to a credible role model or persuasive arguments.

A key concept for the parachute simulator is to appropriately pace the task difficulty, explaining and recalling the learning situation and objectives prior to starting a simulated jump, then eliciting performance, and providing and assessing resulting performance during and after the jump using the scoring and critique program options.

MILITARY TRAINING

Theories of adult learning [7] emphasize that learning though experiences are important to military training [9] because of the extensive interpersonal interaction involved. Decision-making and problem solving are fundamental to military tasks skills. As an example, this illustrates the importance of appropriate simulator initial altitude settings for demanding realistically-paced troubleshooting decisions and sensory-motor skills mastery [10]. While military parachuting tasks rely on critical facts and thus memory, actual proficiency in operational skills is vital. Because military tasks are well-defined, this has lent itself to the cost-effectiveness of the instructional simulator technology [11] incorporated in the parachute simulator.

TRAINING SYLLABUS GOALS

As the simulator training concept has been adopted by the military independently by various individual and command units, they have followed the standard implementation practice of proscribing its usage through Standard Operations Procedures Manuals [12], Instructor Guides [13] and Lesson Plans [14, 15]. The goal, as typically stated [13], of these procedures is to "recall skills and build confidence in the use of emergency parachute procedures". These procedures are quite extensive and vary in content depending on the particular method of emergency escape (ejection or egress), initial altitude, whether over water or land. Over land, specific terrain features (e.g. trees, wires, etc.) may require differing techniques to be mastered. Moreover, "wherever possible, students should see and practice parachute procedures in a logical sequence of events and in its entirety" [13]. The objective is not only to develop and sustain the skills to make the correct decisions and take the correct actions to respond to stimuli presented, but to accomplish all these tasks in the correct order; e.g., malfunctions need to be sensed and corrected before making a 4-line release.

AVAILABLE TRAINING TIME

Although it is not atypical to allocate one to one and a half hours to classroom presentations [16, 17] on post-ejection/bailout topics, typically only ten minutes [14] are scheduled for hanging harness VR parachute simulators. The expectation is that this very brief time allocation will be sufficient to accomplish at least two different simulations, with at least one canopy malfunction, for each aircrew. Two and one half minutes of actual simulator time are required for each run from a 3000 ft start altitude, with a C-9 parachute that starts with a low speed partial malfunction [3] such as a line over or partial inversion. The remaining five minutes will be required to get the trainee into the harness and supplied with pre-run and post-run briefings

SITUATIONAL CONTROLS FOR PRE-SIMULATION LEARNING EXPERIENCE

Prior to the start of a simulator training run, the value of the trainee's educational experience (and to some extent, comfort level) will be greatly advanced if a few moments are spent reviewing proper donning of full-up flight equipment including using flight gloves. Beyond just fitting the harness to avoid a painful experience, now it is possible to use a helmet-compatible Head-Mounted Display (HMD), oxygen mask attached to helmet and, CRU-60/P, to wear flight gloves to replicate the difficulty that they create, or to wear (if desired) the aircrew chemical defense ensemble (First Generation) and the Aircrew Eye Respiratory Protection System (AERPS), as shown in Figure 2.

It is critical to minimize the time the trainee spends encumbered with all this equipment and hanging in an always uncomfortable, at best, parachute harness without the distraction of the challenges of a simulated jump experience. Bearing this goal in mind, it is best if the instructor makes choices among the available simulation run conditions prior to having the trainee hook into and be suspended from the simulator.

The instructor can vary the training challenge simultaneously in a number of ways. Based on the prior discussion of adult learning, an attempt should be made to correlate the resulting combined difficulty with the trainee's existing knowledge and experience with emergency procedures and skills, and any previous simulator training. Variations can include: scenes/sites, malfunctions, winds, weather, time of day, spotting, initial altitude, and training aids.

Figure 2. AERPS Under HMD and Dual Visor Hemet with Head Tracker

Scenes/sites: selecting sites similar to local conditions can help trainees relate to the simulation (better face validity). Available simulator scenes include sites based on real world forest and desert training locations. They also include generic sites specifically developed to provide typical examples of possible scenes challenges. Scenes such those for Military Freefall School Yuma Arizona desert and the generic airport training drop zone scenes provide the minimal collision hazard levels desirable to reduce injuries in initial actual jumps. However, the resulting normal default student landing target locations are less than optimal for simulator training as they have few ground objects to supply visual cuing for height and depth perception. Alternative target selection is probably desirable for these areas.

Jump Partner: if one has been stored, it will provide motivation for the trainee to check the immediate vicinity for potential collisions after correcting parachute condition. The jump partner is only useful if the run from which it was stored closely matches the run with which it is used.

Weather and time of day/night - though these conditions may happen in a real mishap, their particular training value lies in enhancing the appearance of an actual jump and improving the trainee's ability to relate to it as such.

Malfunctions: these may occur somewhat infrequently but, emergency parachuting again occurs in more severe conditions than with operational parachuting and it is critical to include them in each simulation to establish the motivation for the trainee always to look up immediately and check canopy conditions overhead.

Winds: a wide variety are available, varying in magnitude and direction with altitude. While it is true, and it has already been pointed out that emergencies can occur in any winds, wind magnitudes stronger than the canopy forward velocity require skills in flying backwards, an overly difficult situation for the trainee to start with.

Spotting/challenges within a site: the instructor has the ability to start the trainee at various locations within a simulator scene in distances and directions expressed in wind axes. Used with appropriate winds, alternative target, and coaching, the trainee can be directed to make landing attempts at particular target locations that present challenges; setting up situations that will require specific landing procedures, such as in trees or power lines. Spotting far down or cross wind will require simple sustained trajectories (with little training value).

