Helicopters, Simulators, and Training

An Overview of Training and Flight Simulator Technology with Emphasis on Rotary-Wing Requirements

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Although there are many commonalities between fixed-wing and rotary-wing aircraft, both in terms of their performance and the missions they fly, their extensive differences demand that we recognize the training requirements that are unique to rotary-wing vehicles. In addition, the rotary-wing industry is made up of many widely distributed small operators whose training needs and logistics vary widely from those of the well-ordered, capital intensive, air carriers. The relative absence of large operators in the rotary-wing industry is a source of challenge to training-equipment manufactures and to the federal agencies responsible for supporting and regulating the development of aviation. In anticipation of growth in the rotary-wing industry, the Federal Aviation Administration (FAA) has proposed new rules, Part 142 Title 14 CFR, which will authorize and regulate certified training centers. The objectives of the new rules are to increase simulator use, eliminate the need for simulator exceptions, standardize training, and standardize the FAA’s oversight of training.

Overview of Training And Flight Simulation Technology

The principal purpose of this paper is to provide a broad overview of the technology that is relevant to the design of aviation training systems and of the techniques applicable to the development, use, and evaluation of those systems. The issues addressed here in are, for the most part, those that would be expected to surface in an informed discussion of the major characterizing elements of aviation training systems. Indeed, many of the same facets of vertical-flight training discussed here were recognized and, to some extent, dealt with at the 1991 Helicopter Simulator Workshop (Ref. 1). These generic topics, which are briefly described here and covered in considerable detail in Ref. 2, are essential to a sound understanding of training and training systems, and they quite properly form the basis of any attempt to systematize the development and evaluation of more effective, more efficient, more productive, and more economical approaches to aircrew training.

Training Requirements are Driven by Industry

The remarkable versatility of rotary-wing aircraft, both in terms of their performance and the missions they fly, demands that we recognize the training requirements that are unique to vertical flight. The differences in the jobs that these two fundamentally distinct aircraft are designed to do must be addressed in the design and development of their respective training systems and programs, as well as in the regulatory criteria that are imposed on their pilot certification training and operation.

The vertical-flight and virtually unlimited maneuvering capabilities of helicopters and tilt-wing and tilt-rotor aircraft have opened up myriad commercial operations that have
significant economic and social benefits. The well-ordered and widely used training systems for fixed-wing aircraft are not always applicable to rotary-wing operations, which are characterized by a large number of extensively distributed and marginally funded small operators. The unavailability of low-cost training media forces these operators, whether relatively large or small, to depend mainly on their on-line aircraft for both revenue generation and training; as a result, the efficiency of both suffers. Beyond ab initio training, the aircraft is a poor training device. When used for training, it is uneconomical, inefficient, and potentially unsafe, and it is a poor place in which to learn and assimilate new material and to practice newly acquired skills.

The United States has always been the undisputed leader in aviation research, development, and production. Once again the vigor and high quality of these activities have placed us at the threshold of a new era and confronted us with new challenges in the continuing evolution and growth of our national aviation transportation system. That system involves an already burgeoning commercial helicopter industry, and we may soon see the further expansion of vertical-flight commercial carriers with the introduction of the tilt-rotor (the civil version is the CTR-22 and the military version the Osprey) and possibly the tilt-wing aircraft.

Because of the proposed addition of vertiports for off-loading of the runways used by the large carriers, these new vehicles have the potential to produce a profound effect on the infrastructure of the national airspace system. They will require new air-traffic control (ATC) procedures because of changes in the architecture and timing of traffic flow; and that may deeply affect the nature of current feeder-carrier operations, which of course do not have the spot landing capability of rotary-wing aircraft. It is hoped that by anticipating rotary-wing operations our management of rotary-wing training and training equipment requirements will progress apace so that the transition from conventional fixed-wing requirements to the identification and fulfillment of those expressly applicable to rotary-wing training will be accomplished as expeditiously as possible.

A Centralized National Training Program

As mentioned above, the rotary-wing industry is made up of many, widely distributed small operators whose training needs and logistics differ markedly from those of the well-ordered, capital-intense air-carrier training systems. The monolithic organization is rare in the rotary-wing industry, and its absence is a source of challenge to the training equipment community and to the federal agencies supporting and regulating aviation development. Rotary-wing training departments, equipment, courses, and instructors are not an integral part of corporate operations as they are and have been with the large air-carriers.

In anticipation of the growth of the rotary-wing segment of the aviation industry, the FAA is in the process of proposing a new rule, NPRM, Part 142 (Title 14, CFR), which will authorize and regulate Certified Training Centers. The objectives of this new rule are to increase simulator use, to standardize training, and to standardize the FAA oversight of trainers through a centralized, national training-program approval process. In an effort to maintain a broad perspective, the rule would not specify, in any detail, the differences between fixed-wing and rotary-wing flight simulators. Instead, the FAA would issue certificates to qualifying training centers. The issuance of the certificate would depend on the compliance of the training with a set of training specifications, which could if necessary, be changed more easily than the certification. Part 142 would either replace Part 141, Pilot Schools, or complement it; in the latter case, Part 142 schools would cooperate with Part 141 schools in setting up mutually satisfactory arrangements for training students.

These new regulations can be a significant factor in addressing the needs of the many small rotary-wing operators who have severely limited training budgets. In addition to providing for increased simulator use, however, more attention needs to be given to allowing more training and checking credit for the low-end (less-complex) training devices. Also, in keeping with a heightened interest in simpler but
more versatile training systems, more attention should be given to the feasibility of using mobile training devices that can be quickly reconfigured to accommodate the needs of two or more aircraft types.

