CHALLENGES TO THE JOINT SERVICES V-22 OSPREY TOTAL TRAINING SYSTEM

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ABSTRACT

The V-22 Osprey aircraft is envisioned as a versatile and complex weapon system that will offer unprecedented mission flexibility for the Army, Navy, Air Force and Marine Corps well into the next century. The V-22 will incorporate advanced technology in its composite airframe, aerodynamics, avionics, and cockpit design, and will provide the United States with a highly mission capable aircraft. Along with the system's unique flight characteristics and advanced technology underlying its construction and suite of mission systems, an expanded set of challenging new requirements for training system design is rapidly emerging. The degree to which the services and the training industry can successfully anticipate, identify and address the requirements for optimal training will largely determine the ultimate effectiveness of the V-22. This paper reviews major considerations in the V-22 training system development to date, examines some of the more salient training issues, and challenges the training systems community to develop innovative solutions that capitalize on advanced technology and maximize training effectiveness.

INTRODUCTION

The MV-22 design that was negotiated for full scale development in May 1986 will produce a vertical short take-off and landing (VSTOL) aircraft that combines the fixed wing advantages of high-speed, high-altitude (300 kts, 30,000 ft) with the helicopter advantages of confined area landings and slow speed flight. Derived predominately from American technology and ingenuity, the V-22's capability to transition from rotor-borne flight to wing-borne flight will be accomplished by tilting engine nacelles that produce vectored thrust. The airframe will be advanced composite construction, the avionics will be totally computer-controlled, and the cockpit will comprise the latest innovations in control/display technology.

In addition to building one of the most technologically advanced aircraft, the Navy, in cooperation with the Army, Air Force and Marine Corps, must develop the V-22 Osprey for joint operational use. The Marines (552 aircraft) and Army (231 aircraft) will employ the MV-22A in combat assault, combat support, service support and MEDEVAC missions. The Navy (50 aircraft) will use the HV-22A system variant for combat search and rescue, special warfare and fleet support. The Air Force (80 aircraft) will use the CV-22A variant for long range special operations and combat search and rescue. Two other variants are already on the design board: 300 SV-22s to support the Navy's anti- submarine warfare mission; and the VV-22 for the Marines in support of the presidential mission.

The V-22 is a multi-role, multi-service vehicle that poses numerous technical challenges for DOD and the defense industry in meeting the joint services' mission performance requirements. The Navy, as the executive agency for procurement of the V-22, faces the technical challenges with a firm resolve to deliver the Osprey on time and within budget. Training is of paramount concern among these challenges. In the present paper, we review major considerations that have influenced developments in the V-22 training system program to date and describe some current views on outstanding training system requirements. A major objective of the paper is to stimulate the training systems community at large to develop innovative, cost-effective approaches to realize the greatest training and mission effectiveness possible for a new generation of military aviators.

INITIAL TRAINING SYSTEM DESIGN CONSIDERATIONS AND DEVELOPMENTS

Interest in the V-22 from both weapon system developers and training system developers is easy to understand in view of the aircraft's projected multi-service and commercial roles. What is less easily grasped is the complexity of many of the design issues, especially the training system design issues. To appreciate the more salient problems and issues that have arisen in early stages of the training system design, it is necessary to expand upon the uniqueness of the Osprey's design features and mission capabilities. The capability and versatility of this aircraft have dictated novel aspects in the training system design approach to date and, moreover, leave room for considerably more innovation as we attempt to determine the full range of total system requirements.

V-22 General Characteristics

The V-22 is not an aircraft that falls conveniently into one class of system (i.e., helicopter, propellor or jet) with a unidimensional role (e.g., cargo, patrol or attack). Culminating 30 years of research and development in tiltrotor technology, the Osprey is often described as an airplane capable of landing like a helicopter, or a helicopter capable of flying like an airplane. Actually, neither of the above descriptions is adequate; the V-22 is a VSTOL aircraft that flys on vectored thrust. The transition mode from rotor-borne to wing-borne flight is referred to as the conversion corridor and is defined by a complex functional relationship between airspeed and nacelle angle. It is bounded on the low end by the stall speed of the wing, and at the high end by the aeroelastic stability requirements of the wing and nacelle as a unit. As a vectored thrust machine, the V-22 will require new piloting control skills linked to knowledge of vector geometry during transition flight phases.