Altitude: the key is to start high enough to allow the trainee time to understand and react to the challenges presented but low enough to be somewhat timing demanding. This depends on what subjective and objective (have they watched or experienced a simulation before) experience the trainee has had. Certainly most runs should start at altitudes at or below 3000 ft AGL (Above Ground Level), unless a subject is presented with a streamer (high speed partial) malfunction. With one or more egression (bailout/ripcord) trainees, it is desirable to start one run at 25,000 ft. so that they will see blacking out, and the need to activate oxygen, arm the AAD and see it open the parachute below the set altitude. Once the parachute has opened and a malfunction has been corrected, the run should be cut short and restarted at a more normal training altitude.

Training aids (wind line, smoke, targets): The simulation will never be a perfect replication of the real situation; the real situation will be easier. To alleviate this disparity, trainee cueing needs to be supplemented visually with the available aids and by instructor coaching, both in pre-run as well as during run.

Instructors should briefly take time to "put the trainee in the scene", to gain some trainee acceptance, provide a visualization, or set it in role playing as if this were a real event. To do so, they should show and explain (use the visualization option) the location, its features and obstacles, the wind line and smoke/wind sock. They should also get the trainee to show and verbalize operation of the controls, lanyard 4-line release and steering, riser malfunction clearing and steering, and if applicable, location of ripcords. The trainee should not be warned of the specific malfunction challenges.

SIMULATION TRAINING SYLLABUS (DURING RUN)

Trainee Actions: Once the run has begun, depending on the emergency equipment provided and the situation being simulated, the trainee will need to follow a specific sequence of actions [13,15,17].

- if egress, - proper free fall position
  - activate/release parachute
  - decision about altitude
  - for T-38 AAD, normally use immediate/static line; for seat deployment AAD failure use manual ripcord
- oxygen activation as necessary
- check canopy condition, correct malfunction
- check for canopy collisions
- lift visor, remove oxygen mask (and unplug communications) if low enough
- activate LPUs if over water
- activate steering mechanism (with 4-line, stopping oscillations) if parachute canopy is intact
- determine wind from turning and watching ground movement, and other indicators
- pick a target landing site, and fly to it using measured gradual control motions so as to be faced upwind below 200' altitude.
- Avoid low altitude control inputs, particularly over-control
- Be aware of possibility of landing in trees or power lines, opportunity to demonstrate correct body position.
- Verbalize awareness of situation and reasons for actions
- look up at horizon (avoid landing neck whiplash injury).

Instructor role: Some of these trainee actions are purely procedural, such as raising the visor and removing the oxygen mask, and will need the instructor to observe, note, and critique. Other actions, such as canopy control responses and malfunctions corrections, will have automatic scoring and consequences. Both types may require coaching during the run to increase situational cues, and the instructor needs to remain alert for errors, mistakes, and misunderstandings which should be reviewed and critiqued when the run is finished. One suggestion is to have prepared a score form for the observed items with check boxes and comment spaces for notes during the run. This can be inserted in a printer at the run end such that the program can print its run score and trajectory on the other side.

POST-RUN CRITIQUE METHODS

Much of the value of simulator training comes from its ability to facilitate an opportunity for immediate instructor observations, coaching, and dialog with the trainee, both during and after a run.

At the end of a run, the viewpoint tips down and pulls back up to display the landing location. If the run results successfully in a clear ground touchdown, a score screen appears on the instructor's display. This is a good opportunity to briefly and positively reinforce successful landings, and explain score areas of concern, such as excessive ground speeds, usually due to wind misalignment, and a high descent rate, usually due to not fixing malfunctions. Landing oscillations can stem from such inappropriate behavior as over-maneuvering at low altitudes, not releasing 4-line controls, or even making an inappropriate ram-air-type landing flare.

A VCR-playback-type mode is provided primarily to show trainee's observation viewpoint errors (or success). At the start, failure to look up overhead immediately and be aware of canopy opening problems is common. During the run, there may have been an over-focus on ground directly below, with loss of orientation towards the selected target landing site. Just before touchdown, setup for a good Parachute Landing Fall requires looking up at the horizon, which is often misinterpreted as all the way up at the sky. Instructor critiques about these procedures are much more effective when the student is provided a visual review. However, these playback times should be kept short when trainees are wearing an HMD. Prolonged mismatch between the recorded head motions being viewed and current motion or lack of motion can have very adverse affects, particularly immediately after a run where the trainee has learned to expect good synchronization.

The Moving Observer mode can help the trainee understand a malfunction better than afforded by the view directly under it. If the viewpoint is then moved directly over the recorded jumper and up some way, it is much easier to understand the flown trajectory. This is much like the perspective by the stationary observer mode. Again, in the interest of optimizing instructor and student time and interest, run playbacks should be limited to phases noted as concerns by the instructor during the run.

CONCLUDING REMARKS

Adult learning theory identifies the need for paced task difficulties, good establishment of the particular situation, and the provision for performance assessments during and after the task. Real parachuting training experiences being unacceptable, positive transfer of parachute training mandates the established military technique of teaching flight skills through simulation.

Widespread adoption of emergency parachute simulator training has led to the development of procedures manuals, instructor guides, and lesson plans. These plans vary depending on the particular emergency circumstances foreseen, but all share the goal of presenting as complete as possible a sequence of challenges that employ as much equipment and encounter as many of the events as can be expected in a real mishap; that is, a goal of minimizing the part task aspects of this training. Optimal results require continuing to dedicate substantial trainee preparation in the classroom, as well as some at the simulator before starting a training run. Instructors need to learn to carefully select and pace training challenges, assess performance during the simulation, and use the simulator-provided post-run tools to provide a critique through a dialog with the trainee. The success of this approach can be judged from the wide-spread adoption of simulation as an essential training technique, as well as from the very positive assessments of this concept by instructors and students.

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