There are obvious similarities between the infrastructure of the current rotary-wing industry and that of deployed military rotary-wing units. As a result, the training capabilities envisioned by military commanders following the Desert Storm operation may hold equal promise for civil rotary-wing operators. Highly placed military spokesmen, whose comments could well be harbingers of the future in civil rotary-wing training, called for portable and rugged training systems that could be taken into the field for on-site training to maintain and sharpen combat-readiness skills: "deployable, foldable systems are going to help the operating forces immeasurably", increased emphasis on simulated training operations as the military goes through the downsizing brought about by the end of the Cold War; and the design and use of multiple-aircraft-type training simulators with short configuration-type turnaround times (Refs. 3, 4).

One company was said to be "...working on a flexible mission rehearsal simulator in which a C-130 cockpit can be transformed into a helicopter cockpit in 30 minutes." Another is working "[On] an aircrew training system for the Special Operations Forces that will enable them to train in seven different aircraft types" with database turnaround in 48 hr. Another example of training-device economy through simplification is the F-16 multi-task trainer (MTT), developed for the Air Force Reserve by Armstrong Laboratory (Williams AFB, Ariz.) that weighs only 1500 lb. It can be separated into two parts for easy transportation and can easily be rolled through a 66-inch-wide office door. It evolved from an earlier effort to develop an F-16 air intercept trainer (AIT) "to teach the pilot to play the piccolo," that is, to teach him to operate the many radar and weapons controls that are on the stick and throttle. Although rudimentary, an AIT still was required to give pilots a radar display and a small video display and to respond with good fidelity to the side-stick controller and throttle movements as the pilot maneuvered to attack enemy aircraft. The author of the above comment also stated that "if the concept can be duplicated for other types of aircraft, there could be a very large market for MTTs." In particular, the Navy might be very much interested in having "flyable" simulators on board ships (Refs. 3, 4).

**The Shifting Emphasis of Training: Situational Awareness and Cockpit Resource Management**

At the risk of oversimplification, it may be said that there are three overlapping performance domains represented by the activities of the aircrew members: (1) psychomotor activities in the guidance and control domain; (2) serial and procedural cognitive activities in the management of aircraft systems; and (3) cognitive, executive, decision-making activities in flight and resource management. These are all interactive with the need to maintain a veridical and ongoing "situational awareness." Failures in the cognitive activities of aircrew (human errors) are generally conceded to be the major source of aviation incidents and accidents.

Indeed, the role of the human factors practitioners has changed over the years from human engineering and workplace layout to pilot-in-the-loop studies to the current intense interest in the "higher" aircrew intellectual functions. In a landmark paper, Weiner signaled the change of emphasis. Weiner said: "The human factors profession has long recognized the concept of design-induced errors. This paper simply extends the concept to a large-scale system, whose principal components are vehicles, traffic control, and terminals. These three components are embedded in two other components: regulations and weather." (Ref. 5).

And, I would add, the growing need to fly using automatic digital flight-control systems is a mixed blessing, because these systems can both decrease and increase workload. It is obvious how they can decrease workload, but there is also a potential for increasing workload; it results mainly from a poor mating between the logic of digital devices and the logic of the human mind. In changing the pilot's function from one of actual control to one of (principally) symbolic control, there is a danger of fragmenting the continuous situational awareness that is so essential to flight safety. The character of the critical...
training tasks is changing, and the much-discussed issue of training equipment fidelity is taking on new meaning. The new fidelity of interest is the one that pertains to the simulation of Weiner's "large-scale" system with its rich informational context and a flying task that is now more a deliberative than a motor process. Underlining this reality is the fact that procedural flight (intellectual) skills decay after only weeks of no practice, whereas motor skills are retained for months and even years. In line-oriented-flight training (LOFT) and in cockpit-resource management training (CRM) the emphasis is now on such factors as communication, flight strategies, crew coordination, task sharing, decision-making, and effective small-group problem solving. It must be noted that a similar sophistication of rotary-wing cockpits and automated flight-control systems cannot be far behind that of the advanced fixed-wing systems. In consequence of this, the major training task becomes clear, and it differs significantly from that of a decade ago. In turn, that task determines training goals, means, and media.

The reader of NASA RP-1373, which this paper summarizes, will learn of some novel ideas regarding the recognition of the uniqueness of rotary-wing operations (Ref. 2). The authors of Ref. 2 never lose sight of the sharp differences that in so many important ways differentiate the rotary- and fixed-wing worlds. There is a challenge here for the regulatory agencies to support the rotary-wing industry in order to ensure that all operators have available to them training systems and equipment that are systematic, uniform, and cost-effective.

The Challenge

The regulatory mandates for rotary-wing pilot qualification and certification must recognize the significant differences between rotary-wing and fixed-wing requirements. And finally, but of primary importance, it must be possible to satisfy the qualification and certification requirements in more modest but functionally relevant training devices. Emphasis should be shifted from the traditional perception of simulator fidelity---with its primary focus on the preciseness with which the simulator duplicates the physical characteristics of the aircraft it mimics—to one of primary concern with the simulator's effectiveness as a teaching tool, that is, with how well it trains what it is purposed to train.

It is hoped that this paper will provide the incentive and information needed to begin planning the development of a systematic, economical, and universally accessible training system for the vertical flight world. That should be next.

References