Mastery of the basic piloting control skills required by the V-22 will likely represent a secondary challenge compared to the proficiency an aviator will be expected to develop in other interactions with one of the most highly advanced flight crewstations ever designed. The Cockpit Management Display System (CMDS) serves as the nerve center of the total aircraft system integration. The cockpit is described as all electronic and all glass (i.e., all information displayed via CRTs). Other features of the crewstation include: the symmetrical layout of multifunction color displays and controls for pilot and copilot access of all aircraft subsystems and instrument readouts; helmet-mounted displays for sensor (e.g., forward looking infrared system) slewing and targeting capabilities; a digital moving map display; tactical decision aids; and data links to remote tactical controllers. Flight control is accomplished through a digital fly-by-wire, triply redundant system. In the V-22, the concept of the aviator as a systems manager of a broad array of sophisticated capabilities has been fully realized.

From the brief outline of design features presented above, it is clear that the Osprey will significantly impact aviation operations across the services. The V-22 will not only replace numerous aircraft presently in the inventory (e.g., CH-46, CH-53), but also will make obsolete many of the current helicopter and fixed-wing tactics associated with the aircraft for which it can substitute. With extended range, greater speed, and greater payload capacity (2-3 times the CH-46), the V-22 will expand the entire battlefield. Its forward insertion capabilities will threaten enemy communication links, command and control, and supply lines in ways not heretofore possible. The myriad of missions that will be served by the V-22 across the services must be accomplished, however, against increasingly capable threats.

A multitude of training system design implications and strategies follows directly from the V-22's unique design characteristics and multi-mission capabilities. From the outset, it was clear that critical elements of the V-22's training system approach would differ dramatically from any aviation training system predecessor. In the next section, highlights of some of the more important developments in the training system design to date are reviewed.

Initial Developments In V-22 Training System Design

Three major issues were encountered that heavily influenced the early stages of the training system design. The first issue involved joint service agreement on tasks to be trained in operational flight trainers (OFTs) and aircrew system trainers (ASTs). Hardware to support training curricula had to be defined but it was not apparent that a single system could satisfy all the services' requirements. Differences in each of the services's views of their respective mission requirements had to be addressed and the extent of commonality between tasks to be trained by the services had to be established. The second issue concerned the entry level skill requirements of pilots to fly the V-22 and the means by which these requirements would be satisfied. An extensive, objective analysis was required to address the problem that was further confounded by widely disparate views on the V-22's characteristics as mainly an airplane or mainly a helicopter. The third issue required a plan to accomplish transition training for aviators already in the system who must be prepared to fly the first operational V-22s.

The first major issue was resolved through the Instructional Systems Development (ISD) process and efforts of subject matter experts. A pilot task listing was developed by the prime manufacturers, Bell/Boeing, drawing upon the tiltrotor flight expertise of their flight test engineers and test pilots. Due to differences in terminology and multi-service mission requirements, members of the joint service fleet project team (FPT) experienced initial difficulties in validating the accuracy of the task listing. An in-depth analysis by the joint FPT, however, determined that approximately 97% commonality existed among training tasks across the services. Following this assessment, the joint FPT reviewed and approved specifications for the development of 13 OFTs and 6 ASTs for joint service use. A modular design approach was directed for construction of the trainers to allow for pre-planned product improvement, accomodation of service unique requirements, and changes in the aircraft design. The up-front incorporation of modular design technology will allow the necessary room for variation and upgrade as well as the capability for trainers to "grow" into unique mission requirements.

Resolution of the second issue concerning student entry level skill requirements will have far-ranging impacts upon the training system design, organizations, and costs. From a practical standpoint, training conducted in one of the traditional jet, helicopter or maritime pipelines, or possibly some combination or improvement of the existing pipelines, would seem to be a cost-effective solution with the least organizational impact. Popular opinions initially supported improvements to existing pipelines but the opinions were biased by aircraft community specific experience. As another alternative, an entirely new trainer aircraft (TV-XX) could be developed to support a new curriculum.

The Naval Air Systems Command addressed the problem of student entry level skill requirements in conjunction with the Chief of Naval Education and Training (CNET), the Chief of Naval Air Training (CNATRA) and experienced contractor personnel. Generic and specific V-22 task listings were evaluated by instructor pilots from jet, helicopter and maritime pipelines with each task rated as to the degree to which associated skills were trained. Additional reference information was obtained from the same evaluation of task lists and interviews with pilots and instructors from the AV-8B, CH-46 and CH-53 communities; XV-15 pilots were also interviewed. The results indicated that none of the existing pipelines trains a majority of the V-22 piloting and mission systems tasks. Combined helicopter-jet or helicopter-maritime pipelines result in training of only slightly more than 50% of the tasks. The findings bear out a point made above:

the V-22 cannot be classified as either a helicopter or an airplane. It shares the aerodynamic qualities of helicopters, AV-8B's and conventional turboprop aircraft, but these qualities change as the regime of flight changes. Because of the V-22's aerodynamic characteristics and its unique cockpit features, a new and more resourceful approach to pilot training must be considered.

In relation to the third issue, the first aviators to be trained to fly the V-22 for the Navy and Marine Corps will be CH-46 and CH-53 pilots. Since students fully prepared in Undergraduate Pilot Training (UPT) to enter Fleet Replacement Squadron (FRS) V-22 training will not be available until 1994, instructor pilots will be trained beginning in 1992 to support the transition training requirements. A four-stage curriculum is envisioned to provide the transition training. The first stage should employ traditional Computer Aided Instruction (CAI) and programmed texts to teach theory and principles of operation. The second stage will likely consist of classroom training complemented by individual practice on ASTs to acquire basic procedural skills. In the third stage, OFTs could be used for training combined crew operations, crew coordination, flying skills, and mission scenarios. During the fourth stage, aircrews would practice in the aircraft. The transition training can be considered a solution for the short-term. In the long-term, students will leave UPT with basic VSTOL flight skills. Mission specific training will be provided in each services' operational training (i.e., FRS) domain. To handle the joint pilot training requirement, an undergraduate consolidation/ co-location is considered a viable option at this time. It is significant to note that the CH-46 and CH-53 pilots selected for V-22 transition training will be leaving cockpits with conventional controls and "steam gauge" displays to assume the roles of highly coordinated system operators in an all-glass cockpit with highly integrated subsystems and fly-by-wire capabilities.

OUTSTANDING TRAINING SYSTEM REQUIREMENTS AND CHALLENGES

In previous sections, we have pointed out how the V-22 differs significantly from other aviation weapon systems and the substantial impacts upon training system design. In this section, we overview two novel commitments important to the V-22 training system design and implementation, the use of the Manned Flight Simulator and the Ada programming language. From there, we direct our attention to requirements and challenges that still must be met to realize maximum training value and effectiveness from the V-22 training system.

The Manned Flight Simulator And Ada

Traditionally in the development of flight simulators, the services have acquired development testing (DT) and operational testing (OT) for trainers from the manufacturer. In the V-22 program, an early commitment was made to utilize the Manned Flight Simulator (MFS) at the Patuxent River, MD Naval Air Test Center (NATC) to support DT and OT as well as the engineering development of the first article trainer. Present plans call for training of 24 pilots from the joint services on the MFS to enable DT and OT to be conducted at NATC. The MFS will feature a modular, strap-down cockpit on a six degree of freedom motion system and will include a wide-angle visual system. The design flexibility incorporated in the MFS will allow its use in future aircraft development programs and will provide for engineering simulation prototyping for future V-22 OFT modifications. A major benefit of the present approach is the corporate, in-house capability the Navy will have at its disposal for bridging engineering simulation and training simulation problem areas in next generation aviation weapon systems.

Another key decision that should have far-ranging implications for the V-22 training system, as well as for the simulation industry at large, was the commitment to use the standard DOD programming language, Ada. The decision to employ Ada for the V-22 trainers should provide a major stimulation to industry to develop and refine capabilities in the Ada application area. The structured design features of Ada should logically complement the services' modular approach to trainer development discussed earlier. Since Ada programs are modular and re-usable by design, configuration management should be greatly assisted and there is promise for major reductions in the total software life cycle costs.

The Requirements And Challenges

At this point, we turn to consider other training issues associated with the uniqueness of the V-22 and the wide variation in mission requirements across the services. Our primary intent is to challenge the training systems community to react creatively in proposing new elements for the V-22 total training system. We must be able to identify the range and domain of the new training requirements very early if the system user is to produce the most highly qualified, combat ready V-22 aviators. Of a long list of problems and associated training needs that can be anticipated, we have selected a few of the more salient upon which to comment.

Systems Management Training Requirements.

Along with the radical changes in aircraft design characteristics have come greater system complexity and the aviator's new role as a systems manager in the V-22. Superior pilots will no longer be the "best sticks" but will be those with the greatest systems knowledge, decision making skills, and ability to maximize the utilization of system resources to achieve mission objectives. The supervisory role of the V-22 aviator in the CMDS environment does not imply, however, that workload will be decreased as a result of the multifunctional displays/controls, the greater information processing performed by the subsystems, or the improved integration of the information in alpha-numeric and pictorial formats. On the contrary, the numerous computer-driven operations performed by the V-22's subsystems present thousands of options or potential ways for pilots to interact with the "layered" information available in the system. Memory and information processing demands will increase for the V-22 systems manager and in ways that are not easy to predict under the stress of emergency or combat. Moreover, the mental functions and skills required of V-22 aviators in their new systems supervisory roles will not be highly structured activities in most situations. Sequences of specific actions will depend on the events that arise as the operational scenario unfolds. Since the tasks can seldom be described as fixed, deterministic sequences, operators cannot be adequately trained by drill on fixed scenarios. Also, it is difficult to imagine that training on a sufficient number of unplanned conditions could be provided.

In the above discussion, we have alluded to the need for training system capabilities that will ensure delivery of in-depth knowledge and skill bases through extensive exposure to system simulations. Low-cost, microprocessor-based simulations of V-22 displays/controls with scenarios that exercise a very large range of system options, as well as free-play capabilities, are easy means to augment training along these lines. Further discussion of possibilities in this area will follow in a later section. In addition, we have called for a longer term approach that examines the component skills, knowledges, and rules employed by operators in real time to analyze specific conditions and formulate actions to counter threats and achieve mission objectives. Future training for systems managers must focus beyond a procedures orientation upon methods that will enhance an aviator's understanding of total system resources and how these assets can be most effectively utilized.

Crew Coordination Training Requirements.

The combination of the CMDS advanced technology and two systems managers in the V-22 crewstation sets the stage for new kinds of problems. Effective coordination between crew members during mission critical phases will have a major bearing upon operational success. We are concerned now with establishing rules of behavior in dealing with contingencies in high workload, high density threat environments. Technology in the V-22 allows rapid reconfiguration of the entire display/control ensemble as well as helmet-slaved sensor slewing. But creative initiative on the part of crew members in this cockpit could quickly lead to confusion and doubt about system responsibilities or the utility of displayed information. Recent studies of other advanced systems have shown that two crew members perform worse than one under high workload when crew coordination training is lacking. There are numerous examples from military and commercial aviation of the disastrous consequences of breakdowns in crew coordination.

Once again it can be speculated that low-cost simulation technology could be derived to augment OFT and AST capabilities. Enough variety in "canned" sensor imagery and electronic warfare (EW) threat simulation could be achieved at reasonably low cost to make training problems challenging and interesting. The real objective, however, would be to establish the principles and discipline of crew coordination in system operation and resource management. Also, simulation problems with varying workload demands could be designed to challenge crew coordination under stressful conditions.

Mission-Oriented Training Requirements.

The complexity of missions planned for the V-22 implies different training issues than those associated with system complexity. By mission-oriented training we mean training that encompasses intra- and inter-aircraft crew coordination and training in special tactics and missions. Traditionally, fleet training has been designed to maintain proficiency. For the V-22, however, many new and important dimensions of training will begin in the fleet. Moreover, continuous and more highly structured fleet training will be necessary in view of the range of missions and capabilities of the system.

Since a weapon system is seldom launched by itself, there is always a need for integrated air combat tactics training. Other examples of V-22 training conducted by the fleet likely will include formation flying, low level flying, tactical situation assessment, threat avoidance, and forward insertion-extraction procedures. It is the multi-mission capability of the V-22 that may lead to problems in providing adequate training for pilots. Although the V-22 OFTs will comprise numerous advanced capabilities and can support mission-oriented training requirements, the systems could have limited availability under what promises to be a heavy training load. Low-cost, networked simulations with free-play or limited scenario features could be entertained as complements to the OFTs for mission-oriented training. Such systems would need to be flexible, adaptable and contain enough sensor imagery and EW features to ensure continued challenging and novel situations and to provide interest and motivation on the part of pilots. The additional training opportunities provided by the lower cost but sufficiently realistic simulations should provide an expanded base for skill refinement on use of displays/controls and on maximum utilization of system resources to accomplish the mission.

Another technology area that bears watching for trends that will provide new opportunities to enhance the quality of training concerns the integration of mission planning and battle management systems. Once computer-based mission planning becomes a reality, it will relieve the flight crew of most of the tedium of detailed flight planning. The aircrew's time just before a mission could be better spent in verifying the accuracy and completeness of the plans, and in dress rehearsal for the coming mission, the ultimate in realistic training. The drop-in-tape capability of the AYK-14 computer and the commonality of the V-22 with its training simulators should contribute to dress rehearsal capabilities in the future.

Low-Cost Training Simulation Requirements.

Complementing operational practice with simulator time will continue to accelerate, both for economic reasons and because situations can be reproduced and examined that would be unsafe or impractical using actual equipment. From the foregoing views on V-22 training requirements, the need for additional simulation capabilities to satisfy what appear to be outstanding requirements was frequently referenced. Transition training, UPT and FRS training could substantially benefit from the introduction of well-structured and low-cost computer based training (CBT) that complements the training system design elements already planned. We cannot disregard at this point in time any approach that will better ensure the acquisition, maintenance and enhancement of the broad array of skills that will be required of V-22 aviators.

Lower cost simulations of critical system features must be viewed only as tools for training and not as less than perfect renditions of the operational system. It is also most important to determine the training objective(s) we are trying to achieve through any simulation. Coupled with appropriate curricula, measures of learning and performance proficiency, and useful feedback to students, CBT can potentially enhance numerous dimensions of the training system. Acquisition and life cycle costs for microprocessor hardware are minor compared to the same costs for OFTs. Software development costs for simulation on microprocessors also can be contained by drawing upon software developed in the engineering design process. In some instances, the software developed for engineering simulation can be transferred directly to training applications.

CONCLUSIONS

As innovation has been the keynote in the V-22 weapon system design, innovation must also be applied to the development of the training system. The technically sophisticated V-22 is an excellent example of the joint services' strategy to maintain military superiority in the face of our adversaries' numerical advantages in weapon systems. If the philosophy of superiority through technology is to work, however, then we must field operators and maintainers who can efficiently and effectively get the job done. Therein lies the challenge before the training community - to create the skill bases in personnel necessary to take maximum advantage of our systems' capabilities. The process will admittedly not be simple as we must set aside many time-worn ways of training. The critical advantages that can be realized with the V-22 aircraft will depend largely upon our success in developing a comprehensive and effective training system that yields the most combat ready aviators in the world.

ABOUT THE AUTHORS

Major Schultz received a BS in Chemistry in 1975 and entered the USMC the same year. He was the first fleet CH-53E pilot and the first air officer of the light vehicle battalion. Major Schultz chaired the CH-53D and CH-53E FPT and participated on the CH-46 and AV-8 FPT. He is a graduate of the Defense Systems Management College and currently serves as the program manager for V-22 training systems at the Naval Air Systems Command.

Commander Owens holds a Ph.D. in Experimental Psychology with major area of study in human factors psychology and minor areas in Industrial/Electrical Engineering. He entered the USN Medical Service Corps in 1973 and was designated a Naval Aerospace Experimental Psychologist in 1974. He has served in various assignments related to aviation RDT&E management and execution. Immediately prior to his assignment at the Naval Air Systems Command, he was Head, Psychological Sciences Department, Naval Aerospace Medical Research Laboratory, from 1981-1984. On the staff of the Air Program Coordinator for Training Systems (APC205), Commander Owens is presently serving as Deputy for Plans, Programs, Analysis and Evaluation.

Lieutenant Commander Harris received his commission in the USN Medical Service Corps in 1974. He holds a MS in Psychology and is nearing completion of requirements for a Ph.D. in Industrial Engineering and Operations Research. Prior to his assignment at the Naval Air Test Center (NATC) and out-service training at Virginia Polytechnic Institute, he managed the Navy's voice-interactive systems and technology program at the Naval Air Development Center. Lieutenant Commander Harris developed the first artificial intelligence system, "DEMON", to be flight tested in an F-18, and has received wide recognition for his expertise in the application of advanced technology to crewstation design. His current assignment at NATC is Head, Computer Technology and Simulation Department, Systems Engineering Test Directorate.